Indicators of sustainable development in civil aviation

INDICATORS OF SUSTAINABLE DEVELOPMENT IN CIVIL AVIATION

by

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Abstract

Civil aviation provides for large scale, rapid, safe and reliable transport over long distances. In the last half of the 20th century, the reliability of air transport has increased, safety has improved and costs have reduced: the volume of civil aviation has greatly increased and demand continues to rise. The social and economic benefits arising from aviation are substantial while its environmental costs are significant and increasing: with current technologies aviation is considered to be essentially unsustainable. Sustainable development as a concept, arose in the latter part of the 20th century. It may be regarded as a journey of changes through time, a journey navigating a wide range of changes in technology and behaviour thought to be needed to move towards a better level of sustainability. There is a need to apply the principles of sustainable development to the practice of the civil aviation industry.

The research on which this thesis is based draws on sustainable development literature, general systems theory and quality principles to derive a holistic and systemic sustainable development model, and a methodology for deriving indicators of sustainable development. These are then applied to the civil aviation system, to select and construct indicators of sustainable development in civil aviation. The indicator selection process is participative, and seeks the views of stakeholders of UK civil aviation. Stakeholders are asked, via a Delphi study, to give their views on the meaning of sustainable aviation, and on the most important aspects of sustainable development in civil aviation.

The research proposes a set of 29 indicators for sustainable development in civil aviation, including institutional and regulatory indicators. The research findings suggest that, amongst UK civil aviation stakeholders, there is some consensus on the important sustainability issues facing civil aviation, and on their choice of indicators. There is little understanding of the meaning of sustainable aviation, and disagreement on policies to adopt in favour of sustainable development in aviation. Amongst stakeholders from civil aviation organisations, there is strong opposition to regulatory or economic policies in favour of sustainable development. While the safety of civil aviation is institutionalised, there is evidence to suggest that opposition to other aspects of sustainable development is embedded in the regulatory and operational organisations of civil aviation in the UK.

Keywords: Sustainable; development; indicators; systems; methodology; aviation;

Table of Contents

List of Boxes

List of Figures

List of Tables

Glossary

ABI	Annual Business Inquiry
ACARE	Advisory Council for Aeronautical Research in Europe
ACEA	Association des Constructeurs Européens d'Automobiles – European Automobile Manufacturers Association
Agenda 21	Agenda of Action for the 21st Century – action agenda published by the United Nations following the Conference on Environment and Development, Rio-de-Janeiro, June 1992
APD	Air Passenger Duty
ATAG	Air Transport Action Group
ATM	Air Traffic Management
CAA	UK Civil Aviation Authority
CASS	UK Civil Aviation Sustainability Strategy
CBEP	Community Based Environmental Protection
CMI	The Cambridge-MIT Institute
CO_2	Carbon dioxide
DCLG	UK Department for Communities and Local Government
DEFRA	UK Department for Environment, Food and Rural Affairs
DfT	UK Department for Transport
DPSIR	Driving Force-Pressure-State-Impact-Response Indicator Framework
DSR	Driving force-State-Response Indicator Framework
DTI	UK Department of Trade and Industry
EASA	European Aviation Safety Agency
EIA	Environmental Impact Assessment
EPA	US Environmental Protection Agency
EU	European Union
Eurocontrol	European Organisation for the Safety of Air Navigation
FAA	US Federal Aviation Administration
G8	Group of Eight (G8) – seven of the world's leading industrialized nations (Canada, France, Germany, Italy, Japan, the United Kingdom, the United States) and Russia.
GDP	Gross domestic product
GHG	Greenhouse gas (emissions)
GPDO	General Permitted Development Order
GRI	Global Reporting Initiative
GTL	Gas to liquid technology
GVA	Gross value added
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICE	Institution of Civil Engineers
ISO	International Standards Organization
IUCN	International Union for the Conservation of Nature and Natural Resources
MP	Member of Parliament
NASA	US National Aeronautics and Space Administration
NATS	UK National Air Traffic Services
NMVOC	Non-methane volatile organic compounds
OECD	Organisation for Economic Co-operation and Development
OEF	Oxford Economic Forecasting
ONS	UK Office of National Statistics
OPEC	Organization of the Petroleum Exporting Countries

PICABUE	A methodology for developing sustainable development indicators (Mitchell, May et al. 1995)
PPP	Polluter Pays Principle
PSR	Pressure-State-Response Indicator Framework
SARS	Severe Acute Respiratory Syndrome
SASIG	Strategic Aviation Special Interest Group
SDC	UK Sustainable Development Commission
SDI	Sustainable development indicator or Indicator of sustainable development
SI	Sustainability indicator – pseudonym for indicator of sustainable development
SIC	UK Standard Industrial Classification
SoS	UK Secretary of State for Transport
SSA	Systemic Sustainability Analysis. A methodology for developing sustainable development indicators (Bell, Morse 1999)
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development – the Rio Earth Summit 1982
UNCSD	United Nations Commission for Sustainable Development
UNEP	United Nations Environment Programme
WCED	United Nations World Commission on Environmental Development
WHO	World Health Organization
WLU	Work Load Unit – a measure of activity equivalent to 1 passenger or 100 kgs freight
WMO	World Meteorological Office
WSSD	World Summit on Sustainable Development 2002

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Specific thanks to Dr Ian Humphreys: Ian first suggested that I should actually undertake this PhD, and his enthusiasm and powers of persuasion convinced me to start the project. It seemed a good idea at the time! As my initial supervisor, Ian guided me through the first part of the work, before taking up a higher calling to the Ministry. Dr David Gillingwater then took on the role of supervisor. David's advice and guidance has proved invaluable in forming and presenting the work.

Respondents to my survey came from UK civil aviation and various bodies associated with or affected by civil aviation. I was at times surprised by their enthusiasm in replying to the survey, and very heartened by the number and openness of their responses. The confidentiality agreement precludes naming any of my respondents, so an anonymous vote of thanks to them all.

But the greatest thanks and appreciation is due to Jean my wife, who immediately supported the commitment to this PhD, suffered in the low periods, enjoyed the highs, and in the production of this report, offered a meticulous proof reading service. Thank you, Jean.

CHAPTER 1 Introduction

1.1 *Context of Research*

Civil aviation provides for large scale, rapid, safe and reliable transport of passengers and freight over long distances. In the last half of the 20th century, the reliability of air transport has increased, safety has improved and costs have reduced: the volume of civil aviation has greatly increased, and demand continues to rise (Doganis 2000). The social and economic benefits that arise from aviation are substantial: aviation promotes trade, inward investment, travel for leisure and education, tourism and much more (Caves 2003, Upham 2003); on the other hand, the environmental and social costs of air travel are significant and increasing year on year. With current technologies and growth rates, civil aviation is considered to be essentially unsustainable (Upham 2003).

Sustainable development as a concept arose in the latter part of the 20th century. The concept remains somewhat nebulous, and has provoked great debate. It may be regarded as a journey of change through time (NRC 1999, WCED 1987); a journey navigating a wide range of changes in technology and behaviour which are thought to be needed to move towards a better level of sustainability.

Civil aviation continues to grow, though the environmental costs attract increasing attention. The concept of sustainable development gains more widespread support, even if poorly understood. The practice of civil aviation may diverge from the principles of sustainable development, and the projected growth may exacerbate this divergence. There is therefore a need for research that applies the concepts and principles of sustainable development to the practice of the civil aviation industry.

1.2 *Aim and Scope of Research*

Within the general need to explore relationships between sustainable development principles and civil aviation, the specific aim of the research which underpins this thesis is to derive indicators of sustainable development in civil aviation. Transport studies research ranges from research into the transport system itself, the external effects of transport systems, and the motivation to change the system and the demand activities (Allsop 2006). The framework suggested in Figure 1.1 provides a convenient model to illustrate the position and scope of transport studies research.

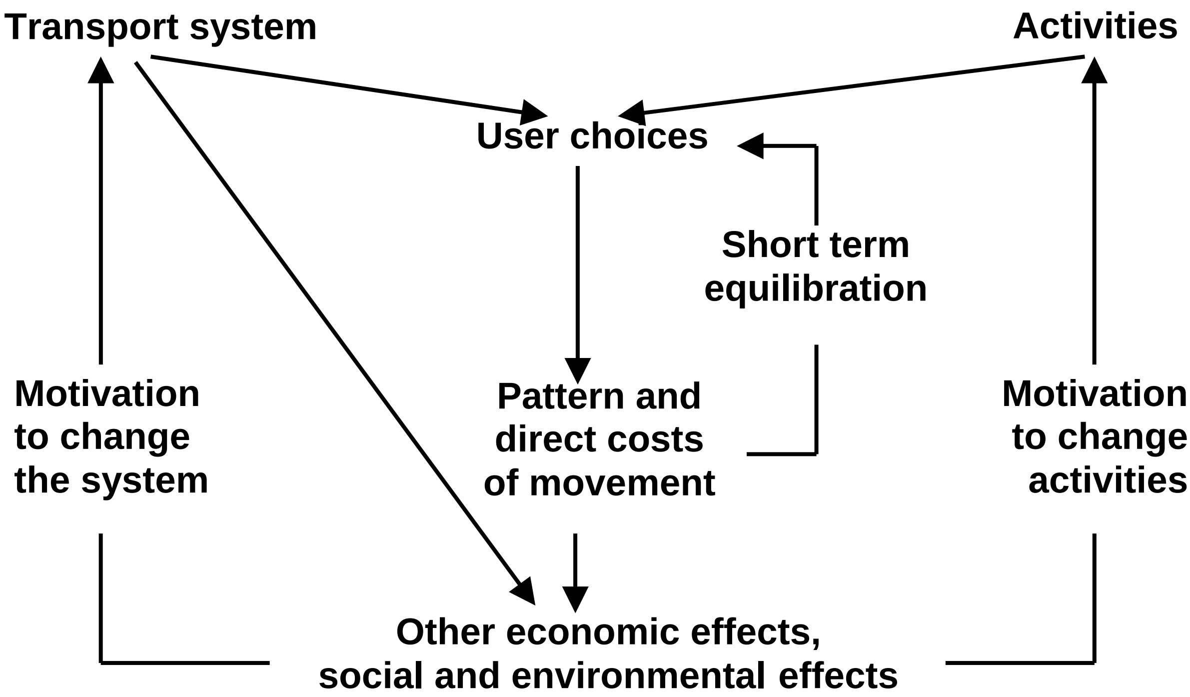


Figure 1.1 A Framework for Transport Studies Research

Source: (Allsop 2006)

The aim of the proposed research is positioned within the category ‘Other economic effects, social and environmental effects’. The research examines the external effects of civil aviation with respect to sustainable development: resultant indicators lie on the interface between ‘Transport system’ and ‘Other effects’. The research therefore avoids examination of the internal technical complexities of civil aviation, except where necessary to understand the external effects.

The research also examines potential changes required to move towards a more sustainable level of operation: resultant indicators lie on the interfaces to ‘Motivation to change system’ and ‘Motivation to change activities’. The two areas of ‘Motivation to change’ include the adoption of policies for change, setting of goals and targets: these are highly politicised processes and are not examined in this research.

The scope of the research is thus limited to applying sustainable development principles to the external effects of, and potential changes to, the civil aviation system. In view of the complexity of civil aviation, and the ambiguity of sustainable development, this is regarded as a sufficient initial challenge.

Sustainable development is a relatively young concept, at best defined as high-level, general principles. There remains some difficulty in applying these general principles in an operational context, and so it is necessary in this research to derive two methodological stepping stones. The first is a sustainable development model, intended to provide a holistic system description in sustainable development terms. The second is a methodology to derive indicators of sustainable development, intended to provide a process for selecting and constructing objective indicators. These two methodologies form the theoretical approach to the research. Each of the methodologies is, in principle, generally applicable to industrial sectors or enterprises. In this research the methodologies are applied to the civil aviation sector.

The term 'sustainable aviation' has come into common usage, and seems to have achieved widespread credence within the aviation industry and government (DfT 2003b, Sustainable Aviation 2005). However, any definition of the term remains elusive. It is thus necessary to explore civil aviation stakeholders' interpretations of 'sustainable aviation' as a part of the process to derive indicators.

1.3 *Research Objectives and Approach*

The aim of the research is to derive indicators of sustainable development for the civil aviation system. In support of this primary aim, the following objectives are investigated:

- To derive a sustainable development model
- To define a methodology to derive indicators of sustainable development
- To explore the meaning of sustainable aviation
- To propose a set of indicators of sustainable development in civil aviation

The theoretical approach is supported by an extensive literature review, drawing on the literature for sustainable development, systems theory and quality management (Figure 1.2). From these roots, a systematic approach is derived showing firstly a descriptive model of sustainable development, and secondly a process for deriving indicators of sustainable development.

The indicator methodology (Figure 1.3) is related directly to the principles of sustainable development, is highly participative, and includes a quality assurance step. The process illustrated forms the basis of the research in this thesis.

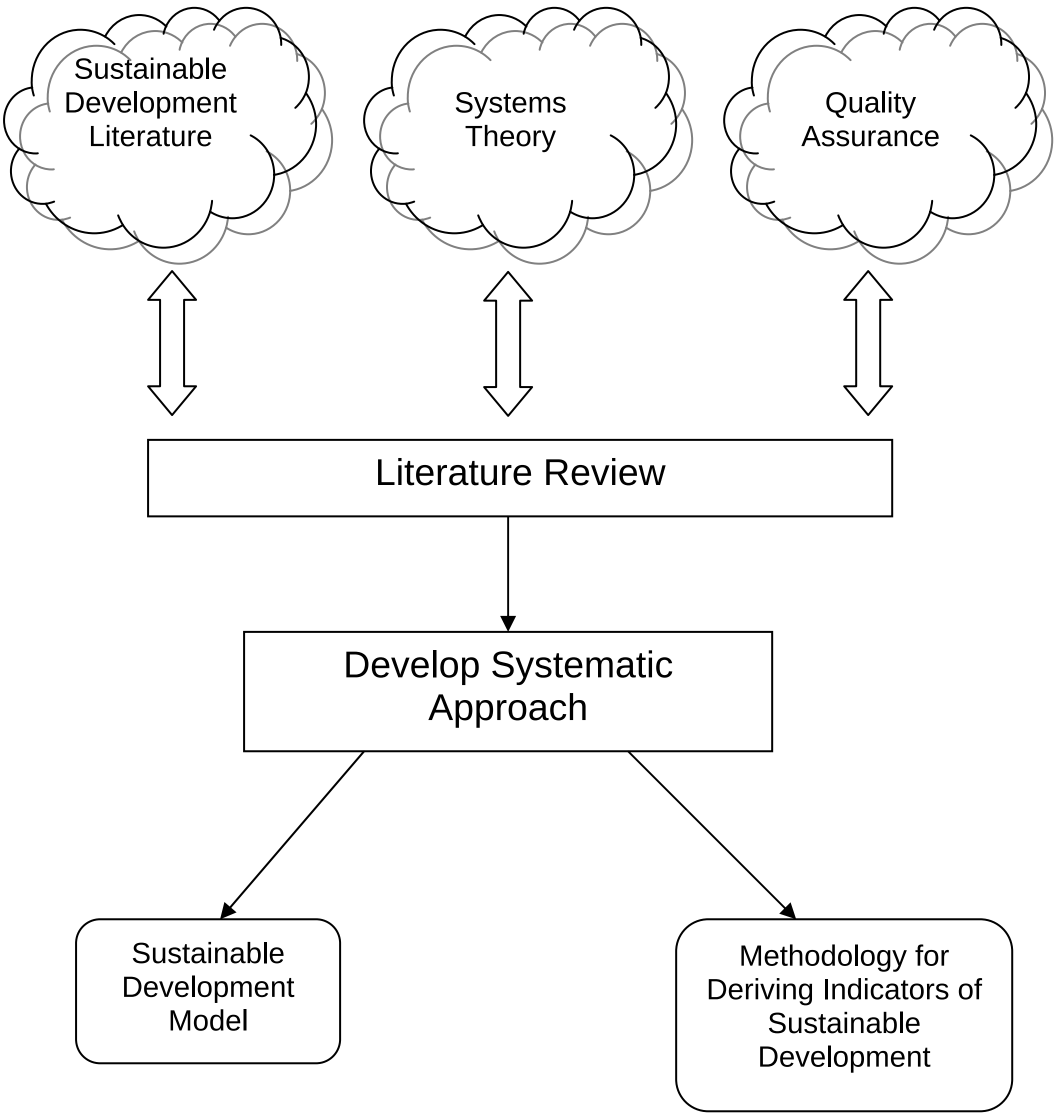


Figure 1.2 Literature Review and Theoretical Approach

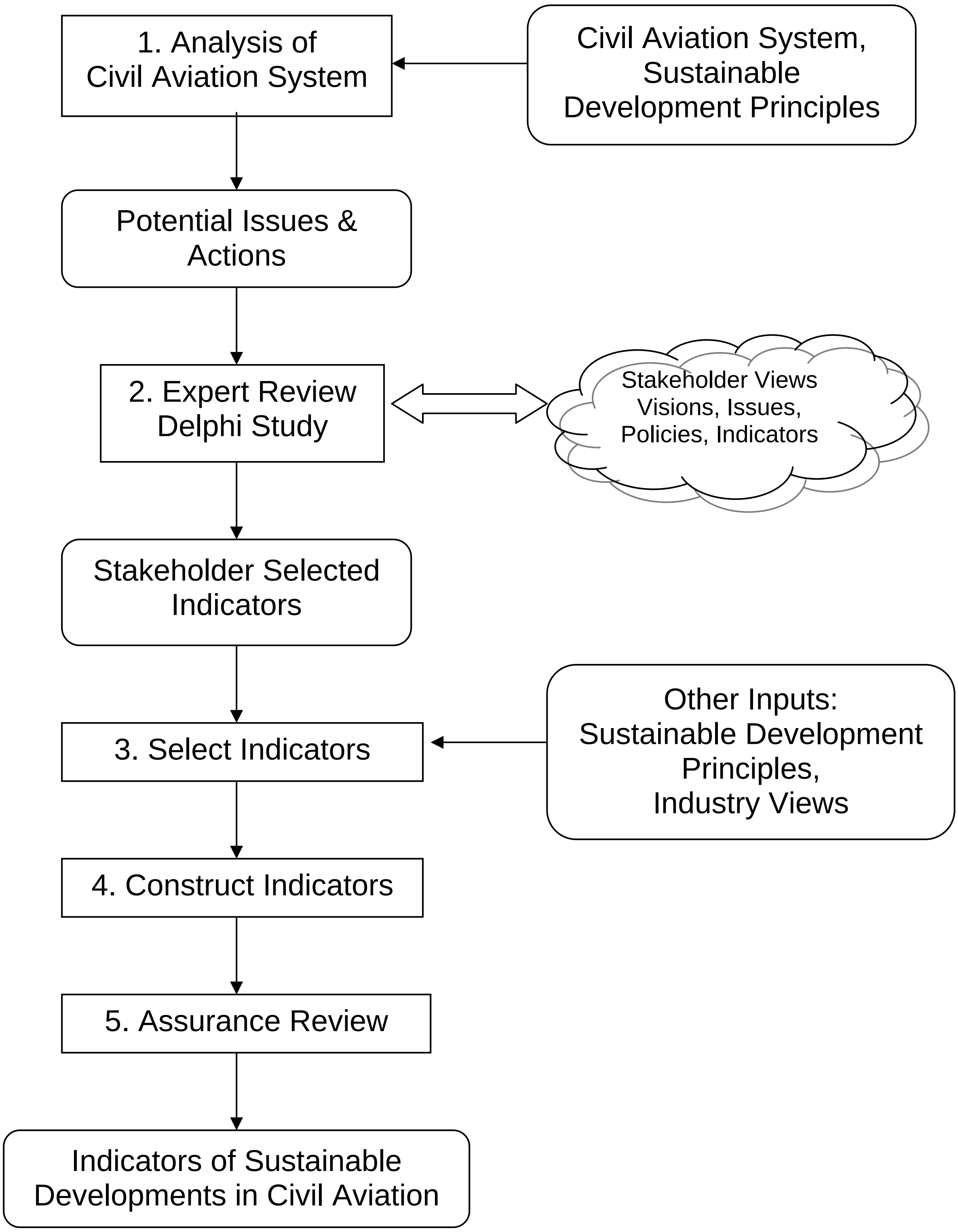


Figure 1.3 Methodology to Derive Indicators of Sustainable Development

1.4 *Outline of Thesis*

The theoretical approach (Figure 1.2) is covered in Chapters 2 and 3 of the thesis. Chapter 2 includes a review of sustainable development with the objective of obtaining an understanding of the theory and practice. The chapter explores sustainable development concepts, the difficulties of converting these concepts to an operational context, and identifies areas where revised approaches may be valuable. Chapter 3 explores the literature on systems theory and quality management, and develops the theoretical basis of the research – a sustainable development model and a methodology to derive indicators of sustainable development.

In Chapter 4, an extensive systems analysis of civil aviation related to sustainable development principles is undertaken, corresponding to Step 1 of the indicator methodology (Figure 1.3). The analysis yields a list of issues and policy actions, potentially relevant to sustainable development in civil aviation, which are subject to stakeholder review.

The stakeholder review (Step 2 of Figure 1.3) is covered at Chapters 5 and 6. The research undertakes a two round Delphi study to explore stakeholder's personal views of the meaning of sustainable aviation, the importance of the potential issues and policy actions derived in the analysis and suitable indicators. The research objectives and propositions, questionnaire design, and the basis of stakeholder selection are described at Chapter 5. The research findings are presented in Chapter 6, and a stakeholder selected indicator set is derived. Organisational attitudes are explored by an analysis of published policies, described in Chapter 6.

Chapter 7 covers the last three steps of the indicator derivation methodology: Select Indicators, Construct Indicators, Assurance Review (Figure 1.3). Factors given lower priority by stakeholders are reviewed against sustainable development principles and considered for possible inclusion in the indicator set. Each indicator is defined and, where possible, populated with data from existing published sources. The complete indicator set is reviewed against criteria derived from sustainable development principles. Chapter 8 reviews the research findings, highlights contributions to knowledge, suggests a range of further research arising from this systematic treatment, and discusses the contributions of this research to the debate on sustainability of civil aviation.

CHAPTER 2 Sustainable Development – Theory and Practice

2.1 *Introduction*

The objective of Chapter 2 is to obtain an understanding of the theory and practice of sustainable development. The chapter explores the literature on sustainable development concepts, the difficulties of converting these concepts to an operational context, and identifies areas where revised approaches may be valuable. These revised techniques are developed in Chapter 3 and applied to civil aviation in the following chapters.

The various roots of the sustainable development concept are traced in section 2.2, leading to the idea of sustainable development as an evolutionary journey based on an anthropocentric view. Section 2.3 examines the inherent ambiguities in definitions of the concept, arising partly from the inevitable political compromise and the uncertainty of future technological developments.

The concept of sustainable development indicators was first formulated by the United Nations (UN) in Agenda 21: section 2.4 explores the Agenda 21 view of an indicator, introducing the notion of a self regulating sustainability system. The burgeoning body of work on the theoretical and practical bases for indicators is reviewed in sections 2.5-2.7. The review is a short excursion designed to illustrate some of the major themes and patterns in the literature, rather than a comprehensive bibliography.

Section 2.5 explores the nature of indicators, examining possible definitions, formats and characteristics. Section 2.6 discusses the hierarchy of international, national and local indicator sets deriving from UN initiatives, identifying potential tensions between national strategies for industry and the transnational nature of many industries.

Section 2.7 explores and reviews a range of methodologies specifically designed to develop sustainable development indicators. Some methodologies may not adhere strictly to all the principles of sustainable development and rarely is there a quality review of the resultant indicator set. It is suggested that indicator selection requires a systematic approach related directly to, and tested against, Agenda 21. Section 2.8 summarises the findings and recommendations of this chapter.

2.2 *The Nature of Sustainable Development*

2.2.1 The Roots of Sustainable Development

Whilst the history of environmentalism may be traced through several centuries, movements associating the state of mankind with economic and environmental concerns have come to the fore in the last part of the twentieth century (Pepper 1996). Latterly, this movement acquired the sobriquet 'sustainable development'. The literature review identifies at least three distinct roots in the sustainable development debate: the ecocentric view, the economic view, the anthropocentric view, each bringing somewhat differing interpretations.

The Ecocentric Root

This view is represented by The Natural Step, which sets out four conditions to be achieved by a sustainable society.

> *In a sustainable society, nature is not subject to systematically increasing:*
>
> *1. concentrations of substances extracted from the earth's crust;*
>
> *2. concentrations of substances produced by society;*
>
> *3. degradation by physical means;*
>
> *and, in that society...*
>
> *4. human needs are met worldwide.*
>
> (The Natural Step 2003)

These conditions, developed by Karl-Henrik Robèrt in the 1980s, have been supported by a number of authors e.g. (Porritt 2000). The Natural Step has developed a methodology to address moving towards these conditions, and reports that work is continuing with a number of corporate clients (The Natural Step 2003).

The Economic Root

The roots in economic theory may be represented by the works of Daly (Daly 1991), who argues that conventional economics places no value on the ecosystem as a source of raw materials or a sink of pollution – rather the ecosystem is regarded as inexhaustible and therefore free. Daly argues that continued unrestricted growth is impossible and there must be an optimal scale to the economy – a limit and scale not recognized in macro economics. The economic arguments lead to 'operational principles' for sustainable development:

(1) Limit the human scale to a level that, if not optimal, is at least within the carrying capacity and therefore sustainable. Once carrying capacity has been reached, the simultaneous choice of a population level and an average standard of living (level of per-capita resource consumption) becomes necessary.
(2) Technological progress for sustainable development should be efficiency-increasing rather than throughput (raw materials) increasing.
(3) Renewable resources, in both their source and sink functions should be exploited on a profit maximising sustained yield basis and in general not driven to extinction. Specifically this means that:
harvesting rates should not exceed regeneration rates; and
waste emissions should not exceed the renewable assimilative capacity of the environment.
(4) Nonrenewable resources should be exploited, but at a rate equal to the creation of renewable substitutes.

(Daly 1991) *p254*

A potential economic treatment of nonrenewable resources (El Serafy 1989) is to invest a proportion of the revenue from nonrenewables into development of renewable alternatives. The proposition is that, properly managed, by the time a nonrenewable resource is depleted, it will be fully replaced by renewable alternatives.

The Anthropocentric Root

The broad outline of the concept of sustainable development (though not the term) may be traced to the United Nations Conference on the Human Environment in Stockholm in June 1972 (UN 1972). ‘Sustainable development’ was discussed as early as 1980 by the International Union for the Conservation of Nature and Natural Resources (IUCN) (IUCN 1980): this may be the first published use of the term (Castillo 2005). Others consider that sustainable development was ‘a concept spawned in the 1980’s notably by Organisation for Economic Co-operation and Development (OECD)’ (Abeyratne 2003). The concept was refined during the 1980s by the United Nations World Commission on Environmental Development (WCED) culminating in the report ‘Our Common Future’ (WCED 1987), popularly known as the Bruntland Report after Dr Gro Bruntland, former Prime Minister of Norway and Chair of WCED at the time of publication.

The anthropocentric definition of sustainable development has progressively evolved since the Stockholm conference. The Stockholm Declaration (UN 1972) gives no succinct definition, but asserts man's rights to freedom, equality, and adequate conditions of life; proposes policies for protection of the world's ecosystems, wildlife, use of renewable and non-renewable resources; and calls for a range of measures to achieve these objectives – economic, national and international institutions, technical and scientific advances, education. The declaration contains direct calls for population controls, reduced consumption in the developed world and nuclear disarmament. In all but name, the Stockholm Declaration may be seen to enunciate the major principles of sustainable development.

The IUCN suggests in 'World Conservation Strategy':

> *for development to be sustainable it must take account of social and ecological factors, as well as economic ones; of the living and non-living resource base; and of the long term as well as the short term advantages and disadvantages of alternative actions*
>
> (IUCN 1980) *p23*

In 'Our Common Future' Bruntland offers the definition:

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*
>
> (WCED 1987) *p43*

The IUCN, concerned about ambiguous interpretations of the Bruntland definition, proposed an alternative interpretation which may be no less ambiguous:

> *improving the quality of human life while living within the carrying capacity of supporting ecosystems.*
>
> (IUCN 1991) *p10*

In the Bruntland interpretation, sustainable development specifically includes the polluter pays principle (previously agreed by member states of the OECD (OECD 1972)), and the timescale is defined as intergenerational. Building on the work of Bruntland, the UN Conference on Environment and Development (UNCED), known as the Rio Earth Summit, took place in 1992. Member states agreed a set of high level principles for sustainable development, the Rio Declaration (UN 1992b) (Appendix 1), and an extensive action list, Agenda 21 (UN 1992a) (Appendix 2).

The Rio Declaration essentially reaffirms the Stockholm principles, though in some respects may be considered more restrained: references to reduced consumption in developed countries and to population control are less prominent than at Stockholm; calls for nuclear disarmament are absent; the precautionary approach is added. Principle 15 states that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Sustainable development is seen by the UN as a process of change, to be achieved through a wide range of policy actions in Agenda 21, a programme for action for the 21st century (Reddish, Green et al. 1996). This is a complex document of over 500 pages in 40 chapters, organised into four sections (Appendix 2): Social and Economic Development, Conservation and Management of Resources for Development, Strengthening the Role of Major Groups, Means of Implementation. Each chapter focuses on a particular issue, and lists the range of policies and actions to be undertaken.

Agenda 21 is very broad, emphasising the need and responsibility for changes in behaviour at all levels of society, government, industry and individual consumer, and advocating a multi-pronged approach. Policies to change economic incentives, regulatory framework, efficiency measures, public education and participation are advocated as complementary and equally necessary. Policies are normally phrased at Nation State level, in a rather general manner; particular legal or economic instruments are not specified and there are few specific targets. Agenda 21 was agreed at UNCED as a non legally binding document (Grubb, Koch et al. 1993). Note: The Rio Declaration and Agenda 21 are mentioned extensively in the rest of this thesis, and will not be formally referenced hereafter.

2.2.2 The Process of Sustainable Development

The roots of sustainable development offer crucially different interpretations of the concept. The ecocentric and economic roots propose, conceptually, some state of global sustainability, defined in the ecocentric view by generalised limit conditions on ecosystem impacts, and in the economic view by limits on population and rates of resource take. In these views, the human condition is perhaps presented as a subsidiary (though important) aspect. Such limit conditions are interpreted as requiring restrictions on consumption and human population: if literally (and rapidly) applied, these would cause great political difficulties for world governments.

The anthropocentric root, as defined by Bruntland, suggests sustainability as a desirable condition for mankind (i.e. to meet the needs of current and future generations), sets overall policy directions for change, but falls short of explicitly suggesting specific targets or limit conditions for global sustainability. Ecosystems are regarded as a resource for development and therefore in need of conservation. In this approach, the sustainability target is left deliberately ambiguous (El Serafy 1991), and the necessary changes remain fuzzy (Goodland 1991).

What the different roots have in common is recognition that changes are required at, and are the responsibility of, all levels of society and technology. It is helpful to consider these changes as a process or journey of evolution to a more sustainable state – a simile used by several writers (Daly 1990, Porritt 2000, WCED 1987). This concept of sustainable development as a process of change runs throughout the anthropocentric root: WCED was asked by the United Nations to formulate a global agenda for change (UN 1983); the WCED report '*Our Common Future*' (WCED 1987) states "Development involves a progressive transformation of economy and society"; Agenda 21 sets out the UN agenda for change for the 21st century.

The analogy to a journey is strongly drawn by the US National Research Council (NRC) (NRC 1999): the NRC Board states that metaphors to 'journey' and 'navigation' are made 'with serious intent', reflecting the board's view that pathways towards sustainability cannot be charted in advance, but will have to be 'navigated adaptively at many scales and in many places'. The target is some state of improved sustainability, though currently with no consensus definition, and the process, the journey of change and evolution, is called sustainable development. The distinction between sustainable development as a process of directed change and sustainability itself (the achievement of a more sustainable state) has been clearly drawn (Lele 1991, NRC 1999, Porritt 2000).

The range of states of sustainability is mapped on the sustainability spectrum (Pearce 1993) shown in full at Table 2.1. The 'sustainability label', from very weak to very strong, illustrates the range of potential states of sustainability. The other dimensions of the spectrum (Type of economy, Management strategies, Ethics) are illustrative of the range of changes required, to reach these states of sustainability and thus, in a general sense, offer a view of sustainable development. The scope of the spectrum encompasses the three roots of sustainable development discussed above.

	TECHNOCENTRIC		ECOCENTRIC	
	Cornucopian	**Accommodating**	**Communalistic**	**Deep ecology**
Green label	Resource exploitive, growth oriented position	Resource conservationist and 'managerial' position	Resource preservationist position	Extreme preservationist position
Type of economy	Anti-green, unfettered free markets	Green economy, green markets guided by economic incentive instruments (EIs) (e.g. pollution charges etc)	Deep green economy, steady state economy, regulated by macro-environmental standards and supplemented by EIs	Very deep green economy, heavily regulated to minimize 'resource take'
Manage-ment strategies	Primary economic policy objective to maximize growth (Gross National Product GNP) Taken as axiomatic that unfettered free markets in conjunction with technical progress will ensure infinite substitution possibilities capable of mitigating all 'scarcity/ limits' constraints (environmental sources and sinks)	Modified economic growth (adjusted green accounting to measure GNP) Decoupling important but infinite substitution rejected Sustainability rules: constant capital rule	Zero economic growth; zero population growth Decoupling plus no increase in scale 'Systems' perspective – 'health' of whole ecosystems very important; Gaia hypothesis and implications	Scale reduction imperative; at the extreme for some there is the literal interpretation of Gaia as a personalized agent to which moral obligations are owed

	TECHNOCENTRIC		ECOCENTRIC	
	Cornucopian	**Accommodating**	**Communalistic**	**Deep ecology**
Ethics	Support for traditional ethical reasoning: rights and interests of contemporary individual humans: instrumental value (i.e. of recognized value to humans) in nature	Extension of ethical reasoning: 'caring for others' motive – Intragenerational and intergenerational equity (ie contemporary poor and future people); instrumental value in nature	Further extension of ethical reasoning: interests of the collective take precedence over those of the individual; primary value of ecosystems and secondary value of component functions and services	Acceptance of bioethics (ie moral rights/ interests conferred on all non-human species and even the abiotic parts of the environment); intrinsic value in nature (i.e. valuable in its own right regardless of human experience)
Label	Very weak sustainability	Weak sustainability	Strong sustainability	Very strong sustainability

Table 2.1 Sustainability Spectrum

Source: (Pearce 1993) pp 18/19

2.2.3 Commentary

The economic and ecocentric roots present valid views of sustainable development, included within the scope of the sustainability spectrum (Pearce 1993), though the anthropocentric Bruntland definition in 'Our Common Future' (WCED 1987) has become the generally accepted definition of sustainable development for research e.g. (Azapagic, Perdan 2000, Bell, Morse 1999, Bossell 1999, Pepper 1996).

The principles of sustainable development were expanded into the Rio Declaration and Agenda 21. These two seminal documents represent the politically accepted (and acceptable) approach to, and the most comprehensive statement of, the meaning of sustainable development. They are used as the basis for national sustainable development strategies (DEFRA 1999, MoE(Fi) 2000), and for much academic work (Azapagic, Perdan 2000, Bell, Morse 1999, Harger, Meyer 1996, Spangenberg, Pfahl et al. 2002). They are adopted as the basis for this thesis.

2.3 *The Ambiguity of Sustainable Development*

2.3.1 Multiple Interpretations

A clear operational definition of sustainable development has proved elusive (Bell, Morse 1999, Kidd 1992, Mitchell, May et al. 1995, Upham 2003). The lack of a broad consensus may lead many authors to use their own definition (Bell, Morse 1999), and there has been a plurality of definitions for sustainable development: prior to the Rio summit it was possible to identify some 24 different definitions (Pearce, Markandya et al. 1989), though on examination many may simply be authors' opinions. Later writers suggest that over 100 definitions may be found in the literature (Moffatt, Hanley et al. 2001). The goal of a precise operational definition may be intrinsically unachievable: there must be unavoidable ambiguities arising from political considerations, the inevitable differences between nations and industrial sectors, and the essential unpredictability of future technological developments.

Perhaps the major objective of the Bruntland definition was to enable global political acceptance of the concept. To achieve this, the definition remained deliberately ambiguous in certain aspects, expressed only in conceptual and directional terms. Observers consider the ambiguity necessary to gain political acceptance (Daly 1991, Goodland 1991), but at the same time may be seen as a potential danger, an excuse for democratic politicians to avoid the large scale problems highlighted by Bruntland (Goodland, Daly et al. 1991, Williams 2002).

The originators of sustainable development did not expect a single precise definition, but admitted the need for multiple interpretations at global and national levels: the WCED acknowledges that the goals of economic and social development must be defined in terms of sustainability in all countries (WCED 1987), and discusses interpretations applicable to the common (i.e. global) threats. Agenda 21 expanded the variation in interpretation to local levels (city or region) and to industry (industrial sectors or corporations). At the level of industrial sectors, authors have also recognized the need for differing interpretations:

> *Sustainability must be made operational in each specific context (eg forestry, agriculture), at scales relevant for its achievement, and appropriate methods must be designed for its long-term measurement.*
>
> (Heinen 1994)

This short exploration suggests that a single definition of sustainable development is not attainable in an operational sense, a view supported by a number of authors e.g. (Bell, Morse 1999, Kidd 1992). Thus the interpretation of sustainable development will be different according to the context, which may vary in scope from local to international, from a single industrial installation to a global industrial sector.

Taking the analogy of the journey above, the staring point is defined by the context and will vary over time. The direction and speed of change will be set by the current issues, political will, and limits on technology. The destination will be defined by the current vision of sustainability. Over time there may be progress in understanding, technology and public attitudes, which could affect all aspects of the journey – the start, direction and destination – so the definition or interpretation of sustainable development may itself be expected to evolve over time.

The proposal that there are many operational interpretations of sustainable development across many contexts may be accepted with no great discomfort: different interpretations may be viewed as merely reflecting the range of issues and actions relevant to the context and time.

2.3.2 Confusion of Sense

While the ambiguity of the Bruntland definition must be recognised as a political and practical necessity, there is an unfortunate, though genuine confusion arising from the sense of the sobriquet itself. IUCN argues that there confusion arises because "sustainable development", "sustainable growth" and "sustainable use" are used interchangeably, as if their meanings were the same, and contends that sustainable growth is a contradiction in terms, since nothing can grow indefinitely (IUCN 1991).

This confusion of sustainable development and growth is explored in an economic assessment by UNESCO (Goodland, Daly et al. 1991) and some authors would argue that the concept has been subverted:

> *it allows politicians and economists to prattle on about 'sustainable growth' even though current patterns of economic growth and genuine sustainability are wholly contradictory concepts.*
>
> (Porritt 1992) *quoted in* (Pepper 1996) *p74*

> *For example many people in the development community who use the phase cannot tell you what is being sustained in sustainable development - whether a* ***level*** *of economic activity or a* ***rate of growth*** *of economic activity!*
>
> (Daly 1991) *p249*

Certainly the concepts of growth, sustainability and sustainable development are inextricably mixed in government and industrial policy documents on aviation e.g. (DfT 2003b, Elliff, Celikel et al. 2004, Sustainable Aviation 2005).

In part, the confusion may be explained by the meanings inherent in the phrase 'sustainable development'. Roget's Thesaurus (Dutch 1962) offers several senses for 'development' including the sense of evolution, improvement and the sense of growth, increase. The very concept of 'sustainable development' unequivocally means the former sense of change and improvement. But the broad rubric of 'sustainable development' actually admits the sense of 'sustainable growth'. It is then little surprise that those with an interest in promoting physical growth of an activity should adopt this sense. Had the originators coined the phrase 'sustainable evolution/ improvement/ progression', then perhaps the sense of 'sustainable growth' would be more readily excluded from the concept.

2.4 *Sustainable Development Indicators in Agenda 21*

2.4.1 Origin

Bruntland (WCED 1987) recognised that there were gaps in the information available to the sustainability debate, and called for strengthening of environmental reporting capabilities. As a means of addressing this information gap, the UN explicitly introduced the concept of indicators of sustainable development in Agenda 21 Ch 40. Agenda 21 uses the terms 'indicators of sustainable development' and 'sustainable development indicators' interchangeably to mean the same thing – a convention adopted in this thesis. The abbreviation SDI may also be used.

Most literature on sustainability prior to 1992 does not specifically refer to sustainable development indicators (Elkin, McLaren et al. 1991, Lele 1991, Pearce, Markandya et al. 1989, WCED 1987): a few authors begin to use the term by the early 1990s (Langeveg, Angeletti 1990, Victor 1991); since the 1992 Rio Conference, use of the term becomes almost universal in the literature, e.g. (Bell, Morse 1999, Bossell 1999, Mitchell, May et al. 1995, Pearce 1993).

2.4.2 Purposes of Indicators

Agenda 21 defines the purposes of indicators of sustainable development as:

> *40.4 Indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems.*
>
> *40.4 The need for information arises at all levels, from that of senior decision makers at the national and international levels to the grass-roots and individual levels.*
>
> *40.22 …. information suitable for both planning and public information.*

Thus within Agenda 21 the purposes of indicators are defined as: Information for decision makers, Public Information, Contribute to self-regulating sustainability of systems. As with many aspects of Agenda 21, there is some ambiguity in these purposes, though more specific requirements may be derived from related references.

2.4.2.1 Information for Decision Making

The term decision–maker has wide interpretation in Agenda 21 including specifically international policy makers, national & local Government and individual consumers. Business is expected to play a full part in implementing Agenda 21, and thus by inference company managers are included as decision makers. Agenda 21 envisages that indicators must reflect the scope of the decision makers, suggesting at Chapter 20 that data should be collected 'at the local, provincial, national and international levels'.

The scope includes all four dimensions of sustainable development – social, economic, environmental, and institutional (Means of Implementation in Agenda 21). The institutional dimension is explicitly included in the scope of sustainable development indicators (Spangenberg, Pfahl et al. 2002, UN 2001). Thus an indicator set should provide coverage of all the dimensions and the corresponding chapters relevant to the context.

2.4.2.2 Public information

Agenda 21 envisages that indicators should be used both to inform decision makers, and be suitable for public information. These two purposes do create some tension: information for decision makers should reflect their needs and may be rather specific, related to their scale of responsibility, potentially leading to the need for a complex hierarchy of indicators; on the other hand indicators for public information need to be very simple, general and few.

The UK has adopted an approach of 'headline' or 'framework' indicators supported by a range of more detailed indicators (DEFRA 1999, DEFRA 2005b): it is suggested that this technique, also adopted by US and Sweden, may form a basis for public information indicators (Hens, De Wit 2003) at a national level.

2.4.2.3 Self-Regulating Sustainability

The purpose to 'c*ontribute to a self-regulating sustainability of integrated environment and development systems*' has wider implications, assuming the existence of some form of self-regulating sustainability system(s). Agenda 21 offers no specific interpretation of such systems, referring only to institutional capacity and capacity building capabilities.

The concept is given more meaning by the Bellagio Principles (Hodge, Hardi 1997) which suggest that sustainable development needs to be driven by a vision, goals and derived targets, and clear institutional responsibilities. Decision making needs to be iterative, adaptive, and capable of adjusting goals as the indicators change and understanding of the issues develops. Others describe the ability to navigate a journey of change towards sustainability in an adaptive way (NRC 1999).

Thus the 'self regulating system' is envisaged to include institutional responsibilities and capacity, supporting an iterative and adaptive decision making process:

- Decision making responsibility and capability
- Directed by and towards the principles of sustainable development
- Adaptive
- Repeatable

2.4.3 Format of Indicators

Agenda 21 is perhaps less forthcoming on the characteristics of an individual indicator, though some useful pointers are available.

It is recognised that the required data may not currently exist (Agenda 21 Chapter 40.2), and that more and different types of data may need to be collected. Where data exists, it may need 'transforming' and should fulfil the needs of specific groups (Agenda 21 Chapter 40.22).

Agenda 21 requires indicators to show programmes of change in addition to existing states. Thus indicator types were subsequently categorised as driving force, state, response (UN 1996, UN 2001). These categories are retained as necessary assessment criteria for indicator sets, to assess relative significance accorded to change programmes (response indicators).

The resulting characteristics are well summarised (Smith 2002) as simple, widely credible, easily understood by policy makers and the public: characteristics which reflect the Agenda 21 purposes of indicators while avoiding prescriptive formats.

2.4.4 Responsibility for Indicators

Bruntland identified that all major international bodies and agencies of the UN system have the responsibility to support sustainable development policies and practices (WCED 1987). Agenda 21, explicitly and implicitly, identifies a range of institutions with responsibility for developing indicators of sustainable development.

Agenda 21 Ch 40.6 specifies that the responsibility lies with countries at the national level and with international governmental and non-governmental organizations at the international level. For areas outside national jurisdiction, Agenda 21 is quite specific on the role of UN agencies:

> *40.7. Relevant organs and organizations of the United Nations system, in cooperation with other international governmental, intergovernmental and non-governmental organizations, should use a suitable set of sustainable development indicators and indicators related to areas outside of national jurisdiction, such as the high seas, the upper atmosphere and outer space.*

The role of business and industry is recognised in chapter 30 of Agenda 21:

> *30.1. Business and industry, including transnational corporations, and their representative organizations should be full participants in the implementation and evaluation of activities related to Agenda 21.*

Business is expected to implement Agenda 21, and the implication is that industry sectors and companies have responsibility to develop indicators of sustainable development.

Agenda 21 directly and indirectly suggests that indicators should be developed by Countries, International Governmental Organisations, UN Agencies, International Non-Government Organisations, Industrial sectors and Companies.

While there is no further clarification of what groups may be included in the category International Non-Government Organisations, it is reasonable to deduce that the UN would expect this category to include international trade organisations and industrial sector representative groups.

2.4.5 Evolution of Indicators

There is an inference throughout Chapter 40 of Agenda 21 that the needs for information may change over time, and the capability of defining indicators will develop. There is recognition that indicators themselves may change, a view given more specific expression by the UN some years after Rio:

> *No set of indicators can be final and definitive, but must be developed and adjusted over time to fit country specific conditions, priorities and capabilities.*
>
> (DiSano 2001)

2.4.6 Indicator Characteristics from Agenda 21

The assessment criteria for indicator sets are summarised at Table 2.2.

Purposes of Indicator sets	
Inform decisions of:	International policy makers National & Local Government Company Managers Consumers
	Provide public information
Characteristics of Indicator sets	
Scope	Four dimensions: social, economic, environmental, institutional All relevant chapters of Agenda 21
Scale	Local, national, international
Targets	Decisions makers: international, national, local government, company managers, consumers Public information
Type	Driving force, State, Response
Characteristics of Indicator	
Availability	May need new data
Characteristics	Simple Widely credible Easily understood by policy makers and the public
Evolution	Variable over time – will evolve
Responsibility for Producing Indicators	
	Countries International Government Organisations UN Agencies International non-Government Organisations Industrial sectors Companies

Table 2.2 Assessment Criteria for Indicator Sets

2.5 *The Nature of Sustainable Development Indicators*

2.5.1 A Range of Definitions

Authors provide a range of definitions for sustainable development indicator, often emphasising the measurement or data aspects, rather than the purpose (Box 2.1).

> Indicators are repeated observations of natural and social phenomena that represent systematic feedback. They provide quantitative measures of the economy, human well being, and impacts of human activities on the natural world (NRC 1999).
>
> Indicators are pieces of information that highlight what is happening in a large system (Abolina, Zilans 2002).
>
> A measure of performance either qualitative or quantitative (GRI 2002).
>
> A policy-relevant variable that is specified and defined in such a way as to be measurable over time and/or space. It need not be quantified; measurement can be on the basis of qualitative scales (Pastille Consortium 2002).
>
> An indicator is something that represents a particular attribute, characteristic or property of a system (Gallopin 1997).

Box 2.1 Sample of Indicator Definitions

The diversity of views leads some to suggest that there is no agreed definition of the terminology of sustainable development, and a pressing need for an agreed lexicon of terminology (McLellan 2003). It is helpful to differentiate terms in the discussion; data, indicators, indices and information, may mean different things to different people (Segnestam 2002).

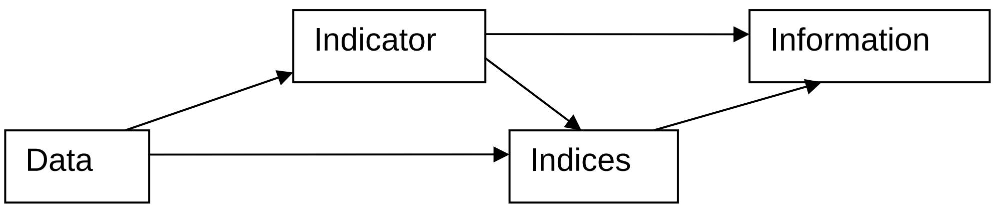


Figure 2.1 Data, Indicators and Information

Source: (Segnestam 2002)

Data is taken to mean the basic measurement, which can be transformed into a more meaningful level (indicator) and used to show trends or performance against a target.

Indices may be complex combinations of indicators and/or data. The analyses result in Information – input to the decision making process. Indicators should provide information:

> *They can translate physical and social science knowledge into manageable units of information that can facilitate the decision making process.* (UN 2001)
>
> *An indicator is something that helps you understand where you are, which way you are going and how far you are from where you want to be.* (Hart 1999)

For the purposes of this thesis, the latter interpretations will be adopted i.e. that an indicator helps you understand where you are, where you are going (Hart 1999), and translates data into information suitable for decision making (UN 2001). This interpretation remains consistent with the Agenda 21 purposes.

2.5.2 Indicator Characteristics

Authors have suggest numerous lists of the desirable characteristics for sustainable development indicators (Appendix 7), offering a variety of views, with little consistency. To some degree the characteristics appear to reflect the authors' interests rather than general characteristics: thus for instance the UN emphasises the national level (UN 2001); the Environmental Protection Agency emphasises isolation of transport impacts – a formidable challenge (US EPA 1996). Most authors do not specifically differentiate between the characteristics of an individual indicator, and the scope of the indicator set.

There are recurring themes amongst the suggested characteristics e.g. simplicity and sensitivity to change. There are also characteristics not entirely consistent with the original concepts of Agenda 21: the defined scope may exclude the institutional dimension (Harger, Meyer 1996); the requirement for information to be readily available (Anderson 1991) mitigates against the possibility of new indicator types (UN 1992a, WCED 1987); the requirement for measurement (Anderson 1991, Harger, Meyer 1996, Mitchell, May et al. 1995) would preclude subjective indicators, elsewhere deemed valid and necessary (NRC 1999, UN 2001). Most authors use the suggested characteristics to form part of the indicator selection process, though some use characteristics merely as assessment criteria (Mitchell, May et al. 1995).

The diversity of views is difficult to reconcile. In reality the characteristics of an indicator and an indicator set must be derived from the purposes of the indicator rather than any intrinsic pre-defined rules:

> *The necessary key qualities of suitable sustainability indicators result from their purpose.*
>
> (Spangenberg, Pfahl et al. 2002)

A set of indicator characteristics reflecting the original Agenda 21 purposes and avoiding prescriptive derivation rules is suggested by Smith (Smith 2002):

- simple,
- widely credible,
- easily understood by policy makers and the public

2.5.3 Indicator Formats

Most indicators will be quantitative in nature, based on a measurement made on an appropriate interval or ratio measurement scale. The data is normally of a direct physically measured value, e.g. air pollution level at a given point and time, or noise from an aircraft, and applies to an individual event. Such data is likely to be too specific to show general levels or trends, and may need transformation to a derived value which may provide meaningful information. This transformation may take many forms e.g. by calculation, accumulation, averaging, or combinations of these and other processes. In some cases if the measurement is made on a limited sample, there may be extrapolation to the whole domain. Some examples are: calculation of CO_2 from measured fuel usage; accumulation of a National level indicator from a series of local and regional measurements; average of measures over time; an index – a complex accumulation of factors and measures e.g. Gross domestic product (GDP) used to represent the total output of a national economy.

Such measured or derived data, may be presented as absolute values or some form of normalised ratio: a rate represents the frequency or number of occurrences related to a constant base unit such as population, area or time e.g. a consumption rate per person; a relative scale presents the indicator expressed relative to some selected base line; a ratio may show the relationship of one value to another e.g. an efficiency ratio showing amount of input (e.g. energy, materials) against output production. Normalised indicators do not show absolute levels, and normally need to be accompanied by a corresponding absolute value indicator.

The presentation may show a graphical or numerical trend over time, or a performance against previously quantified targets. It may be helpful to show some issues as a diagram e.g. a noise contour map, though this normally needs to be accompanied by a quantitative measure (e.g. area of contour), and trend over time.

Where relevant aspects are difficult to measure or a suitable measurement system has not yet been developed, an indicator may be qualitative. Potential qualitative indicators may use a subjective assessment: a nominal scale i.e. a discrete classification scale where the characteristic is not measured, nor ordered, but is placed into distinct categories, often only two (Yes or No); or an ordinal scale, a scale based on a hierarchy of qualitative states, commonly used to indicate levels of satisfaction e.g. the assessment of public participation on Arnstein's Ladder of Citizen Participation (Arnstein 1969). No precise measurement is involved in the scale, merely an assessment of the state. In some cases qualitative assessments may be presented as a measurement e.g. UK indicator K9 (Fear of Crime), a percentage of the population being 'very worried' by fear of crime. This is a qualitative factor, derived from the UK National Crime Survey (Walker, Kershaw et al. 2006), assessed on an ordinal scale, and presented in a quantitative manner as a percentage of people. In principle, such a qualitative factor could be presented in any of the various quantitative formats.

Again, the choice of format should be related to the purposes of the indicator (Spangenberg, Pfahl et al. 2002).

2.6 *Existing Indicator Sets*

2.6.1 International Perspectives

Following the Rio convention, the United Nations embarked on a work programme to develop suitable indicators to assess Nation States' progress towards sustainable development. In 1996, the UN Commission for Sustainable Development (CSD) proposed a working list of national indicators (UN 1996) using a framework based on four dimensions of sustainable development (social, economic, environmental, and institutional). Within these four dimensions, three types of sustainability indicators were proposed – driving force, state, and response indicators (DSR Framework):

- "Driving Force" indicators indicate human activities, processes and patterns that impact on sustainable development
- "State" indicators indicate the "state" of sustainable development
- "Response" indicators indicate policy options and other responses to changes in the "state" of sustainable development

A state indicator is normally used to measure the state of a variable, e.g. water quality. A driving force indicator measures some aspect which will affect the state of a variable e.g. the rate at which a pollutant is passed into the environment. State and driving force indicators may be related e.g. the rate of pesticide application influences water quality. Response indicators are used to gauge progress in the response of governments to make changes by the use of environmental legislation, economic incentives, public education, etc. The 1996 working list of 132 national indicators, consists of 42 driving force, 53 state, and 37 response indicators (UN 1996).

From 1996-2000 the working list of indicators was tested and refined by 22 member states in co-operation with the UNEP (UN 2001). The framework of four dimensions was retained and expanded to 15 themes and 37 sub-themes. Themes are not directly organised by, but can be traced back to, Agenda 21 chapters. 58 core indicators are proposed (21 driving force, 29 state and 8 response). Testing nations indicated some unease with the DSR framework (UN 2001) which is used to categorise, though not to derive indicators. The UN regards the core indicator set as a starting point for countries to develop their own indicators. In parallel developments, other international organisations have proposed environmental indicator sets e.g. World Bank (Segnestam 2002, World Bank 2002), OECD (OECD 1993).

2.6.2 National Perspectives

In 1997, at the 5 year review of the Rio Conference, the UN General Assembly called on member states to implement national sustainability strategies (including national indicator sets) by 2002 and to encourage implementation of Local Agenda 21s (UN 1997b). In 1999 the United Kingdom Government published a sustainable development strategy 'A Better Quality of Life' stating four main aims (DEFRA 1999):

- social progress which recognises the needs of everyone;
- effective protection of the environment;
- prudent use of natural resources; and
- maintenance of high and stable levels of economic growth and employment.

While these aims are claimed to be based on Agenda 21, the reference to economic growth seems at odds with the Agenda 21 call for economic changes, and appears to exploit the ambiguity of the Bruntland definition (section 2.3). Institutional aspects, a strong part of Agenda 21, do not explicitly feature in the UK Government's four main aims. The strategy includes 15 Headline indicators and 147 National indicators, arranged in a framework of four themes (Sustainable economy, Managing environment and resources, Sending the right signals, International co-operation and development) and 18 sub-themes. The 1999 strategy was superseded in 2005 by 'Securing the Future' (DEFRA 2005b), setting five 'Guiding Principles':

- Living within environmental limits
- Ensuring a strong healthy and just society
- Achieving a sustainable economy
- Using sound science responsibly
- Promoting good governance

The strategy is supported by 20 Framework Indicators and 48 other indicators. Framework indicators, agreed by UK National & Regional Governments (DEFRA 2005c), replace the previous Headline indicators. There is no very clear relationship between the UN and the UK indicator sets: the UK indicator sets do not adopt the four dimensions of sustainable development, are presented in groupings different from the UN themes and sub-themes, and are not split into driving force, state and response indicators. Most other European states are following parallel, though varying, paths to the UK in developing their own sets of national indicators (Wolfe 2004).

2.6.3 Local Perspectives

The UK Government developed 29 Local indicators (DEFRA 1999), as a menu of indicators from which local authorities may select for reporting on their Community Strategies. There are numerous examples of sustainability indicators being developed at a city or community level. Norwich City Council undertook a highly participative programme (Norwich 1999) to develop a set of 23 sustainability indicators. The approach seeks to balance economic development, social development and environmental protection, but omits the institutional dimension. Indicators are mostly state indicators, with some driving force and no response indicators. They tend towards 'quality of life' indicators, and some of these aspects may not be directly reflected in the UN Agenda 21 actions. Each indicator has a simple directional 'target' to increase/decrease as appropriate, though there is no quantification of the targets.

2.6.4 Industrial Perspective

Agenda 21 recognises the role of international corporations:

> *30.1. Business and industry, including transnational corporations, and their representative organizations should be full participants in the implementation and evaluation of activities related to Agenda 21.*
>
> (UN 1992a) *Chapter 30*

The role of international industrial sectors was brought into focus at the 2002 World Summit on Sustainable Development (WSSD) (UN 2002b). The United Nations Environment Programme (UNEP) launched a reporting initiative, 'Industry as a Partner for Sustainable Development', designed to gauge progress by the private sector towards sustainable development. Twenty two industry sectors participated (UNEP 2002), with reports produced by sector representative bodies e.g. an aviation sector report by Air Transport Action Group (ATAG 2002), an automotive sector report by Association des Constructeurs Européens d'Automobiles, Japan Automobile Manufacturers Association Inc. and the US Alliance of Automobile Manufacturers (ACEA 2002).

The reports raise issues of sustainable development, though generally support and defend the performance of the particular sector. Within the transport sectors, the aviation, road transport and railway reports display intermodal rivalry (ATAG 2002, IRU 2002, UIC 2002), each attempting to show one transport sector in a better light than the others and making a case for greater future growth for the sector. The reports offer some general direction for future developments, but tend to be rather unspecific about visions, targets and actions of the sector. Generally, these reports cannot be considered as substantial sustainable development strategies and do not include indicator sets.

Industrial sustainable development strategies may be envisaged at the country level (Spangenberg 2002). The UK strategy ‘A Better Quality of Life’ (DEFRA 1999), recognises that improvements in industrial performance depend on business decisions and investment, targets specific sectors of industry, and introduces the concept of a sectoral sustainability strategy. It is envisaged that such strategies would be developed by the responsible trade bodies, and applied to all the companies within that trade organisation.

At least three of the industry associations identified in the UK Government strategy have since published sustainable development strategies for the relevant sector - the Aluminium Federation (ALFED 2002), the Non Ferrous Alliance (under the auspices of the Lead Development Association International) (LDAI 2002) and the Society of Motor Manufacturers and Traders (SMMT 2000). Thus the UK Government places strong emphasis on the active co-operation of industry and encourages industry sectors to be proactive in setting their own sustainable development strategies and targets. Commentaries suggest that this approach underpins the UK Strategy for Sustainable Development (Azapagic, Perdan 2000). Such sectoral strategies are absent from the later UK strategy (DEFRA 2005b).

There have been some attempts to develop indicator sets specific to a particular industry. A general framework for industry (Azapagic, Perdan 2000) has been applied to the mining and minerals industry (Azapagic 2004), an approach based on the social, economic and environmental dimensions of sustainable development. An approach for UK Civil Aviation (Sustainable Aviation 2005) is related to the themes of the I999 UK National Strategy (DEFRA 1999), and aligned to the three dimensions of sustainable development – social, economic and environmental.

2.6.5 A Hierarchy of Indicator Sets

The previous sections have described the indicator sets developed as a result of UN initiatives, following the hierarchy of the UN, its member states, and within national states cities and regions.

United Nations	UN CSD Core SDIs – recommended
UN Member States	National SDI sets
City/Region and Business	Local Agenda 21 SDIs Sector or Company SDIs

In this hierarchical approach, indicator sets for industry are largely framed within a national state, presumably on the assumption that business will be driven by the national conditions and governed by the national legislation. This may appear sensible to the UN and EU, since their agents of change are the nation state.

There is however a significant tension between this national approach, and the transnational nature of many industries e.g. air transport. The industry and its companies operate on an international basis, not wholly regulated by an individual national state. The Rio Declaration and Agenda 21 recognise the international nature of the issues, and do include commitments on international cooperation and action. However, there is no evidence that indicator sets have been constructed to specifically measure the sustainable development of trans-national industries.

2.7 *Indicator Methodologies*

There are various proposals for methodologies to develop and construct indicators of sustainable development, reviewed below. This review is representative of the range of initiatives rather than a comprehensive bibliography.

2.7.1 A Range of Methodologies

PICABUE (Mitchell, May et al. 1995). A somewhat tenuous acronym to describe a seven step framework for the development of indicators of sustainable development. The approach was developed to address sustainability issues in developed-world cities, though is presented as a flexible and general approach. The methodology is based on four 'principles of sustainability' – Futurity, Environment, Equity, Participation – proposed as a framework of sustainable urban development (Elkin, McLaren et al. 1991). Stakeholders are central to the methodology: stakeholders are expected to decide on the principles of sustainable development, the objectives of the indicator program, the issues of concern and to select indicators. Six 'quality of life components' – Health, Security, Personal development, Community development, Physical environment, Natural resources, goods and services – are suggested as bases for indicator selection. The authors then augment the indicators according to sustainable development principles, and evaluate the indicators against a set of nine acceptance criteria.

The methodology does not seem to include any step to define the system being studied, nor is there any indication of how stakeholders should be selected. The authors incorporate, without debate, Daly's (1991) sustainability limits on renewable and non-renewable resources, and assume these should be used both to define the indicators and the possible target levels.

Balaton Approach (Bossell 1999). The methodology, intended for deriving indicators for sustainable communities, suggests that sustainable development of human society has nine dimensions: environmental, material, ecological, social, economic, legal, cultural, political and psychological. The approach emphasises the importance of a good conceptual understanding of the total system, potential indicators are derived from systems theory, basic system orientors and Biesiot indicators, and are reviewed and agreed by a participative process involving stakeholders of the system.

Systemic Sustainability Analysis (SSA) (Bell, Morse 1999). The methodology is based primarily on the experience of aid projects in developing countries. The authors do recognise the four dimensions of sustainable development (social, economic, environmental, institutional) though it is not entirely clear whether the methodology delivers institutional indicators. The approach emphasizes the importance of defining the whole system, and sets out a five step process to develop indicators based on a participative process. Stakeholder participation is assumed to be 'a self-evident good', though the authors acknowledge difficulties in practice –

> *… the tool (SSA) becomes unmanageable as the frame (system) expands and conflicts of interest between stakeholder groups emerge.*
>
> (Bell, Morse 1999) *p147*

The means of resolving conflicts is not recorded. In the SSA methodology, stakeholders set the sustainability targets, though there is no reference to the political goal setting agenda or the empowerment of stakeholders.

General Framework for Industry (Azapagic, Perdan 2000). A general framework for sustainable development indicators for industry proposes an extensive range of generic indicators, suggesting that these may be applicable across many industrial sectors. The intention is that the framework can be used effectively as a checklist and the indicators can be developed from the generic form to specific measurements to suit a particular industrial sector.

The approach is based on social, economic and environmental dimensions of sustainable development. The work would appear to be based primarily on process or manufacturing sectors, and there may be a question on how well it would apply to services or transport sectors. Indicators of social aspects are directed mainly towards employees of the enterprise, and do not recognise potential social impacts on the community outside the enterprise.

In the framework, there is an implicit assumption that the need for the product or service is assured and will continue. Thus the indicators are concerned with the sustainability and efficiency of the production process: there is no consideration of an external view of the sustainability of the production and consumption patterns as required in the Rio Declaration principle 8 ('reduce and eliminate unsustainable patterns of production and consumption').

2.7.2 Definition of the System

There is a widespread recognition in the various approaches of the need to define the system in question, both in time and space, though the importance accorded to system definition varies widely (Table 2.3). Some approaches emphasise that the system should be well defined and understood (Bell, Morse 1999, Bossell 1999, Clayton, Radcliffe 1996, Hardi, Zdan 1997). Approaches targeted more specifically towards industry include definition of the system, but seem to restrict the scope to the industrial process or plant in question (Azapagic, Perdan 2000, Callens, Tyteca 1999) and perhaps place less emphasis on the spatial and timescale dimensions. In some approaches, the purpose of the system e.g. road transport, may be assumed to be well defined and understood, but the spatial and timescale dimensions may be left unspecified (Castillo 2005). The PICABUE methodology (Mitchell, May et al. 1995) appears to assume that the system scope is well known and does not need further definition. National approaches e.g. (Ekins, Simon 2001) may perhaps validly make the assumption that the system is predefined geographically by national boundaries. It is proposed that in the industrial environment it is essential that the system should be clearly defined and bounded.

System Definition	**Comment**	**Source**
Strong	System purpose, spatial and timescale dimensions all defined	Clayton and Radcliffe, Hardi and Zdan, Bell and Morse, Bossell
Medium	System scope may be restricted	Azapagic and Perdan, Callens and Tyteca
Medium	Not all dimensions defined, some assumed	Ekins and Simon, Castillo
Weak	System definition assumed	Mitchell

Table 2.3 System Definitions in Indicator Methodologies
Source: Author

2.7.3 Approaches to Indicator Selection

The preceding sections offer a brief exploration of the very large volume of work on sustainable development indicators, characterised by the range of contexts considered and the diversity of approaches taken. The UN suggests 'A framework for organising the selection and development of indicators is essential' (UN 2001) p19. From the great body of literature, there emerges no consistent framework, though several types of approach may be discerned.

Approaches based on Dimensions of Sustainable Development

The chapters of Agenda 21 are originally presented in four sections (Appendix 2) – Social and Economic Dimensions, Conservation and Management of Resources for Development, Strengthening the Role of Major Groups, Means of Implementation – redefined by the UN into the four dimensions of sustainable development (Table 2.4).

Dimension	**Agenda 21 Chapters**
Social	3, 5, 6, 7, 36
Economic	2, 4, 33, 34
Environmental	9–22
Institutional	8, 23–32, 35, 37, 38, 40

Table 2.4 Dimensions of Sustainable Development from UNCSD
Source: United Nations (UN 1996)

The UN Core Indicator set (UN 2001) is firmly based on the four dimensions, though national and local indicator sets progressively give the institutional dimension less emphasis: institutional indicators represent 12% of the UN core indicator set (UN 2001), 10% of the UK 1999 set (DEFRA 1999), and 1% of the UK 2005 set (DEFRA 2005b). Research supports the need for institutional indicators (Spangenberg, Pfahl et al. 2002), but in practice many authors appear to consider only the first three dimensions (Table 2.5) – social, economic and environmental (Azapagic, Perdan 2000, Callens, Tyteca 1999, Harger, Meyer 1996), an approach formalised and popularised as the Triple Bottom Line (Elkington 1997).

When this three dimensional framework is applied in industrial settings, there is a tendency towards applying a 'balance' of social and economic benefits justifying environmental damage (Azapagic, Perdan 2000, Elliff, Celikel et al. 2004, Sustainable Aviation 2005). This theme seems to derive from financial project justifications, and requires a value judgement on economic and social benefits and environmental damage. Since economic theory does not value the environment as a source of raw materials or a sink of pollution (Daly 1991), the economic justification may predominate, leading to justification of 'sustainable growth' e.g. in the UK Aviation White Paper (DfT 2003b).

Agenda 21 Sections	CSD Dimensions	Literature
1 Social and Economic 2 Conservation and Management of Resources for Development 3 Strengthening the Role of Major Groups 4 Means of Implementation	Social Economic Environment Institutional	Social Economic Environment

Table 2.5 Dimensions of Sustainable Development in Literature
Source: Author

Sustainable development requires change towards making trade and environment to be mutually supportive (Agenda 21, chapter 2) and a full integration of environment and development (Rio Declaration Principle 4). On this basis, approaches based on the three dimensional balance may not be fully consistent with sustainable development principles.

Approaches based on Principles of Sustainable Development
Approaches may be based on a small number of major principles of sustainable development, e.g. Futurity, Environment, Equity, Participation (Elkin, McLaren et al. 1991, Mitchell, May et al. 1995), though it is argued that Equity is the single defining principle, which other principles serve to qualify (George 1999).

There is great attraction in using a small number of principles: the issues are fewer and are presented as apparently simpler and more tractable. The ever present danger is of over-simplification and loss of meaning. Principles at this high level are stated as generalisations and require considerable expansion to be meaningful in a particular operational context. In practice it may be necessary to refer to Agenda 21 for adequate clarification.

Approaches based on Thematic Structures

A thematic structure of 15 themes and 37 sub-themes appears in the work of the UN CSD Core indicators (UN 2001), designed to assess national achievement, and related to Agenda 21. Different thematic structures have since been adopted at national level e.g. in the UK (DEFRA 1999, DEFRA 2005b), Finland (MoE(Fi) 2000, MoE(Fi) 2005), Sweden and the USA (Hens, De Wit 2003). These national thematic structures are variable across nations, are readily changeable (e.g. by the UK and Finland) and are less readily related to Agenda 21. They tend to be driven by national policy (Wolfe 2004) rather than being strictly principle based. The thematic approach is also adopted for some local initiatives (Mitchell, May et al. 1995, Bossell 1999), again with very variable themes, perhaps suggesting some reflection of the researcher's interests.

The thematic approach proves very flexible, enabling policy makers to select themes and establish links to policy objectives (Hens, De Wit 2003), thus interlinking political objectives with sustainable development principles.

Pressure-State-Response Frameworks

The pressure–response framework is based on the environmental cause and effect model, i.e. a human activity has some effect on the environment, and may be altered by a response from society or industry (FAO 1999). The simplest version of this general family is the Pressure-State-Response (PSR) framework, used by OECD (OECD 1993) to create national environmental indicators. This evolved into Driving Force-State-Response (DSR) framework, intended to extend the scope beyond environmental aspects to include the social, economic and institutional dimensions of sustainable development, used by the UN CSD in their working list of indicators (UN 1996), and retained as classification in the UN core set (UN 2001).

A further development of this framework led to the rather more complex Driving force-Pressure-State-Impact-Response (DPSIR) framework, in use for some environmental indicators (Segnestam 2002).

2.7.4 Adherence to Principles

All approaches examined are based on the anthropocentric definition of sustainable development, the principles of Rio Declaration and Agenda 21. The observations suggest that a characteristic of most approaches is to allow some divergence from the full range of these principles by (amongst others):

- Omission of Institutional dimension
- Economic dimension interpreted as economic benefit rather than change
- Introduction of the concept of ‘sustainable growth’
- Introduction of other themes e.g. political policies

It is possible to suggest reasons for the divergence from principles, for instance the need to reconcile differing timescales: politicians must be seen to take short term initiatives; effective sustainable developments, such as de-coupling economic growth and resource consumption, are necessarily much longer term. While there may, in some circumstances, be reason for divergences from sustainable development principles, the approaches rarely include such justification. In most cases, the selected approach (or choice of strategy, dimensions, themes) is merely presented without justification. Some observe that political policies may be incorporated into sustainable development themes (Hens, De Wit 2003), others more cynically suggest that politicians may usurp sustainability strategies for political ends (Porritt 1992). There is recognition that politically it is difficult to face these hard problems (Goodland 1991, Williams 2002).

In summary, existing sustainable development strategies and indicator methodologies are characterised by an ability to diverge from strict sustainable development principles, and a lack of justification for the divergence.

It is proposed that a process to develop sustainable development indicators should be transparently related to agreed sustainable development principles.

2.7.5 Indicator Assurance

The approaches and methodologies outlined above have as a product, a set of indicators of sustainable development, which in principle may be assurance tested against the original principles (Rio Declaration and Agenda 21). In general, the approaches reviewed do not specifically include an assurance check against the original statement of principles. PICABUE (Mitchell, May et al. 1995) alone reviews the indicators against defined criteria for good indicators, though these criteria do not originate directly from Agenda 21.

It is proposed that a process to develop sustainable development indicators should include a quality assurance process.

2.7.6 The Need for an Operational Model

The above discourse demonstrates that the concept of sustainable development is ambiguous, may be diverted by political pressures and policies, and genuinely has different operational interpretations in different contexts and times. In many other areas, there exist commonly applied operational models, e.g. financial procedures, quality management (Juran 1999), aviation safety (ICAO 2006b). Within the world of sustainable development, there is, as yet, no agreed or operational model. The proposition is that there is a need for an operational model of self regulating sustainability, including a full system definition, rigorous relationship to sustainable development principles, and a self regulating ability (Box 2.2). The model includes indicators which should be derived by a transparent and rigorous process (Box 2.3). Both are further developed in Chapter 3.

Characteristics of Sustainable Development Model

• Clear definition of operational system
• Clear relationship of operational system to principles of sustainable development
  - Rigorous
  - Transparent
• Self-regulating capability
  - Decision making responsibility and capability
  - Directed by and towards principles of sustainable development
  - Adaptive
  - Repeatable

Box 2.2 Characteristics of Sustainable Development Model

Characteristics of Indicator Selection Methodology
• Covers whole operational system • Relates to all relevant sustainable development principles • Participative • Rigorous and transparent • Reflects purposes of sustainable development indicators • Quality assured

Box 2.3 Characteristics of Indicator Selection Methodology

2.8 *Summary*

The above discussion has presented some of the major conceptual and operational aspects of sustainable development. From the discussion, a number of premises and propositions are made for the purposes of this thesis.

From Section 2.2 – The Nature of Sustainable Development
The anthropocentric root and Bruntland definition (WCED 1987) are accepted as the interpretation of Sustainable Development. The Rio Declaration and Agenda 21 are accepted as the base documents. Other roots are acknowledged as potential contributions to research. Sustainable development is regarded as a journey, a directed process of change over time (Lele 1991, NRC 1999, Porritt 2000, WCED 1987).

From section 2.3 – The Definition of Sustainable Development
The conceptual definition is inherently ambiguous. An operational definition is elusive and depends on the context, the time and the available technology.

From section 2.4 – The Purpose of indicators
Sustainable Development Indicators are intended to provide information to decision makers within a self regulating system of sustainability and provide public information. Indicators should be selected and designed to fulfil these purposes.

Quality assurance criteria for sustainable development indicators are derived (Table 2.2). There is a need for multiple indicator sets for decision making at different levels and for public information. Indicators may need to evolve over time.

From Section 2.7 – Indicator Methodologies
There is a need for a descriptive operational model to relate the operational context directly to sustainable development principles. Indicator selection should be related directly to, and assured against, sustainable development principles. There is a need for a more rigorous approach to deriving indicators of sustainable development. The characteristics of a sustainability model are summarised at Box 2.2.

The operational model and indicator derivation process are explored in Chapter 3.

CHAPTER 3 Operationalise the Concepts

3.1 *Introduction*

The objective of Chapter 3 is to explore new methods of making sustainable development operational in an industrial context. Chapter 2 discusses the origins of the concept of sustainable development, the ambiguity of the meaning and the political and technical difficulties of achieving an operational definition. The proposition of Chapter 2 is that the concept may be made operational by describing a self-regulating sustainability system, and a process to derive indicators, both rigorously and transparently related to sustainable development principles. The model and indicator derivation process are developed in this chapter and applied to the civil aviation system in the following chapters.

Borrowing from systems theory, section 3.2 explores Checkland's systems typology. This typology is used firstly to classify the model of sustainable development (Section 3.4) and secondly as a convenient approach to classifying civil aviation systems in Chapter 4. Section 3.3 examines Quality Management principles which are used as a basis for a quality assurance step in the derivation of indicators.

Agenda 21 suggests that indicators contribute to a self-regulating sustainability system. Section 3.4 explores the nature of information systems and describes the components required to constitute a self-regulating system. This model is used to describe the civil aviation system in Chapter 4.

The self-regulating sustainability systems include sustainable development indicators, and a methodology to derive indicators is described at section 3.5. This method is used in Chapters 4-7 to derive sustainable development indicators in civil aviation.

3.2 *A Systems Typology*

A number of authors (Boulding 1964, Bowler 1981, Churchman 1971) suggest characteristics to describe the nature of systems, and others present differing systems theories e.g. (Lovelock 1988, Laszlo 1973), well documented elsewhere (Skyttner 2001). There have been efforts to build a common mathematical general systems theory – notably by Ludvig von Bertalanffy (von Bertalanffy 1968), but some authors consider that this is not entirely successful *(*Avgerou, Cornford 1993).

It is suggested that these various systems theories may be formulated from the originator's background, and are explanatory structures intended to correspond to something in the real world (Skyttner 2001). Thus, there is no single, definitive systems view, but there is a range of systems theories, each helpful in illuminating some aspect of the world. One of these, a systems typology (Checkland 1981) offers a classification scheme of systems in the real world, proposing four classes of system to describe existing reality within the universe (Figure 3.1):

- Natural systems
- Designed physical systems
- Designed abstract systems
- Human activity systems

Natural systems are those arising from the origin of the universe and formed by evolution, with two major branches: the non-living systems such as inorganic crystals, rocks, minerals and the atmosphere; the organic branch of living things, from single cell organisms, plants, animals and living ecosystems.

Designed systems are made by man by conscious design, designed for some human purpose, and existing to serve this purpose. A designed physical system may be anything from a hammer to a motor car to a jet airliner. Designed abstract systems are purely abstract constructs such as poems, mathematics or philosophies. The systems typology itself is a designed abstract system.

The fourth class, Human activity systems, is a very large grouping covering the whole range of human activities: Checkland offers a number of examples, from a man wielding a hammer, a football team, a transportation system (British Rail), through to international political systems. The larger and more complex systems in this class may themselves consist of an association of many other systems, including natural

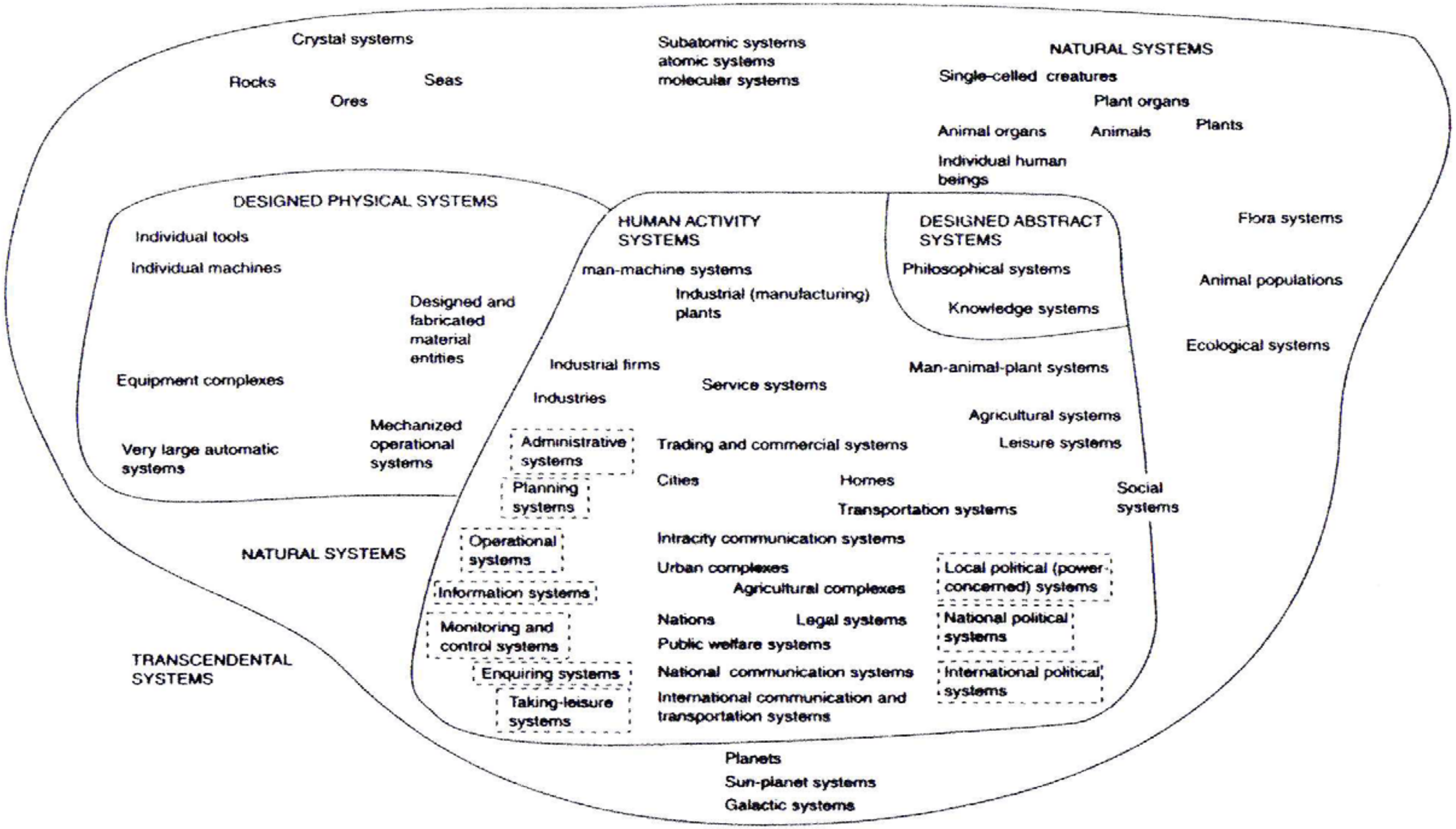


Figure 3.1 Checkland's System Typology

Source Skyttner (2001)

systems, designed systems, both physical and abstract, and human activity systems. In the example of a transport system (British Rail), the stations, track, and rolling stock would be designed physical systems, whereas service or safety principles may be regarded as designed abstract systems, setting out the standards of the company.

Checkland acknowledges that beyond these classes of system there has to be a category to include the systems beyond knowledge – transcendental systems – which will not be of concern to this thesis.

The enormous range of human activity systems is illustrated in the typology diagram (Figure 3.1), consisting of broad system categories:

- Homes, cities, nations
- Organisations including industry and transportation systems
- Political and planning systems
- Procedural systems including administrative, information, operational and regulatory systems

Checkland observes that the human activity systems are less tangible than natural and designed physical systems. Most are observable as combinations of physical components and activities, though the latter category of systems above, called procedural systems, may not have physical components and may consist entirely of ideas. These may be regarded as conceptual systems (Skyttner 2001) and can be used to regulate or modify ('engineer' in Checkland's words) the operation of a physical or human activity system.

Where then does sustainable development fit in the systems typology? In the debate on the meaning of sustainable development, there is a recurring theme for authors to differentiate between the theoretical meaning and the practical implementation in a particular context (Heinen 1994, Clayton, Radcliffe 1996, Bell, Morse 1999, Upham 2003). The theory and principles of sustainable development may be a philosophy or set of beliefs (Pepper 1996) and in Checkland's typology are regarded as a designed abstract system. The practice of sustainable development in a particular operational context is a human activity system, and can be identified as a procedural system designed to modify the operation of other systems. The system is essentially a management information system designed to monitor and control progress toward sustainability. Thus, the anthropocentric Bruntland definition (WCED 1987), the Rio Declaration and Agenda 21 are taken as the principles, and are regarded as a designed abstract system. It may be argued that Agenda 21 is concerned with control actions, but it is phrased at general level, and does not regulate the operation of any particular operational context. A system designed to implement Agenda 21 in a particular context is taken to be a human activity system – a procedural, management information system.

3.3 *Quality Management Principles*

Quality management principles assert that for any product the design characteristics should be driven by the purpose and requirements. Product quality has a range of definitions:

- Degree to which a set of inherent characteristics fulfils requirements (ISO 2000)
- Fitness for use (Juran 1999)
- The total composite product and service characteristics of marketing, manufacture and maintenance through which the product and service in use will meet the expectation by the customer (Feigenbaum 1991)
- Conformance to requirements (Crosby 1991)

These definitions may be regarded as complementary, laying emphasis on the full range of product characteristics and how well these meet customer requirements. Crosby argues that the requirements must be clearly stated and fully understood, and on this basis, conformance to these requirements can be measured – thus quality becomes definable and measurable. Within the industrial or service delivery context, requirements are taken primarily to be those of the customer for the product, and the commercial vision is increased quality (zero defects) at reduced cost. The industrial processes of product manufacture and service delivery are generally repeatable, and quality management may be applied cyclic procedures of quality planning, control and improvement.

It is not suggested that industrial quality practices can be applied directly to sustainable development indicators but the principles of quality assurance may be applied to any product, including a set of sustainable development indicators. The ‘customer’ for indicators is not readily identifiable at the outset, and thus specific customer requirements may be difficult to identify. However, the purposes and use of indicators are clear in Agenda 21, and general criteria can be derived (Table 2.2). These quality criteria may be used as the basis for a quality review to be included in the process for deriving indicators (Section 3.5).

3.4 *Towards a Sustainable Development Model*

The concept of self-regulating sustainability systems originates from Agenda 21 Chapter 40.4. The characteristics of such a system are summarised at Box 2.2, and in Checkland's typology the self-regulating system is identified as information system within the group of Human Activity systems. This section derives the components of an information system required to constitute a self- regulating sustainability system.

3.4.1 The Nature of Information Systems

From the general nature of systems, the system characteristics most relevant to information systems are identified as (Avgerou, Cornford 1993, Bell, Morse 1999):

- Environment
- Boundary
- Closed or open – open system has inputs and outputs
- Purposeful
- Goal seeking
- Control exerting

A sustainability system is by its nature an open system, and the third bulleted item is interpreted as system inputs/outputs. These attributes are expanded for a self-regulating sustainability system in the following sections. Environment, Boundary, Inputs and Outputs are grouped as System Description, while System Behaviour covers the Purposeful, Goal seeking, Control exerting attributes.

3.4.2 System Description

The scope of the following sections includes systems and interfaces with potential relevance to all principles of Rio Declaration. It is recognised that in some dimensions, Agenda 21 has more detail and may be used to guide the definition of relevant systems.

Environment. In this context 'Environment' means the totality of the system's surroundings, not just the natural environment. It is necessary to identify all the adjacent external systems. The systems typology (Checkland 1981) offers a useful checklist for the types of systems to be considered: Natural systems; Designed Physical systems – e.g. infrastructure, plant and machinery; Human Activity systems including procedural systems e.g. economic, legal and control systems

In highly complex systems, it may be necessary to show the major subsystems or component parts of the system to properly define the surrounding systems and interfaces (Avgerou, Cornford 1993). The range of systems will be extremely variable depending on the context.

Boundary. The term Boundary in this context means the boundary of the information system, in physical, logical and temporal terms, and often coincides well to the physical or logical bounds of the actual systems being managed.

Boundaries may be of many types. There may be physical boundaries between designed physical systems, and between designed physical systems and natural systems. Some systems e.g. countries, cities or industrial sites may have geographic boundaries. Between human activity systems there may be physical boundaries to delimit the site or location of an activity, or logical boundaries may define limits of responsibility, authority or autonomy, performance or regulatory standards, and financial or legal interfaces.

Thus the legal instruments represent the interface between the legal system and industry: performance standards of physical components may represent a logical interface e.g. the eco-efficiency standards for large buildings (hangars, terminals) may be regarded as the logical interface between the civil engineering and aviation sustainability systems.

For some highly interdependent human activity systems such as tourism and air transport, it is difficult to discern clear boundaries. In these cases it is necessary to apply agreed limits to the scope of the relevant information system, and to ensure that a corresponding self-regulating sustainability system for the adjacent industry is compatible (see section 3.4.5). Without such boundary definition, the scope of a particular information system could be considered to expand to such an extent as to become unmanageable and impractical. Thus the boundary between two human activity systems may be a combination of logical and physical, general and site specific.

Boundary definition should define the temporal extent of the system. Sustainable development is defined by Bruntland (WCED 1987) and the Rio Declaration as inter-generational i.e. requiring a timescale that ‘spans both human and eco-system time scales’ (Hodge, Hardi 1997). A human generation is taken as about 35 years; an ecosystem timescale may be much longer. Such timescales do present challenges, since most observers will have difficulty in projecting so far into the future. The timescale of ecosystem change e.g. atmosphere and oceans, is little understood, and there remains scientific uncertainty about the required timescale. The essential aspect here is not to attempt accurate predictions, but to identify issues which may have potential impact on the needs and aspirations of future generations, or may have some future impact on the ecosystems.

Inputs/Outputs

The input & outputs across system boundaries should be defined to assess against sustainable development principles whether there are any sustainability issues. For natural systems the interface flow may typically be resources used, waste products, land use, habitat. For interfaces between human activity systems the interface flows are more diverse and may include:

- Volumes of activity, demand or consumption
- Performance standards
- Governance or legal standards
- Participation standards
- Economic or social issues

It is necessary to analyse the type, volume and effect of the boundary input or output, and the effect on external systems, to assess whether or not there is a sustainability issue.

3.4.3 System Behaviour

Agenda 21 envisages 'self-regulating sustainability' (see Section 2.4). Thus the overall system behaviour has to include a cyclic capability of vision and goal setting, action taking, review and resetting goals. The minimum components required to achieve this are discussed below.

Purposeful

A purposeful system is one which can select its goals (Avgerou, Cornford 1993). The Bellagio principles suggest a sustainable development system should have a guiding vision, supported by goals, which may be further refined to quantifiable targets and timescales to achieve those targets (Hodge, Hardi 1997). These terms are seen as a hierarchy:

- Vision sets the frame of reference within which change is to take place and reflects the overall values of the community or region
- Goals can then be articulated which formally express the trends
- Targets are quantified values used for comparing indicators

The general definitions from the Bellagio Principles are adopted as an interpretation of Vision in this thesis, and the system components are taken as:

Vision

- Frame of reference for change
- Reflecting community/ organisational values
- Desired position to achieve on sustainability spectrum (Pearce 1993)

Goals

- More specific definition of vision
- Particular sustainability issue(s)
- Desired direction or level of change
- Applicable to specific system – e.g. industrial sector or company

Target

- Particular issue
- Quantified level or threshold value
- Timescale to achieve the level

The self-regulating system is capable of setting its own vision, goals and targets.

Goal Seeking

A 'Goal seeking' system displays the ability to change behaviour to achieve a particular outcome – its goal (Avgerou, Cornford 1993). In sustainable development terms the appropriate range of development actions may, at least in part, be derived from Agenda 21. Potential policy actions should be assessed against the issues and effects identified in the system description section above: not all Agenda 21 actions are relevant to every industry. The changes envisaged in Agenda 21 are phrased in rather general terms. For practical implementation in a state or industry, these need to be formalised into political, economic or industrial policy, and implemented by initiatives which may include legal instruments, economic incentives, public information & education or voluntary measures. Thus the system components are change policies and specific instruments for change.

Control Exerting

Avgerou and Cornford (1993) suggest that the control exerting characteristics of a system require information, a decision making process, decision makers and means of communications (feedback loops). A sustainable development system should be self-regulating (UN 1992a). The Bellagio Principles (Hodge, Hardi 1997) suggest that responsibility for decision making should be clearly identified and an institutional capability is needed to provide information. The decision making process needs to be ongoing and adaptive. The system should therefore include:

- Identified decision makers
- Decision making process – ongoing and adaptive
- Institutional capability – for information provision
- Information

In the sustainable development system the information takes the form of Indicators of Sustainable Development.

3.4.4 Self-Regulating System Components

The above sections have described the components of a self-regulating sustainability system, summarised at Box 3.1. Information (the indicators of sustainable development) does not of itself cause any change: 'Good information is not a decision' (Redman 1999). Information needs to be synthesised and used to formulate potential courses of action (Redman 1999, Awad 1998), which will align with the visions for sustainable development (Hodge, Hardi 1997). Communication of information to decision makers makes the selection and setting of goals possible (Avgerou, Cornford 1993) and in turn setting of specific targets.

Thus the system actually operates through a complex, cyclical process. Initially a vision and goals for change are formulated, change policies and specific instruments (legal, economic and/or educational) are defined and implemented in order to pursue these goals and targets (Hodge, Hardi 1997). Quantified targets may arise directly from the goals, or from the implemented instruments for change. Over time, the system will change, and the effects are assessed. As appropriate, visions and goals are adjusted, policies and instruments for change are revised in a cyclical process . Information (in the form of sustainable development indicators) serves to inform the decision makers in the initial formulation of vision and goals and targets, monitoring implementation of change policies and progress towards targets, and reassessing policies and goals in a cyclic process. Indicators are integral to the functioning of the system processes, though are not themselves the agent of change..

Sustainable Development Model – Components
1 - System Description • Principles relevant to context (Rio Declaration & Agenda 21) • Internal subsystems and external systems • Boundary definitions (physical/logical) • Nature of boundary (type of interface, volumes, standards etc) • Effect on external system - Current state, Rate of change • Timescale – intergenerational • Sustainability issues
2 - Vision and Goals • Vision – desired position • Goal – for specific issue to define the vision • Targets
3 - Change Programmes • Policy Actions relevant to context – Agenda 21 Chapters • Change programmes – based at least on Agenda 21 - Policies - Legal instruments, economic incentives, information/education - Targets
4 – Control Mechanisms • Identified decision makers • Decision making process – ongoing and adaptive • Institutional capability – for information provision • Information
5 - Information • Indicators of Sustainable Development - Current system status - Boundary conditions - Change programmes

Box 3.1 Sustainable Development Model

Source: Author

3.4.5 Context of Sustainable Development Models

Multiple Sustainable Development Models for Industrial Sectors

The preceding section outlines a model of a self-regulating sustainability system, designed for use in a particular operational system. In this thesis the model is applied to a single industrial sector – Civil Aviation.

It is however recognised that such sustainable development models cannot realistically exist in isolation: for every boundary with another human activity system, there should be a corresponding sustainable development model. Conceptually there will be similar sustainable development models for all industrial sectors and activities, at global or national levels, interlocking in a complex matrix. Each model has a series of defined boundaries and interfaces with adjacent models: the boundary definition will establish how sustainable development issues and actions are split between the two models (see also section 3.4.2 Boundary).

For some highly interdependent human activity systems such as tourism and air transport, it is difficult to discern clear boundaries. In these cases it is necessary to develop consistent sustainable development systems to cover the range of dependent and overlapping sustainable development issues and actions.

Definition of Sustainable Development

In this thesis the anthropocentric definition is taken, and the principles set out in Rio Declaration and Agenda 21 are incorporated in the model. Should a different or modified set of principles be adopted, then these can, in theory, be readily substituted into the criteria used in the model, i.e. a different set of sustainable development principles could be used.

Intra-Sector Sustainable Development Models

It is tempting to think of a single sustainable development model for a particular sector. However, within a complex sector such as civil aviation, there may be many sustainable development aspects, perhaps having different significance, timescale, decision makers and potentially at different levels of maturity. Thus there may be several different, though interconnected models within the same industrial context.

3.5 *Towards an Indicator Selection Methodology*

The characteristics of an indicator selection methodology are listed at Box 2.3 (repeated below).

Characteristics of Indicator Selection Methodology
• Covers whole operational system • Relates to all relevant sustainable development principles • Participative • Rigorous and transparent • Reflects purposes of sustainable development indicators • Quality assured

To encompass the characteristics a five step approach is proposed:

- Step 1 – Map system against sustainable development principles. This exercise is designed to ensure that the whole system is covered and all relevant sustainable development principles are considered. Step 1 produces the system description envisaged in Item 1 of Box 3.1 above and yields a list of potential issues and policy actions.
- Step 2 – Participative review. A level of participation is ensured by stakeholder review of the issues and policies from Step 1. The review employs a Delphi study (Dalkey, Helmer 1963, Linstone, Turoff 1975).
- Step 3 – Select indicators. Selection reflects stakeholder priorities and sustainable development principles (Mitchell, May et al. 1995). Each selection is justified.
- Step 4 – Construct indicators. This step defines the form and format of each indicator according to the purposes of Agenda 21. Populate indicators from available data.
- Step 5 – Quality assurance review against requirements of Agenda 21.

A diagrammatic representation of the methodology is shown at Figure 3.2.

3.6 *Summary*

The preceding sections propose a revised approach to making sustainable development operational in specified systems.

From Section 3.4

A sustainable development system model is derived in section 3.4 Box 3.1. This model is used to guide the mapping of the civil aviation system against sustainable development principles in Chapter 4:

System Description – a system description in sustainable development terms is undertaken.

Vision and Goals – existing visions and goals are researched. There is no intention to attempt to set visions and goals for the industry.

Change programmes – existing change programmes for civil aviation are documented as part of the system description. There is no intention to attempt to suggest further change programmes for the industry.

Control Mechanisms – Regulations and relevant regulatory organisations are recorded as part of the system description. There is no intention to analyse the political processes or regulatory decision making processes.

Information – Indicators of sustainable development are derived.

From Section 3.5

A methodology is proposed to derive sustainable development indicators directly related to, and assured against, Agenda 21. The methodology forms the basis of the research described in Chapters 4-7.

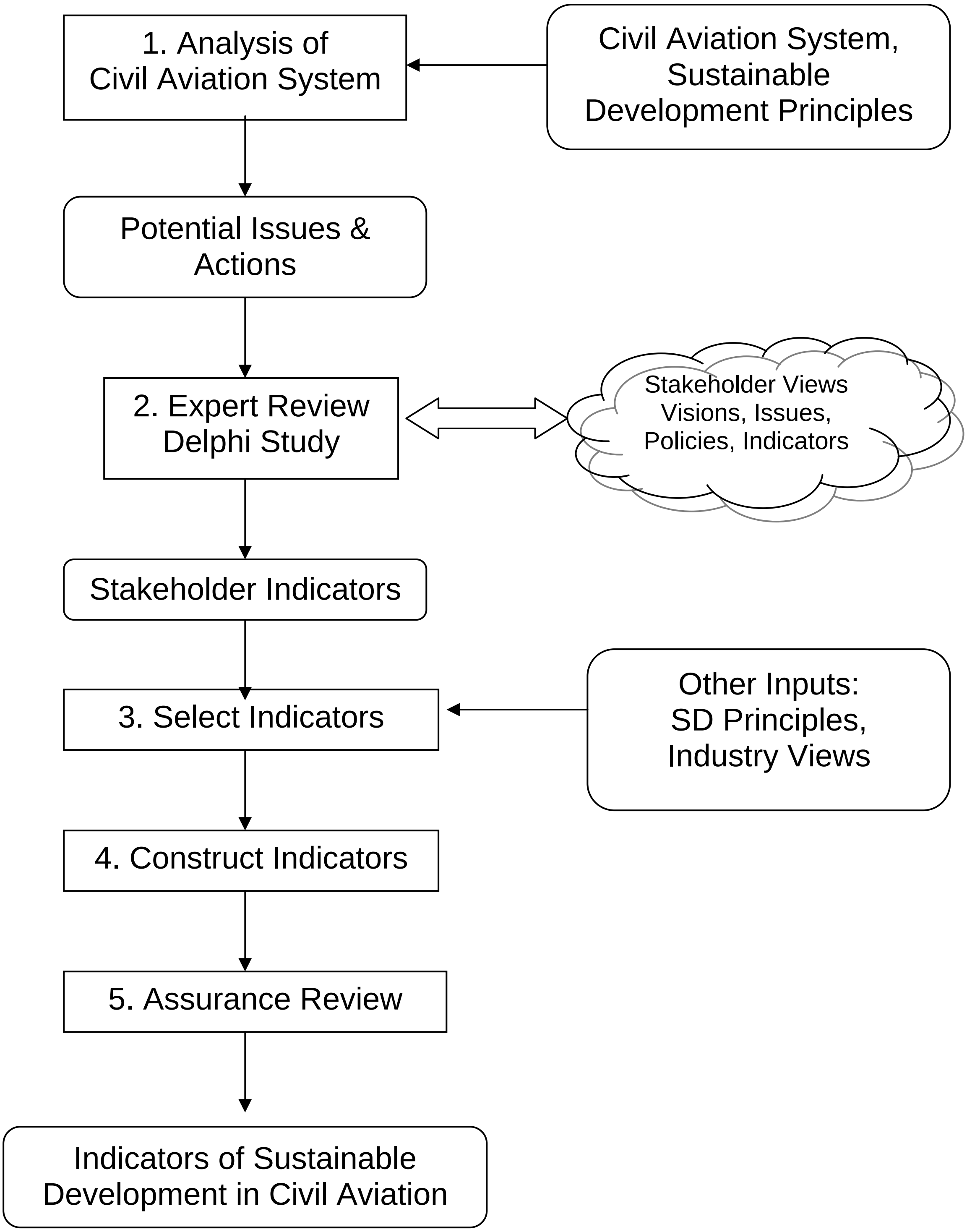


Figure 3.2 Methodology to Derive Sustainable Development Indicators

CHAPTER 4 Civil Aviation & Sustainable Development

4.1 *Introduction*

The objective of this chapter is to analyse the civil aviation system against sustainable development principles, using the Sustainable Development Model derived in Chapter 3 (Box 3.1). This model includes a system description, vision & goals, change programmes and control mechanisms.

For such a large and complex system as civil aviation, there are many possible views designed to describe various aspects. Section 4.2 derives a particular view of civil aviation considered suitable for analysis against sustainable development principles.

Section 4.3 (A System Description) undertakes a systematic mapping of civil aviation systems against the principles of the Rio Declaration and Agenda 21 according to Item1 of Box 3.1. This yields a definition of system boundaries and potential issues for sustainable development. The description includes analysis of existing regulatory arrangements in the UK, and the responsibilities of regulatory bodies. There are no common institutional arrangements covering the various aspects of sustainable development, so this section considers each major aspect separately.

Section 4.4 (A Vision Analysis) explores the literature for existing visions of aviation relevant to sustainable development (Box 3.1, Item 2). There is no intention here of attempting to set visions or goals for the industry. Section 4.5 (Change Programmes) examines each chapter of Agenda 21 to assess which policies and actions may be relevant to the civil aviation industry, yielding a list of potential policy actions.

Section 4.6 (Control Mechanisms) briefly summarises the assessment of regulatory arrangements. Section 4.7 summarises this extensive chapter, by providing a review on the approach and a summary of the findings, and raises questions concerning the level of acceptance of sustainable development in the civil aviation business.

4.2 *A System View*

The civil aviation sector as a whole is hugely complex, consisting of many sub-systems, components, and operational procedures. To consider it as a single system would present an impractical challenge of scale and complexity. In practice, for such a large system, many system views are possible, each representing the system from the viewpoint of the observer (Skyttner 2001), and each designed to serve a particular purpose. Authors present different views of the system, highlighting particular aspects e.g. airports may be viewed as part of the air traffic management system (Bernabei 2001), as systems of airports (Caves, Gosling 1999), and there are multiple views of systems within airports (Ashford, Moore 1999, Ashford, Stanton et al. 1997, Ashford, Wright 1992, Graham 2001, Wells 1999).

There is less evidence in the literature of a system view specifically designed to analyse sustainable development, though some come close (Whitelegg, Cambridge 2004). Sustainable development may be expected to impinge on many aspects of aviation and be relevant to many aviation systems and sub-systems of different types. It is helpful therefore to consider the nature of the component systems, which make up the civil aviation system as a whole, and to understand the different types of system. One approach to assist this understanding is Checkland's system typology (Checkland 1981) described in section 3.2. In this typology, the civil aviation system is seen as a human activity system, consisting in turn of many other human activity systems and designed physical systems. These may be represented in a variety of ways: Figure 4.1 presents a logical model rather than physical linkages.

The designed physical systems (physical components) of the aviation system are taken as aircraft, airports and available airspace (Caves, Gosling 1999). The atmosphere is a natural system, but use as *airspace* to guide and separate aircraft, is regarded by Caves as a physical component. Each component is itself a complex hierarchy or assembly of many physical units or sub-systems: the internal complexity is not examined in this review. Components may be grouped at various levels, according to the purpose (Caves, Gosling 1999).

Civil aviation stakeholders (Caves, Gosling 1999) are shown as organisations, which are classed as human activity systems, each designed for a purpose; each may be very complex and may be described in a multitude of ways. They are taken as groups of people with potential relevance for sustainable development.

Procedural systems are human activity systems designed to manage operational systems and may take many forms:

- Management systems – An airport operations manual and the associated management structure (Ashford, Stanton et al. 1997)
- Regulatory systems – ICAO regulations (ICAO 2006b) and the regulatory structure to apply them (Wells 1999)
- Planning systems (Owens, Cowell 2002)
- Political systems (Caves, Gosling 1999)

Systems concerned entirely with the internal management of civil aviation e.g. airport operations manual, are grouped collectively as internal management and control systems, and are not analysed. They are assumed to reflect external influences and requirements. External procedural systems having an effect on the operation of civil aviation, (regulatory and planning systems) relevant to sustainable development are included in the following analysis.

Demand for air transport services derives from a series of external systems shown in Figure 4.1 as Demand systems.

Natural systems (oil resources, atmosphere and waste systems) are shown as external systems. Interfaces between an industrial system and natural systems are considered to occur through the means of production (Azapagic, Perdan 2000, Bonazzi 1999) i.e. in this case through the operation of the physical components – airports and aircraft.

It is recognised that the view at Figure 4.1 is not prescriptive: it does present, however, a valid and convenient basis for the analysis of sustainable development issues for civil aviation.

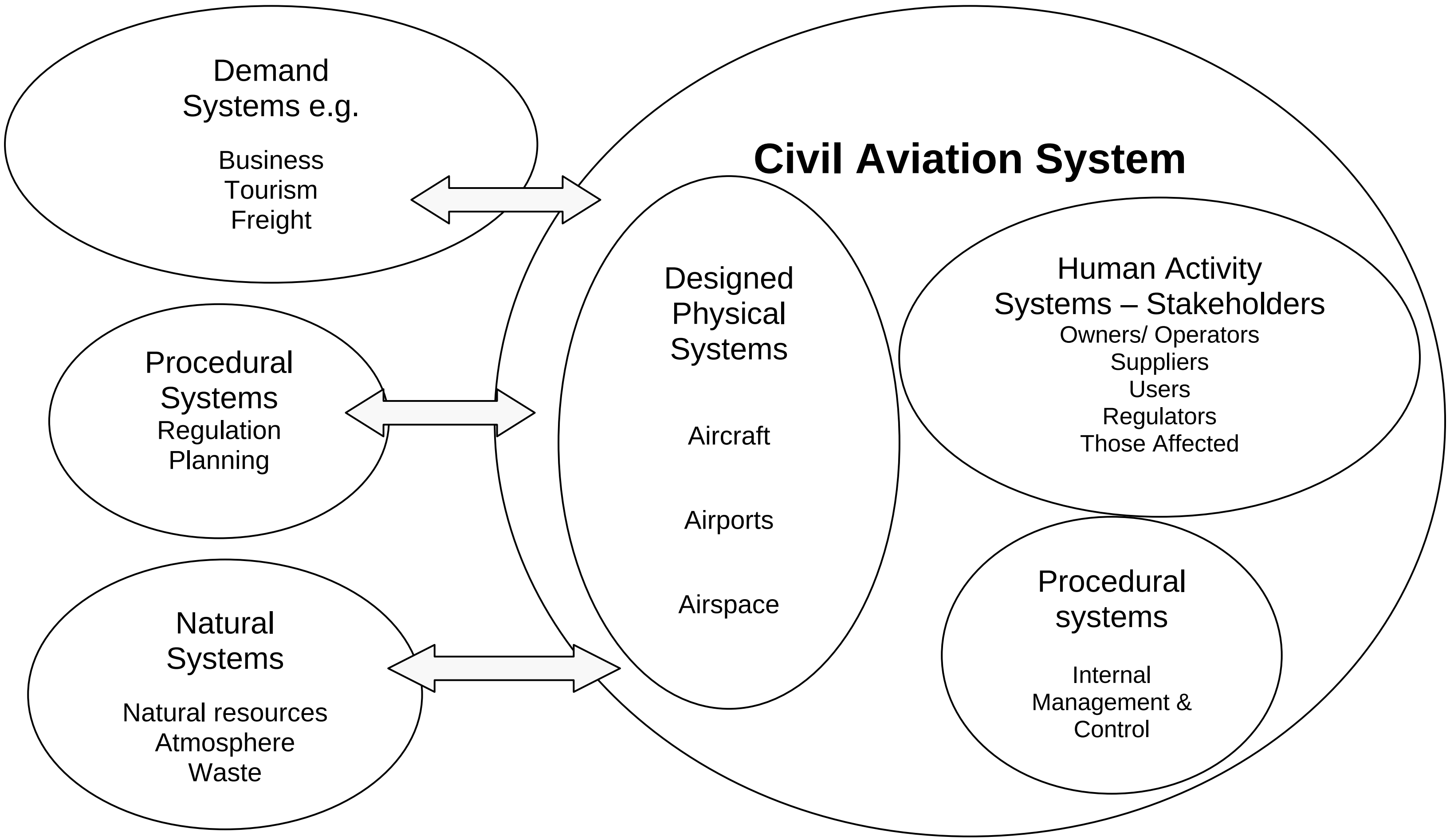


Figure 4.1 Civil Aviation Systems – Typology Diagram

Source: Author: Systems Typology based on Checkland (Checkland 1981): System groups based on Caves (Caves, Gosling 1999)

4.3 *A System Description*

4.3.1 Approach

This section analyses civil aviation systems to identify potential issues for sustainable development using:

- Sustainable development principles (Rio Declaration and Agenda 21)
- The civil aviation system typology Figure 4.1
- The system description components Box 4.1 (extract from Box 3.1)

Sustainable Development Model – Components
1 - System Description • Principles relevant to context (Rio Declaration & Agenda 21) • Internal subsystems and external systems • Boundary definitions (physical/logical) • Nature of boundary (type of interface, volumes, standards etc) • Effect on external system   - Current state, Rate of change • Timescale – intergenerational • Sustainability issues

Box 4.1 System Description from Box 3.1

The principles relevant to civil aviation are assessed in section 4.3.2 giving a more usable checklist. For each system or system group, the analysis identifies the relevant sustainable development principles, the nature of the boundary and potential sustainable development issues, shown in the text as:

ISSUE	**Principle**	**Description**	**Section**

Civil aviation depends on the sustainable behaviour of many other industrial sectors, but it is not feasible to include information on the performance of other industries within the civil aviation information system. Thus, throughout this analysis, boundaries are defined between the information systems for civil aviation and interfacing sectors. Each of these sectors is envisaged to need a sustainable development information system interfacing with the civil aviation information system. This analysis intends to highlight issues, rather than to define measurements or indicators, which are derived in Chapter 7, Construct Indicators.

4.3.2 Principles Relevant to Civil Aviation

The Rio Declaration includes 27 principles varying from fundamental rights of nations and human beings, to participation and the means of implementation (Appendix 1). These are expressed at the level of Nation States and not all principles are directly relevant to a particular industrial sector. The first step therefore is to analyse which principles apply to civil aviation (Table 4.1). For each principle, the topic is summarised, a broad classification is derived and the relevance to civil aviation assessed. Principles classed as Human Rights, National Rights, International Relations, are regarded as the remit of National States and are not within the direct responsibilities of a particular industrial sector.

Principle 10 of the Rio Declaration defines Public Participation as a necessary part of the process of sustainable development. Participation is regarded as a fundamental principle (Elkin, McLaren et al. 1991, Mitchell, May et al. 1995), and is viewed by many others as an essential input to the sustainable development process (Bell, Morse 1999, Hodge, Hardi 1997, VanderZwagg 1995). For civil aviation there are a range of participation aspects so this principle is regarded as relevant. Principles 20-22 relate to specific classes of people, and are regarded as a matter of national policy, not specifically the responsibility of a single industrial sector.

Principles classed as implementation generally correspond to the institutional dimension defined by the United Nations (UN 2001), a dimension frequently omitted from sustainable development studies as noted at Section 2.7. It is, however, argued that aspects of means of implementation are extremely important e.g. integration (Spangenberg, Pfahl et al. 2002, VanderZwagg 1995) or law reform (VanderZwagg 1995). For this reason, implementation principles are regarded as relevant, except where they are specifically defined at a national or international level.

Those principles related to Equity, Implementation, Consumption, Environment are regarded as relevant to civil aviation.

	Topic	Type	Relevant to Civil Aviation
1	Human Rights and Health	Human Rights	Y - Health
2	National Rights	National Rights	N
3	Intra and inter generational equity	Equity	Y
4	Integrate environmental protection & development process	Implementation	Y
5	Eradicate poverty	Equity	Y
6	Developing countries	Equity / International relations	N
7	Conserve, protect and restore the health and integrity of the Earth's ecosystem	Environment	Y
8	Improve quality of life, Reduce and eliminate unsustainable patterns of production and consumption, Appropriate demographic policies	Equity	Y (Quality of life, Production, Consumption)
9	Capacity-building and transfer of technologies	Implementation/ International relations	N
10	Participation	Participation	Y
11	Effective environmental legislation	Implementation	Y
12	Promote a supportive and open international economic system	International relations	N
13	Liability and compensation for the victims of pollution	Implementation	Y
14	Prevent cross-boundary relocation of polluting activities	International relations	N
15	Apply precautionary approach	Visions/ Target	Y
16	Apply polluter pays principle	Visions/ Target	Y
17	Environmental Impact Assessment	Implementation	Y
18	Emergencies and Natural Disasters	National rights/ Implementation	N
19	Trans-boundary pollution		N
20	Women	Participation	N
21	Youth		N
22	Indigenous people		N
23	People under oppression, domination and occupation	Human rights	N
24	Warfare	International relations	N
25	Peace		N
26	Resolve environmental disputes peacefully		N
27	Implementation of Rio Declaration	Implementation	Y

Table 4.1 Analysis of Rio Declaration

Source: Author

Principle 8 covers a range of aspects, quality of life, unsustainable production and consumption and demographic policies. The first of these, quality of life, has widespread acceptance: IUCN used the expression 'improving the quality of human life' as part of the definition of sustainable development (IUCN 1991), the UK sustainable development strategy ‘A better quality of life’ (DEFRA 1999) would seem to be predominantly concerned with this issue, as are the UK local sustainable development initiatives e.g. Norwich (Norwich 1999). The Bellagio principles (Hodge, Hardi 1997) also suggest that ‘*access to services*’ should be considered as an issue. Thus ‘Quality of Life’ is included in the checklist. Demographic policies are regarded as outside the responsibility of civil aviation.

Two principles, Principle 15, the Precautionary Approach, and Principle 16, Polluter Pays, are classed as Visions/Targets on the basis that these principles are primarily concerned with influencing the visions of sustainable development and forming targets. These are included in the list as relevant to civil aviation, but may not manifest themselves in the following analysis of the physical and procedural systems of civil aviation (Figure 4.1). They will be more strongly considered in Visions analysis (Section 4.4) and programmes of change (Section 4.5). The result is a more useable checklist of relevant principles (Table 4.2).

Principle	**Topic**
1	Human health
3	Intra and inter generational equity
4	Integration
5	Poverty
7	Conserve Ecosystems
8	Production & Consumption
8	Quality of Life
10	Participation
11	Effective Environmental Legislation
13	Compensation
15	Precautionary Approach
16	Polluter Pays Principle
17	Environmental Impact Assessment
27	Implementation of Rio Declaration

Table 4.2 Checklist of Criteria for Civil Aviation

Source: Author

4.3.3 Demand Systems

4.3.3.1 General

The demand for air transport is normally considered to be a derived demand from other trade and business systems (Caves, Gosling 1999): air passenger demand from leisure, tourism, business systems (Humphreys 2003, Whitelegg, Cambridge 2004); air freight from international trade systems (Gillingwater, Humphreys et al. 2003). This range of systems will be termed in this thesis ‘Demand systems’.

It is recognised that each demand system consists of many ‘systems’ e.g. the tourism system ranges from many individual travellers to large scale tour operators. In this thesis, there is no intention to analyse in any detail the complexity of each demand system. Rather the demand systems are viewed as high level systems with definable interfaces to the air transport system. In sustainable development terms the interface is concerned with unsustainable consumption patterns (Principle 8) and equity (Principle 3). The nature of the interface includes the volume of consumption, the distribution of consumption, and the performance standards between industries.

Within the model envisaged in this thesis, it is suggested that, in principle, each demand system should have a sustainable development system, equivalent to and interfacing with the civil aviation sustainable development system (section 3.4.5). Thus, information on the impacts of the demand systems is then validly within the remit of their own information system (sustainable development system), rather than that of civil aviation. For completeness, some of the effects are discussed in Social and Economic Impacts (section 4.3.3.5) below.

4.3.3.2 Consumption Patterns – Volume

Passenger transport tends to be strongly related to the distribution of economic wealth (Humphreys 2003). It is suggested that the growth in freight transport is largely driven by the development of global supply chains and ‘just-in-time’ logistics models (Gillingwater, Humphreys et al. 2003).

Demand for air transport services has grown steadily in the last half of the 20th century, illustrated by the number of UK airport passengers (Figure 4.2). It is suggested that growth may be due to a complex set of drivers (Whitelegg, Cambridge 2004) Box 4.2, which in turn may be enabled or stimulated by the reduction in the real cost of airfares: Figure 4.3 illustrates the number of weeks' salary to pay for a Sydney to London return ticket. It is recognised that the significant reduction in the real cost of air transport is a major driver in the growth of passenger and freight traffic.

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

Box 4.2 Driver Variables for Aviation Demand

Source: Whitelegg (Whitelegg, Cambridge 2004)

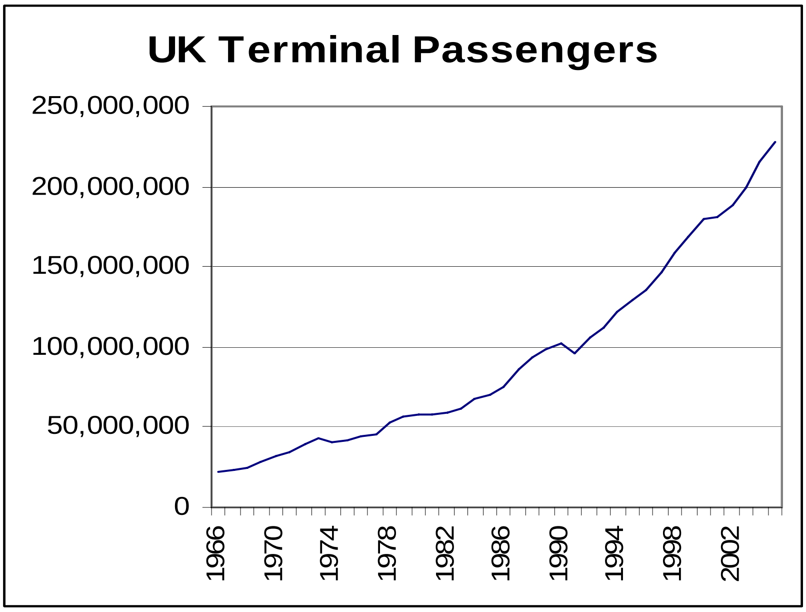


Figure 4.2 UK Airport Terminal Passengers

Source: Civil Aviation Authority (CAA 2005a)

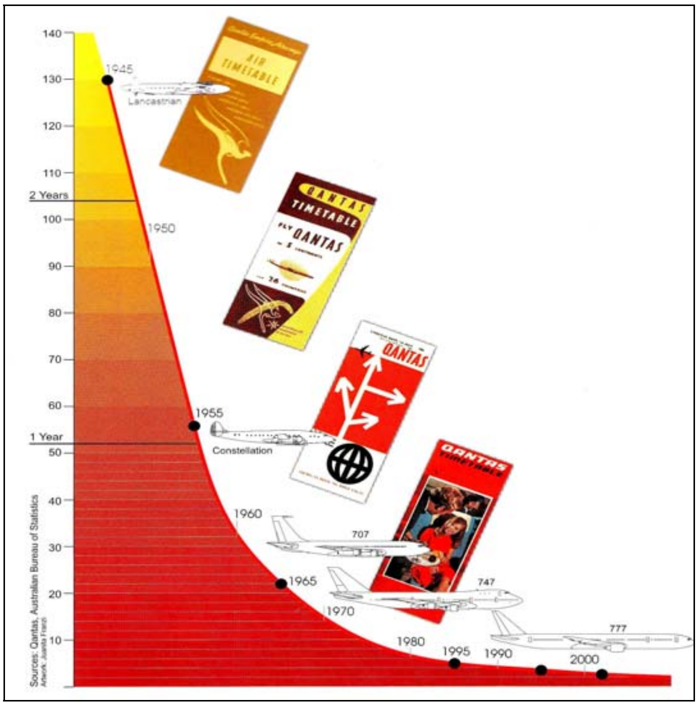


Figure 4.3 Weeks' Salary to buy London-Sydney Return Air Fare

Source: Thomas (Thomas, Forbes Smith 2003) page 181

The basic boundary condition is the volume of air transport consumed. Consumption may be measured for airport level by number of passengers, volume of freight, or for airline activity performed i.e. passenger/freight multiplied by distance flown. Air transport consumption is well documented in a number of statistical publications e.g. for the UK by the Civil Aviation Authority (CAA) Statistics (CAA 2005a), and internationally by International Civil Aviation Organization (ICAO) (ICAO 2003) and International Air Transport Association (IATA) for member airlines (IATA 2004b). The actual indicator is debated in Chapter 7.

ISSUE	**Principle 8**	**Volume of air transport**	**4.3.3**

4.3.3.3 Consumption Patterns – Sustainability

Rio Declaration Principle 8 calls for the elimination of unsustainable patterns of consumption (Box 4.3), without defining ‘unsustainable consumption’.

> *Principle 8 – To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.*

Box 4.3 Rio Declaration Principle 8

The consumption of air transport, dependent on aviation fuel currently derived entirely from non-renewable fuel (oil), and emitting waste gases to the atmosphere, may be regarded as intrinsically unsustainable (Upham 2003). The justification appears to be that economic gain or social benefit justifies environmental costs (Caves 2003). Operationally, it is perhaps desirable to develop some means of assessing levels of unsustainable consumption by means of similar indicators across different sectors. Possible assessments may involve the environmental cost related to economic benefit (energy ratio) or to social benefit.

The concept of an energy ratio (or energy intensity) to show energy used per unit of economic value, is well established. Energy ratio is recommended by the UN as an indicator at a national and sector level (UN 2001) and is adopted at a national level by the UK (DEFRA 1999) at national level (Indicator A2 Energy Efficiency of Economy) and sector levels (Indicator D3 Energy and water consumption by sector), though the latter are absent from later revisions of the UK sustainable development indicators (DEFRA 2005c). Reducing energy intensity remains integral to UK Government energy policy (DTI 2003) and sustainability strategy (DEFRA 2005a).

In the case of aviation, the energy ratio at a national level may be based on aviation fuel used and contribution to national GDP. At a local level it may be more appropriate to consider jobs created or salaries paid since local economies benefit from the value of jobs.

ISSUE	Principle 8	Unsustainable consumption pattern	4.3.3.

4.3.3.4 Consumption Patterns – Equity

The concept of equity derives from Rio Declaration Principle 3 (Box 4.4), and applies to air transport in terms of equity in air transport consumption in the current population and the forecast changes for future generations.

> *Principle 3 – The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.*

Box 4.4 Rio Declaration Principle 3

Regional Equity

The consumption of air transport differs greatly between world regions, (Table 4.3 and Table 4.4). World regions are defined by ICAO, air traffic data and growth rates are taken from ICAO annual reports (ICAO 2003, ICAO 2005, ICAO 2006a), based on scheduled flights of the airlines of the region and regional population and growth rates are taken from United Nations Population division (UN 2002a, UN 2005). Consumption in North America is over 50 times that of Africa in terms of passengers/person, and over 40 times in passenger kilometres/person. For air freight tonne-kilometres, Africa again has the lowest rate of all regions, and Asia/Pacific, despite having the largest volume of any region, has a consumption rate 12% that of North America.

ISSUE	Principle 3	Regional Equity	4.3.3

Region	Pass (000s)	%	Pass /1000 people	Pass Kms (M)	%	Pass Kms/ person
Africa	29,920	1.9	36	66,220	2.3	80
Asia/Pacific	400,320	24.8	111	785,110	26.7	218
Latin America & Caribbean	97,100	6.0	182	132,330	4.5	248
Middle East	50,140	3.1	255	106,700	3.6	543
Europe	422,620	26.2	583	769,710	26.2	1062
North America	615,140	38.1	1923	1,082,340	36.8	3383
Total				2,942,410		

Table 4.3 Air Passengers by World Region in 2002

Region	Freight Tonne Kms (M)	%	Freight Tonne Kms/ person
Africa	1,860	1.6	2.2
Asia/Pacific	42,060	36.1	12
Latin America & Caribbean	3,940	3.4	7
Middle East	5,350	4.6	27
Europe	32,830	28.1	45
North America	30,590	26.2	96
Total	116,630		

Table 4.4 Air Freight Consumption by World Region 2002

Future Consumption Patterns

Forecasting future trends is problematical and is not the primary objective of this thesis. However, it is relevant to examine the potential effect of the forecast increases in air traffic on the equity issues outlined in the previous section.

Global forecasts, based primarily on forecast increases in GDP across regions, are provided annually by, for instance, International Civil Aviation Organization (ICAO) (ICAO 2006a), Boeing (Boeing 2005) and Airbus (Airbus 2005). ICAO uses a 3 year timescale and a regional split: the manufacturers use more ambitious 20 year projections, and a rather different regional split from ICAO. These industry forecasts are expressed in terms of passenger kilometres, and freight tonne kilometres. The average growth rates from these sources are used to extrapolate regional consumption rates over a 10 year period (Figure 4.4).

Projected annual % growth (Passenger kms)	
Source	
ICAO (average over 3 years)	6.7
Boeing (world average)	4.8
Airbus (world average to 2013)	6.0

Table 4.5 Projections of Air Transport Growth (Annual percentages)

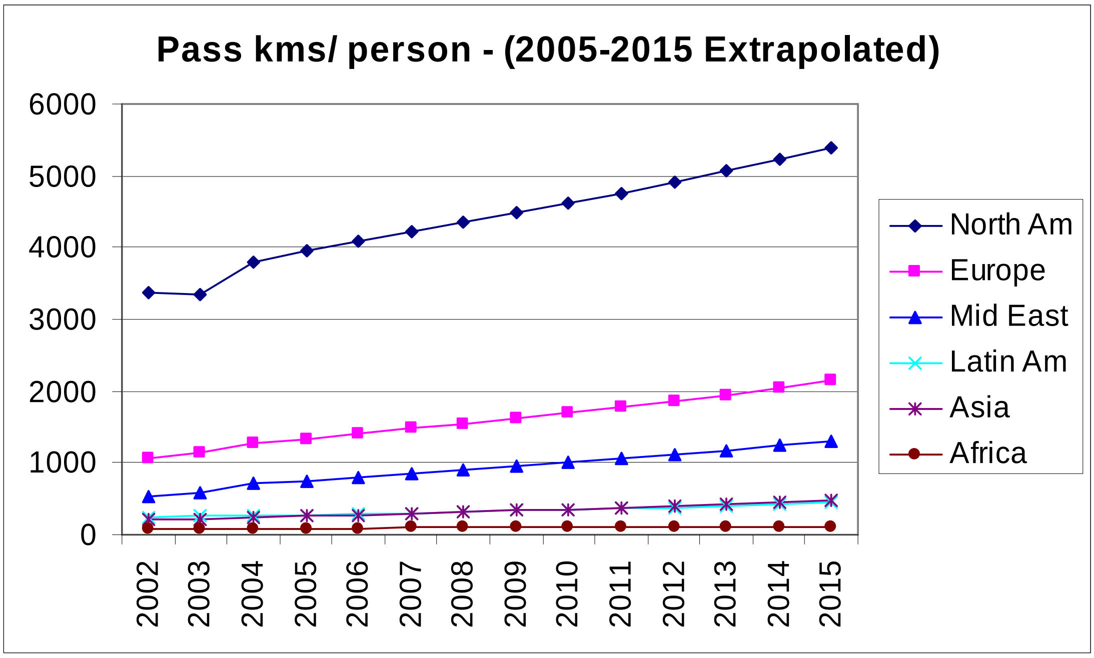


Figure 4.4 Regional Air Transport Consumption Extrapolation to 2015

The extrapolation suggests that all regions will increase their consumption rate in passenger kilometres. In terms of share of traffic, North America and Europe reduce slightly, Asia Pacific and Middle East increase, while Latin America and Africa shares remain constant. The highest current consumers make the highest actual increases, and thus the consumption per person increases most in North America. This extrapolation suggests that inequity between North America and the other regions may increase.

It should be stressed that this extrapolation is for indicative purposes: the calculated figures have little reliability; though small changes on growth assumptions do not materially change the resulting pattern. The exercise indicates that the current regional forecasts of air transport growth are likely to actually widen the inequity in consumption rates across world regions.

Social Equity in United Kingdom

Within the UK, consumption of passenger air transport is heavily weighted towards the wealthier sectors of society: for instance in 2004 at Stansted Airport, 80% of leisure passengers were from socio-economic groups ABC1, 11% from group D and 9% from group D (CAA 2005), whilst 97% of business passengers were ABC1. Similar patterns are recorded at other airports in the UK (CAA 2005) and Europe (T&E 2006).

Currently the economic framework of the UK and Europe exempts aviation from many taxes, including VAT and fuel duty (Bishop 2003, DfT 2003). There is a strongly felt argument that this economic framework redistributes real income to the benefit of wealthier groups in society, and is thus socially unjust: the lost revenue could be used to promote more socially just policies (CPRE, SERA 2003, Sewill 2005, T&E 2006). The counter argument, that low air fares enable poorer groups in society to travel by air, is hardly supported by the relatively few air passengers from low income groups (CAA 2005, CPRE, SERA 2003, T&E 2006).

Sustainable development principles are not drawn into the debate on the perceived inequities of taxation systems, but do require that nations move toward 'Environmentally Sound Pricing' of goods and services (Agenda 21 Chapter 4): appropriately designed taxation is envisaged to play a part in this. In sustainable development terms, environmentally sound pricing, considered in section 4.5.3, must therefore be regarded as the overriding principle.

4.3.3.5 Demand Systems – Social and Economic Impacts

This section considers some of the impacts of air transport demand systems. Airport employment is considered under 'Operators' (section 4.3.9.2). The activity of air transport is to move passengers for tourism, business or social reasons, and freight, normally in pursuit of trade, and this movement will have an economic impact.

The economic effects of tourism operate in both directions, removing spending power at the source and stimulating employment at the destination. At UK airports, outbound international leisure represents approximately 50% of passengers (CAA 2005), rising to over 70% at some regional airports e.g. Nottingham East Midlands, Cardiff (CAA 2004), contributing to a net tourist trade deficit for the UK (Table 4.6).

Each individual leisure passenger, whether travelling for tourism or social reasons, derives benefit from cultural or pleasurable activities, and at the tourist destination, there is normally some economic gain through new employment, though overall benefits to the local community may be variable, with benefits flowing to the owners of airlines, and hotel facilities (Caves 2003). There is also a range of positive and negative environmental impacts and social effects which may be complex and variable depending on the destination and type of tourism. Potential physical impacts include excessive infrastructure development and degradation of natural habitat e.g. high mountains and sensitive coral reefs: social effects range from culture clashes to ethical problems such as child labour, prostitution and sex tourism (UNEP 2006, WTTC 2002).

Year	UK Tourism Trade Deficit (£m)
2000	11,446
2001	14,026
2002	15,225
2003	16,695
2004	17,238
2005	17,929

Table 4.6 UK Tourism Trade Deficit
Source: Office for National Statistics (ONS 2006b)

It is claimed that the availability of air services stimulates the creation of additional industries close to a major airport (ATAG 2005, OEF 1999), though, in developed countries, there may be no clear relationship between the availability of air services and the location of industry (Caves, Gosling 1999). The combination of internet technology and rapid air freight services has driven the growth of e-commerce, enabling many specialist enterprises to supply a global market (Gillingwater, Humphreys et al. 2003).

The air transport industry does enable the creation of industries in places and countries that were not previously possible e.g. tourism, fresh crops grown for export, relocation of manufacturing industry to lower cost economies. Generally, the ability to transfer activities to lower cost economies is regarded as beneficial, contributing to lower costs in the consuming countries, generating employment in less developed countries, and thus contributing to alleviation of poverty (ATAG 2005, Wolf 2005). Where an industry is relocated, then unemployment may be created in the original site or country e.g. UK clothing industry (Jones, Hayes 2004). The drive towards minimum costs, regardless of location, may carry with it the potential threat of lower wage rates, poorer employment conditions and reduced bargaining powers for workers (Stiglitz 2000). It is also argued that social and economic inequalities between developed and developing world and within developing countries have increased (Scholte 2005).

The demand systems using air transport contribute to a range of economic and social effects. There is great difficulty in quantifying the benefits (Caves 2003): it may be that protagonists of civil aviation are enthusiastic in emphasising the benefits (AOA 2005, ATAG 2005, OEF 1999) whilst others may be more restrained in their benefit assessments (CPRE, SERA 2003, T&E 2006).

Information Systems View

How do these impacts relate to the systems scenario envisaged in this thesis?
In systems terms, the above impacts are strictly the effects of the various demand systems i.e. of the multiple business and tourism systems. Within the concepts of this thesis, it is assumed that each demand system will have its own sustainable development systems and associated indicators, discussed previously in section 3.4.5.

While it may be argued that air transport plays a major role in the development of the globalised economy (ATAG 2005), the falling real cost of transport is but one of many technology and policy changes driving world trade systems (Wolf 2005). Thus air transport may be regarded as one of many factors enabling world trade systems, which in turn create a demand for air transport services. The global business and trade enterprises are distinct from, while dependent upon, air transport. Thus these systems are shown as separate from the civil aviation system (Figure 4.1): each trade system is envisaged to have a sustainable development system, including the use of air transport as an energy requirement and pollution source.

While aviation is not the only means of tourist transport, and tourism demand depends on many factors apart from air services (Caves 2003), it is true that tourism and civil aviation are highly interdependent physically and economically. However, the tourism system extends far beyond the aviation system to include non-aviation based tourism and the impacts on tourist destinations. Thus it is necessary in this thesis to draw a boundary to the information system (Avgerou, Cornford 1993) and regard tourism as a separate demand system in terms of management information (Figure 4.1).

There is ample precedent for this. The United Nations Environment Programme has a reporting initiative to gauge progress towards sustainable development (UNEP 2002), which differentiates between the tourism sector (WTTC 2002) and transport sectors – Aviation (ATAG 2002), Railways (ATAG 2002) and Road transport (IRU

2002). Separate studies are undertaken of sustainable tourism. There are dangers that these studies may be ‘place-based’, concentrating on the tourist destination (WTO 1995, WTO 2000), though there is now recognition of the need to take a holistic approach in analysing tourism systems, including all transport used (Aronsson 2000, Miller, Twining-Ward 2005, WTO 2001), and in particular air transport (Becken 2002). These approaches suggest the development of indicators, to include the tourist destination and the wider impacts of tourism transport.

It is not realistic to include, within the civil aviation information system, full data on all impacts of the associated demand systems. This approach is consistent with the development of indicators in other transportation sectors: reviews of transport sustainable development indicators suggest that the impacts of demand systems are not normally included in transportation indicator sets (Castillo 2005, Hall 2006).
Of 13 transportation indicator sets analysed by Hall (2006), 11 exclude benefits to the economy. One indicator set (Rahman, van Grol 2005) includes indirect benefits of transport (described as ‘indirect positive growth and structure effects realised by the transport sector’), though does not specifically define this as the benefits of demand systems. Thus the effects of demand systems are not included in the following analysis of civil aviation.

4.3.3.6 Industrial Performance Standards

Interfaces between human activity systems may include required performance standards (section 3.4.2). Between industrial companies, these may define standards of ethical or environmental behaviour, normally set by investors or by purchasers for their suppliers. Standards for environmental procurement may be implemented as general purchasing policies (Scottish Parliament 2002) through to formal supplier accreditation systems (Nokia 1999).

There is little evidence that purchasers of air transport services apply environmental standards or sustainability criteria when making their purchasing decisions (Caves, Gosling 1999). At the Johannesburg Earth Summit (UN 2002b), UNEP launched a reporting initiative ‘Industry as a Partner for Sustainable Development’: on the issue of emissions, the tourism sector report (WTTC 2002) presents the policy of tour operators as ‘seek the lowest seat mile cost’, suggesting that this leads to higher load factors, more fuel efficient aircraft and a reduction in emissions per passenger. Such a policy emphasises purely price (and indirectly eco-efficiency), failing to address the growing consumption of air transport. There is no clear evidence that freight customers apply environmental or sustainability criteria to air transport purchasing.

For suppliers to civil aviation, there are initiatives to improve fuel efficiency of aircraft and to reduce the environmental impact of their manufacture, maintenance and disposal (ACARE 2002) covered at section 4.4.3. Amongst major UK aviation companies, there are moves towards 'responsible procurement policies' (BA 2005) though it is acknowledged that these are early steps. There is no evidence that overall sustainability criteria are included in performance standards required of or by civil aviation.

While such standards may become powerful tools in changing supplier standards, the Rio Declaration and Agenda 21 do not specifically identify procurement standards as a means of implementation. Instead, Agenda 21 Chapter 30 strongly emphasises the need for each business and industrial sector to take responsibility for its own performance, with recognition that businesses may 'influence' suppliers.

4.3.4 Natural Systems – Oil

The systems typology diagram (Figure 4.1) identifies three major systems: Natural resources (Oil), considered in this section; Global Atmosphere, considered in Section 4.5; Waste systems considered in Airport Operation (Section 4.3.7). Protection of natural systems is covered by Principle 7 (Box 4.5).

> *Principle 7 – States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.*

Box 4.5 Rio Declaration Principle 7

Fossil fuels serve a wide range of different purposes and sectors of which aviation is one (Figure 4.5). Currently, the main aircraft propulsion fuel – kerosene or jet-fuel – is primarily derived from oil. Aviation accounts for a small percentage of total oil use, and is not of itself, responsible for depleting oil reserves: it is just one of many end users contributing to oil depletion.

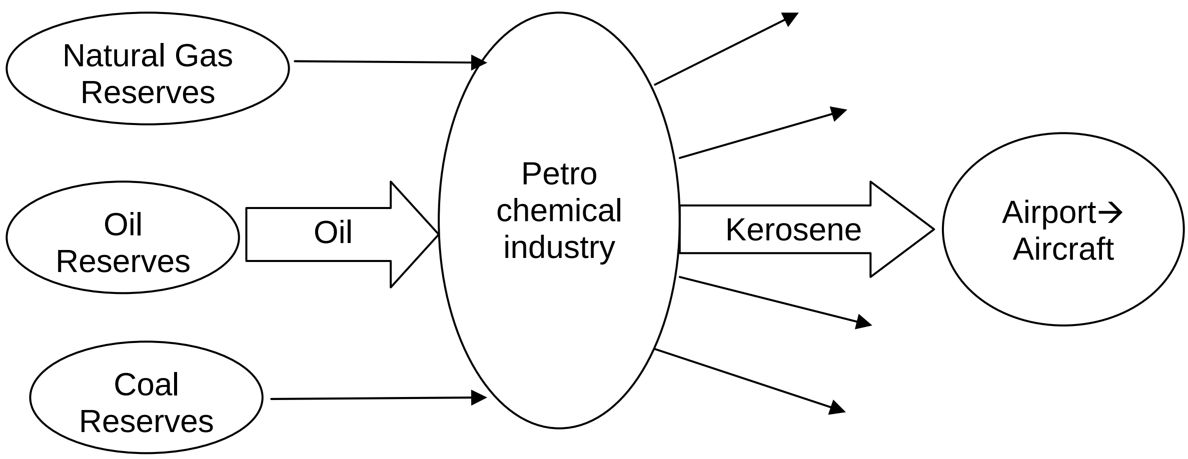


Figure 4.5 Petro-chemical System

4.3.4.1 Oil Reserves and Flow

Essentially, oil extraction is a one way interface: oil is extracted from reserves and not replaced. Any renewal of fossil fuel resources will take place over many millennia, beyond the timescales relevant to this thesis (Leggett 2005). Because of the reliance of aviation on oil supply, this issue is explored in some detail.

Global oil production has steadily increased in the latter part of the 20th century (Figure 4.6 Chart A & B), ensuring generally adequate supplies of oil and aviation fuel at moderate prices. The declared level of recoverable oil reserves has also increased steadily (Figure 4.6 Chart C), replenished by new discoveries and improved recovery techniques increasing the proportion of recoverable oil in a field.

Oil reserves are subject to some uncertainty and published figures should be treated with caution. The BP Statistical Review (BP 2006) states, in explanatory notes, that reserves figures are drawn from many disparate sources: these may not all reach the standards published by company regulators e.g. the US Securities and Exchange Commission or UK GAAP; nor do these figures necessarily represent BP's view of proved reserves by country. In 1982, the Organization of the Petroleum Exporting Countries (OPEC) allocated a production quota to each member according to proven reserves: subsequently OPEC Gulf members progressively increased their declared reserves, accounting for the steep increase in the late 1980s (Figure 4.6 Chart C). Some observers question whether these re-declarations reflect true additional reserves or the need to justify quota production levels (Leggett 2005).

The remaining production lifetime of oil reserves is generally expressed as Reserves v Production (R/P) – the ratio of current proven recoverable reserves divided by the current annual production rate – expressed in years. Globally the R/P ratio has remained slightly over 40 years since the late 1980s (Figure 4.6 Chart D) with extraction largely replaced by additional finds and improved extraction technology. There are of course inherent problems with this ratio: the reserves figures may be unreliable and the ratio cannot take into account future changes in production, new oil finds or improved extraction technologies.

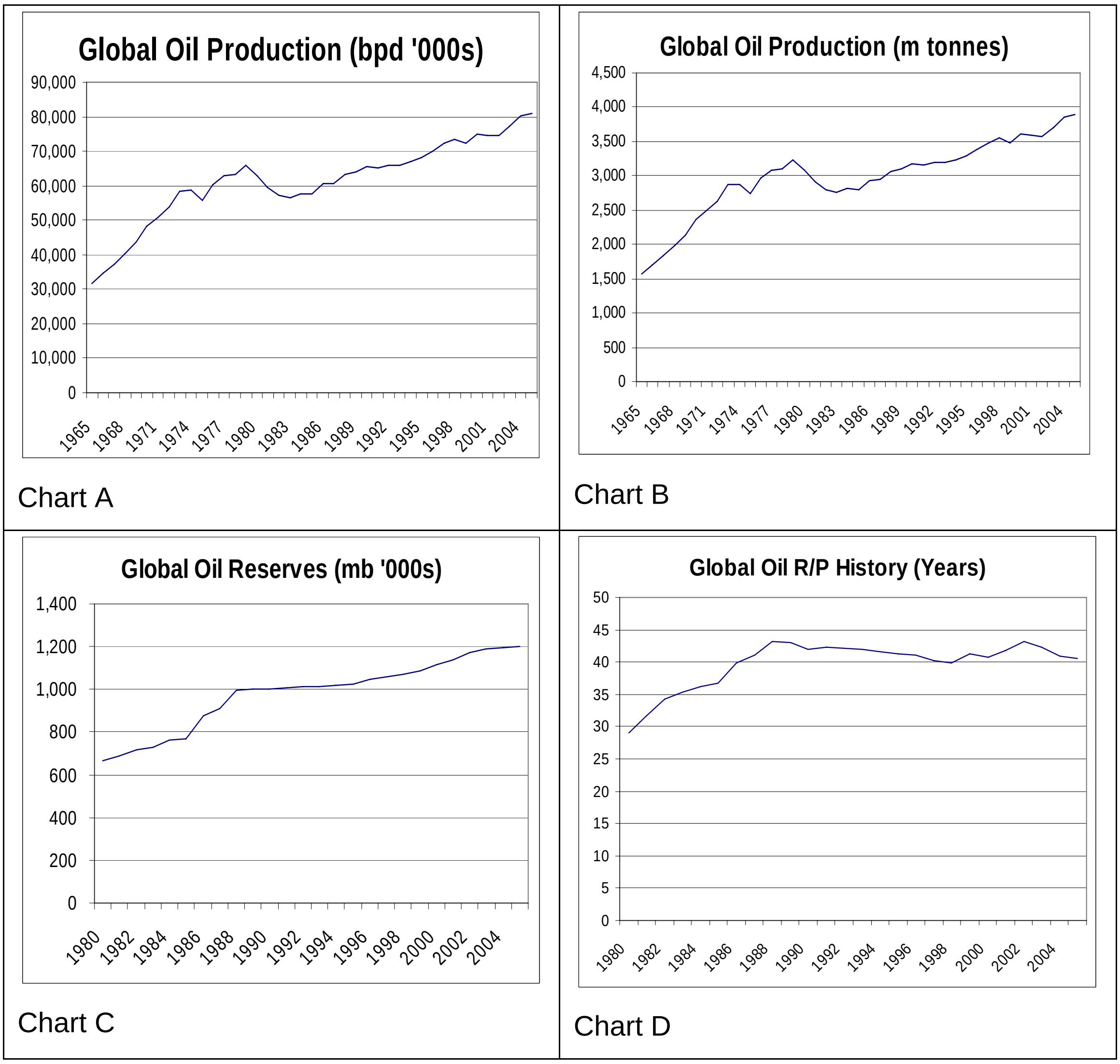


Figure 4.6 Oil Reserves and Production History

Source: BP (BP 2006) (bpd – Barrels per day, mb million barrels)

4.3.4.2 Oil Supply – Future Issues

It is not within the scope of this thesis to attempt to estimate the future pattern of oil supplies, though some consideration is helpful to highlight potential issues for civil aviation.

US Government forecasts (US DOE 2005) show global oil consumption rising steadily from 80 million barrels/day (mbpd) in 2004 to 119 mbpd in 2025, though admits to 'significant uncertainties' in this scenario: oil prices remaining in a moderate range, peaking at US$43/barrel in 2005 and falling back to US$35/barrel (2003 dollars) by 2025. By early 2006, such price scenarios look unlikely.

The peak oil theory (ASPO 2006, ODAC 2006) offers a rather different scenario. Production from an oil field typically shows a pattern of increase, peak and decline (Figure 4.7 Chart A). It was postulated (Hubbert 1956) that a similar pattern would occur for groups of oil fields, and that US oil production would peak in 1971: the peak actually occurred in 1970 (Figure 4.7 Chart B). The peak oil theory suggests global oil production will peak and decline.

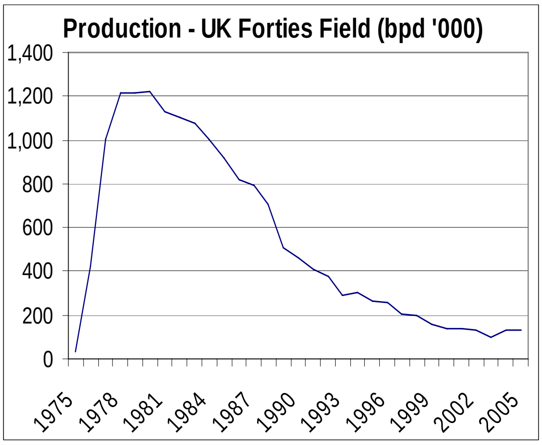


Chart A

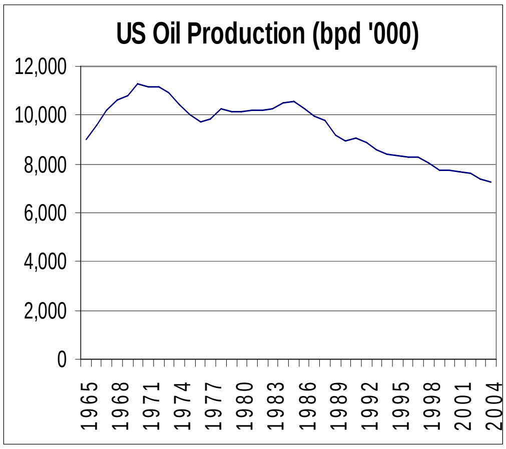


Chart B

Figure 4.7 Typical Oil Flows from Fields and Countries

Source: Chart A - DTI (DTI 2006), Chart B - BP (BP 2006)

It is argued (Campbell, Laherrere 1995, Fleay 1998) that cumulative extraction of oil has already accounted for almost half of known reserves and that total world oil production may peak early in the 21st century, declining thereafter. Campbell argues that oil production outside the Gulf of Arabia may decline sometime in the first decade of the 21st century and production from the Gulf in the second decade (Campbell, Laherrere 1998). Certainly US and UK oil production is falling (BP 2006): it is suggested that of 60 countries possessing oil, 49 have already passed their production peak (Leggett 2005).

There remains great debate on the likely date of peak oil production (Hirsch, Bezdek et al. 2006) (Table 4.7). Many of these projections are based on estimates of oil reserves: Skewbowski analyses production capacity of existing fields and known future production projects, suggesting a peak as early as 2008 (Skrewbowski 2005).

Date	Source of projection	Background
2006–2007	Bakhitari, A. M. S.	Iranian oil executive
2007-2009	Simmons, M. R.	Investment banker
After 2007	Skrebowski, C.	Petroleum journal editor
Before 2009	Deffeyes, K. S.	Oil company geologist (ret.)
Before 2010	Goodstein, D.	Vice Provost, Cal Tech
Around 2010	Campbell, C. J.	Oil company geologist (ret.)
After 2010	World Energy Council	Non-governmental org.
2010-2020	Laherrere, J.	Oil company geologist (ret.)
2016	Energy Information Agency – nominal case	US Department of Energy analysis/information
After 2020	CERA	Energy consultants
2025 or later	Shell	Major oil company
No visible peak	Lynch, M. C.	Energy economist

Table 4.7 Projections of the Peaking of World Oil Production
Source: (Hirsch, Bezdek et al. 2006)

The peak oil scenario is now increasingly considered in official planning scenarios e.g. by the US Military (Westervelt, Fournier 2005), citing significant price increases and security risks. Alternative views are that further oil reserves may be discovered, and improved extraction technologies may recover more oil (Lomborg 2001), though both are expensive, only viable with high oil prices.

Peak oil theory and the expanding supply scenario, while differing on their view of oil supplies, would both indicate a continuing elevated price for oil. In turn, the higher oil price may itself delay peak oil by depressing oil demand (Campbell, Laherrere 1998) and by stimulating oil production from more difficult sources e.g. tar sands, deep sea oil: there remains some doubt on the recoverable volumes of these alternative sources (Leggett 2005, Westervelt, Fournier 2005). Inevitably, oil is a limited resource and supplies will decline at some time in future though the timing is debated. For civil aviation this is likely to mean a continuing elevated price for oil, and at some time, a reduction in raw material availability. Although most projections place global peak oil production within the 20-25 year planning horizon of the aviation industry (Table 4.7), current aviation forecasts from government and the industry do not publicly address the peak oil scenario.

4.3.4.3 Kerosene Supply

The main aircraft propulsion fuel – kerosene or jet-fuel – is currently derived from oil (Figure 4.5). Other hydrocarbon resources are also shown, since it is possible to manufacture kerosene from natural gas by gas-to-liquid (GTL) fuel technology by the Fischer-Tropsch (F-T) synthesis process (Lee 2003) and thus from other primary fuels (coal and biomass) by the prior gasification of these fuels. There is continuing research to improve the technology e.g. in clean coal-diesel processes (Goldman, Roy et al. 2006). Such technologies are considered to have future potential (Saynor, Bauen et al. 2003) but remain expensive and are not used commercially to produce kerosene: thus aviation currently remains dependent on oil.

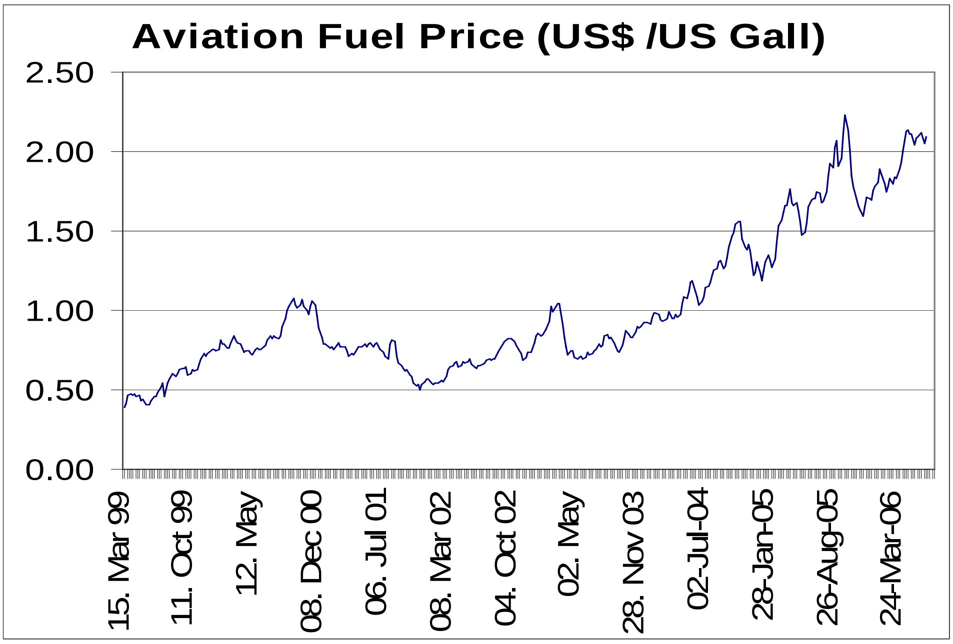


Figure 4.8 Price of Aviation Fuel

Source: Lufthansa (Lufthansa Cargo 2006)

In the past, increasing oil supplies and adequate refinery capacity have led to a period of generally cheap and plentiful kerosene. However, in the last few years prices have increased (Figure 4.8), largely due to increasing oil prices. Approximately 10% of oil may be refined to aviation fuel, though using existing plant and technology this could be increased to some 15% (Farmery 2003). Global use of aviation fuel in 2002 is estimated at 176 m tonnes, increasing in 2025 to 369 m tonnes (Eyers, Norman et al. 2004). The latter volume of aviation fuel would require some 2,500-3,600 m tonnes of oil feedstock. Oil production in 2005 was 3,895 m tonnes, suggesting little problem in physical supplies of aviation fuel. However, if the peak oil scenario proves correct, then the prospect arises that reducing physical supply of conventional oil may, at some time in future, be unable to meet projected increasing demand for aviation fuel. Further research is required on potential scenarios to explore this prospect.

The discussion above suggests a prolonged period of elevated oil prices and potentially reducing supplies. Aviation fuel prices are therefore likely to remain high with the possibility of restricted supply. Aviation is heavily dependent on plentiful and cheap supplies of oil (Wells 1999), and future projected growth of the industry may well depend on supply and price of aviation fuel (IPCC 1999). Alternatives to kerosene are discussed under Change Programmes at section 4.5.3.

4.3.4.4 Sustainable Development Issues

A number of inter-related principles are relevant to this systems boundary:

3	Intra and inter generational equity
7	Conserve ecosystems
8	Production & Consumption

Consumption patterns related to current equity are discussed in Demand systems at section 4.3.3. The consumption issue is the use of aviation fuel.

Aviation fuel derived from oil contributes to oil depletion, raising wider issues of intra and inter-generational equity. The practice of the oil industry is to work an oil field to depletion, an approach apparently not entirely consistent with Principle 7 (conserve resources) and ultimately, intergenerational equity (Principle 3). In the systems approach, it can be argued that this is an issue in the petro-chemical sustainable development system, rather than the civil aviation system. Higher oil prices in themselves may act as a rationing factor, potentially reducing supplies to poorer countries and people – thus creating intra generational inequity. This is part of a wider debate for international political systems, and is not explored further here.
Oil depletion affects civil aviation in two respects: in the short to medium term potential reduction of oil flows may increase the cost of aviation and thus limit aviation growth; in the long term depletion of oil reserves limits the timescale of current aviation technology.

ISSUE	**Principle 8**	**Use of aviation fuel**	**4.3.4**
ISSUE	**Principle 3**	**Depletion of oil reserves**	**4.3.4**

4.3.5 Natural Systems – Global atmosphere

System Interfaces

Kerosene is input to the airport(s), and thence to aircraft. The kerosene is burned by the aircraft engine and waste gases are dumped into the atmosphere, including greenhouse gases (e.g. CO_2, water vapour, methane). Many other activities emit greenhouse gases into the atmosphere, and aviation emissions currently constitute a small proportion of the total. Accumulation of greenhouse gases in the atmosphere is thought to cause an increase in ambient temperatures (global warming), in turn impacting on sea levels and natural ecosystems. The effects of different gases may be compared via the concept of radiative forcing – how much each gas contributes to heat retention (measured in watts/sq metre).

Climate Change – The Global Warming Model

The US Environmental Protection Agency offers a explanation of global warming:

> *Energy from the sun drives the earth's weather and climate, and heats the earth's surface; in turn, the earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat.*
>
> (US EPA 2000)

In pre-industrial times few greenhouse gases were released by human activity, but burning of fossil fuels in industrial, domestic and transport sectors has led to an accumulation of these gases in the global atmosphere (IPCC 2001) Table 4.8.

Greenhouse Gas	Original Concentration	Current Concentration	% Increase	Radiative Forcing (Wm^{-2})
Carbon Dioxide	280ppm	360ppm	31	1.46
Methane	700ppb	1750ppb	150	0.48
Nitrous Oxide	270ppb	310ppb	17%	0.15
Hydrocarbons				0.34

Table 4.8 Increase in Long-lived Greenhouse Gases

Source: Intergovernmental Panel on Climate Change (IPCC 2001)

ppm = parts per million; ppb = parts per billion

The science of global warming is still imprecise, but there is widespread scientific agreement of some connection between accumulation of greenhouse gases and climate change (G8 2005b, IPCC 2001, US EPA 2000). IPCC suggests that for doubled atmospheric carbon dioxide, relative to pre-industrial conditions, estimates of surface temperature warming range from 1.5 to 4.5C°. Recent work suggests that a rise of over 2C° may be regarded as 'dangerous climate change' (Schneider, Lane 2006). Potential impacts of rising temperatures range from melting of icecaps and sea level rise (Lowe, Gregory et al. 2006, Rapley 2006, US EPA 2000), sudden climate change (Challenor, Hankin et al. 2006) and eco system loss (IPCC 1997, Lanchbery 2006, van Vliet, Leemans 2006). Most potential effects of climate change are generally regarded as undesirable, though the IPCC report (IPCC 1997) does anticipate that in the shorter term, large areas of the northern hemisphere land masses in Russia, Europe and North America could become warmer and agriculturally more productive provided water supplies are maintained.

Contribution of Aircraft

What then is the aviation contribution to greenhouse gas emissions and to global warming?

Aircraft in flight produce a range of emissions: principle greenhouse gasses are carbon dioxide (CO_2) and water vapour (leading to contrails and possibly cirrus cloud formation); other major emissions are nitrous oxides (NO_x), which lead to ozone and methane, sulphur oxides (SOx), and soot (IPCC 1999). The effect of carbon dioxide from aircraft is relatively easy to estimate: the radiative forcing of carbon dioxide is scientifically well known; CO_2 emissions are a direct function of fuel burn (Lee, Raper 2003). The effects of other emissions are less easy to estimate. In 1999 IPCC estimated the radiative forcing effects of aircraft, assigning levels of scientific uncertainty to the gases (IPCC 1999) Figure 4.9. CO_2 emissions are long lived (over 100 years), and the IPCC report suggested that aviation CO_2 is well mixed in the atmosphere and indistinguishable from CO_2 emissions of other sectors. Other aircraft emissions are shorter lived and spatially concentrated around flight paths. The total effect of aviation has been taken to be a factor of 2.7 times the CO_2 effect (derived by accumulating the various radiative forcing impacts identified by IPCC - Figure 4.9). This factor is widely quoted e.g. (DfT 2003a), though with recognition from some authors of the uncertainty of the model e.g. (Bows, Upham et al. 2005).

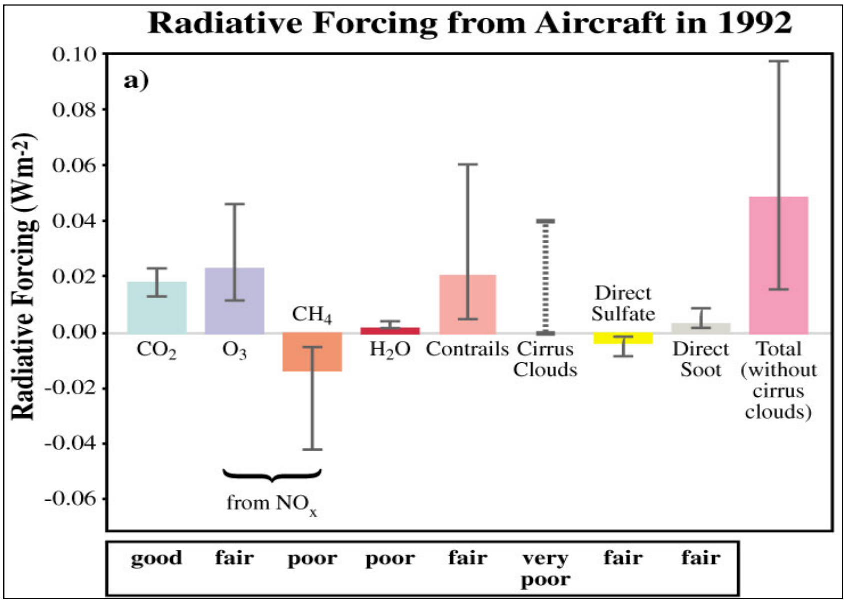


Figure 4.9 Radiative Forcing from Aircraft – 1992

Source: IPCC (IPCC 1999)

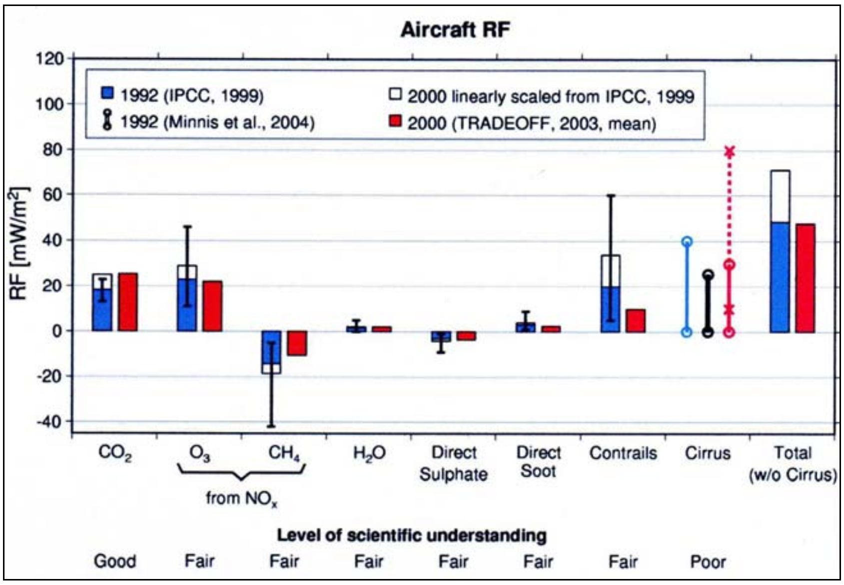


Figure 4.10 Radiative Forcing from Aircraft – 2000

Source: (Sausen, Isaksen et al. 2005)

Work continues on attempting to resolve the scientific uncertainties e.g. (Brasseur, Cox et al. 1998, Minnis, Schumann et al. 2004), much funded by the Commission of the European Union (TRADEOFF project). Resulting from this, an update of the

IPCC work has been published (Sausen, Isaksen et al. 2005) (Figure 4.10). This suggests a reduced impact from contrails and that the radiative forcing factor may be somewhat lower (approximately 1.9). Both studies omit the potential effects of aviation-formed cirrus cloud, which remains very uncertain.

UK total carbon dioxide emissions remain slightly below 600 million metric tonnes per annum (US DOE 2006), while CO_2 from aviation in UK, calculated from UK aviation fuel deliveries (DTI 2006b), shows a steady rise, reaching 6.4% of total UK CO_2 by 2004 (Figure 4.11).

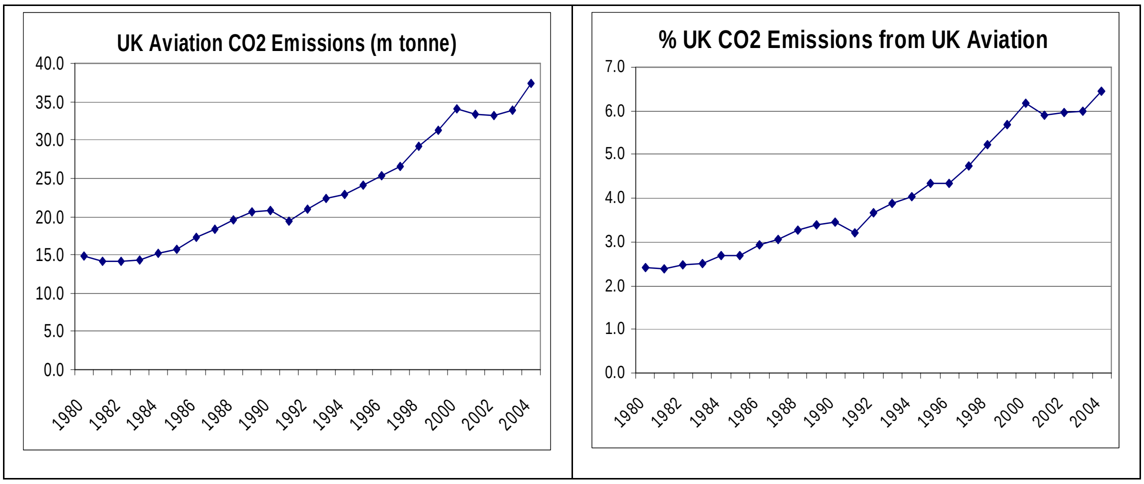


Figure 4.11 UK Carbon Dioxide Emissions – Total and Aviation

Source: UK CO_2 emissions (US DOE 2006), Aviation CO_2 from DUKES (DTI 2006b).

On a global scale, aviation fuel usage is calculated at 133 million tonnes in 1992, 176 m tonnes in 2002, and estimated to increase to 327 m tonnes by 2025: 1992 data is from the mean of 3 inventories (IPCC 1999), 2002 and 2025 data is from the AERO2K project (Eyers, Norman et al. 2004). Equivalent CO_2 emissions are 420 million tonnes in 1992, representing 2% of global anthropogenic CO_2 emissions, 553 m tonnes in 2002 (2.26% of total), and 1,029 m tonnes in 2025.

The overall radiative forcing for all human activities is estimated to be, at most, a factor of 1.5 larger than that of carbon dioxide alone (IPCC 1999). The radiative forcing factor for aviation emissions is still subject to some uncertainty. IPCC estimated the factor to be between 2 and 4 (IPCC 1999), with a figure of 2.7 being widely accepted. Recent research suggests that a factor closer to 1.9 (Sausen, Isaksen et al. 2005) may be more appropriate. Neither factor includes the potential effect of aviation induced cirrus clouds which remains very uncertain (IPCC 1999, Sausen, Isaksen et al. 2005).

IPCC suggests that aviation emissions accounted for 3.5% of total anthropogenic radiative forcing at 1992, and, for a mid range growth scenario, may grow to 5% by 2050. Aviation emissions remain a small proportion of the global total, though are rapidly growing, and have a radiative forcing impact somewhat higher than emissions from other sectors.

Sustainable Development Issues and Indicators

The relevant principle is Principle 7 Ecosystems – protection of global atmosphere.

ISSUE	**Principle 7**	**Greenhouse gas emissions from aircraft**	**4.3.5**

Gaseous emissions (NO, CO, H_2O, and CO_2) from aircraft engines may be measured under experimental conditions (Haschberger, Lindermeir 1996, Schulte, Schlager 1996) using specialised infrared spectrometers, though such techniques are not normally employed for aircraft in commercial service. Emissions may be calculated from fuel consumption or aircraft performance. Construction of an indicator is discussed at Chapter 7.

4.3.6 Physical Systems – Aircraft

The designed physical systems within the civil aviation system have been defined as aircraft (covered in this section) , airports (section 4.3.7) and available airspace (section 4.3.8) (Caves, Gosling 1999). Analysis of these should include a full lifecycle analysis of manufacture/construction, operation and disposal or reuse. There is no attempt to limit the following analyses to organisational responsibility boundaries. Aircraft in this context means commercial civil aircraft and excludes general and military aviation.

Principles 8 Consumption (Box 4.3), 7 Ecosystem (Box 4.5) and 17 Environmental Impact Assessment (Box 4.6) are relevant.

> *Principle 17 – Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.*

Box 4.6 Rio Declaration Principle 17

4.3.6.1 Aircraft Manufacture

In the systems model envisaged in this thesis, aircraft manufacturing is regarded as a separate system that would have its own sustainable development system, outside the aviation sustainable development model. Thus issues of the manufacturing system are not considered.

4.3.6.2 Aircraft Entry Into Service

Interfaces are:

- Physical – number of new aircraft delivered
- Logical – performance standards of the new aircraft i.e. fuel consumption and noise levels
- Legal – licensing of new aircraft types and individual aircraft

New aircraft delivered into service have two major effects: to increase fleet size, and thus increase total consumption; where older aircraft are replaced, to contribute to improved efficiency of the fleet, since modern aircraft are generally more fuel efficient. Fleet size is reflected in consumption levels identified as an issue in

Demand Systems (Section 4.3.3) above, so the number of new aircraft is not identified as a specific sustainable development issue.

Performance standards of the new aircraft is identified as an issue. Performance targets are discussed in Visions (section 4.4). Licensing of new aircraft types and individual aircraft fulfils both criteria for Environmental Impact Assessment stated in Principle 17 (Box 4.6).

ISSUE	**Principle 8**	**Efficiency of new aircraft**	**4.3.6**
ISSUE	**Principle 17**	**Environmental Impact Assessment - new aircraft**	**4.3.6**

4.3.6.3 Aircraft Operation

Aircraft operation is taken to mean flight, ground operations and maintenance. In many respects, the inputs and outputs of aircraft in flight are concentrated at the airport and are thus covered in airport operations.

Flight inputs:

- Aviation fuel – covered in Natural Systems Section 4.3.4 above.
- Supplies, catering etc – covered in Airport site operation Section 4.3.7.

Flight outputs:

- Greenhouse gas emissions – covered in Global Atmosphere Section 4.3.5.
- Waste produced at airport – covered in Airport site operation Section 4.3.7.
- Noise – covered in Those Affected Section 4.3.11.

Flight efficiency – overall efficiency of the aircraft fleet – is identified as a consumption issue. The overall efficiency of the fleet is affected by the addition of new, more efficient aircraft and the removal of older, less efficient aircraft.

ISSUE	**Principle 8**	**Efficiency of aircraft fleet**	**4.3.6**

Ground operations – covered in Airport site operations at Section 4.3.7 and Those Affected at Section 4.3.11.

Maintenance – covered in Airport site operations Section 4.3.7.

4.3.6.4 Aircraft Disposal

Retirement. Aircraft which are taken out of service are predominantly older and less efficient aircraft, tending to increase the overall fleet efficiency (IATA 2004b). An interesting illustration is the reaction of the US airlines in 2001 following the events of 9/11. Airlines in the US were faced with falling revenue, and the need to reduce capacity, so a large number of older aircraft were withdrawn from service. It has been suggested (Burleson 2003) that this retirement process had a significant (if temporary) effect on the overall efficiency of the US fleet. The overall efficiency of the fleet is taken to be the sustainable development issue at section 4.3.6.3, rather than the numbers of aircraft retired.

Disposal. Increasingly, components in airframes and aircraft engines are manufactured using carbon fibre, and complex advanced materials. The Boeing 787 will use up to 60% composite materials while the Airbus 350 will use 39% composites and an additional 21% 'advanced materials' (aluminium lithium) (Kingsley-Jones, Norris 2006). There is little public reference to disposal options for these materials in the publications of major manufacturers and regulators i.e. Airbus, Boeing, Rolls Royce, US Federal Aviation Authority, UK Civil Aviation Authority. Metallic components can be recycled, and it may be possible to break down the composites into their constituents, but essentially many of the advanced materials are extremely durable, will not decompose and cannot be recycled. The materials are however, inert, and those in use at present are not thought to generate any toxic or hazardous residue. There is no requirement from the certification authorities for any disposal plan for new aircraft, though it is thought that some component manufacturers are considering ISO 14001 certification which may require documentation of the full product lifecycle, including disposal (Arrowsmith 2006).

Forecasts for total civil aircraft retirements over 20 years vary: 7,200 (Boeing 2005) or 6,400 (Airbus 2005). The average weight may not exceed 300 tons, and the proportion of non-reclaimable material is lower in older aircraft, perhaps 10-20%. Thus total un-recyclable waste is unlikely to exceed 20,000 tons pa. As the proportion of advanced materials used in aircraft (Vermeeren 2002) and engines increases (Rolls Royce 1996), then this is likely to become an increasing problem.

ISSUE	**Principle 7**	**Aircraft disposal**	**4.3.6**

4.3.7 Physical Systems – Airports

A UK airport is defined for planning purposes by Planning Policy Guidance 13 (PPG13) (ODPM 2003b) as the operational site delimited by the perimeter fence, and various installations outside the airport perimeter such as off-site warehouses, offices, car parks, which exist wholly to serve the air transport business. For the purposes of this thesis, the PPG13 definition is used and the term 'airport' includes the airport main site plus remote car parks, offices, warehousing etc.

4.3.7.1 Airport Construction

Airport construction removes land from the original use and value, and creates hard surfaces (runways, aprons, taxiways, roads and car parks) and buildings. Construction will normally be phased: a first construction phase to establish initial infrastructure, followed by progressive expansion of infrastructure as demand grows. In the systems model envisaged in this thesis, the actual process of airport construction is regarded as part of civil engineering and would be subject to a civil engineering sustainable development system (ICE 2002, Venables 2002). Thus the construction process and use of materials is not considered here.

Relevant principle: 17 – Environmental Impact Assessment (Box 4.6 above). Airport construction destroys the existing use of the land, its use as a habitat and any historic legacy. Airport construction and subsequent development falls with the criteria of Principle 17 – Use of Environmental Impact Assessment.

ISSUE	**Principle 17**	**Loss of land, habitat and heritage**	**4.3.7**
ISSUE	**Principle 17**	**Use of EIA – airport infrastructure**	**4.3.7**

4.3.7.2 Airport Operations

Airport operations are taken to include (Figure 4.12):

- Ground access to and from the airport site
- Operations on the airport site(s)
- Aircraft flight operation

The actual airport site operation may, in many respects, be regarded as any other industrial site, though with a different mix of processes. The product is the service provided by the airborne operation rather than a physical product. In sustainability terms, it has a range of material and energy inputs, carries out processes and has a range of waste outputs. Other industrial sectors interface with civil aviation and have responsibility for certain sustainable development issues:

- Performance of buildings – civil engineering (ICE 2002, Venables 2002)
- Ground vehicle performance – motor manufacturing (SMMT 2000)
- Energy generation, retail goods, food supplies

These issues are not considered as part of the civil aviation system.

Principles 7 – Ecosystems, and 8 – Consumption, are relevant.

Airport Ground Access. Airport ground access includes movement of passengers, employees, freight, supplies and waste. The means of ground access may be road or rail transport or a combination.

Sustainable development issues relating to provision and operation of surface transport are the concern of surface transportation systems, and therefore outside the remit of civil aviation. The boundary of the two systems is taken to be the volume of surface traffic generated by an airport: the specific issue is emission of greenhouse gases from the use of fossil fuel which may be calculated from journey intensity (number and length) and vehicle performance.

Journey intensity is the product of the number of vehicle movements and length of journey generated by the airport i.e. how many vehicles travel how far. The number of vehicles arriving at an airport boundary has been proposed as an indicator (Upham, Mills 2005), though the definition of airport boundary is left unclear. In this context, airport boundary includes the airport site and remote car parks, offices and warehouses as defined in PPG13 (ODPM 2003b).

It is not valid to include vehicle performance as a sustainability issue for civil aviation: this is more properly included as part of the automotive industry sustainable development system (ACEA 2002, SMMT 2000).

ISSUE	**Principle 7**	**Emissions from surface transport**	**4.3.7**

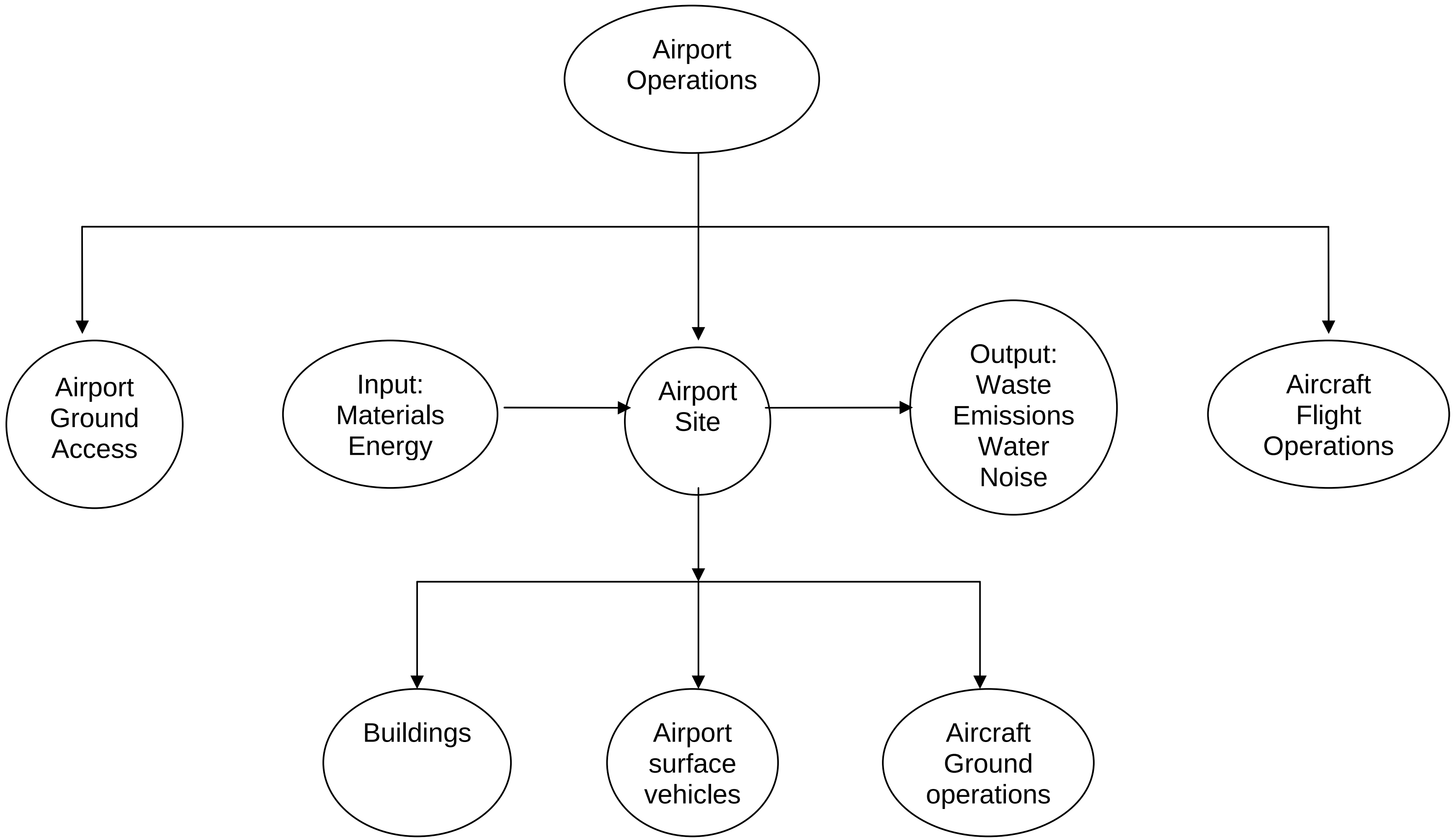


Figure 4.12 Airport Operations

Airport Site Operations

The airport site may be considered as an industrial site carrying out a varied set of processes. These include movement of passengers and cargo, catering, retail, engineering activities, fuel storage and management. Each of these processes needs energy and materials input and each may generate waste output. The schematic (Figure 4.12) shows the airport site as three systems: buildings and equipment, ground vehicles and aircraft ground operations. The latter includes all aircraft handling, maintenance and fuelling, but taxiing to and from a flight is taken to be part of the flight operations. These three ground systems are not analysed individually, but taken together to assess the major resource and waste streams.

Resource use

The airport is not a manufacturing site and there is no large scale material input to the ground operation. Catering and retail operations use materials, and these should be included in the appropriate sector sustainable development system. The major resource input to the airport site is kerosene fuel, to be loaded into aircraft (included at section 4.3.4). Additionally, there will be input of motor fuel (petrol and diesel) for the ground vehicles and possibly some fuel (oil, gas or solid) for onsite boilers and equipment and electrical energy.

Energy use

The airport uses energy in many ways, major users being the airport buildings (terminals, warehouses, hangars) and airport surface vehicles. It is not valid to count sustainability issues concerned with the construction and energy efficiency of buildings on airport sites within the scope of the civil aviation sustainability system. These issues are more properly considered within the scope of a Civil Engineering sustainability system (ICE 2002, Venables 2002). The actual energy used to operate a building on an airport is an issue for the operation of civil aviation. All energy used by the airport should be included, whether directly through on-site boiler houses or indirectly through electricity consumption.

Airport surface vehicles include all vehicles used within the site, and between sites e.g. for shuttle buses from remote car parks. The issue here is the general contribution to greenhouse gas emissions from fossil fuel use and the local issue of a concentration of air pollutants.

Gaseous emissions – covered at Those Affected – Section 4.3.11.

Waste Output – Solid Waste

An airport generates waste material from the airline, retail and general operations. There may be certain specific issues because of the nature of civil aviation e.g. it may be necessary to incinerate or send to controlled sites 'international' food waste, and there may be issues of security in transferring some waste from airside to landside (Graham 2001). Normally local or national legislation regulates the safe disposal of waste (Graham 2001, Wells 1999). In the UK waste strategy is implemented through the Environmental Protection Act (UK Government 1990b) and the Environment Act (UK Government 1995a), which enable the UK Waste Strategy and the setting of recycling and reuse targets for domestic waste while industrial waste is controlled primarily by economic pressures (Land Fill Tax). The aircraft and vehicle related engineering activities involve a series of potentially hazardous materials and processes (Wells 1999). These are managed in accordance with national health and safety and environmental legislation.

Waste Water

Water runoff occurs from the hard surfaces in an airport and may be contaminated by chemicals from de-icing, maintenance, washing aircraft and vehicles, and from fuel spillage. In the UK an airport (like any other industrial site) is subject to water quality legislation, and will need to take appropriate measures to reduce and trap any spillage. Balancing reservoirs are needed to prevent rapid runoff into local streams and possible flooding. In the UK the quality of water discharged to a water course is regulated by the Environment Agency under the Water Act 1989 (UK Government 1989) and Environmental Protection Act 1990 (UK Government 1990b). Under this legislation the Environment Agency defines legally binding discharge consents for maximum concentrations of a range of pollutants from each water discharge point.

Issues

ISSUE	**Principle 7**	**Airport site GHG Emissions**	**4.3.7**
ISSUE	**Principle 7**	**Airport site Waste**	**4.3.7**
ISSUE	**Principle 7**	**Airport site Waste Water**	**4.3.7**
ISSUE	**Principle 8**	**Airport site Resources**	**4.3.7**

4.3.7.3 Airport Land Re-use

Land re-use is not specifically covered by any principles of the Rio Declaration.

4.3.8 Physical Systems – Airspace

Principles 8 – Consumption, and 17 – Environmental impact assessment, are relevant.

Airspace as a designed system consists of permits for use, and designed rules for operation: these two aspects are examined below. The only physically built components are navigation aids and air traffic control centres; both are relatively small in their impact and are not considered here. National Governments have sovereignty over their own airspace (ICAO 1944), and thus the authority to control commercial air transport. Permits to operate international flights have normally been agreed between two countries by bilateral agreements specifying the allowed number, destinations and operators of commercial flights. Bilateral agreements are being replaced by ‘open skies’ agreements whereby any airline operator from consenting countries can operate any routes in the agreed area: the European Community has already established an open skies agreement (EU 1992) and negotiations between the US and EU are in progress (at 2006). Neither bilateral nor open sky agreements are subject to formal environmental impact assessment.

Management of the airspace is intended to provide safe and efficient passage of aircraft between airports. At least within Europe, the management of airspace is recognised as being insufficiently integrated and somewhat inefficient (EU 2001). It has been suggested that the inefficiencies in operating procedures and air traffic control are worth up to 6% of fuel burn (Wiltshire 2003), though the EU research targets suggest that savings of 10% in fuel burn can be achieved (ACARE 2002). Eurocontrol acknowledges inefficiencies in fuel use attributable to air traffic management of over 10% (Chesneau, Fuller 2002, Chesneau, Fuller et al. 2003). It is desirable to reduce inefficiencies and delays in the air traffic management system and thus reduce unnecessary fuel burn. However, there is a view that increases in air traffic management efficiency may translate to better service, lower prices and thus higher demand, potentially increasing fuel burn (Pastowski 2003). The overall sustainable development issue remains the total volume of fuel burned for whatever reason. Efficiency of airspace is considered to be highly significant and thus is identified as an issue.

ISSUE	**Principle 8**	**Efficiency of Air Traffic Management**	**4.3.8**
ISSUE	**Principle 17**	**Use of EIA for route agreements**	**4.3.8**

4.3.9 Operators

The term operator means ‘the operators of the system’s components’ (Caves, Gosling 1999) i.e. the operators of the airports, aircraft and airspace. This is taken to mean airlines and airport companies and employees. The analysis is concerned primarily with those sustainability issues which are specific to civil aviation. Issues such as employment conditions are general to all types of industry within a particular country and these are not analysed. Indicators for issues common to all industrial sectors can be derived from the general texts (Azapagic, Perdan 2000, GRI 2002).

4.3.9.1 Licensing

In the UK, airport and airline companies are required by the Civil Aviation Act 1992 (UK Government 1982) to hold an operating licence. Such licences fulfil the criteria for an EIA according to Principle 17 (Box 4.6).

ISSUE	**Principle 17**	**Use of EIA for airport/airline licences**	**4.3.9**

4.3.9.2 Airport Employment and Poverty Reduction

Airports are a major employer, generating a chain of economic activity through the local economy. Following a methodology advocated by the Federal Aviation Administration (FAA) (Butler, Kiernan 1986), it is suggested that the effects on the economy can be calculated from the value of direct impacts (on airport site), indirect impacts (off airport site) and induced impacts (the expenditure chain through the local economy). The relevant impacts are mostly in job creation, and the spending derived from these salary earners. There is some debate about the multiplier between direct effects and indirect/induced effects (Caves, Gosling 1999, Graham 2001). A factor of 2.1 has been used to calculate indirect/induced employment from direct employment (AOA 2005, OEF 1999), though this factor is challenged as being unrealistically high and leading to double counting of employment benefits if applied to all industries (FOE 2006).

Principle 5 of the Rio Declaration (Box 4.7) concerns the eradication of poverty, primarily concerned with poverty in the developing world, but applicable to poverty in the developed world. Thus the relevance of economic benefits may be the degree to which these benefits contribute to eradicating poverty.

Principle 5 – All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Box 4.7 Rio Declaration Principle 5

In the UK, the relationship between civil aviation and poverty was explored in a Government consultation (DfT 2002), which included questions on deprivation and social exclusion and how the benefits of airport expansion could be spread to the economically less successful areas. The resulting Government White Paper (DfT 2003b) did not make any positive proposals to spread the benefits to, or monitor the effect on, deprived areas or the poorer sections of UK society.

ISSUE	**Principle 5**	Airport employment	4.3.9
ISSUE	**Principle 5**	Contribution to poverty reduction	4.3.9

4.3.9.3 Integration

Principle 4 – In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Box 4.8 Rio Declaration Principle 4

The Integration principle (Box 4.8) is rather complex and is discussed in more detail at Section 4.3.12 Regulatory System: this section makes general comment on potential commercial views. A commercial operator of an airport, airline or supporting company makes development decisions driven primarily by the possibility of commercial profitability. Environmental protection will be incorporated into the commercial decision making process by two factors, legal constraints and costs incurred. Most companies wish to operate within legal constraints, and will thus work within any environmental protection limits imposed by law, even when this incurs extra costs. In the lack of legal constraints, most companies will, by choice, take the least cost approach: if environmental protection incurs extra costs, then such measures may be reduced; if a cost is incurred by environmental pollution, then pollution will tend to be reduced.

The integration principle requires that environmental protection be integrated with the development process. At a commercial and industrial level, this depends upon a legal system to set appropriate environmental limits, and economic incentives to encourage environmental protection, and set high prices on polluting activities. The necessary legal and fiscal frameworks within which companies operate, are Government responsibilities. The integration principle is discussed in more detail at Section 4.3.12 Regulatory System.

4.3.9.4 Social Effects

The relevant principles include Principle 1 - Human rights, 8 – Quality of life, 10 – Participation. Research by the Global Reporting Initiative (GRI 2002) suggests an extensive range of issues covering Labour Practices and Decent Work, Human Rights, Society, Product Responsibility. These are phrased by the GRI in terms of good corporate governance rather than sustainable development principles. Thus an Advertising issue is concerned with adherence to advertising codes of practice rather than giving environmental product information. Other similar general lists are suggested (Azapagic, Perdan 2000).

Some aspects of corporate governance and labour practices may be regarded as relevant to sustainable development, but are general issues across all industries, not specific to aviation. In the systems view adopted in this thesis, there needs to be a matrix of sustainable development models (Section 3.4.5), with an appropriate model covering corporate governance and employment practices. Thus only those aspects specific to civil aviation are covered here.

Employee health and safety. For all employees at an airport, there are a number of potential risks e.g. air pollution, vehicles and mechanical tools, and noise. These may be regarded as general issues in an industrial work environment and in the UK are covered by health and safety at work legislation. Accidents to workers on airport sites, which result in injury or fatality, are recorded by the UK Civil Aviation Authority (CAA 2002). It is not suggested that additional indicators be designed in this area.

There may be additional risks for airline aircrew arising from the time they spend at high altitudes and their exposure to cosmic radiation (Hume, Watson 2003), and some studies suggest an increased risks of certain types of cancer. Research combining the results of six previous studies which had observed a total of 13,971 aircrew, suggests evidence of increased incidence of brain and prostate cancer for male pilots, and increased incidence of melanomas and breast cancer in female flight attendants (Ballard, Lagorio et al. 2000). Elevated mortality rates were detected from melanomas and brain cancer among male crew. A study of Swedish male civil and military pilots (Hammar, Linnersjö et al. 2002) suggested that, compared with the general Swedish population, aircrew had similar overall cancer rates, though a significantly elevated incidence of malignant melanomas and other skin cancers.

ISSUE	**Principle 1**	**Aircrew health (cancer risk)**	**4.3.9**

Society. Community issues are covered in Those Affected (Section 4.3.11).

Product Responsibility. Customer Health and Safety is covered in Users (Section 4.3.10 below). Principle 10 – Participation requires that information on the environmental effects should be made available to the public. It may thus be argued that product labelling and advertising should include information relating to the sustainability of the product. In the case of civil aviation, this would include information on the environmental impacts of air transport.

ISSUE	**Principle 10**	**Environmental Product Information**	**4.3.9**

4.3.10 Users

Users may be interpreted to mean the consumer (passenger) or the representatives of the systems which generate demand for air transport services e.g. tourism, just-in-time delivery systems. In this context the former is assumed i.e. the consumer or passenger. The latter are considered in Demand systems at Section 4.3.3.

Passenger Health

For passengers, air transport does present a number of potential health risks previously documented (Hume, Watson 2003). These include potential risk of deep vein thrombosis, jet lag, infection through cabin air.

Passenger Safety

The safety of air transport is of paramount concern to the regulators and operators of civil aviation as well as to the passengers. Responsibility for the safe development of civil air transport was originally accorded to ICAO in the Chicago Convention (ICAO 1944). ICAO executes this responsibility through a series of safety recommendations and regulations (ICAO 2006b), which are translated by member states into national statutes, regulations and licensing provisions, and enforced by appropriate national regulators e.g. in the UK, the Civil Aviation Act (UK Government 1982) and the Civil Aviation Authority (CAA). All airlines and airports in UK are licensed by the safety regulator. Accident and fatality statistics are maintained by the national aviation authorities (CAA 2002). For the UK airlines, accident and fatality rates for civil transport operations in the UK show a generally reducing trend during the last 10 years (ONS 2005) Table 15.27.

Where accident statistics do highlight a poor safety record, then specific initiatives may take place e.g. Nigeria suffered a number of accidents in 2005 resulting in initiatives, including the ICAO Universal Safety Oversight Audit Programme and the IATA ‘Focus on Africa’ programme (Learmont 2006). In many respects the civil aviation safety system may be regarded as an example of a ‘self regulating sustainability system’ envisaged in Agenda 21. Safety standards are institutionalised into legislation and operational procedures; costs are fully internalised; safety and reliability standards are fully embedded into the supply chain. Accidents are fully investigated and remedial action may be incorporated into the appropriate level of procedure. Accident statistics contribute to this self regulating system. Despite the good and improving safety record, safety remains a sustainability issue.

Spread of Diseases

The danger of disease spread by civil air transport was recognised in the Chicago Convention (ICAO 1944) article 14 – Spread of Communicable Diseases. For previously well diagnosed diseases, with known treatment regimes, this has not proved a great threat. However, the potential for a disease which is both infectious and not previously known is demonstrated by the outbreak of severe acute respiratory syndrome (SARS) in 2002/3. This was a previously unrecognised disease that was spread by air travel:

> *Though much about the disease remains poorly understood and frankly puzzling, SARS has shown a clear capacity to travel along the routes of international air travel.*
> *SARS demonstrates dramatically the global havoc that can be wreaked by a newly emerging infectious disease.*
>
> (WHO 2003) *p2*

Long distance movement of infectious diseases is not a new phenomenon, and in the past many diseases have spread around the world by surface transport. But there is perhaps a new dimension, in that a newly emerged infectious disease can now be transmitted extremely rapidly by air transport on an international and potentially global basis. This is a risk which is not confined to the air passenger, but spreads to the whole community, and is actively monitored by international aviation organisations (IATA 2006).

ISSUE	**Principle 1**	**Passenger Health**	**4.3.10**
ISSUE	**Principle 1**	**Passenger Safety**	**4.3.10**
ISSUE	**Principle 1**	**Spread of Infectious Diseases**	**4.3.10**

4.3.11 Those Affected

The term 'Those Affected by the system' is taken to mean the local community around an airport. There are a number of relevant principles and effects.

Principle	Issue
1 – Human Rights – Health	Noise, Air Quality, Accident risk
8 – Quality of Life	Traffic Congestion
10 – Participation	Participation in decision making
13 – Compensation	Victims of environmental damage

4.3.11.1 Local Community – Noise

Aircraft noise is frequently discussed as an environmental issue (Caves, Gosling 1999, Graham 2001, de Neufville, Odoni 2003), though noise is a transient phenomenon, without lasting effect on natural ecosystems. In sustainable development terms, noise is included in the social dimension and identified as a human health issue in Agenda 21 Chapter 6.

Potential adverse impacts of noise in the community are recognised as interference with communications, hearing impairment, sleep disturbance, cardiovascular and psychophysiological effects, performance effects including children's reading ability and memory, reduced productivity and annoyance responses (Berglund, Lindvall 1995). Berglund suggests that vulnerable groups – people with particular diseases or medical problems (e.g. high blood pressure), people in hospitals or in rehabilitation, people dealing with complex cognitive tasks, the blind, people with hearing impairment, babies and young children and elderly in general – may be more sensitive to the impact of community noise.

Noise from aircraft ground manoeuvring and testing, and from landing and takeoff, represents a particular issue concentrated on communities close to the airport, while aircraft in flight cause widespread increases in noise, affecting previously tranquil country areas (CPRE, SERA 2003). Manufacturers and operators point out that modern aircraft are much quieter, suggesting a 75% reduction in noise over the last 30 years (Beesley 2003), based on comparing, under certification conditions, noise from a new aircraft of 30 years ago with an equivalent new aircraft today. At many airports, although there has been a significant increase in the number of aircraft movements, ‘average’ noise levels have fallen due to reduced use of older very noisy aircraft.

There is increasing evidence that community exposure to aircraft noise may be associated with health problems: at Amsterdam Schiphol airport, poor general health status, use of medication for sleep and cardiovascular diseases (Franssen, van Wiechen et al. 2004); at Stockholm Arlanda, the possibility of a hypertension risk factor, particularly amongst the elderly (Rosenlund, Berglind et al. 2001); reports from Bourgas (Turnovska, Staykova et al. 2004) of a range of diseases, included diseases of the nervous system and of the sense organs, mental disorders, cardiovascular diseases, particularly arterial hypertension, and diseases of the digestive system. Associations between aircraft noise and raised blood pressure in children have been detected (Morrell, Taylor et al. 1997), though not confirmed by later research (van Kempen, Van Kamp et al. 2006), and are reported in the population aged over 40 (Matsui, Uehara et al. 2001).

Exposure to aircraft noise is considered to be associated with a range of cognitive problems in children: reduced reading ability (Clark, Martin et al. 2006, Haines, Stansfeld et al. 2001, Hygge, Evan et al. 1996, Hygge, Högskolan 2000, WHO 2004), though one study around Heathrow suggests that the association of aircraft noise with poor reading and mathematical ability may not be statistically significant after adjustment for the socioeconomic status of the school intake (Haines, Stansfeld et al. 2002); impaired memory (Hygge, Evan et al. 1996, Matsui, Stansfeld et al. 2004, WHO 2004); increased annoyance (Haines, Stansfeld et al. 2001) and a detrimental effect on academic performance (Shield, Dockrell et al. 2005). There are suggestions that an increase in aircraft noise may be associated with up to 6 months impairment of reading age (WHO 2004).

While there is recognition that aircraft noise may have heightened effects on certain vulnerable groups (Berglund, Lindvall 1995, Hume, Watson 2003, Morrell, Taylor et al. 1997), there appears to be little research directed at these groups, except for studies into children’s learning ability.

Aircraft noise at night causes great public concern and considerable debate on the relationships between aircraft noise and disturbance (Diamond, Stephenson et al. 2000, Flindell, Bullmore et al. 2000, Porter, Kershaw et al. 2000). Early studies, while showing relationship between aircraft noise and sleep difficulties, had difficulty in establishing objectively measured causal relationships between noise levels and 'awakenings' (CAA 1980, Ollerhead 1992), results described as 'counter intuitive' (Flindell, Bullmore et al. 2000). A UK Government review of noise research in UK and abroad acknowledges that perceived disturbance and annoyance may be difficult to objectively measure (Porter, Kershaw et al. 2000), and a methodological trial confirms this difficulty (Flindell, Bullmore et al. 2000). However, a social study reports that '30-60% of respondents perceived their health to be somewhat affected by aircraft noise' at sites around six UK airports (Heathrow, Manchester, Gatwick, East Midlands, Coventry, Stansted) (Diamond, Stephenson et al. 2000).

It is now recognised that aircraft noise may prevent sleep onset at the beginning of the night, or delay return to sleep after awakening during the night or in the early morning (Hume, Van et al. 2003), and later studies examine sleep arousals and sleep stage changes as well as awakenings, associating these minor sleep disturbances with health issues (Basner, Samel et al. 2006, Raschke 2004).

The growth of the integrated freight services, predicated on a network of night flights, causes particular problems at their hub airports (Gillingwater, Humphreys et al. 2003). Increasingly in Europe, such airports attempt to mitigate the night noise problem with community sound insulation schemes based on night noise levels (Leipzig Airport 2006, NEMA 2006), though the geographic extent of these schemes tends to fall short of community expectations: the scheme proposed for Leipzig Halle airport has been subject to an unsuccessful legal challenge (Basner, Samel et al. 2006), and the area of the scheme at Nottingham East Midlands Airport was considered unacceptable by the Airport Consultative Committee (NEMA 2005).

Large numbers of people are currently affected by aircraft noise and these numbers are projected to increase at many airports in the UK and Europe over the next 30 years (Johnson 2003b, Whitelegg, Cambridge 2004). Undeniably, the noise from aircraft does cause annoyance to the local community (Diamond, Stephenson et al. 2000) and consequent opposition to expansion of airport operations, a long standing reaction recognised as early as the 1920's (Thomas 2002) which led to an exemption of civil aviation noise from nuisance law, still in force in the UK (UK Government 1982). Local and national political pressure has resulted in noise controls at some airports: Thomas (2002) records that two thirds of European airports have operations constrained by noise related issues and that this may increase to 80% over the next 10 years. Somewhat earlier, in a survey by Airports Council International, 77% of airports in Europe reported some form of operational restriction due to aircraft noise (ACI Europe 1995).

The evidence above confirms that, in sustainable development terms, aircraft noise represents a health issue in the community. The UK Legislative Framework is covered at 4.3.12 and noise targets at section 4.4.4 (Visions).

ISSUE	**Principle 1**	**Aircraft Noise**	4.3.11

4.3.11.2 Local Air Quality

Air pollutants from airports originate from a range of activities associated with aircraft operations – ground testing and manoeuvres, landing and takeoff, surface transport to the airport, ground traffic within the airport, and airport operations including boiler plants, fire exercises, paint and repair shops etc. Emissions include nitrous oxides, carbon monoxide, sulphur dioxide, ozone, particulates, and a range of non-methane volatile organic compounds (NMVOC) – a collective term for organic atmospheric compounds including chemicals such as benzene, polyaromatic hydrocarbons, kerosene, diesel fuel, and de-icing compounds such as ethylene glycol (Hume, Watson 2003). Ambient air quality standards for the protection of human health are specified in UK and EU regulations: levels of sulphur dioxide, nitrous oxides and particulates are subject to mandatory EU directive with exceedance tolerances progressively reducing from 2001 to 2010 (EU 1999).

Air quality is routinely measured at UK airports, and most achieve the required standards (Birmingham Airport 2005, Manchester Airport 2004), though there is a particular problem at London Heathrow. Within the Borough of Hillingdon, in which Heathrow is situated, approximately 60% of nitrogen oxide (NOx) emissions emanate from the airport, and there are regular exceedances of air quality standards around the airport due in part to emissions from aircraft on the ground or in the air (LB Hillingdon 2004, LB Hounslow 2005).

There exist well co-ordinated air quality plans, both London-wide and for individual Boroughs, calling for actions at Heathrow to minimise emissions from surface transport, onsite activities (vehicles, heat and power supplies), and from aircraft by encouraging the adoption of the newest, cleanest aircraft designs, minimising emissions during taxiing and idling, and using taxation to encourage further reductions (GLA 2002). In general these policies are reflected by the airport operator (BAA) in the Interim Heathrow Master Plan (BAA 2005b), with some change of emphasis: there is reference to introduction of an emissions element to airport charges, though no support for the stronger taxation proposals suggested by the Mayor of London (GLA 2002) and no suggestion of changing taxiing procedures.

The proposed Heathrow third runway is contingent on air quality improvement, but, even using an optimistic emissions reduction scenario, the model used by BAA suggests that the third runway would lead to nitrogen dioxide exposure to the population above the EU Directive limits (LB Hounslow 2005). While there are existing regulations, air quality at airports remains an issue.

ISSUE	**Principle 1**	**Local Air Quality**	**4.3.11**

4.3.11.3 Third Party Risk

A third party accident is defined by the UK Civil Aviation Authority as:

> *An accident which involves injury to third parties only, such as people on the ground, in another aircraft or vehicle.*
>
> (CAA 2002) *Chapter 18 page 3*

The CAA statistics for third party risk detail accidents arising from all types of aviation – from emergency and recreational aviation, from civil aviation to staff and passengers within the airport boundaries, and the general community. The latter includes accidents involving aircraft, parts of aircraft and ice falling to the ground. The accident rates in all these areas are low.

One issue which does cause concern to communities close to airports, not covered in the CAA statistics, is the incidence of wake vortex strike. Vortex strike can be noisy and frightening and is known to dislodge roof tiles. It is likely that most commercial airports in the UK repair such damage without debate e.g. London Heathrow and Manchester airports state this on their public websites: other UK airports seem rather more reticent in offering any publicity for the issue and for their repair service. There are no publicly available statistics on the incidence of wake vortex strikes: indeed, it is probable that airports do not actually have any good idea of the frequency since only those instances which cause recognisable and immediately obvious damage are likely to be reported to the airport. Dislodged roof tiles become dangerous projectiles, and could cause serious injury. However, there is no instance recorded in the CAA safety statistics of injury actually occurring from this cause in the UK in the last ten years (CAA 2002).

Third party risk around airports is currently calculated primarily from the risk of an aircraft accident, and public safety zones have been defined for the highest risk areas at the ends of runways. Research related to community accident risk continues (Hale 2002, Kirkland, Caves et al. 2004).

ISSUE	**Principle 1**	**Community Accident Risk**	**4.3.11**

4.3.11.4 Community Participation

The UN view of public participation, embodied in Rio Principle 10 and Agenda 21, and re-iterated at the Johannesburg Earth Summit (UN 2002b), includes 'the need of individuals, groups and organizations …. to participate in decisions, particularly those which potentially affect the communities in which they live and work' (UN 1999a). The level of power which citizens may exercise has long been debated: a scale of participation, the Ladder of Citizen Participation (Arnstein 1969), has been proposed, but there are views that participation techniques may be used for political purposes 'to give the illusion of citizen power while actually serving the interests of policy makers' (Amy 1987).

A framework for participation – Community Based Environmental Protection (CBEP) which set as a core principle collaborative working amongst a full range of stakeholders (US EPA 1999), has formed the basis of numerous projects. A range of practical problems are reported with CBEP projects: enabling community action, equitable participation, community delivery, and a deliberative planning process (Lane, McDonald 2005). More significantly, many reports of participative environmental projects examine the process, and remain silent on the environmental outcomes: little evidence is presented that environmental protection is actually improved, except where the community has recourse to legal remedies via byelaws (Meyer, Konisky 2005).

Within the UK, major airports are required under the Civil Aviation Act 1982 section 35 (UK Government 1982), to provide consultation facilities which include representatives of the local community. Government guidelines suggest that airport consultative committees are an opportunity for exchange of information but specifically state that they are not a dispute resolution forum, and have no executive or decision-making powers (DfT 2003c). Thus the airport community is denied any participation in the decision making process, though has a right to be informed: there is evidence to suggest that groups representing airport communities in the UK are dissatisfied with this level of consultation (Grimley 2001).

The evidence suggests that there remain difficulties with the practical application of community participation in environmental decision making. Nevertheless, this is fundamental part of Rio Principles and is identified as an issue.

ISSUE	**Principle 10**	**Community Participation**	**4.3.11**

4.3.11.5 Compensation

Principle 13 of the Rio Declaration requires that States develop national law regarding liability and compensation for the victims of pollution and other environmental damage. In the case of airports, the communities potentially suffer from noise and degradation of air quality, as noted above. In the United Kingdom, there is no legal basis for these communities to be compensated for the damage. The UK Civil Aviation Act at section 76 specifically exempts the civil aviation business from liability for noise nuisance.

ISSUE	**Principle 13**	**Compensation**	**4.3.11**

4.3.12 Regulatory System

4.3.12.1 Regulatory Overview

Regulation of civil aviation is a highly complex set of systems, illustrated in a very simplified schematic at Figure 4.13.

Rules for the conduct of civil aviation are derived from multiple sources: ICAO defines international agreements and standards; the European Union implements directives; bilateral agreements may be negotiated by two states; national government enacts primary legislation. Currently, international agreements and European directives become legally effective when they are embodied into national law – in the UK either directly by Act of Parliament or by a legal instrument, order or direction, itself given legal status by overarching clauses in a relevant Act. Thus the national legal system is shown in the system diagram (Figure 4.13) to give legal force to the various sources of regulation.

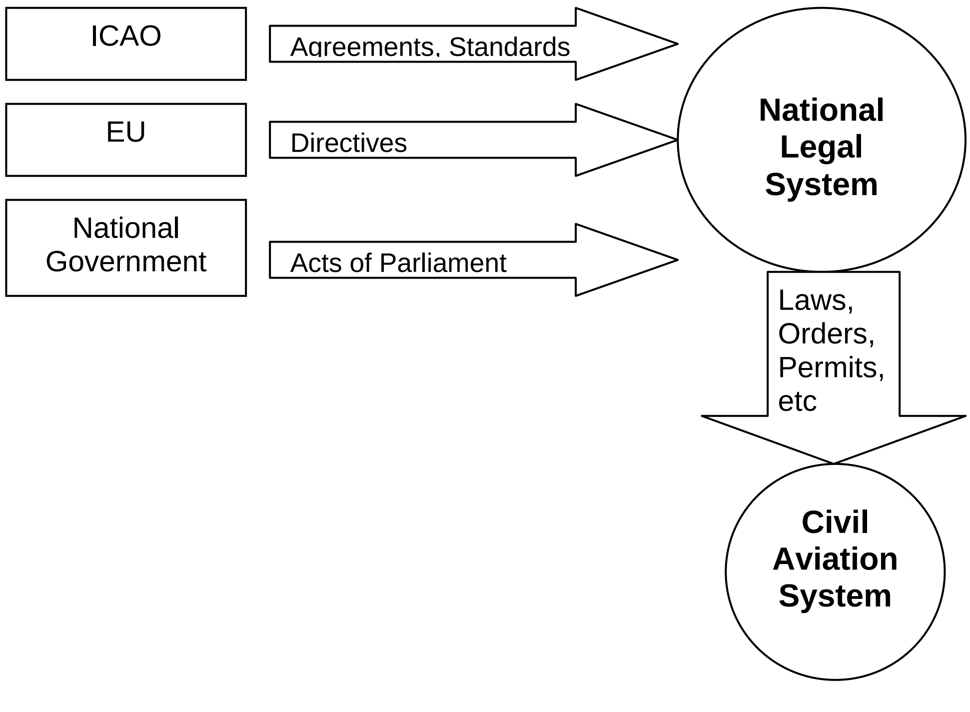


Figure 4.13 UK Aviation Regulation

Source: Author

4.3.12.2 Regulatory Authorities

A range of major sustainable development issues is identified in the sections above. For each general issue, the regulatory authority and enforcement authority are identified (Table 4.9). The regulatory authority is taken to be the organisation which has a remit and authority to make regulations. The enforcement authority is the organisation with the legal power to enforce regulations.

Topic	**Regulatory Authority**	**Enforcement authority in UK**
Aviation safety	ICAO	National Government, Department for Transport, Civil Aviation Authority
Airspace	EU/ UK Government	NATS
Resource use (aviation fuel)	None identified	None
GHG Emissions	National Government Note 1	DEFRA?
Air Quality	EU	Local Authority
Water Quality	UK Government	Environment Agency
Aircraft Noise New aircraft	ICAO	Certification authority e.g. EASA in Europe
Aircraft Noise Total	National Government Note 2	Department for Transport, Civil Aviation Authority, Local Planning Authority, Airport
Airport Waste	National Government	Local Authority
Aircraft disposal	None identified	None

Table 4.9 UK Civil Aviation Regulatory Authorities
Source: Author

Note 1. National Government may be responsible for national GHG. The only initiative which may apply to aviation is the EU Emissions Trading Scheme.
Note 2. The responsibility for total levels of aircraft noise is complex. ICAO and National Governments both have a responsibility, but have not set any quantifiable overall limits. Health and environment agencies (WHO and in the UK DEFRA) have

an interest, but no direct authority to set regulations. The enforcement authority In the UK may be DfT and CAA for airports designated under section 76 of the Civil Aviation Act 1982, and local authorities for airports subject to local agreements. The Civil Aviation Bill (UK Government 2005) envisages that airports will become the enforcement authority. The above analysis indicates very different regulatory systems for different aspects of sustainable development.

4.3.12.3 Relevant Principles

The boundary between civil aviation and the regulatory system is defined by extant national legislation, and how these laws relate to the relevant sustainable development principles (Box 4.9): Principles 4 – Integration, 11 – Effective Environmental Legislation, 13 – Compensation, 17 – Environmental Impact Assessment, 27 – International law in the field of sustainable development.

Principle 4 – In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.
Principle 11 – States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and development context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.
Principle 13 – States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.
Principle 17 – Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.
Principle 27 – States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

Box 4.9 Rio Declaration Principles Relevant to Regulation

4.3.12.4 Principle 4 – Integration

Principle 4 – The Principle of Integration (of environmental protection and the development process) is extremely important and far reaching; it is explored in this section, for reference by other sections (Operators 4.3.9, Planning System 4.3.12).

To understand the full implications, and thus assess the current situation, it is helpful to explore the potential implementation options, expanded in Agenda 21 Chapter 8 (see also Section 4.5.5). The principle suggests that integration should apply at all levels and influence all groups in society, Government, industry and individuals. At the Government policy making level, the objective is to integrate environmental protection into the national legal and fiscal framework. The expectation is that, given appropriate legal constraints and fiscal incentives, environmental protection will be integrated into the decision making processes of industry as suppliers of goods and services, and individuals as consumers.

To achieve integration at Government policy level, Agenda 21 suggests that it is necessary to review the current national policies, and strengthen institutional structures, inferring the need to change Governmental processes or responsibilities.. This raises difficult questions for National Government. There are arguments that the integration process should be embodied in law (VanderZwagg 1995). This legalization may take the form of 'external integration' whereby national plans, policies and budgets are assessed for integration of economic and environmental concerns, or 'internal integration' involving structural re-organisation in departmental responsibilities to overcome fragmentation. The latter (change to departmental responsibilities) does not appear to be favoured by UK Government. As early as July 1988, in comments endorsed by the then Prime Minister, Margaret Thatcher, the UK Government seemed minded not to make any structural changes:

> *All interested departments are involved in the decision-making process through inter-departmental consultations and discussions in cabinet. Accordingly we are not convinced of the need for changes to the machinery of the UK Government.*
>
> (DoE 1988)

Responsibilities affecting UK aviation remain split over several Government Departments (Figure 4.14). This schematic is not intended to make any inference on the effectiveness of inter-departmental discussions at civil servant or Ministerial level:

a study of such discussions could be a thesis in its own right. The figure is intended only to illustrate the existing separation of UK Government departmental interests.

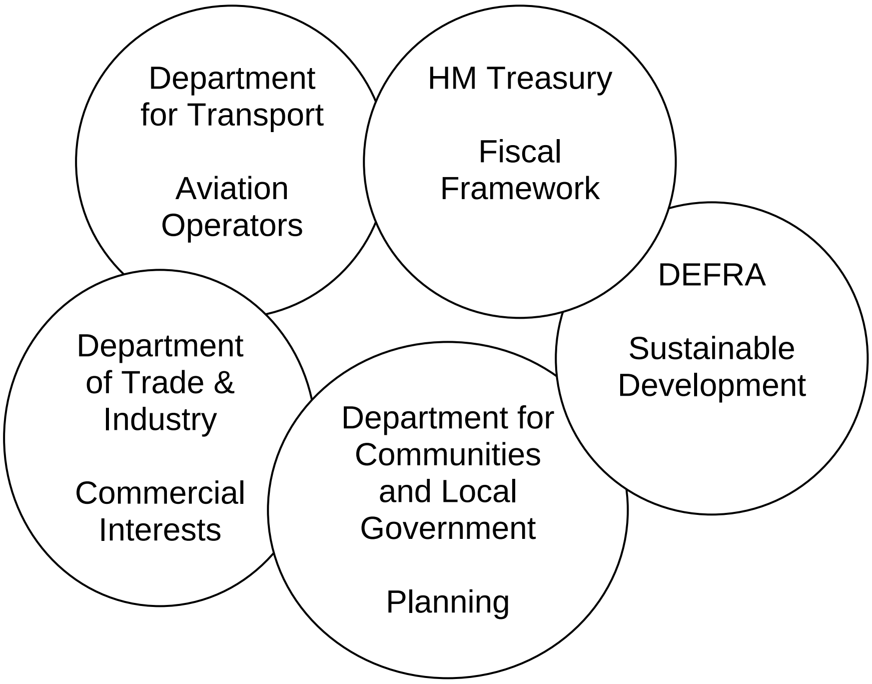


Figure 4.14 UK Government Departmental Responsibilities

Source: Author

The level to which Integration is embodied in the legal framework is debatable. The major extant Act relating to aviation (the Civil Aviation Act 1982 (UK Government 1982) predates Rio and sustainable development concerns and does not have any recognition of integration.

The UK Transport Act 2000 appears to be drafted in contradiction of integration. At section 1, the Act lays a general duty on the Secretary of State (SoS):

> *(a) to further the interests of operators and owners of aircraft, owners and managers of aerodromes, persons traveling (sic) in aircraft and persons with rights in property carried in them;*
>
> (UK Government 2000) *Section1 (2)(a)*

The Act places no corresponding duty on the SoS for environmental issues, merely offering discretionary powers at section 39 of the Act. Thus it may be argued that at the highest Government level, there is actually a separation of development and environment in the policy making for civil aviation, a separation embedded in the legal duties of the SoS.

In 2002, the UK Department for Transport was able to produce a document on airport expansion (DfT 2002) which clearly, and it would appear consciously, separated the options for expansion of airports and the environmental impacts of the expansion. The document suggested a series of new runways without proposing commensurate environmental control or mitigation measures. Consultees were asked whether they considered such measures are needed, clearly separating environmental protection and development.

4.3.12.5 Principle 11 – Effective environmental legislation

The sections above identify a number of environmental issues relevant to aviation (Table 4.8), which may be the subject of legislation. General legislation covers environmental standards for Air quality (EU Directive 1999/30/EC (EU 1999)), Airport waste and runoff water quality (UK Environmental Protection Act (UK Government 1990b).

Legislation on aircraft noise is complex and incomplete. Noise from civil aviation is exempted from nuisance law by the Civil Aviation Act 1982 (UK Government 1982). This principle dates from section 9 of the Air Navigation Act 1920 (UK Government 1920), apparently to protect a small growing industry. The Environmental Protection Act 1990 s.79 (6) specifically excludes noise from aircraft (other than model aircraft) from powers to control environmental noise nuisance.

There is no overall legislation in the UK to regulate aircraft noise or emissions, though the Secretary of State does have discretionary powers to limit aircraft movements at a particular airport (Designation of an Airport under section 78 of the Civil Aviation Act 1982) or to apply environmental directions under Section 39 of the Transport Act 2000. The former power (designation) has been used only for the London Airports (Heathrow, Gatwick and Stansted): there is no evidence that the latter power has been used. The Civil Aviation Bill 2005 (UK Government 2005) will give airports discretionary powers to set up ‘noise control schemes’, but defines no obligation to do so, nor standards to be achieved. This appears to embody in law an essentially self–regulatory regime.

Communities around airports have a right to consultation (UK Government 1982), but the consultation guidelines exclude any decision making role for the community on environmental issues (DfT 2003c). There are no provisions in UK Law for compensation to people suffering from airport noise and pollution.

4.3.12.6 Principles 13, 17, 27

Principle 13 – Compensation

There is no effective legislation in the UK to compensate for air and noise pollution from airports.

Principle 17 – Environmental Impact Assessment

This is covered in the relevant sections above and summarised at Table 4.9.

Principle 27 – International Law

International law affecting civil aviation is framed by the 1944 Convention on Civil Aviation (ICAO 1944) known as the Chicago Convention, and the annexes thereto. This convention set out the principles which States should apply in the governance of civil aviation, and created the International Civil Aviation Organization (ICAO) with the remit of developing and applying the convention principles. The convention can be changed by a Resolution of the ICAO Assembly. Contracting States, by ratification of the convention, are committed to applying the principles of the convention into national law, by legal statute, national licensing systems or regulations.

The Chicago Convention predates the UN principles on sustainable development (Rio 1992) and there is no specific reference to sustainable development in the convention or annexes. The convention has not been updated or amended to reflect sustainable development principles.

Safety of civil aviation is extensively covered by international agreements and national law and may be regarded as a sustainable development issue.
At an international level ICAO has not formally adopted the Rio Principles, nor defined its own role in implementing Agenda 21. In Europe, the EU has placed the essential tenets of sustainable development at the centre of the transport policy discussions, but legal instruments to incorporate the principles have not yet been developed.

The process of incorporating sustainable development principles and actions into legal instruments must be regarded as, at best, at an early stage. There is no existing legislation applying to the civil aviation industry, nationally or internationally, which incorporates or recognises the principles of sustainable development. The

Bruntland Commission recognised difficulties in the legal structure supporting sustainable development:

> *National and international law has traditionally lagged behind events. Today legal regimes are rapidly being outdistanced by the accelerating pace and expanding impacts on the environmental base of development. Human laws must be reformulated to keep human activities in harmony with unchanging and universal laws of nature.*
>
> (WCED 1987)

There have been calls to overcome the slowness of international law development through a revamped international Law Commission (Allott 1988) and for a new UN environment organisation with law making powers along with strong monitoring and enforcement powers (Palmer 1992).

4.3.12.7 Summary of UK Regulatory Framework

In the United Kingdom, the extant legal instruments pertaining to civil aviation do not incorporate any sustainable development principles, nor any specific requirements to apply environmental considerations. The United Kingdom regulator, the Civil Aviation Authority, has powers under the UK Transport Act 2000 to apply environmental objectives as directed by the Secretary of State: the SoS has provided procedural guidance (DTLR 2002) rather than environmental directives or targets.

The range of sustainable development issues relevant to civil aviation, and which may be subject to legislation, are summarised in Tables 4.10 and 4.11, showing the status and source of UK legislation. Safety is institutionalised, water quality and air quality have mandatory limits. Other sustainable development issues are currently omitted from UK Law or have the benefit of only partial coverage.

ISSUE	**Principle 4**	**Integration**	**4.3.12**
ISSUE	**Principle 11**	**Effective Environmental Legislation**	**4.3.12**
ISSUE	**Principle 13**	**Compensation**	**4.3.12**
ISSUE	**Principle 17**	**Environmental Impact Assessment**	**4.3.12**
ISSUE	**Principle 27**	**International Law**	**4.3.12**

UK Environmental Legislation		
Topic	**Legislation/ Regulation**	**Comment**
Aviation fuel use	None	
GHG Emissions from Aircraft, Airport, Surface Transport	None	
Air Quality – EU	EU Directive 1999/30/EC	Mandatory limits
Air Quality – UK	Transport Act 2000 S39	Discretionary powers
Water quality	Water Act 1998 S107-110, Environmental Protection Act 1990 S145	Mandatory limits
Airport Waste	Planning regulations	
Aircraft Noise (UK Legislation)	Civil Aviation Act 1982 S76	Exemption from nuisance law
	Environmental Protection Act 1990 S79	Exemption
	Civil Aviation Act 1982 S78	Discretionary powers
	Transport Act 2000 S39	Discretionary powers
	Town & Country Planning Act 1990 S106	Voluntary
	Civil Aviation Bill (2005)	Voluntary
Aircraft Noise (EU)	EU Directive 2002/49/EC	Measurement
National Noise Criteria	None	
Aircraft Disposal	None	

UK Scope of Environmental Impact Assessment		
Type of Development	**EIA**	**Legislation**
New Airfield	Yes	EU Directive 97/11/EC (EU 1997)
For airports with runway over 2100m – runway or runway extension.	Yes	
Intermodal transport terminal (airport passenger/freight terminal)	Yes	
Other airport infrastructure developments	No	
New aircraft type	No	
Airspace route permits	No	
Airspace changes	No	
Airport & Airline licensing	No	Civil Aviation Act 1982

Table 4.10 UK Legislation – Environmental Issues & EIA

Source: Author

Topic	Legislation/ Regulation	Comment
Policy Integration	Transport Act 2000 S1	Separation
Participation	Civil Aviation Act 1982 S35	Exclusion
Product Information	None	
Compensation	None	
Safety	ICAO SARPS & Civil Aviation Act 1982	Institutionalised
International Programme	None identified	

Table 4.11 UK Legislation – Other Sustainable Development Issues

Source: Author

4.3.13 Planning System

4.3.13.1 Introduction

This section considers the interface between airports and the planning system. Relevant Rio Principles are 4 – Integration and 17 – Environmental Impact Assessment. The Planning System is taken to be the set of processes which must be followed in the UK to obtain permission for any development. The planning system applies to all types of infrastructure and building, and in principle, all changes are subject to planning permission (UK Government 1990a). Clearly, a literal application of this principle would create an unmanageable workload for planning departments. A wide range of developments are defined as permitted developments under the General Permitted Development Order (GPDO) (UK Government 1995b), and thus exempted from planning permission. For airports, the GPDO allows without the need for planning permission:

> *The carrying out on operational land by a relevant airport operator or its agent of development (including the erection or alteration of an operational building) in connection with the provision of services and facilities at a relevant airport.*
>
> (UK Government 1995b) *Part 18*

The GPDO goes on to define as 'not permitted' (i.e. requiring planning permission):

- construction or extension of a runway
- passenger terminal exceeding 500 sq metres or 15% of existing floor space
- buildings other than operational buildings

With these exceptions all operational developments within an airport are permitted without planning permission: hangars, freight sheds, taxiways, aircraft stands and car parks.

4.3.13.2 Integration

Within the UK, different government departments have responsibility for economic development, aviation, sustainable development and planning (Figure 4.14).

'Regional Sustainable Development Frameworks' (RSDF) are proposed as a key regional implementation process for the national sustainable development strategies – A Better Quality of Life (DEFRA 1999) (para 7.81). These non-statutory documents are intended to identify regional needs and priorities and set regional visions of sustainable development.

The 'Guidance on Preparing Regional Sustainable Development Frameworks' (DETR 2000) suggests setting regional sustainable development visions, objectives, indicators and targets, and emphasises the need for regular monitoring and review. It is not entirely clear how sustainable development visions and objectives pertaining to civil aviation can be set at a regional level. The UK Planning and Compulsory Purchase Act 2004 (UK Government 2004) placed a statutory duty on regional planning bodies to produce the Regional Spatial Strategy Document (RSS) to reflect Government policies on the use of land within the region. These RSS documents are subject to a sustainability appraisal according to guidance produced in 2005 (ODPM 2005) – Sustainability Appraisal of Regional Spatial Strategies and Local Development Documents: Guidance for Regional Planning Bodies and Local Planning Authorities. Advice on identifying sustainability issues is unspecific and not related to Rio Principles or Agenda 21. The guidance document advises that sustainability objectives should be taken from relevant policies and plans, which in the case of aviation is defined as the Aviation White Paper (AWP) (DfT 2003b).

The AWP, discussed in more detail below (4.4.1 Vision Analysis), essentially sets a vision of growth and development, with little integration of environmental protection, and no environmental objectives, except where required by existing UK or EU law. So, the mechanisms for regional sustainable development appear to be in place through the various regional planning documents (RSDF, RSS) and the requirement to carry out a sustainable development appraisal (ODPM 2005). However, for civil aviation, the basic policy document fails to provide visions supportive of sustainable development, and the process does not seem to allow alternative external visions to be introduced.

4.3.13.3 Environmental Impact assessment

The use of Environmental Impact Assessment (EIA) is discussed in the previous sections and summarised at Table 4.10.

The requirements for an EIA for an infrastructure project in UK are specified by EU directives 85/337/EEC of 27 June 1985 (EU 1985) amended by directive 97/11/EC of 3 March 1997 (EU 1997). The 1985 directive omitted provisions for the use of EIA in forward planning and policy making, and is described as 'a first meagre step' (Wathern 1988). The directive did include categories of projects for which EIA is mandatory, amended by the 1997 directive.

With respect to civil aviation, the amended directive requires a mandatory EIA for a new airfield, for transport 'intermodal terminals' (it is not clear whether this includes freight terminals), and, for an airport with a runway over 2,100 metres, for runway construction or extension.

Within the UK, airports are required to seek planning permission from the relevant local authority for runway construction/extension and for passenger terminals exceeding 500 sq metres or 15% of existing floor space: other operational developments within the airport, e.g. taxiways, apron extensions, smaller terminal extensions, fuel farms, are exempted from planning permission by virtue of falling within the general permitted development order (UK Government 1995b).

Thus, local planning authorities can require an EIA only for runway construction or extension and for major expansions of passenger terminal capacity. In practice, it is possible that progressive developments can take place at an airport giving a cumulative increase in capacity, and thus increasing impact on local and global environment, without the benefit of an EIA. Within EU or UK law, there does not appear to be any process for undertaking an EIA on cumulative effects of multiple small developments.

Principle 17 calls for EIA for 'proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority'. Within EU and UK law, the EIA is required only for certain airport infrastructure projects, and not at all for forward planning and policy making. Thus Principle 17 is only partially applied to civil aviation infrastructure.

The EIA guidelines (ODPM 2003a) provide a comprehensive catalogue of environmental issues to be included in the EIA. Broadly, these include the impacts arising from the project construction, the operation of the facility and where appropriate, decommissioning.

There are suggestions that the EIA process cannot, at the local level, be an effective tool for assessing sustainable development (George 1999), without suitable criteria. The suggested criteria (intra-generational equity at various spatial levels, intra-generational equity, biodiversity and climate change) (George 2001), may themselves prove somewhat elusive for practical assessment by a local authority planning department. In the Rio principles, the EIA is seen as a tool for assessing environmental impact rather than the means of assessing overall adherence to the wider sustainable development principles.

ISSUE	**Principle 4**	**Integration**	**4.3.13**
ISSUE	**Principle 17**	**Environmental Impact Assessment**	**4.3.13**

4.3.14 Potential Sustainable Development Issues

Issues from the above analysis are summarised by sustainable development principle (Table 4.12). Multiple occurrences are consolidated, the source is referenced, and implementation issues are shown separately.

Principle	Issue	Source
Principle 1 – Human rights and health	Aircrew health (cancer risk)	4.3.9
	Passenger Health	4.3.10
	Passenger safety	4.3.10
	Spread of infectious diseases	4.3.10
	Aircraft noise	4.3.11
	Local air quality	4.3.11
	Community accident risk	4.3.11
Principle 3 – Equity	Regional Equity	4.3.3
	Depletion of oil reserves	4.3.4
Principle 5 – Poverty	Airport employment	4.3.9
	Contribution to poverty reduction	4.3.9
Principle 7 – Eco systems	Sustainability of aviation	4.3.3
	Greenhouse gas emissions from aircraft	4.3.5
	Aircraft disposal	4.3.6
	GHG emissions from surface transport	4.3.7
	GHG emissions from airport site	4.3.7
	Airport site Waste	4.3.7
	Airport site Waste Water	4.3.7
Principle 8 - Consumption	Volume of air transport	4.3.3
	Unsustainable consumption pattern (energy ratio)	4.3.3
	Use of aviation fuel	4.3.4
	Efficiency of new aircraft	4.3.6
	Efficiency of aircraft fleet	4.3.6
	Airport site Resources	4.3.7
Principle 17 – EIA	Loss of land, habitat and heritage	4.3.7

Principle	Implementation Issue	Section
Principle 4 – Integration	Integration of environmental protection and development	4.3.12/ 13
Principle 8 - Consumption	Efficiency of Air Traffic Management	4.3.8
Principle 10 - Participation	Environmental Product Information	4.3.9
	Community Participation	4.3.11
Principle 11	Effective Environmental Legislation	4.3.12
Principle 13	Compensation	4.3.11/12
Principle 17 EIA	Use of Environmental Impact Assessment	4.3.6/7/8/9 4.3.12/13
Principle 27	International Law	4.3.12

Table 4.12 Potential Sustainable Development Issues

4.4 *A Vision Analysis*

4.4.1 Approach

The previous section (4.3 System Description) identified a list of potential issues for sustainable development in civil aviation. The system model (Box 3.1) identifies the need for visions to set the frame of reference within which changes may take place (Hardi, Zdan 1997). This section explores the literature for existing visions of aviation relevant to sustainable development (Box 3.1, Item 2). There is no intention here of attempting to set visions or goals for the industry.

Sustainable Development Model – Components
2 - Vision and Goals • Vision – desired position • Goal – for specific issue to define the vision • Targets

Box 4.10 Vision and Goals from Box 3.1

A 'vision' may include any sustainability issues relevant to civil aviation, and may be influenced by any of the Rio Principles relevant to aviation (Table 4.2). Two overriding principles are relevant to vision setting – the Polluter Pays Principle and the Precautionary Principle.

Principle 15. In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
Principle 16. National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Box 4.11 Rio Declaration Principles 15 and 16

The following represents the closest approximation to a vision statement from the various industry organisations and governments. Where the organisation is recorded as having no vision statement this means that none has been identified by the literature search.

4.4.2 Government and Industry

United Nations

There is no specific mention of aviation in the Rio Declaration, Agenda 21 (UN 1992a) or the UN core set of indicators (UN 2001). The World Summit on Sustainable Development, Johannesburg 2002 identified the aviation sector as a partner for sustainable development (UNEP 2002), covered in the ATAG section below. Apart from this, no specific aviation related visions or targets are identified.

Group of Eight (G8)

G8 consists of seven of the world's leading industrialized nations (Canada, France, Germany, Italy, Japan, the United Kingdom, the United States) and Russia. At the Gleneagles summit in 2005, the G8 committed to support operational improvements, and research into climate science and aviation technology (G8 2005a). There are no specific goals or targets.

European Union (EU)

The EU has outlined an overall vision of reducing the climate change impact of aviation (EU 2005) and has adopted the goal of including aviation in the European emissions trading scheme. Other economic instruments have been considered e.g. an aviation fuel tax (EU 2001) but have so far not been adopted as goals. There are general commitments to improving operational methods and efficiency.

United Kingdom Government

UK Government projects significant increases in UK air transport:

> *Passengers - from 180 million per annum (mppa) in 2000 to 500 mppa in 2030.*
> *Air freight - from 2.3 million tonnes (mt) in 2000 to 13.6 mt in 2030.*
>
> (DfT 2002) *p30/99*

These projections are based on a continued decrease in the real price of air transport services of 1% pa. Thus the overall vision appears to be reducing real cost and increasing volume.

UK Government statements support the Polluter Pays Principle, the internalisation of external environmental costs (DEFRA 1999) section 6.72, (DfT 2002): to date there is no evidence of legal or economic instruments to apply the principle.

The Aviation White Paper (AWP) (DfT 2003b) must be taken as the formal statement of the UK Government vision for aviation. The AWP is based on the projected growth above and supports expansion at many UK airports: environmental protection is not integrated with this development except where constrained by existing UK or EU law; there are assumptions of improved eco-efficiency (ACARE targets section 4.4.3 below); apart from these efficiency targets, the AWP does not set any environmental vision. There are no proposals to internalise the external environmental costs of aviation. Essentially, the AWP sets growth targets without integrating environmental protection.

International Civil Aviation Organization (ICAO)

ICAO policy on sustainable development is formalised in Assembly Resolution 33–7:

> *To achieve maximum compatibility between the safe and orderly development of civil aviation and the quality of the environment.*
>
> (ICAO 2001) *Appendix A*

Resolution 33-7 covers a range of issues including the environmental impact of aviation on the atmosphere, though on this issue ICAO does not take a proactive stance. ICAO thanks the Intergovernmental Panel on Climate Change (IPCC) for their report (IPCC 2001), urges member states to promote atmospheric research,

> *Invites Contracting States and international organizations to keep ICAO informed of developments in this field.*
>
> (ICAO 2001) *Appendix H*

In the past, ICAO has been generally opposed to environmental taxes (ICAO 1995b), a view basically unchanged. However, ICAO has since endorsed the concept of an international open emissions trading scheme (ICAO 2004).

There are no published environmental targets or limits.

Air Transport Action Group (ATAG)

As part of the contributions to the World Summit on Sustainable Development in Johannesburg in 2002, the United Nations Environment Programme (UNEP) facilitated a series of reports ‘Industry as a Partner for Sustainable Development’.

The Air Transport Action Group (ATAG) prepared the aviation sector report for UNEP. The ATAG sustainable aviation policy is:

> *ATAG plans to contribute to the debate by ….. defining ATAG stakeholders' common interests in order to promote a common vision on sustainable aviation, on the understanding that detailed strategies will be produced by individual players.*
>
> (ATAG 2002)

ATAG forecasts increases in passenger kilometres of 250% by 2030, and 460% by 2050, compared to 2000 (ATAG 2002).

International Air Transport Association (IATA)

IATA defines the organisation's role as:

> *- Develops and promotes industry strategies for improving the environmental performance of air transport whilst enhancing its role in the sustainable development of society.*
>
> *- Works to promote global solutions to environmental concerns whilst protecting the interests of its Member airlines.*
>
> *- Assesses the potential impact of regulatory measures on the industry, formulates strategies and co-ordinates lobbying efforts.*
>
> (IATA 2003)

No specific visions or targets for sustainable aviation are recorded by IATA.

Eurocontrol

Eurocontrol defines:

> *The overall objective of the air transport industry is to meet market demand for air traffic services without sacrificing present and future social and ecological value.*
>
> (Knudsen 2004)

This definition would seem to be directly at odds with the principles of sustainable development, which envisage societal and industrial changes to reduce unsustainable consumption patterns (Rio Declaration Principle 8), rather than expanding capacity to meet demand. Eurocontrol vision is of increased volume of air transport, based on forecasts of ICAO, IATA, Airbus and Boeing, a rate of efficiency improvements slower than growth, and thus an overall increased environmental impact (Knudsen 2004). No targets are offered other than growth forecasts.

4.4.3 Technical Efficiency Targets

United States

The National Aeronautics and Space Administration (NASA) has launched a research programme (Ultra-Efficient Engine Technology) with the objectives of reducing fuel consumption by 15% and NOx emissions by 70% (NASA 2001). The baseline and timescales of the programme are unclear from the published website.

European Union

As part of a strategic research agenda for the European Union, the Advisory Council for Aeronautical Research (ACARE) has set environmental targets for 2020:

- *To reduce fuel consumption and CO_2 emissions by 50%*
- *To reduce perceived external noise by 50%*
- *To reduce NOx by 80%*
- *To make substantial progress in reducing the environmental impact of the manufacture, maintenance and disposal of aircraft and related products* (ACARE 2002) *p20*

These targets apply to new aircraft delivered in 2020, compared with equivalent new aircraft in 2000, with contributions from engine technologies and airframe/engine design and optimised air traffic management (ATM). It is anticipated that there may be improvements of up to 10% from optimised ATM procedures (Beesley 2003). In a scenario of increasing traffic, it would seem that the ATM contribution is likely to prove rather difficult to measure. Individual manufacturing companies have set their own targets for environmental improvements of their component e.g. Rolls Royce have voluntary targets for 2010 of CO_2 reduction of 10%, noise reduction of 10dB relative to the 1998 equivalent engine and a reduction in NOx to 50% of CAEP2 levels (Beesley 2003). It is expected that these company targets will contribute to the ACARE overall targets.

The Silent Aircraft Initiative

The Cambridge-MIT Institute (CMI) research programme, The Silent Aircraft Initiative (CMI 2005), has a vision 'to reduce aircraft noise dramatically to the point where it would be virtually unnoticeable to people outside the airport perimeter'. This is a conceptual project exploring airframe and engine designs, supported by many industrial partners. There remain many technical challenges to be overcome before the concepts could become a reality: 2030 is suggested as the earliest timeframe.

4.4.4 Indirect Targets

Atmospheric Emissions

World Meteorological Office (WMO) has recommended a maximum CO_2 concentration of 500 parts per million in the global atmosphere (WMO 1992).

United Nations – the Kyoto Protocol (UN 1997a) commits signatory nations to reducing overall emissions of greenhouse gases by at least 5% below 1990 levels in the period 2008-2012. This includes domestic air transport, but excludes international flights.

United Kingdom – UK Government has stated an ambition to reduce greenhouse gas emissions by 60% by 2050 (Blair 2003, DTI 2003). It is not clear whether this includes civil aviation (internal or international flights) and if so, how.

The above are termed indirect targets since they apply generally across all sources of greenhouse gas emissions, and do not apply specifically to aviation. Depending on how the targets are split across industry sectors, it may be expected that all sectors, including aviation, should make some contribution to the targets.

There is an obvious tension between the CO_2 reduction targets and the forecast increases in aviation (Bows, Upham et al. 2005, Shackley, Anderson 2005, Upham, Butlin et al. 2005); the latter describe this as a direct conflict. It is not clear how this conflict may be reconciled.

Noise

Based on research into the effects of noise in the community (Berglund, Lindvall 1995), the World Health Organization (WHO) has defined guideline levels for community noise in a range of specific environments (WHO 1999a) (Table 4.12).

Individual noise events are measured in terms of sound energy (decibels), weighted to account for the response of the human hearing system – dBA scale. For noise over a long period, the sum of the total sound is accumulated and averaged over the time period to give an equivalent continuous sound level $L_{eq\ dBA,T}$ (T is the time period in hours). WHO states that $L_{eq\ dBA}$ should be used for continuous noise, but when there are distinct events to the noise, as with aircraft noise, measures of the maximum noise of individual events e.g. LAmax, should be used. The WHO guidelines thus include, where appropriate, maximum levels for the continuous equivalent noise over a period and the maximum for an individual event.

Specific environment	**Critical health effect(s)**	**LAeq (dB)**	**Timebase (hours)**	**LAmax (dB)**
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	
Dwelling indoors Inside bedrooms	Speech intelligibility and moderate annoyance, daytime and evening Sleep disturbance, night time	35 30	16 8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School classrooms and pre-school indoors	Speech intelligibility, disturbance of information extraction, message communication	35	During class	
Pre-schools, bedrooms, indoors	Sleep disturbance	30	Sleeping time	45
School, Playground outdoors	Annoyance (external source)	55	During play	
Outdoors in parkland and conservation areas	Disruption of tranquillity	*		

* Outdoors in parkland and conservation areas – existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low.

Table 4.13 Guideline Values for Community Noise

Source: World Health Organization (WHO 1999a)

WHO recommends that governments should adopt the guidelines levels as targets to be achieved in the long term, and legislation be put in place to reduce noise levels. The guidelines have been endorsed by European Governments including the UK (WHO 1999b), though the noise guidelines are not legally binding. These guidelines are not specifically accepted by the aviation industry, though UK Government suggests they should be ‘taken into account’ (DfT 2003b, DfT 2004) when setting aviation operating conditions.

4.4.5 Comment

Vision statements for sustainable aviation tend to be of a general nature, rather than specific or quantifiable visions. Government policies may appear somewhat inconsistent, offering support for sustainable development principles, but lacking in concrete implementations of these principles. A pattern emerges amongst the aviation related organisations: to make a public generalised commitment to sustainable development and sustainable aviation as a good and desirable overall principle, yet at the same time to espouse continued growth of the aviation sector and oppose measures which may constrain growth. There is no element in these visions of setting limits, thresholds or environmental targets for the industry (Upham 2003). Since there are few specific visions, there can be few identifiable targets for sustainable development in civil aviation.

The only aspect of the sustainable development debate which has targets is eco-efficiency i.e. the performance of individual aircraft. The ACARE and NASA targets on eco-efficiency do certainly reflect the commitment of the aero-engine and airframe manufacturing sector to address the environmental issues faced by the industry. These do represent quantifiable targets.

The indirect targets (or ambitions) for an actual reduction in greenhouse gas emissions apply across all sources of emissions. It is not clear how aviation may be expected to contribute to these target reductions.

In all these visions there is little evidence of the Integration of environmental protection and development, the Precautionary Principle or the Polluter Pays Principle.

4.5 *Change Programmes*

4.5.1 Approach

The previous sections documented a system description (section 4.3), yielding a list of potential sustainable development issues, and explored the visions of civil aviation (Section 4.4). This section analyses Agenda 21 to identify potential changes and actions relevant to the sustainable development of civil aviation.

Sustainable Development Model – Components

3 - Change Programmes
• Policy Actions relevant to context – Agenda 21 Chapters
• Change programmes – based at least on Agenda 21
  - Policies
  - Legal instruments, economic incentives, information/education
  - Targets

Box 4.12 Change Programmes from Box 3.1

Agenda 21 (UN 1992a) consists of 40 chapters (Appendix 2) setting out policies and actions in support of sustainable development, phrased at the level of nation states – the members and agents of the UN. Agenda 21 provides a checklist of actions potentially applicable to an industrial sector.

Agenda 21 chapters are analysed by general responsibility (Table 4.14). 'National Government' means the responsibility for action remains with the Nation State and cannot be assigned to a specific industrial sector. 'Outside scope of Civil Aviation' means that civil aviation has no direct impact or responsibility for the topic, which may be more directly affected by other industrial sectors. These Agenda 21 chapters are not analysed.

Agenda 21 Chapter	Responsibility
5. Demographics	National Government
7. Sustainable human settlement	National / Local Government
10. Integrated Land Management	
11. Deforestation	Outside scope of Civil Aviation
12. Desertification and drought	
13. Sustainable mountain development	
14. Promoting sustainable agriculture	
15. Biodiversity	National Government
16. Biotechnology	Outside scope of Civil Aviation
17. Protection of the oceans	
19. Toxic chemicals	
22. Radioactive wastes	
24. Action for women	National Government
25. Children and youth	
26. Indigenous people	
27. Role of NGOs	
32. Role of farmers	Outside scope of Civil Aviation
28. Local authorities initiatives	National / Local Government
29. Role of workers and trade unions	National Government
33. Financial resources and mechanisms	
37. National mechanisms and international cooperation for capacity building in developing countries	

Table 4.14 Agenda 21 Chapters not relevant to Civil Aviation

Source: Author

For analysis purposes, the Agenda 21 chapters are grouped into dimensions of sustainable development as defined by the UN (UN 1996) (Table 4.15).

Dimension	Agenda 21 Chapters	Civil Aviation Relevant
Social	3, 5, 6, 7, 36	3, 6, 36
Economic	2, 4, 33, 34	2, 4, 33, 34
Environmental	9–22	9,15,18, 20, 21
Institutional	8, 23–32, 35, 37, 38, 40	8, 23, 27,30, 35, 38, 40

Table 4.15 Dimensions of Sustainable Development

Potential policy actions are summarised at Table 4.17 and shown in the text as:

ACTION	Agenda 21 Chapter	Policy	Section number

4.5.2 Social Dimension

The social dimension includes Agenda 21 chapters 3, 6, 36.

4.5.2.1 Chapter 3 – Combating Poverty

Principle 5 of the Rio Declaration and Chapter 3 of Agenda 21 are concerned with eradicating poverty, no doubt primarily concerned with poverty in the developing world, but this must also apply to poverty in the developed world.

The effects of aviation may contribute to reduction of poverty in a number of ways:

- Airport Employment – either directly employing people currently in poverty or through indirect and induced effects
- Stimulation of economy – other industries established in the proximity of the airport may bring similar direct and induced effects
- Direct programmes to transmit benefits to less economically successful areas and sectors of the population

There could also be possible adverse effects where an airport could create areas of deprivation e.g. from export of tourism (UN 1996).

In the UK the relationship between civil aviation and poverty was explored in a Government consultation (DfT 2002), which included questions on deprivation and social exclusion and how the benefits of airport expansion could be spread to the economically less successful areas. Thus the UK Government expects that the expansion of the civil aviation business may contribute to poverty reduction and is seeking specific measures to achieve this.

ACTION	**Chapter 3**	**Spread benefits of aviation to deprived areas and unemployed**	**4.5.2.1**

4.5.2.2 Chapter 6 – Human Health

Human health conditions are considered in some detail in the sections on employees, passengers and communities around airports (sections 4.3.9/10/11). Agenda 21 chapter 6 specifically defines actions of national governments to control noise:

> *Develop criteria for maximum permitted safe noise exposure levels and promote noise assessment and control as part of environmental health programmes;*
>
> (UN 1992a) *chapter 6.41*

The UK Government has not developed any national criteria for community noise, though the World Health Organization (WHO) has suggested Guidelines for Community Noise (WHO 1999a) discussed in section 4.4.3 Indirect Targets.

ACTION	**Chapter 6**	**National noise criteria**	**4.5.2.2**

Other health issues are identified in Section 4.3.10 Users: these are not the subject of any specific change programmes.

4.5.2.3 Chapter 36 – Promoting education, public awareness and training

Programme areas described in this chapter are:
(a) Reorienting education towards sustainable development;
(b) Increasing public awareness;
(c) Promoting training.

Within the UK, public perceptions of aviation may be heavily influenced by the great volume of foreign holiday and tourism advertisements, which carry no information on the environmental effects. Public awareness of the environmental consequences may be low.

ACTION	**Chapter 36**	**Public awareness programmes**	**4.5.2.3**

4.5.3 Economic Dimension

The economic dimension includes Agenda 21 chapters 2, 4, 33, 34.

4.5.3.1 Chapter 2 – Developing Countries

Programme areas within this chapter are:

2A. Promoting sustainable development through trade

2B. Making trade and environment mutually supportive

2C. Providing adequate financial resources to developing countries

2D. Encouraging economic policies conducive to sustainable development

Essentially, these actions are targeted at nations to ensure that international trade arrangements and environmental rules do not disadvantage, and if possible encourage, underdeveloped nations. It is generally difficult to extract actions in this chapter specific to a particular sector of industry.

2A. Promoting sustainable development through trade

The UN argues here for an open and equitable world trade system, allowing underdeveloped countries access to the markets of the developed countries, on the assumption that this will enable increased trade and thus generate wealth for the undeveloped countries. The civil aviation business remains highly regulated by the system of bilateral agreements supported, though not negotiated, by ICAO, with little opportunity for airlines from the less developed world to access markets in the developed world. It is debateable whether rapid liberalisation of air transport markets would benefit or harm the less developed nations (Rattray 2002).

2B. Making trade and environment mutually supportive

The UN suggests a range of actions to do with avoiding restrictions on trade, and suggests;

> *(a) Elaborate adequate studies for the better understanding of the relationship between trade and environment for the promotion of sustainable development;*

This activity is relevant to all areas of trade including air transport. The initial assessment of this aspect may be a measure based on the energy intensity of trade (section 4.3.3.3 Consumption Patterns – Sustainability).

2C. Providing adequate financial resources to developing countries

2D. Encouraging **economic policies conducive to sustainable development**

These two actions are essentially envisaged at government level and are not applicable to an individual industrial sector.

ACTION	**Chapter 2**	**Make trade and environment mutually supportive**	**4.5.3.1**

4.5.3.2 Chapter 4 – Changing Consumption Patterns

This chapter focuses on 'unsustainable patterns of production and consumption' and promotes actions to change these patterns. The major thrust is unequal consumption between the developing and industrialised nations (WCED 1987), and the pressing need to change consumption patterns in the industrialised nations. The word 'change' is diplomatically chosen, meaning to reduce consumption in industrialised nations. Since civil aviation is a major and growing consumer of resources, and by its nature is not sustainable (Upham 2003), the actions of this chapter are highly relevant to the sector. A range of actions are suggested.

4A) Encouraging greater efficiency in the use of energy and resources

New Aircraft

More effective use of non-renewable resources (Eco-efficiency) is an immediate sustainability issue for the aviation industry (Upham 2003). There are existing programmes in Europe and USA to improve the eco-efficiency of new aircraft: the ACARE targets (ACARE 2002) are previously discussed (Section 4.4.3).

Fleet efficiency

Overall fleet efficiency depends largely on how rapidly older aircraft are replaced by newer, more efficient types. Replacement may be slow, since aircraft life may be measured in decades. Airbus suggest that 2,712 'old generation' aircraft were in service in 2004 (Airbus 2005), estimates supported by other aviation inventories: at end of 2003 there were still in service, for example, 163 DC8 aircraft (last produced in 1972), 483 DC9 (older than 1982), 788 B727 (1984) (SpeedNews 2005). It is suggested (Airbus 2005) that high oil prices may trigger retirements of less efficient aircraft. Manufacturers' views on fleet size and retirements vary (Table 4.16) but Airbus and Boeing agree that most aircraft flying in 2004 will still be in service in twenty years.

Fleet projections 2004-2024	Boeing To 2024	Airbus To 2023
Total Fleet (2004)	16,800	13,612
Retirements	7,200	4,297
New Aircraft	25,700	17,328
Total Fleet 2023 or 24	35,300	26,643
(of which Currently Flying)	9,600	9,315

Table 4.16 Jet Fleet Projections

Source: Boeing (Boeing 2005), Airbus (Airbus 2005)

Other observers are somewhat more pessimistic on the replacement of old aircraft:

> *Two thirds of all the aircraft which will be flying in 2030 are already in use*
>
> (RCEP 2002)

The benefits of improved efficiency of new aircraft are only slowly propagated through the fleet. There have been proposals to accelerate scrappage of aircraft (von Weizsacker, Lovins et al. 1998), with the objective of bringing forward the efficiency benefits of new aircraft. There is a potential action to phase out older aircraft.

Renewable Energy

Chapter 4 Agenda 21 defines the need to develop new and renewable sources of energy, which must be a long term requirement for aviation. Currently, aviation is dependent on oil-derived kerosene. Many alternatives have been considered including alcohols, methane, hydrogen and bio-mass derived fuels. Of these, biomass derived kerosene, bio-diesel, and hydrogen are considered to have potential for aviation use (Lee 2003, Saynor, Bauen et al. 2003).

Technically it is feasible to produce kerosene natural gas by gas-to-liquid (GTL) fuel technology (the Fischer-Tropsch synthesis process (Lee 2003)), and thus from other primary fuels (coal and biomass) by the prior gasification of these fuels. Fuel suppliers and engine manufacturers have voiced concern over fuel standards (DEFRA 2006b), and there are disadvantages with the process: the gasification and the GTL processes both require energy, and thus the release of carbon dioxide.

Since these are static industrial processes it may be possible that the majority of the CO_2 could be captured rather than released into the atmosphere. The GTL process is being developed at several sites, for example by SASOL Chevron is planning GTL plants in Nigeria and Qatar (SASOL/Chevron 2003). It is not clear what the price implications of large scale GTL technology would be.

Hydrogen fuel may be technically feasible, but currently is not available in industrial quantities from renewable sources. There are also suggestions that the total radiative forcing effect from cryoplanes (hydrogen powered) may be greater than conventional kerosene powered aircraft (Marquart, Sausen et al. 2001). Both biomass derived kerosene and hydrogen are considered to raise technical difficulties which may require some decades to overcome.

It is considered technically difficult and expensive to transfer aviation to other fuels, and alternative energy sources (e.g. biomass or hydrogen from renewable sources) may be easier to substitute into ground transport applications – thus releasing a higher proportion of available oil for aviation fuel (Farmery 2003). It is suggested that aviation could become the last user of dwindling oil supplies (Beesley 2003).

Current aviation research programmes (ACARE 2002, NASA 2001) extending for up to 20 years, are based firmly on a continuation of the existing fuel technology. There is thus little likelihood of introduction of renewable fuels in this timescale. Within one or two generations (a human generation is taken to be 35 years), there is likely to be some significant decline in the supply of oil and later of natural gas. On this timescale the current technology of civil aviation is not sustainable and alternative energy supplies must be developed.

ATM Efficiency

There is a particular issue of waste generation within the operation of the Air Traffic Management system, which was explored in Airspace analysis (Section 4.3.8). There are numerous calls for the improvement of air traffic management e.g. (Lieuwen, Elliff 2003, Lucas 2003), and ACARE has identified this as one of the areas for efficiency improvements (ACARE 2002). However, there is an argument that operational efficiency gains from air traffic management improvements may not result in lower carbon emissions (Pastowski 2003). ATM improvements should reduce delays and fuel burn and, if passed on to air passengers in the form of lower costs, the induced demand may lead to a negligible decrease, or even an increase in emissions.

ACTION	**Chapter 4**	**Improve fuel efficiency of new aircraft**	**4.5.3.2**
ACTION	**Chapter 4**	**Accelerate phase-out of old aircraft**	**4.5.3.2**
ACTION	**Chapter 4**	**Develop renewable energy for aviation**	**4.5.3.2**
ACTION	**Chapter 4**	**Improve efficiency of air traffic management**	**4.5.3.2**

4B) Minimizing the generation of wastes

This section is concerned primarily with recycling and packaging. Airport waste is covered in section 4.3.7.

4C) Assisting individuals and households to make environmentally sound purchasing decisions

Currently most consumers of passenger air transport services make decisions based primarily on the basis of price and availability of the service:

> *The ultimate goal of consumers is to minimise their overall disutility of travel. This implies minimising time, cost and discomfort, and maximising safety, security, punctuality, choice and convenience.*
>
> (Caves, Gosling 1999) *p50.*

According to Caves, environmental issues do not feature in consumers' goals, and within the UK there is very little information available to passengers on the overall environmental impact of civil aviation, or of their particular decision to use an air transport service. In 2003 only one group in the UK, Future Forests Ltd, now renamed The Carbon Neutral Company, offered a facility on their website to calculate the carbon emissions caused by a passenger flight (CarbonNeutral 2005), suggesting the number of trees to be planted to offset this emission i.e. to re-absorb (over time) the CO_2 emissions. By 2005 a range of other websites offered passenger emissions calculators e.g. (Climatecare 2006, KLM 2006, SAS 2005b), though the calculators yield significantly differing emissions for the same journey and aircraft type. The concept of offsetting carbon emissions is not specifically recognised in Agenda 21, rather the emphasis is on reducing consumption levels.

Equally, there is little information available and no public means of calculating the environmental impact of despatching goods by air cargo. Only one airline, SAS, offers a similar calculator for cargo (SAS 2005a). The ultimate consumer may not even be aware that he/she is buying an article which has travelled by air. Goods on the supermarket shelves may have the country of origin, but will not make it clear to the consumer the carbon cost of the purchase.

ACTION	**Chapter 4**	**Environmental product information for air passengers and air cargo**	**4.5.3.2**

4D) Exercising leadership through government purchasing

In the UK there does not appear to be any specific Government policy directed at controlling the level of aviation services purchased. There is a recent policy to offset the impact of Government air travel by investing in projects to save carbon emissions elsewhere (DEFRA 2006a).

ACTION	**Chapter 4**	**Government purchasing of air transport services**	**4.5.3.2**

4E) Moving towards environmentally sound pricing

Agenda 21 states:

> *4.24. Without the stimulus of prices and market signals that make clear to producers and consumers the environmental costs of the consumption of energy, materials and natural resources and the generation of wastes, significant changes in consumption and production patterns seem unlikely to occur in the near future.*

This action is of fundamental importance in civil aviation. The meaning of the term 'environmentally sound pricing' is not defined by Agenda 21, nor readily agreed, but is intended to encompass at least two of the Rio Principles – Principle 8 (Reduce unsustainable patterns of consumption) and Principle 16 (The Polluter Pays Principle). Thus 'environmentally sound pricing' of any activity must include internalisation of external environmental costs (Polluter Pays), and in addition Agenda 21 suggests the need for a price stimulus to change behaviour patterns. The major economic instruments to apply environmental pricing are taxes or charges on aviation fuel or aircraft emissions. The Chicago Convention (ICAO 1944) precludes taxation or charges on fuel brought into a country on an aircraft, and retained for onward flight. The Convention does not make specific reference to taxes or charges levied on fuel sold in a member state, nor to emissions charges. The various amendments to the Convention have not altered this wording (ICAO 2000). Thus, it appears that aviation fuel tax may be allowable under international regulations, though some governments may have committed not to levy such taxes in their bilateral air agreements (DfT 2003a). The use of taxes on fuel or emissions is strongly opposed by the civil aviation industry (ATAG 2002, ICAO 1995a).

Transport (including air transport) is frequently seen as a need or a right (DfT 2003b, EU 2001, Sustainable Aviation 2005), and thus 'environmentally sound pricing' is normally interpreted as internalising the external environmental costs (Polluter Pays). An example in aviation is provided by the UK Government consultation on the use of economic instruments (DfT 2003a). The consultation document concentrated solely on the external environmental costs of aviation, and explored attitudes to potential instruments to recover such external costs – a direct application of the Polluter Pays Principle (Principle 16), but did not consider the use of economic instruments as a stimulus for changing consumer behaviour. As a result of this consultation process, the UK Government did not make any recommendations to introduce environmentally based charges for UK aviation.

ACTION	**Chapter 4**	**Environmentally sound pricing of air transport services**	**4.5.3.2**

4F) Reinforcing values that support sustainable consumption

> *4.26. Governments and private-sector organizations should promote more positive attitudes towards sustainable consumption through education, public awareness programmes and other means, such as positive advertising of products and services that utilize environmentally sound technologies or encourage sustainable production and consumption patterns.*

The current public awareness programmes emanating from civil aviation are driven by the commercial imperative to increase consumption of air transport. There is massive advertising of airlines and holidays, and cost cutting competition. Little environmental awareness is presented, and expansion programmes are described in terms of their perceived benefits rather than potential environmental disbenefits.

ACTION	**Chapter 4**	**Public awareness campaigns**	**4.5.3.2**

4.5.3.3 Chapter 34 – Transfer of environmentally sound technology, co-operation and capacity building

This chapter is concerned with transfer of environmentally sound technology to developing countries. There is specific commentary on transfer of privately owned technologies, including reference to ‘transfer … on non-commercial terms’.

Manufacturing capability

Within the civil aviation industry, advanced manufacturing technology is predominantly owned by the engine and airframe companies and their suppliers. It is in the manufacturers’ interest to capitalise on the costs of research by retaining the control and rights to the technology. On the other hand, manufacturers may wish to take advantage of lower labour rates in the developing countries by transferring manufacturing facilities. Transfer of such technology to developing countries remains subject to commercial confidentiality but is likely to be made only at an acceptably high commercial price, which may include joint ventures, partial ownership of the enterprise in the developing country e.g. in China, Rolls Royce and Xian XR Aero Components Ltd. (Rolls Royce 2003). The manufacture of airframes and aero-engines has already been noted as a separate manufacturing system (section 4.3.6.1) and actions that may be taken within that system will not be considered.

Equipment Transfer

There has been a general pattern of old equipment (aircraft) from airlines in developed countries being sold on to airlines in the less developed world. This may be one factor in worse safety records of some developing countries (Learmont 2006).

Skills Transfer

Representative bodies have various initiatives to transfer technologies or skills e.g. IATA Training funds (IATA 2004a).

It may be that the behaviour of the civil aviation industry in transferring technologies to the developing countries is not entirely consistent with the objectives of Chapter 34, but is constrained by commercial agreements and pressures. The transfer of technologies to developing countries falls within the remit of national governments and the international representative organisations, rather than civil aviation operations. Thus no action is specifically identified for this chapter.

4.5.4 Environmental Dimension

The environmental dimension includes Agenda 21 chapters 9, 15,18, 20, 21.

4.5.4.1 Chapter 9 Protection of the Atmosphere

The programme areas in Chapter 9 are:

A) Addressing the uncertainties: improving the scientific basis for decision-making;

B) Promoting sustainable development:

- *Energy development, efficiency and consumption;*
- *Transportation;*
- *Industrial development;*
- *Terrestrial and marine resource development and land use;*

C) Preventing stratospheric ozone depletion;

D) Transboundary atmospheric pollution.

Programme area A) recommends Governments to undertake further research to *'improve the understanding of processes that influence and are influenced by the Earth's atmosphere on a global, regional and local scale',* and be undertaken by Governments *'with the cooperation of the relevant United Nations bodies …. and the private sector'.* Aviation has a unique role in emitting waste gases high in the atmosphere and thus there is a strong case that ICAO as a relevant UN body and the civil aviation industry as a whole, should sponsor or take part in appropriate research. It is noted at section 4.3.5 that there remains considerable scientific uncertainty on the impacts of aviation on the atmosphere. It is also noted at section 4.4.1 that ICAO has appeared somewhat passive in this respect, merely suggesting that states should inform ICAO of the environmental impacts of aviation (ICAO 2004).

ACTION	**Chapter 9**	**Research into effect of aircraft emissions**	**4.5.4.1**

Programme area B) (Energy development) calls for the development of '*environmentally sound energy sources'* and this would include renewable energy sources for aviation – covered at section 4.5.3.2 (Consumption) above.

Programme area B) (Transportation) covers Transportation and transport systems in general terms, and does not specifically refer to air transport. The overall objective of the Transportation sections of Chapter 9 is:

to develop and promote cost-effective policies or programmes, as appropriate, to limit, reduce or control, as appropriate, harmful emissions into the atmosphere and other adverse environmental effects of the transport sector,

There is an action to limit harmful emissions. Efficiency of operation is covered at section 4.5.3.2 (Consumption) above.

Programme area B) (Terrestrial and marine resource development and land use) makes reference to sinks of greenhouse gases:

The conservation, sustainable management and enhancement, where appropriate, of all sinks for greenhouse gases;

This raises the possibility that the civil aviation industry may invest in some form of carbon sequestration.

ACTION	**Chapter 9**	**Limit harmful emissions from civil aviation**	**4.5.4.1**
ACTION	**Chapter 9**	**Investment into carbon sinks**	**4.5.4.1**

4.5.4.2 Chapter 18 Protection of Freshwater

Chapter 18 outlines a range of programme areas designed to protect the quality of freshwater. Relevant aspects for airports are water runoff from hard surfaces and possible spillage of polluting substances covered at section 4.3.7. These are regulated in the UK by the Water Act (UK Government 1989) and Environmental Protection Act (UK Government 1990b). It is considered that no further policy actions are required.

4.5.4.3 Chapter 20 Hazardous Wastes

Airports in the UK are treated as industrial sites subject to the Environmental Protection Act (UK Government 1990b). It is considered that no further policy actions are required.

4.5.4.4 Chapter 21 Solid Wastes

Airports in the UK are treated as industrial sites subject to local regulation on waste disposal via the Planning regulations. No further action is identified here (see section 4.3.7 Airport Operations).

4.5.5 Institutional Dimension

The Institutional dimension includes Agenda 21 chapters 8, 23, 27,30, 35, 37, 38, 40.

4.5.5.1 Chapter 8 Integrating environment and development in decision making

Chapter 8 is an extremely important, though little referenced, part of Agenda 21. The objective is to restructure decision making at all levels so as to incorporate environmental issues, i.e. to 'institutionalise' environmental issues in much the same way as economic value is currently institutionalised in government, commerce and society, and safety considerations are institutionalised within civil aviation (Section 4.3.10). Integration is discussed at section 4.3.12 Regulatory System.

Programme areas in Chapter 8 are:

8A. Integrating environment and development at the policy, planning and management levels
8B. Providing an effective legal and regulatory framework
8C. Making effective use of economic instruments and market and other incentives
8D. Establishing systems for integrated environmental and economic accounting

Integration Section 8A – Integration at policy level. A range of actions is identified, primarily targeted at Governmental organisations and Ministries, suggesting a review of national policies and priorities, with potential changes to the structure of Government departments. The actions are relevant to civil aviation policy making by the UK Department for Transport. There are no public initiatives from UK Government in this respect.

Section 8B – Legal and regulatory framework. This section suggests that integration of environment and development should be incorporated into the national legal framework, arguments expanded by VanderZwagg (VanderZwagg 1995). Currently there are no public initiatives from UK Government in this respect.

Section 8C is concerned with using economic instruments as a means to influence commercial decision making in such a way that environmental and developmental considerations are integrated, and specifically:

8.31 (a) To incorporate environmental costs in the decisions of producers and consumers, to reverse the tendency to treat the environment as a "free good" and to pass these costs on to other parts of society, other countries, or to future generations;

In business, development decisions are currently made primarily on financial grounds. Environmental issues such as noise and pollution are not given a value, and thus do not feature in the economic decision. In aviation, environmental issues are frequently considered as constraints or threats to the business expansion (Thomas 2002). Effectively, this section is applying the principle of 'The Polluter Pays' and internalisation of environmental costs – Rio Declaration principle 17. The relevance to civil aviation lies in the internalisation of environmental costs – atmospheric emissions, noise, health and compensation.

The last section (8D) is primarily concerned with establishing international and national systems of integrated environmental and economic accounting, seen as complementing traditional accounting practices and playing a part in the national development decision making process. These integrated accounting systems would no doubt have a great influence on, but are not the responsibility of, the civil aviation industry itself. Actions from this section are not included.

ACTION	**Chapter 8**	**Integration at policy level**	**4.5.5.1**
ACTION	**Chapter 8**	**Provide legal framework for integration**	**4.5.5.1**
ACTION	**Chapter 8**	**Use economic instruments for integration**	**4.5.5.1**

4.5.5.2 Chapter 23 Participation

Chapter 23 is a general preamble emphasising the essential role of public participation. This is very relevant to airport environmental issues (Section 4.3.11 Community Participation).

ACTION	**Chapter 23**	**Public participation in airport environmental decisions**	**4.5.5.2**

4.5.5.3 Chapter 30 Role of Industry

Chapter 30 calls upon industry to adopt and implement Agenda 21.

> *30.1 Business and industry, including transnational corporations, and their representative organizations should be full participants in the implementation and evaluation of activities related to Agenda 21.*

The chapter outlines a series of actions to be taken by business and industry in terms of cleaner production and responsible entrepreneurship. This chapter is further developed in the initial UK Sustainability Strategy (DEFRA 1999) chapter 6 which calls for Sectoral Sustainability Strategies.

ACTION	**Chapter 30**	**Aviation sector sustainable development strategy**	**4.5.5.3**

4.5.5.4 Chapter 35 Science for Sustainable Development

This chapter suggest actions leading to an improved scientific understanding of sustainable development issues. There is a need for research into the effects of aviation emissions- discussed at Section 4.3.5.

ACTION	**Chapter 35**	**Research into the effect of aircraft emissions**	**4.5.5.4**

4.5.5.5 Chapter 38 International Institutional Arrangements

Chapter 38 defines a specific mandate for UN Agencies:

> *All relevant agencies, organizations and programmes of the United Nations system should adopt concrete programmes for the implementation of Agenda 21 and also provide policy guidance for United Nations activities or advice to Governments, upon request, within their areas of competence;*
>
> (UN 1992a) *Chapter 38.8(b)*

The International Civil Aviation Organization (ICAO), in its assembly resolution on environmental protection (ICAO 2001), acknowledges that ICAO is a relevant agency in this context. However, the resolution falls somewhat short of adopting a concrete programme for implementing Agenda 21, and does not address many Agenda 21 actions relevant to aviation, indeed in some aspects e.g. environmentally sound pricing, the ICAO policy seems to be counter to Agenda 21.

ACTION	**Chapter 38**	**ICAO programme for sustainable development**	**4.5.5.5**

4.5.5.6 Chapter 40 Information for decision making

This chapter discusses the need for information to support decision making at all levels – from international organisations and governments to individual purchasers, and introduces the concept of Indicators of Sustainable Development. Chapter 40 very specifically mandates the relevant UN agencies to develop and use indicators for international use:

> *40.7. Relevant organs and organizations of the United Nations system, in cooperation with other international governmental, intergovernmental and non-governmental organizations, should use a suitable set of sustainable development indicators and indicators related to areas outside of national jurisdiction, such as the high seas, the upper atmosphere and outer space. The organs and organizations of the United Nations system, in coordination with other relevant international organizations, could provide recommendations for harmonized development of indicators at the national, regional and global levels, and for incorporation of a suitable set of these indicators in common, regularly updated, and widely accessible reports and databases, for use at the international level, subject to national sovereignty considerations.*

This appears to be an unequivocal mandate for ICAO as a UN organisation, to develop sustainable development indicators for the upper atmosphere. There is no evidence that ICAO is developing relevant sustainable development indicators.

ACTION	**Chapter 40**	**ICAO develop sustainable development indicators**	**4.5.5.6**

4.5.6 Potential Sustainable Development Actions

The potential actions identified above are summarised at Table 4.17. Actions are presented in order of Agenda 21 Chapter and consolidated where the same action is identified more than once.

Agenda 21 Chapter	Action	Section
Chapter 2 Developing Countries	Make trade and environment mutually supportive	4.5.3.1
Chapter 3 Combating poverty	Spread benefits of aviation to deprived areas and unemployed	4.5.2.1
Chapter 4 Changing consumption patterns	Improve fuel efficiency of new aircraft	4.5.3.2
	Accelerate phase-out of old aircraft	4.5.3.2
	Develop renewable energy for aviation	4.5.3.2
	Improve efficiency of air traffic management	4.5.3.2
	Environmental product information for air passengers and air cargo	4.5.3.2
	Government purchasing of air transport services	4.5.3.2
	Environmentally sound pricing of air transport services	4.5.3.2
Chapter 4 & 36 Public Awareness	Public awareness campaign	4.5.3.2/ 4.5.2.3
Chapter 6 Human Health	National noise criteria	4.5.2.2
Chapter 8 Integrating environment and development in decision making	Integration at policy level	4.5.5.1
	Provide legal framework for integration	4.5.5.1
	Use economic instruments for integration	4.5.5.1
Chapter 9 Protecting the atmosphere	Limit harmful emissions from civil aviation	4.5.4.1
	Investment into carbon sinks	4.5.4.1
Chapter 9 & 35	Research into effect of aircraft emissions	4.5.4.1/ 4.5.5.4
Chapter 23 Participation	Public participation in airport environmental decisions	4.5.5.2
Chapter 30 Role of Business	Aviation sector sustainable development strategy	4.5.5.3
Chapter 35 Science	Research into effect of aircraft emissions	4.5.5.4
Chapter 38 International institutional arrangements	ICAO programme for sustainable development	4.5.5.5
Chapter 40 Information	ICAO develop sustainable development indicators	4.5.5.6

Table 4.17 Potential Sustainable Development Actions

4.6 *Control Mechanisms*

The previous sections document a system description (section 4.3), yielding a list of potential sustainable development issues, explore published visions of civil aviation, (Section 4.4), and identify potential changes and actions relevant to the sustainable development of civil aviation (Section 4.5). The overall system description Box 3.1 identifies two further components - Control Mechanisms and Information.

Sustainable Development Model – Components
4 – Control Mechanisms • Identified decision makers • Decision making process – ongoing and adaptive • Institutional capability – for information provision • Information
5 - Information • Indicators of Sustainable Development - Current system status - Boundary conditions - Change programmes

Box 4.13 Control Mechanisms and Information from Box 3.1

Regulatory decision makers are identified at section 4.3.12 (Regulatory system), which highlights multiple different control systems related to the different aspects of sustainable development. The decision making processes of these systems as they relate to civil aviation are extremely complex, and are not explored here.

Information takes the form of indicators of sustainable development which are derived in the following chapters (5, 6, 7).

4.7 *Summary*

4.7.1 Review the Approach Taken

This chapter has undertaken an analysis of the civil aviation system against sustainable development principles, deriving the products defined in the sustainable development model (Box 3.1). The effectiveness of the approach is reviewed here.

System Description

The initial analysis to produce a system description (Section 4.3, corresponding to Item 1 of Box 3.1), is based on a full systematic view of the civil aviation system. The analysis examines each system (or subsystem) in turn, assesses which of the Rio principles is relevant to the action of this system, and produces a set of potential issues for later consideration.

The approach has certain strengths: it provides complete system coverage; all systems and subsystems are included; all Rio Principles are considered. There is flexibility in the level examined: the system view is hierarchical, allowing high level systems to be split to the level required. The system components may be viewed in a general, 'logical' sense or as physically identified units. In this analysis the view is normally of high level systems, and at a logical view i.e. airports are considered as a general system rather than as individual airports.

The approach is effective in analysing the natural, physical, and procedural systems and boundaries for civil aviation, allowing both physical and logical interfaces, and in relating these interfaces to the relevant Rio principles.

In some areas the approach may be less effective owing to the nature of the Rio Principles. Two principles (Principle 15, the Precautionary Approach, and Principle 16, Polluter Pays) are regarded as highly significant, but do not feature at all in the analysis of physical and procedural systems at section 4.3. Principles 15 & 16 are relevant to setting sustainable development visions and goals, but there is no evidence of their application in the vision analysis (section 4.4 above) or in change programmes (section 4.5 above).

Principle 4 (Integration of environmental protection and development) is difficult to position in this systems approach. The principle is intended to be all pervading through government, industry and society, and as such does not readily sit in a single system or interface. An overview of Integration is included in the Regulatory systems analysis.

There is some overlap between Principles concerned with implementation (Section 4.3.2 Table 4.1) and Agenda 21. The approach taken yields a valid and valuable view of the current situation on these implementation aspects. Two aspects (Liability and compensation, Principle13, and Environmental Impact Assessment, Principle 17) are not mentioned specifically in Agenda 21, so are only referenced by the analysis of Rio Principles.

Change Programmes

For the analysis of change programmes (Section 4.5) a somewhat different approach is taken. Here, the starting point is Agenda 21, and the analysis process examines the full text of each chapter to assess relevance to civil aviation, referencing the previous systemic analysis as appropriate. This approach is necessary because of the size and complexity of Agenda 21.

4.7.2 Summary of Findings

Chapter 4 uses the concept of the sustainable development system derived in chapter 3 (Box 3.1) to document civil aviation in sustainable development terms.

Section 4.3 has performed a system boundary analysis with respect to Rio principles, yielding a list of potential sustainable development issues (Table 4.12). Section 4.4 explores the stated visions of sustainable development in aviation: these are predominantly based on growth of the industry: there is little evidence in these visions of the application of Principle 4 (Integration of environmental protection and development), Principle 15 (Precautionary Principle) or Principle 16 (Polluter Pays).

Section 4.5 undertakes an analysis of Agenda 21 against the civil aviation system, yielding a list of potential actions (Table 4.17). The potential issues and actions are used as a basis for a survey of stakeholder opinions (Chapters 5 and 6).

The regulatory analysis suggests that there are multiple sustainable development systems pertaining to civil aviation, which are concurrent and interacting.

The analysis suggests that the policies and operation of the civil aviation industry supports sustainable development principles in terms of safety and eco-efficiency, but not in terms of regional equity, future equity and damage to global atmosphere. There is no evidence of initiatives to introduce legal constraints or economic incentives, which would reduce unsustainable consumption patterns.

4.7.3 Is Non-Sustainability Institutionalised in Civil Aviation?

The analysis above raises questions on the acceptance of sustainable development in the governance of civil aviation. At the international level, ICAO is required (by Agenda 21) to develop a concrete programme for implementing Agenda 21: there is little evidence of such a programme. ICAO and international aviation representative organisations are consistently reluctant to support environmentally based taxation: international law as implemented in bilateral agreements would seem to present legal barriers to applying taxation to aviation fuel and to revision of charges for air traffic management: these views largely mitigate against the principle of environmentally sound pricing.

The existing legal framework for civil aviation within the UK does not specifically incorporate the principles of sustainable development, and in some cases legislates against the principles e.g. integration and compensation. There is little evidence that the UK Department for Transport embraces sustainable development principles within their plans for the civil aviation sector. The policies of aviation representative organisations assume continued growth, though with some eco-efficiency improvements. There is no existing legislation applying to the civil aviation industry, nationally or internationally, which incorporates or recognises the principles of sustainable development. The process of incorporating sustainable development principles and actions into legal instruments must be regarded as, at best, at an early stage.

The potential implication is that opposition to certain aspects of sustainable developments may be institutionalised in the civil aviation industry: attitudes mitigating against sustainable development may be deeply embedded into the regulatory organisations, the representative organisations and the rule sets that apply. This proposition is explored in the stakeholder survey in Chapters 5 & 6.

CHAPTER 5 Civil Aviation & Sustainable Development: Research Approach

5.1 *Introduction*

In Chapter 4, an analysis of the civil aviation system against sustainable development principles, yields lists of potential issues (Table 4.12) and policy actions (Table 4.17) for sustainable development in civil aviation (Step 1 of Indicator methodology at Figure 3.5). These potential lists are subject to stakeholder review, corresponding to Step 2 of the indicator methodology (Figure 3.5): Chapter 5 describes the research methods and approach, while Chapter 6 analyses research results.

The research process is based on a 2 round Delphi study (Figure 5.1), exploring the personal views of stakeholders. Reasons for selecting a Delphi study are described at section 5.2. Section 5.3 defines the research objectives, research propositions and questions for both rounds of the Delphi study. Questionnaire design and the derivation of the actual questions are covered in section 5.4, and practical execution of the Delphi Study, including stakeholder selection, is described at section 5.5. A schematic overview of the Delphi research process is shown at Figure 5.1.

5.2 *Why Delphi?*

The Delphi technique was developed within the Rank Corporation for use on a national defence problem, possibly as early as 1948 (Gupta, Clarke 1996) though not published until much later (Dalkey, Helmer 1963). The technique was more fully defined and documented in 1975 (Linstone, Turoff 1975).

Delphi has the objective of providing a more reliable response to complex issues, by providing a structured means of communication between a number of experts. The method involves several rounds of questionnaires or interviews that ask similar or progressive questions, while providing feedback from the previous round. Feedback is in the form of group responses, and anonymity is maintained throughout.

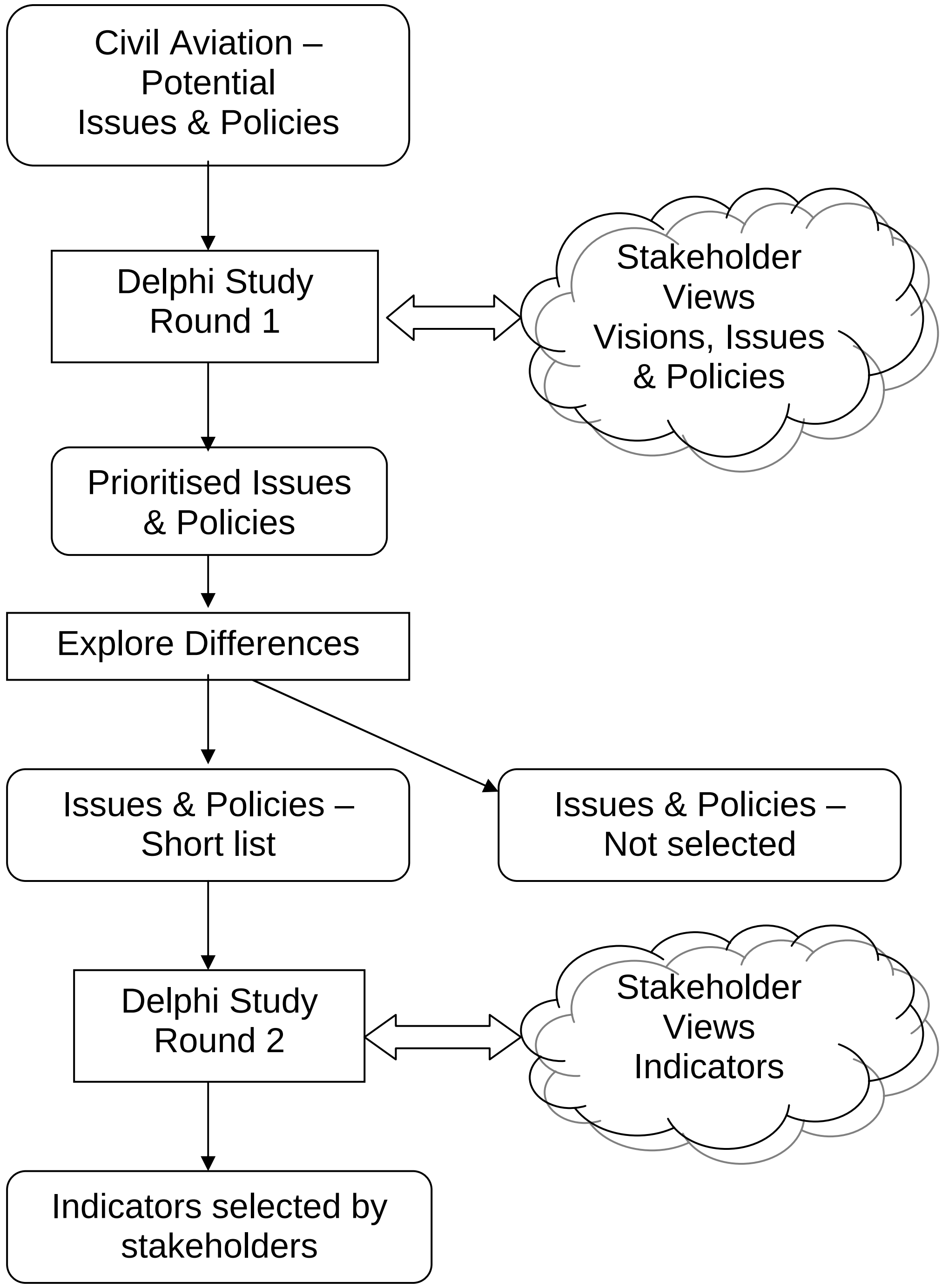


Figure 5.1 Stakeholder Review – Delphi Study

It is suggested that there are few complex areas of human endeavour which are not candidates for Delphi (Linstone, Turoff 1975), and a bibliography of Delphi studies (Gupta, Clarke 1996) reveals applications in a large number of application areas: business, education, healthcare and many commercial sectors including transportation. There are examples of Delphi studies to explore sustainable development objectives (Hoole, Milne 1995) and as a participative process in deriving sustainable development indicators (Bell, Morse 1999, Miller 2001).

It is suggested that the characteristics of the communication process determine the suitability of Delphi rather than the nature of the task:

> *Usually, one or more of the following properties of the application leads to the need for employing Delphi:*
>
> - *The problem does not lend itself to precise analytical techniques but can benefit from subjective judgements on a collective basis*
> - *The individuals needed to contribute to the examination of a broad or complex problem have no history of adequate communication and may represent diverse backgrounds with respect to experience or expertise*
> - *More individuals are needed than can effectively interact in a face-to-face exchange*
> - *Time and cost make frequent group meetings infeasible*
> - *The efficiency of face-to-face meetings can be increased by a supplemental group communication process*
> - *Disagreements among individuals are so severe or politically unpalatable that the communication process must be refereed and/or anonymity assured*
> - *The heterogeneity of the participants must be preserved to assure validity of the results i.e. avoidance of domination by quantity or by strength of personality ("bandwagon effect")*
>
> (Linstone, Turoff 1975) *p 4*

The research in this thesis sets out to obtain stakeholders' views on what is meant by sustainable aviation, what is meant by sustainable development in civil aviation, and how progress towards this could be measured (i.e. which sustainable development indicators are needed). Stakeholders need to be experts on the civil aviation aspects of sustainable development or environmental issues; they are from diverse backgrounds both inside and outside the industry; they are employed or located in many different organisations across the United Kingdom. The communication process displays most of the properties defined by Linstone. The history of communication of the individuals is mixed: some may have communicated well in the past, others less well, and others may not have communicated in any direct sense at all. Stakeholders do represent diverse backgrounds (see section 5.5.1, Selection of Stakeholders).

The Delphi technique is frequently used in a forecasting role, and is often designed to bring about a group consensus on the issue – indeed most of the applications documented by Gupta (Gupta, Clarke 1996) are of this type. Various means of achieving consensus are applied; multiple passes when experts are asked to modify their opinions (Dalkey, Helmer 1963), or fuzzy Delphi (Hsu 1999). In many application areas, the emphasis on a consensus outcome is understandable since some level of convergence of views is required for forecasting or decision making.

However, the early text on Delphi by Linstone does not suggest that a consensus is required, but merely refers to an overall evaluation, and specifically admits the possibility of disagreement:

> *If there is significant disagreement, then that disagreement is explored …. to bring out the underlying reasons for the differences and possibly evaluate them.*
>
> (Linstone, Turoff 1975) *p5/6*

A relative assessment of different techniques (Gutierrez 1989) suggests that Delphi does not require a consensus view to be formed. Disagreements are regarded as valid outcomes of the communication process.

A variation on the Delphi approach, the Disaggregated Delphi, has been suggested in a transport and environmental context (Tapio 2003) to study CO_2 emissions from transport in Finland. In the Disaggregated Delphi the goal of consensus between the participants was not adopted. Instead, a set of alternative long-term traffic and environmental policy scenarios was produced and participants were asked for views on the feasibility and probability of each scenario.

Thus, while Delphi has predominantly been used to achieve consensus views across groups of experts, it can be seen that the Delphi process is fundamentally a communication process, and does not predefine that the outcome should be either consensus or disagreement – both are valid outcomes. In this research it is expected that stakeholders may disagree on the actions required for sustainable development in aviation, but it may be possible to achieve some consensus on indicator selection.

5.3 *Research proposal*

The processes adopted to derive research proposals for Delphi study Round 1 and 2 are illustrated at Figure 5.2 and 5.3 respectively. For Round 1 the inputs are the original project objective and the list of potential sustainable development issues (Table 4.12) and policy actions (Table 4.17) derived in Chapter 4. Research propositions and questions are regarded as corollary concepts i.e. it is convenient to express a proposition as a question which in turn will test the proposition. For Round 2 the inputs are the original project objective and the prioritised list of issues and policy actions from Round 1 analysis.

5.3.1 Research Objectives

The project aim is to derive a set of sustainable development indicators for civil aviation: a number of supporting research objectives are derived for the two Delphi Rounds.

The term ‘sustainable aviation’ is in wide use in Government and the industry e.g. (Sustainable Aviation 2005), though there is no clear definition of the term (See A Vision Analysis, Section 4.4). The first objective is to explore the meaning of sustainable aviation. The second objective is to undertake a stakeholder review of the potential issues and actions from Chapter 4. Initial indications from the system analysis are that industry visions and actions do not coincide with sustainable development principles (section 4.7) so a further research objective explores why. These three objectives are assigned to Delphi Round 1.

For sustainable development indicators, there are two objectives: to explore views first on the purposes of indicators, and secondly on which indicators should be used to assess sustainable developments in civil aviation. These two objectives are assigned to Delphi Round 2.

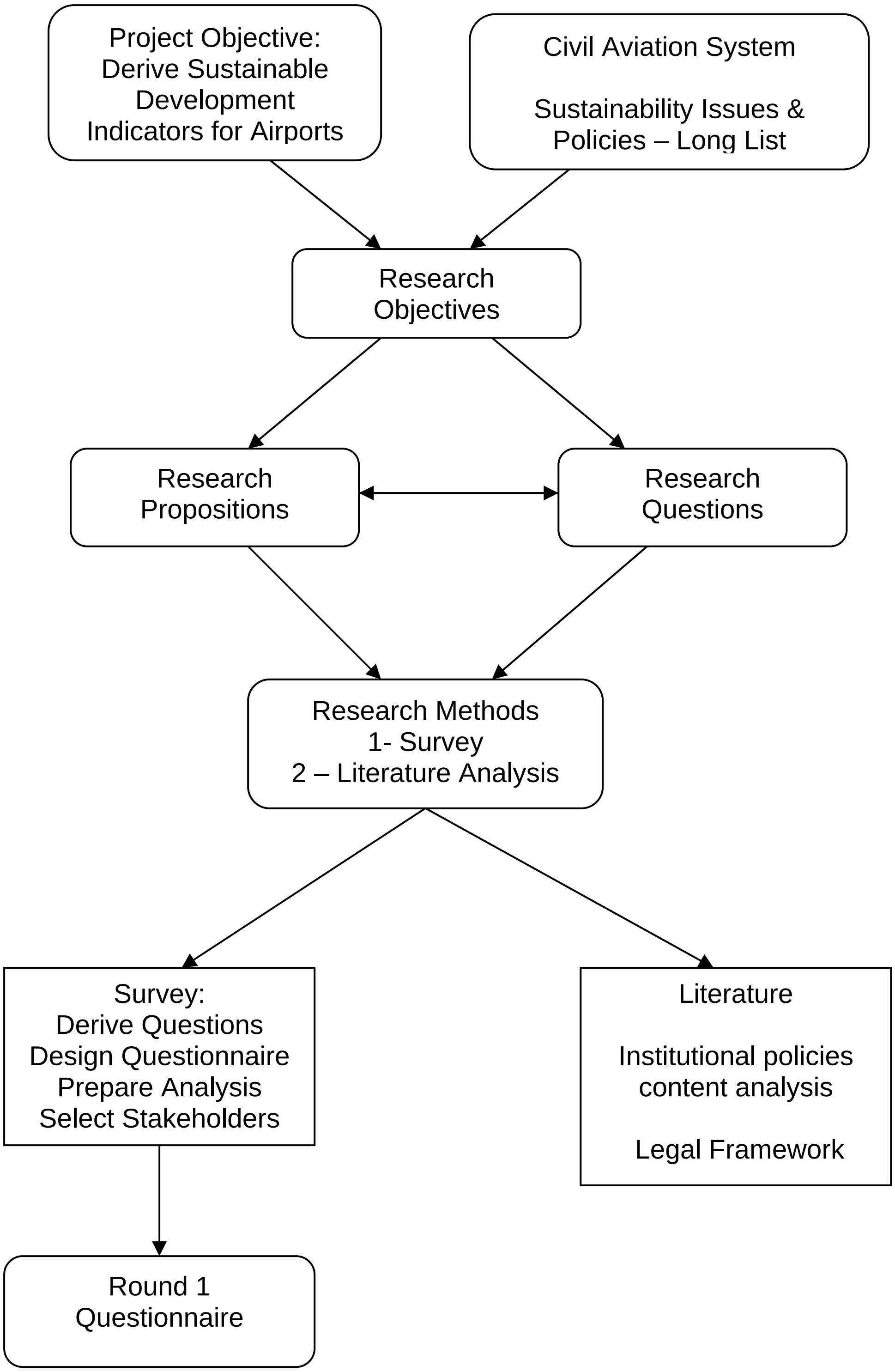


Figure 5.2 Delphi Round 1 – Derive Research Proposal

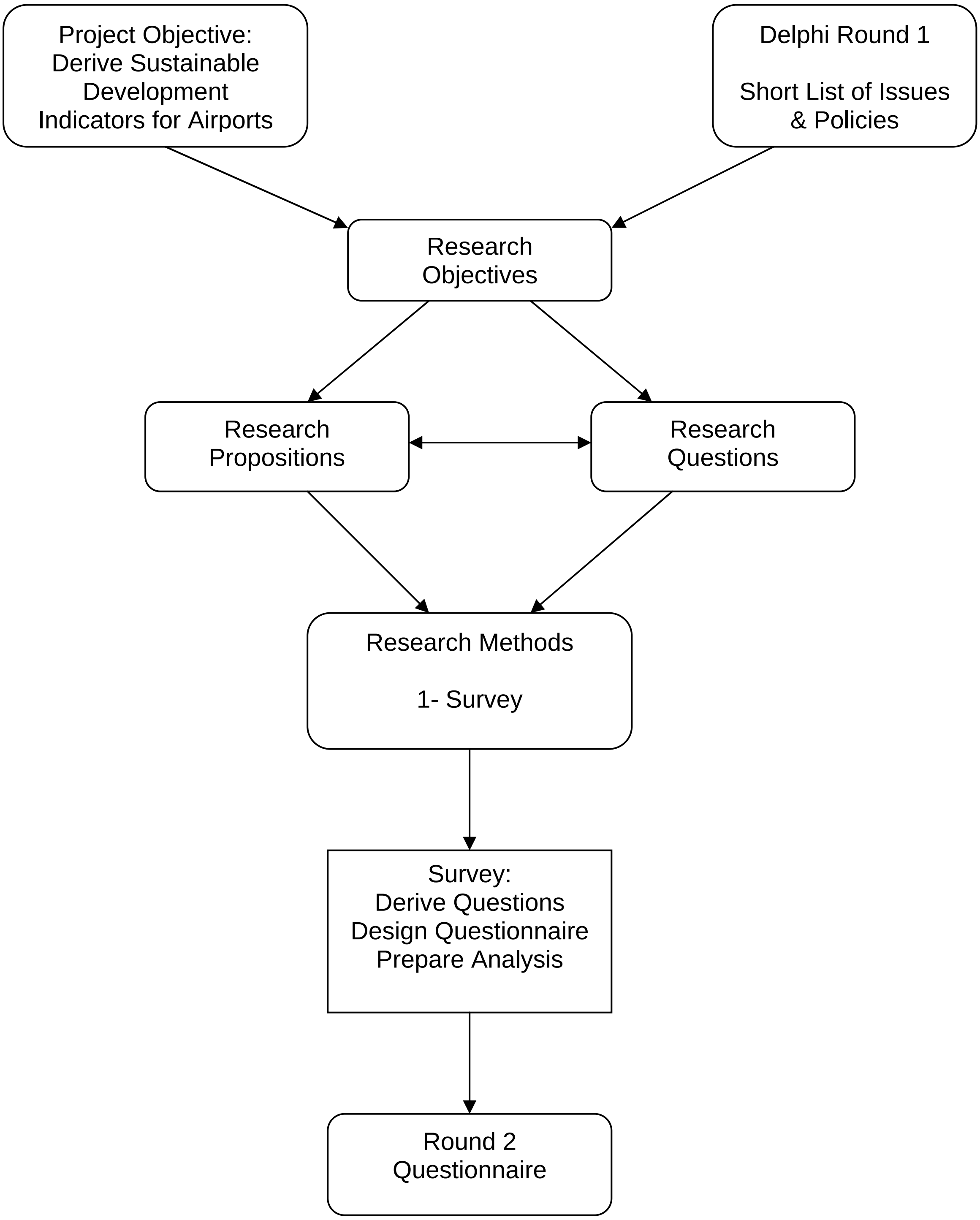


Figure 5.3 Delphi Round 2 – Derive Research Proposal

Round 1 Objectives

1 To determine stakeholder interpretations of sustainable aviation.

2 To determine stakeholder views of the most important factors for sustainable development in civil aviation.

3 To determine why the observed actions of the civil aviation industry diverge from the principles of sustainable development.

Round 2 Objectives

4 To explore stakeholder views on the purpose and scope of sustainable development indicators.

5 To obtain stakeholder views on suggested indicators of sustainable development for civil aviation.

The analysis of civil aviation raises the suggestion that opposition to certain sustainable developments may be institutionalised (Section 4.7.3). This is not taken as a specific research objective, though the research results are used to inform the debate at Section 6.10.

5.3.2 Research Propositions and Questions

Research propositions and corresponding research questions are derived (Table 5.1). The following commentary discusses each objective in turn.

Objective 1 – To determine stakeholder interpretations of sustainable aviation

The proposition is that there will be no agreement on the meaning of sustainable aviation, tested by questions to explore vision and goals.

Objective 2 – To determine stakeholder views of the most important factors for sustainable development in civil aviation

Stakeholder views on the importance of potential issues and actions for sustainable development of aviation from Chapter 4 are explored. The proposition is that there will be some agreement on the important issues, but significant differences on the most important policy actions. This is tested by research questions exploring the perceived importance of each issue and each policy action.

Objective 3 – To determine why the observed actions of the civil aviation industry diverge from the principles of sustainable development

There may be a large number of contributory factors to the divergence observed above. To address the issue a number of propositions are suggested:

- There is a low level of understanding of sustainable development.
- There is no agreement on the meaning of sustainable aviation.
- Commercial/ financial pressures dominate decision making.
- Institutional arrangements preclude sustainable development in civil aviation.

There is a low level of understanding of sustainable development

This proposition may be addressed by direct questions on the meaning of sustainable development or by an indirect assessment of the stakeholders' responses against sustainable development principles. Since this survey is primarily concerned with aviation, the latter approach is taken. The relevant question is "How do stakeholders' views relate to sustainable development principles?" Responses are assessed against sustainable development principles. No specific questionnaire questions are generated for this research question.

There is no agreement on the meaning of sustainable aviation

This proposition is covered at Objective 1.

Commercial/ financial pressures dominate decision making

The relevant question is "Why do you support this view on sustainable development?"

Institutional arrangements preclude sustainable development in civil aviation

This proposition requires some clarification. Three aspects of institutions are identified in Agenda 21 (Spangenberg et al. 2002b):

- Institutional Organisations (the formal organisations)
- Institutional Mechanisms (the formal rule sets and legal frameworks)
- Institutional Orientations (the implicit or informal systems of rules that structure the choices of actions of individual or collective actors within a society)

In this context, formal institutions include the regulatory, representative and operational organisations in civil aviation. The attitudes and arrangements of these organisations can be derived from an analysis of public statements on sustainable development visions and policies.

Institutional Mechanisms means the UK and international regulatory framework. Institutional Orientations, in the Spangenberg interpretation, include the informal rule sets or attitudes that apply within an organisation, and the wider cultural norms and role models within society as a whole. The former (attitudes within an organisation) falls within the scope of this research. The latter (culture and norms of society) represents a wider research area. Public attitudes to sustainable development in aviation are highly relevant to the demand side of air transport and may be a complex mix of attitudes to leisure travel, the perceived benefits resulting of air travel, and general views on environment and pollution. However, the objective of this project is to research the views of the civil aviation industry, and research in the area of public attitudes is considered to be outside the scope of this project. This may be an area for further research.

Thus the propositions may be refined to:
3.1 There is a low level of understanding of sustainable development.
3.2 Commercial/financial pressure dominates in civil aviation organisations.
3.3 Institutional orientations preclude sustainable development in civil aviation.
3.4 Organisational policies preclude sustainable development in civil aviation.
3.5 The legal framework precludes sustainable development in civil aviation.

3.3 Institutional orientations preclude sustainable development in civil aviation.
Institutional orientation is interpreted as the sets of rules and attitudes in an organisation which influence the choice of action of the decision makers. It is regarded as distinct from the organisational policy, but is concerned with the attitudes and beliefs of individuals within the organisation. The orientation may be assessed by individuals' attitudes to specific instruments for change, rather than to general principles. The research question is "What is your attitude to instruments for change in support of sustainable development?"

3.4 Organisational policies preclude sustainable development in civil aviation
The research question is "How do organisational policies relate to sustainable development issues?" The question may be addressed by a document analysis of the organisations' published visions and policies with respect to sustainable development, described in Section 6.4.3.

3.5 The legal framework precludes sustainable development in civil aviation
This proposition is covered by the regulatory analysis at Section 4.12.

Objective 4 – To explore stakeholder views on the purpose and scope of sustainable development indicators for civil aviation

It is expected that respondents may not have strong views. The proposition is that there will be general agreement on the purpose and scope of sustainable development indicators for civil aviation. Research questions are:

What are the purposes of sustainable development indicators for civil aviation?

What should be the scope of sustainable development indicators for civil aviation?

Objective 5 – To obtain stakeholder views on suggested indicators of sustainable development for civil aviation

The proposition is that there will be some agreement on which indicators should be used to assess progress towards sustainable development in civil aviation. The research question is ‘Which indicators should be used to assess progress towards sustainable development in civil aviation?’

Research Proposition	Research Question	Research Method	Questionnaire Round & Area
Objective 1 – To determine stakeholder interpretations of sustainable aviation.			
1.1 There is no agreement on the meaning of sustainable aviation.	What are your vision and goals of sustainable aviation?	Questionnaire	R1 – Vision
Objective 2 – To determine stakeholder views of the most important factors for sustainable development in civil aviation.			
2.1 There is some agreement on the most important issues relevant to sustainable development in civil aviation.	What sustainable development issues are relevant to civil aviation? Which issues are most important for sustainable development in aviation?	Questionnaire	R1 – Issues
2.2 There is little agreement on the most important actions relevant to sustainable development in civil aviation.	What sustainable development policy actions are relevant to civil aviation? Which policy actions are most important for sustainable development in aviation?	Questionnaire	R1 – Policy Actions
Objective 3 – To determine why the observed actions of the civil aviation industry diverge from the principles of sustainable development.			
3.1 – There is a low level of understanding of sustainable development.	How do stakeholders' responses relate to sustainable development principles?	Analysis	
3.2 – Commercial/ financial pressure dominates in civil aviation organisations.	What are the reasons for your views?	Questionnaire	R1 – Influences
3.3 – Institutional orientations preclude sustainable development in civil aviation.	What is your attitude to instruments for change in support of sustainable development?	Questionnaire	R1 – Instruments

Research Proposition	Research Question	Research Method	Questionnaire Round & Area
3.4 – Organisational policies preclude sustainable development in civil aviation.	How do organisational policies relate to sustainable development issues?	Document Analysis	
3.5 – The legal framework precludes sustainable development in civil aviation.	What UK and international law applies to sustainable development in civil aviation?	Literature Review	
Objective 4 – To explore stakeholder views on the purpose and scope of sustainable development Indicators for civil aviation.			
4.1 There will be general agreement on the purpose and scope of sustainable development indicators for civil aviation.	What are the purposes of sustainable development indicators for civil aviation? What should be the scope of sustainable development indicators for civil aviation?	Questionnaire	R2 – Purposes
Objective 5 – To obtain stakeholder views on suggested indicators of sustainable development for civil aviation.			
5.1 There will agreement on which indicators should be used to assess progress towards sustainable development in civil aviation.	Which indicators should be used to assess progress towards sustainable development in civil aviation?	Questionnaire	R2 – Indicators

Table 5.1 Research Objectives

5.4 *Questionnaire Design*

5.4.1 Approach to Deriving Questionnaire Questions

The literature offers much advice on derivation of questions e.g. (Bouma, Atkinson 1995, Bryman 2001, Czaja, Blair 1996, Frankfort-Nachmias, Nachmias 2000). This advice broadly covers guidance on whether or not to include a question and on the phrasing of the question.

Advice on inclusion essentially reduces to the twin criteria of necessary and sufficient to answer the research question. If the questionnaire question is necessary to explore the research question, then include it; if not, don't. If the research question is not sufficiently probed then derive further questions (Bryman 2001, Czaja, Blair 1996).

Advice on formulation of the question generally takes the form of suggesting that the researcher should avoid particular types of question or phraseologies – well summarised by Bryman:

> *Avoid ambiguous terms in questions*
> *Avoid long questions*
> *Avoid double-barrelled questions*
> *Avoid very general questions*
> *Avoid leading questions*
> *Avoid questions which are actually asking two questions*
> *Avoid questions which include negatives*
> *Avoid technical terms*
> *Does the respondent have the requisite knowledge?*
> *Make sure there is a symmetry between a closed question and its answers.*
>
> (Bryman 2001) *p149*

The above are generally sensible criteria, though there may be justification to vary some. For instance, avoidance of technical terms is intended to reduce misunderstanding, perfectly valid for a non-technical target group. However, for a technical survey directed at technical experts, it may be appropriate to use well defined technical terms, since they can contribute to precision and enhanced understanding.

Having offered advice on what to avoid in phrasing the questionnaire questions, authors seem to offer little practical advice on how to actually derive the questions i.e. what questions to ask. Perhaps there is an assumption amongst authors that the skilled and knowledgeable researcher will naturally know what questions need to be asked. In this project, the topics are rather complex, and the researcher did not find that question selection and construction occurred in any easy or intuitive manner. It was necessary to develop a systematic approach to this.

The objective is to develop questionnaire questions that will yield information to specifically answer the research question, and secondly to develop information analysis and display techniques that will reflect both the research proposition and research objective. The approach closely links research objective → research proposition → research question → questionnaire questions → information analysis → research objective, illustrated diagrammatically at Figure 5.4. The approach draws advice and techniques from a number of different authors, and combines these into a systematic process that suits the problem area and the researcher.

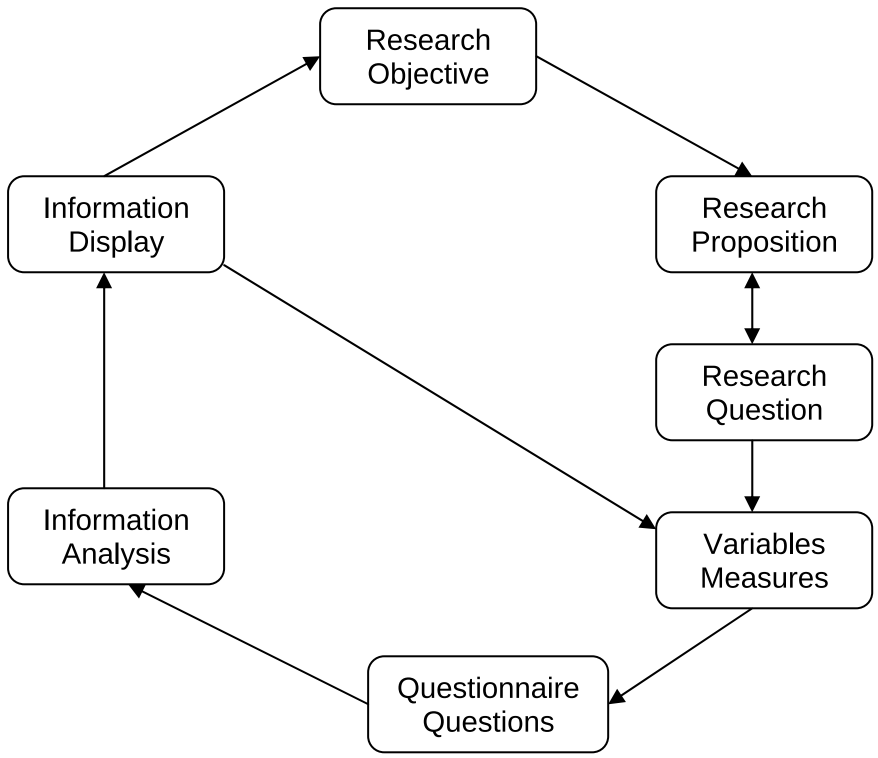


Figure 5.4 Derive Questionnaire Questions

For each research question the following data and information is derived and documented:

- Relates to
- Variables and Measures
- Questions
- Target Respondents
- Analysis and Display

Relates to

Many authors (Bouma, Atkinson 1995, Bryman 2001, Frankfort-Nachmias, Nachmias 2000) emphasise the need to relate the questionnaire questions to the research question, and thence to the objectives and hypothesis or proposition.

The relationship of the research question back to the research proposition(s) and research objective(s) is restated here to ensure prominence of the relationship.

Variables and Measures

It is suggested that the research question may be analysed into variables, a concept helpfully defined by Bouma and Atkinson:

> *What is a variable? A variable is a concept that varies in amount or kind. A variable is a concept of which it is possible to have more or less, or different kinds. The variables that interest us are variables which not only vary in amount or kind but are also measurable.*
>
> (Bouma, Atkinson 1995) *p 51*

The importance of measurement is emphasised by other authors, some giving the issue explicit and extensive coverage (Frankfort-Nachmias, Nachmias 2000), others rather assuming that a measurement is possible (Czaja, Blair 1996).

The approach adopted specifically identifies the variables needed to answer the research question, the measure and scale by which these variables are differentiated. Where the measurement is qualitative, the choice of scale may present some difficulty. In this case it may be useful to consider how the results will be displayed to illustrate the original objective; the display mechanism may help to clarify the scale(s) to be used. The diagram (Figure 5.4) shows a link from display to measurements.

Suggested scales (Bouma, Atkinson 1995) are attitude, frequency or timescale. Others may come from specialist measurement scales – normally an ordinal scale – relevant to the survey area e.g. a ladder of citizen participation (Arnstein 1969), a spectrum of sustainability (Pearce 1993).

The measurements and scales will influence the construction of the questions.

Question(s)

Questionnaire questions should be necessary and sufficient to answer the research question, and should not be included if they are not relevant to the research question (Bouma, Atkinson 1995, Bryman 2001, Czaja, Blair 1996). They should avoid the pitfalls of setting questions (Bryman 2001, Frankfort-Nachmias, Nachmias 2000). Additionally, the questions are constructed to seek out the identified variables and measures as discussed above.

In each question area, the use of open or closed questions is determined by considering the nature of the variables and how best to gain the information needed. Many of the questions in the questionnaire are constructed using lists of specific aspects of civil aviation or of sustainable development e.g. issues, actions, specific instruments for change. For each aspect, the source and reason for inclusion are documented.

Target Respondents

It is necessary to clearly identify whether each question is relevant to all or a part of the target respondents (Czaja, Blair 1996).

Analysis and Display

An initial view of how responses will be analysed and displayed (Bouma, Atkinson 1995) is developed. Where possible this view defines how the measurements are analysed, where to look for clustering of results, and how the information will be displayed to illustrate the original objectives and propositions.

5.4.2 Round 1 Questionnaire

For the Round 1 questionnaire, the questionnaire areas are identified at Table 5.1. For each area the questionnaire questions are derived using the approach outlined in section 5.4.1 above. The relationship to the research objective and proposition is shown at Table 5.1, and all questions are targeted at all respondents. The remaining three criteria are summarised below.

5.4.2.1 Vision

The questionnaire needs a short explanatory note of what is meant by a vision.

Measures

Variable	Measure	Scale
1 Existence of a vision	Respondent's opinion	Y/N
2 Existence of a vision	Goals	Number
3 Nature of vision	The goal definition – the variable – value – timescale	

Questions

1 Do you have a personal vision of any aspect of sustainable aviation in the UK?

Yes or No

Respondents can give their own answer of whether or not they have a vision.

2 In your vision of sustainable aviation, how should the following aspects change compared with current levels in the UK?

Increase/ decrease/ stay about same/ no opinion

The question introduces an indicative, but not comprehensive range of aspects, and asks for directional targets. Suggested aspects are derived from potential issues (Table 4.12), covering the size, benefits and disbenefits of aviation:

- Number of flights
- Aircraft greenhouse gas emissions
- People affected by daytime aircraft noise
- People affected by night time aircraft noise
- Employment benefits of airports

2a What other aspects are included in your vision of sustainable aviation?
Free format question giving the respondent the opportunity to raise other aspects.

3 Do you have any quantified targets, goals or limits for any future aspect of civil aviation? Yes or No
This question introduces the idea of a quantified target.

3a If you have any quantified goals, targets or limits, would you please define these? What aspect does the target apply to? What is the target?
These questions allow a free format response on targets, and need an explanatory note on the nature of a target.

5.4.2.2 Issues

Measures

Variable	**Measure**	**Scale**
1 Importance of issue	Perceived Importance	Likert scale 1→5
2 Other issues		
3 Comments	Open	

The perceived importance is measured on a 5 point scale ranging from very important to very unimportant, the Likert scale (Bouma, Atkinson 1995, Frankfort-Nachmias, Nachmias 2000).

Questions
1 Please indicate how important you think each of the following issues is to the sustainable development of civil aviation: Very high → Very low.
2 Are there any other issues that you believe are important for, or not relevant to, the sustainable development of civil aviation? Very high → Very low.
3 Do you have any comments on any of the above issues?

Question 1 is designed to obtain respondents' views on the issues identified at Chapter 4 Table 4.12. The original list of 25 issues is reduced to 21 for the questionnaire:

- Airport waste (solid waste and water runoff) is combined into one issue
- Aircraft efficiency of new aircraft and total fleet are combined into one issue
- 'Unsustainable consumption pattern' and 'Sustainability of Aviation' are considered too vague to include in questionnaire

The order of the issues in the questionnaire is randomised using a random sequence generator (TCD 1999).

Question 2 enables respondents to suggest other issues: the last question is open for any relevant views.

5.4.2.3 Actions

Measures

Variable	**Measure**	**Scale**
1 Importance of action	Perceived Importance	Likert scale (–2→+2)
2 Other actions		
3 Most important actions	Priority order	5 → 1
4 Reason	Open	

Questions

1 Please indicate how important you think each of the following policy actions is to the sustainable development of civil aviation: Very high→ Very low.
2 Are there any other policy actions that you believe are important for, or are not relevant to, the sustainable development of civil aviation? Very high→ Very low.
3 In your opinion, which are the most important policy actions needed to move towards sustainable aviation? Please rank up to five policy actions.
4 Why do you think these policy actions are the most important?

The list of policy options at Question 1 is based on potential actions derived in Chapter 4 Table 4.17, modified as shown in Table 5.2 and the following notes showing reasons for not including potential actions in the questionnaire:

Source	Action	Ref	Include
Ch 2 Developing Countries	Make trade and environment mutually supportive	4.5.3.1	Note 1
Ch 3 Combating poverty	Spread benefits of aviation to deprived areas and unemployed	4.5.2.1	Y
Ch 4 Changing consumption patterns	Improve fuel efficiency of new aircraft	4.5.3.2	Y
	Accelerate phase-out of old aircraft	4.5.3.2	Y
	Develop renewable energy for aviation	4.5.3.2	Y
	Improve efficiency of air traffic management	4.5.3.2	Y
	Environmental product information for air passengers and air cargo	4.5.3.2	Note 2
	Government purchasing of air transport services	4.5.3.2	Note 3
	Environmentally sound pricing of air transport services	4.5.3.2	Note 4
Ch 4 & Ch 36	Public awareness campaign	4.5.3.2/ 4.5.2.3	Note 2
Ch 6 Human Health	National noise criteria	4.5.2.2	Y
Ch 8 Integrating environment and development in decision making	Integration at policy level	4.5.5.1	Y
	Provide legal framework for integration	4.5.5.1	Note 5
	Use economic instruments for integration	4.5.5.1	Note 6
Ch 9 Protecting the atmosphere	Limit harmful emissions from civil aviation	4.5.4.1	Y
	Investment into carbon sinks	4.5.4.1	Y
Ch 9 & Ch 35	Research into effect of aircraft emissions	4.5.4.1/ 4.5.5.4	Y
Ch 23 Participation	Public participation in airport environmental decisions	4.5.5.2	Y
Ch 30 Role of Business	Aviation sector sustainable development strategy	4.5.5.3	Y
Ch 35 Science	Research into effect of aircraft emissions	4.5.5.4	Y
Ch 38 International institutional arrangements	ICAO programme for sustainable development	4.5.5.5	Note 7
Ch 40 Information	ICAO develop sustainable development indicators	4.5.5.6	Note 7

Table 5.2 Potential Policy Actions for Questionnaire

Note1 – Make trade and environment mutually supportive – this is considered too vague and elusive a concept to be included in the questionnaire.

Note 2 – Public awareness campaign and environmental product information are combined.

Note 3 – Government purchasing is considered to be a small element in total civil aviation – omitted.
Note 4 – Environmentally sound pricing may not be meaningful to respondents and is rephrased as external cost internalisation.

Note 5 – Legal framework for integration may not be meaningful to respondents – omitted. The legal framework is assessed at Section 4.12.
Note 6 – Use of economic instruments for integration is not separable from environmentally sound pricing and is omitted as a separate question. Attitudes to economic instruments are explored at the Instruments section of the Round 1 questionnaire.
Note 7 – Actions relating to ICAO initiatives are grouped together as one question.

This list is augmented by two policies derived from Rio Principles (Section 4.3.14, Table 4.12):

- Use of environmental impact assessment
- Effective Environmental Legislation

The consolidated list of actions included in the questionnaire is shown at Table 5.3. The order is randomised using a random sequence generator (TCD 1999).

Actions from Agenda 21
Spread benefits of aviation to the unemployed
Improve fuel efficiency of new aircraft
Accelerate phase-out of old aircraft
Develop renewable energy for aviation
Improve efficiency of air traffic management
Civil aviation to pay full external environmental costs
Public education on sustainability of air transport
National noise criteria
Integrate environment and development in civil aviation policy making
Sponsorship of atmospheric research by civil aviation sector
Limit greenhouse gas emissions from civil aviation
Investment in carbon sinks (e.g. forests)
Community participation in airport environmental decisions
UK sustainability strategy for civil aviation
ICAO program for sustainable aviation
Environmental impact assessment for all civil aviation activities
Effective environmental legislation for civil aviation

Table 5.3 Policy Actions included in Questionnaire

5.4.2.4 Instruments for Change

Measures

Variable	Measure	Scale
1. Attitude to specific instruments in favour of sustainable development	Level of Support	Likert scale (+2→-2)
2. Other instruments		
3 Reason	Open	

Questions

1. Please indicate your level of support for the following potential instruments for change: Strongly support → Strongly oppose.

2. Are there any other potential instruments for change that you support or oppose?

3. What are the reasons for your views on economic and legal instruments?

The objective of the questions is to assess respondents' attitudes to change, rather than to research all the potential effects of each instruments. The instruments chosen for the questionnaire do not need to be comprehensive, but should be limited in number, commonly understood by respondents, representative of the range of possible instruments and selected to elicit a clear response. In selecting instruments for the questionnaire it is helpful to consider how the results are analysed and displayed.

Analysis and Display

Responses are analysed against the sustainability spectrum (Pearce 1993), and potential questions show answers from Very weak to Very strong (Table 5.4).

Sustainability	Type of economy	Type of Instrument
Very weak	Anti-green – free market	None
Weak	Green – use of economic incentive instruments	Environmental charges, Economic incentive instruments
Strong	Deep green - macro environmental standards	Limit on GHG Emissions Limit on noise
Very strong	Very deep green - minimise resource take	Limit on use of aviation fuel

Table 5.4 Sustainability Spectrum – Instruments for Civil Aviation

Source: Author

The instruments may broadly be considered as:

- Environmental charges – designed as a charge on an environmental issue
- Economic instruments – designed to affect demand
- Legal controls on performance, inputs or outputs

These are convenient groupings from which to select a number of representative instruments - no more than 3 or 4 from each group. Agenda 21 supports the use of instruments in these areas, but does not prescribe specific instruments. There are numerous suggestions for environmental charges and economic instruments for aviation, though no single definitive list presents itself. Examples are shown below and summarised at Table 5.5.

Pastowski (Pastowski 2003) suggests: Phase out subsidies, kerosene tax, Emission charge, Trust fund charge (using money for research and mitigation), Emissions trading.

IPCC (IPCC 1999) supports: Levies on fuel (kerosene tax), En-route charges, Emissions trading.

The Aviation Environment Federation (AEF) (Sewill 2003) supports: Tax on aviation fuel, VAT on air travel, Remove duty free concessions, Runway slot auctions at congested airports.

The UK Sustainable Development Commission (SDC 2004) suggests that an economic framework for airports should include: Dual till accounting (to avoid cross subsidies from non-aeronautical income), Peak load pricing at airports, Airport slot auctions, Emissions charge, Noise 'allowances' trading.

UK Commission for Integrated Transport (CFIT 2003) espouses: CO_2 Emissions trading, En-route charge based on CO_2 emissions, Noise charges, Charges on local emissions (NOx, HC and PM_{10}), Congestion charging, Slot auctions.

The Institute of Public Policy Research (Bishop 2003) suggests: Tax on aviation fuel, VAT on air travel, Remove duty free, Remove cross-subsidy of non aeronautical income at airports.

Environmental Charges	**Economic Charges**
Tax on aviation fuel	Phase out subsidies
Emission charge	Trust fund charge
Emissions trading	VAT on Air Travel
En-route charges	Remove duty free concessions
Noise 'allowances' trading	Runway slot auctions
Noise charges	Dual till accounting (to avoid cross subsidies from non-aeronautical income)
Charges on local emissions (NO_x, HC and PM_{10})	Peak load pricing at airports / Congestion charging
	Develop alternatives to business travel e.g. video-conferencing
	Make business air travel non tax deductible

Table 5.5 Possible Environmental Charges and Economic Instruments

Some authors have suggested very specific changes to reduce demand e.g. develop alternatives to business travel e.g. video-conferencing (Lucas 2003, Whitelegg 2003), make business air travel non tax deductible (Whitelegg 2003).

The basis of an emissions trading scheme is to set a cap or maximum limit to the emissions permits. Thus it may be regarded as a regulatory limit on emissions, but is normally regarded as an economic measure.

Environmental charges are selected to include the major environmental problems – greenhouse gas emissions and noise (Table 5.6). Selected economic instruments should be significant and easy to understand. In financial terms, VAT may be worth more than £4bn per annum (Sewill 2003). Airport dual till and Runway slot auctions are seen by the Sustainable Development Commission (Pearce 2004) as important means of introducing true costing into the airport framework.

The Rio Declaration and Agenda 21 have general references to the use of legislative frameworks and recommend that national legislation should include compensation and national noise criteria. The former is supported in the UK by the Sustainable Development Commission (Pearce 2004). The latter is supported by the UK Aviation Environment Federation (Johnson 2003a) and in the form of noise permits by UK

Sustainable Development Commission (Pearce 2004) and Commission for Integrated Transport (CFIT 2003). Schipol airport would seem to already apply a regulatory noise limit (Krul 2003).

Many authors suggest limits on local air quality e.g. (Pastowski 2003). These are already incorporated into EU Law (EU 1996) and thus will not be included in the questions.

The economic instruments above are forms of economic incentive instruments within the weak sustainability. Legal instruments limiting environmental outputs e.g. emissions or noise, represent a move towards strong sustainability and regulatory limits on resource use towards very strong. It is thus possible to include questions on legal instruments to span the range of sustainability levels.

Type	**Instrument**	**Sustainability Label**
Legal	Liability and compensation	Weak
	Noise limits	Strong
	Emission limits	Strong
	Limits on Resource use	Very Strong
Environmental charges	Tax on aviation fuel	Weak
	Emissions trading	Strong
	Noise charges	Weak
Economic	VAT on Air Travel	Weak
	Dual till accounting at airports	Weak
	Runway slot auctions	Weak

Table 5.6 Instruments included in Questionnaire

5.4.2.5 Influences

Measures

Variable	**Measure**	**Scale**
1. Factors influencing opinion	Relative importance of factors	5 point scale
2. Other Factors	Open	

Questions

1. Your views on sustainable aviation may be influenced by many different factors that can be difficult to reconcile. Some of these factors are arranged on scales below. Please locate your position on each of the scales by selecting the appropriate box.

2. Are there any other major factors that influence your vision of sustainable aviation?

The major reasons for respondents' attitudes are postulated to be economic and environmental. The question is designed to elucidate whether financial pressures dominate attitudes in civil aviation, and sets economic factors against environmental factors.

A subset of the major influences is selected:

- Economic – Airport employment benefits and Airport/airline profitability
- Environmental – Climate change and Noise

5.4.3 Round 2 Questionnaire

The relationship between questionnaire questions and research proposition is summarised above (Table 5.1). The questions apply to all respondents to the questionnaire.

5.4.3.1 Indicator Purpose & Scope

Measures

Variable	Measure	Scale
1 Purpose of indicators	Perceived Importance	Likert scale (–2→+2)
2 Other purposes		
3 Scope of indicators		
4 Other aspects		

Questions

1. Sustainable development indicators for civil aviation should be designed to:
(List of Purposes)
Agree strongly/ agree/ no view/ disagree / strongly disagree
2. Other purposes
3. Sustainable development indicators for civil aviation should provide information about: (List of aspects of scope)
Agree strongly/ agree/ no view/ disagree / strongly disagree
4. Other aspects

For Question 1, the suggested purposes of indicators are derived from Agenda 21 (Table 2.2):

- Inform the decisions of national government policy makers
- Inform the decisions of local government policy makers
- Inform the decisions of airline & airport managers
- Inform the decisions of air transport consumers – freight users and passengers
- Provide public information

For Question 3, the suggested information aspects are derived from Agenda 21, shown as Scope in Table 2.2 with clarification of institutional aspects. Thus aspects included are: Social and economic, Environmental, Public participation, Regulatory arrangements, Effect of programmes for change, Progress towards agreed targets.

5.4.3.2 Suggested Indicators

Measures

Variable	Measure	Scale
1 Indicator needed	Perceived need	Y/N
2 Indicator suitable	Perceived suitability	Y/N
3 Other indicators	Open	
4 Comments	Open	

Questions

The following are possible indicators of sustainable development in civil aviation. For each indicator please show whether you think

- the indicator is needed

- the indicator is suitable to give the information required.

The list of potential indicators is derived from the short list of issues and actions from the Round 1 analysis (Section 6.6). In the Round 1 questionnaire, the issues and actions are arranged in random order so as not to influence responses. In this questionnaire, it is considered necessary to place indicators in groups so that respondents may more readily prioritise preferences for similar indicators. The groups are selected to reflect physical or logical connections:

- Consumption and efficiency of air transport
- Local airport impacts
- Economic aspects
- Current change programmes
- Institutional and legislative arrangements

The issue of unsustainable consumption patterns and the environmental cost of trade are omitted from Round 1 Questionnaire (section 5.4.2.2). Two indicators reflecting the environmental cost of aviation benefits (Energy ratio of local economic benefits and Energy ratio of contribution to GDP) are included to assess respondents' views.

5.5 *Delphi Study: Practical Application*

5.5.1 Selection of Experts

5.5.1.1 Approach to Selection

Many authors on sustainable development indicators recommend that expert opinions be sought from the interested stakeholders (Bell, Morse 1999, Bossell 1999, Mitchell, May et al. 1995). Most authors seem to assume that the stakeholders in the system will be obvious and effectively self-selecting, and few offer any practical advice on how appropriate stakeholder groups or individuals may be identified.

Within civil aviation, authors may identify the stakeholders with an interest in a specific part of the aviation system, e.g. stakeholders of the passenger terminal building (de Neufville, Odoni 2003). A wider view of stakeholders is offered by Caves (Caves, Gosling 1999):

The stakeholders of the system comprise:

- *the owners of the system's components*
- *the operators of the system's components*
- *the suppliers of the system's components*
- *the users*
- *the regulators*
- *those affected by the system*

Caves identifies the system components as aircraft, airports and the available airspace, though the precise definition of stakeholder groups is not given. The scope of groups identified by Caves is global, but for reasons of scale and accessibility, this survey is limited to UK civil aviation, and selected organisations are primarily UK based. Even within the UK, there are very large numbers of stakeholder organisations and it is impracticable to attempt comprehensive coverage. Thus selected organisations should represent the major players within the industry, and a range of opinions outside, but affected by, the industry. Because the survey is rather specialised, it is necessary to identify the individual respondent within each organisation, and to obtain his/her agreement to take part in the survey.
Identification of individuals becomes a selection hierarchy:

- Stakeholder groups
- Specific organisations
- Individual within each organisation.

5.5.1.2 Identify Stakeholder Groups

Stakeholder groups are described below and summarised at Table 5.7.

Owners and Operators. Aircraft are owned and operated by airlines, airports by airport companies. In the privatised ownership model in place in the UK, the owners strictly are shareholders, but policies on sustainable development are primarily formed and implemented by the airline and airport companies. Thus airlines and airport companies are regarded as the relevant organisations.

For airspace, there is no owner as such, but the operators may be regarded as the air traffic services providers - National Air Traffic Services (NATS) in the UK, and Eurocontrol in Europe.

Operators may also be taken to include the personnel who actually work in the industry – aircrew and land based workers. Trade unions are included in this group.

Suppliers. There are numerous suppliers and sub-contractors to the aviation industry. In this context the suppliers of major components are included i.e. aircraft, engine and fuel suppliers.

Many other suppliers should be included in other sustainable development systems e.g. airport construction companies are part of the civil engineering system (ICE 2002); ground vehicle suppliers are included in the automotive industry system (SMMT 2000).

Users. Caves (1999) assumes ‘User’ to mean the consumer of air services and specifically discusses air passengers. For completeness, the term also includes the originator of freight consignments. Users of civil aviation may be interpreted as the consumer (as Caves assumes), or the representatives of the demand systems – e.g. tourism, just-in-time delivery systems. In this thesis the former is assumed – i.e. the consumer or passenger. In the systems model envisaged in this thesis, there should be a separate sustainable development system for each demand system (Sections 3.4.5 and 4.3.3).

Regulators. The term Regulators is not defined by Caves. It is taken here to mean the bodies which formulate and apply regulations. The former includes national government and parliamentarians, the latter the national aviation authority (CAA) and Local authorities. Thus within the UK Regulators are taken to include:

- National regulators including Government departments, statutory and advisory bodies
- Local regulators – Local authorities with an airport in their area
- Parliamentarians

There is a wider interpretation of regulator, to including decision makers in ICAO and the European Union. It is recognised that such regulators are extremely important in influencing the development of civil aviation in the UK, but for reasons of scale, these are not included in this stakeholder selection. Attitudes amongst these regulators may be the subject of further research.

Those Affected. Caves takes the term 'Those affected' to mean the local airport community. In terms of the sustainable development system, other bodies may be considered to have an interest in the wider (non-local) effects of aviation i.e. national and international environmental groups, and bodies concerned with sustainable development.

Other Groups. In the UK, many other groups with a valid interest in Civil Aviation may not be directly included as stakeholders in the above definitions.

At the major UK airports, there are Airport Consultative Committees (ACC), set up as a result of the Civil Aviation Act 1982 section 35 (UK Government 1982), to provide facilities for consultation between the airport and airport users, local authorities and local interest groups. The act confers no powers on these committees, though clearly each committee will have an interest in the development of the relevant airport. The committees include a diverse range of interests largely represented in the stakeholder groups above.

A number of UK academic institutions have groups concerned with air transport or sustainability studies, but do not qualify as stakeholders. Similarly excluded are general aviation, recreational and enthusiasts' groups.

Groups	**Included**	**Not Included**
Operators	Airlines, Airports, Air Traffic, Trade Unions	
Suppliers	Airframe manufacturers Engine manufacturers Fuel suppliers	Subcontractors to manufacturers Construction industry Automotive industry Service suppliers
Users	Passengers Freight consigners	Trade bodies
Regulators	National Government Statutory bodies Local Government Parliamentarians	
Those Affected	Local Community Environmental groups Sustainable Development groups	
Others		Airport Consultative Committees Academic institutions General aviation Recreational groups Enthusiasts' groups

Table 5.7 Civil Aviation Stakeholder Groups

5.5.1.3 Identify Target Organisations

The stakeholder groups above were split into subgroups and up to 10 target organisations were identified for each subgroup according to the criteria in Table 5.8.

5.5.1.4 Identify Stakeholders

Respondents to this survey needed knowledge and expertise in the environmental impacts or sustainable development issues of civil aviation. Individual respondents were selected according to criteria summarised in Table 5.8. Respondents had organisational responsibility for, or in the case of Parliamentarians, interest in and knowledge of, these matters.

At the time of the research, only one UK airline had an environmental manager as a specific appointment: environmental issues in airlines were generally subsumed into wider management roles such as 'Corporate Responsibility' or fleet management. In contrast, most airports had a specific management role covering environmental duties. This difference may illustrate lower management priority for environmental issues in airlines compared to airports.

For National Regulators, respondents were specialists with nominated responsibility for aviation environmental issues, though the specific management title varies between department and organisation. Respondents from Local authorities were normally planning or environmental officers with responsibility for aviation issues, including one nominated Aviation Strategist.

Selected MPs represented a constituency with, or affected by, an airport and have displayed an interest or expertise by membership of the All Party Group on Sustainable Aviation and/or by taking part in Parliamentary debates on aviation.

Stakeholders within each organisation were identified by a number of means: previous knowledge, recommendation, direct introduction, enquiry to organisation. In each case, the identified stakeholder was contacted to obtain positive agreement to take part in the survey. When an identified stakeholder was unwilling to take part, an alternative within the same or a similar organisation was sought.

Stakeholder Organisation		Target criteria	
Group	**Subgroup**	**Stakeholder organisations**	**Individual Stakeholders**
Operators	Airlines	UK owned or based airlines Cover the majority of UK air services Range of different types of airline Representative organisations	Environmental manager
	Airports	UK Airports Cover the majority of airport capacity Representative organisations	Environmental manager
	Air Traffic	NATS, EuroControl	Manager responsible for environmental issues
	Trade Unions	Flight crew and ground workers	Officer responsible for aviation issues
Suppliers		Airframe, aero engine, fuel	Manager or spokesman for environmental policy
Users		Passenger representative groups Cargo representative groups	Spokesman with knowledge of environmental issues
Regulators	National	National Government – DfT, DEFRA, DTI Statutory bodies – CAA Advisory bodies	Specialists with nominated responsibility for aviation environmental issues
	Local	SASIG, Airport Local authorities	Officer responsible for aviation issues
	Parliamentarians	Members of Parliament	Constituency affected by airport; knowledge and interest in aviation issues
Those affected	Local Community	Aviation Environment Federation, Local residents' groups	Spokesman with organisational responsibility for aviation environmental issues
	National	Environmental/ Sustainable Development groups	Nominated environmental expert

Table 5.8 Selection Criteria for Organisations and Stakeholders

5.5.2 Round 1 Survey Process

Both rounds of the survey were designed as electronic e-mail based surveys. The questionnaires were intended to be completed and returned electronically and used tick boxes and drop-down menus as appropriate. However, the questionnaires were designed in the A4 page format and may be printed and completed as hard copy should respondents prefer: in this case there would be restricted space for the open responses. Communication with respondents was by email after the initial contact.

The Round 1 questionnaire is (Appendix 3), follows the question areas outlined in Table 5.1. The questionnaire was subject to review by a panel included academic and industry members. Academic reviewers were researchers and staff within Loughborough University, having experience of air transport and questionnaire design. Industry reviewers with knowledge of aviation environmental issues, were recruited from airports in Canada and New Zealand, avoiding industry stakeholders in UK. Reviewers provided a range of comments, which were all considered and incorporated as appropriate. Each reviewer was informed by email of the action taken on each comment.

Potential respondents were identified as outlined above (section 5.5.1), and contacted to ascertain whether he/she would be willing to take part in the survey. Respondents were sent the questionnaire with a covering letter. If no response was received, reminders were sent after 14 and 28 days. On receipt of a response, a personal letter of thanks was sent. All letters and reminders were individual to the respondent, and sent by email. Round 1 respondents were asked whether they wish to receive a summary report and would be willing to take part in the second round survey. Samples of letters and the Round 1 summary report are shown at Appendix 4.

5.5.3 Round 2 Survey Process

The Round 2 Questionnaire is shown at Appendix 5 and R2 sample letters at Appendix 6. The questionnaire and covering letter were sent to Round 1 respondents who indicated willingness to take part in Round 2. A chase letter was sent after 14 and 28 days if no response was received. When a response was received a personal letter of thanks was sent. Following the analysis of Round 2 a summary was sent to respondents.

5.5.4 Research Responses

The responses for Round 1 and Round 2 questionnaires are shown at Table 5.7 for each stakeholder group and subgroup. The overall response rate for Round 1 was high (85%): this is considered to be due to obtaining respondents' agreement prior to the survey, and the rigorous two stage chase procedure. Also, in some cases, a questionnaire sent to a representative organisation resulted in more than one respondent e.g. Users, Environmental groups. 75% of Round 1 respondents indicated a willingness to take part in Round 2. Round 2 response rate was 77%. Low numbers of respondents were noted in the User and Air Traffic Management (ATM) groups. The former reflects some difficulty in identifying independent user organisations: the latter reflects perceived difficulties by employees of the major ATM supplier in offering personal opinions.

Responses were received from stakeholders in the major airports (BAA, Manchester Airports Group, and Birmingham) plus a number of regional airports and from the major UK full service airlines (BA, Virgin and BMI) plus a number of low cost, inclusive tour and integrated freight airlines. Together these covered the majority of airport and airline activity in the UK, and gave a reasonable representation of the views of industry stakeholders.

Stakeholder Group	**Stakeholder Sub-group**	**Round 1**		**Round 2**	
		Sent	**Ret**	**Sent**	**Ret**
Operator	Airports	13	9	6	6
	Airlines	13	10	7	3
	ATM	2	1	0	0
	Trade Unions	4	4	4	4
Suppliers		7	6	5	3
Users		2	3	3	3
Regulators	National Government	7	8	5	5
	Local Government	10	9	9	6
	Parliamentarians	14	8	4	3
Those Affected	Environmental Groups	7	9	6	4
	Local Community	9	8	7	6
Total respondents		88	75	56	43

Table 5.9 Questionnaire Responses

CHAPTER 6 Civil Aviation & Sustainable Development: Stakeholder Views

6.1 *Introduction*

The objective of Chapter 6 is to report and analyse the research findings. Stakeholder personal views are explored by questionnaires in a two round Delhi study while organisational policies of airlines and airports are analysed by analysis of published documentation. The research objectives, propositions and questions for both questionnaires and for the document analysis are described in Chapter 5. The overall structure of this chapter follows the two round Delphi process, each section corresponding to a research objective from Chapter 5:

6.2 – Round 1 Interpretation of Sustainable Development

6.3 – Round 1 Sustainable Development in Aviation

6.4 – Round 1 Reasons and Orientations

These sections analyse the round 1 questionnaire responses, and section 6.4 also includes document analysis of organisational policies. The following two sections explore stakeholder differences, and prioritise findings:

6.5 – Round 1 Explore differences

6.6 – Round 1 Prioritise Findings

Round 2 responses are analysed in:

6.7 – Round 2 Purpose of Indicators

6.8 – Round 2 Stakeholder Indicator Selection

For each research objective, the descriptive section follows a similar pattern:

1 Statement of research objective, proposition and research method.

2 Analyse responses. This may cover several aspects.

3 Assess results against proposition and objective.

Section 6.9 considers stakeholders' understanding of sustainable development, and section 6.10 summarises the findings of the research.

Confidentiality

All respondents are assured of confidentiality, and that comments and specific responses will remain non-attributable. Responses are recorded in a database identified solely by a unique response number, with no personal identification data. All analysis is carried out without personal identification data and results are attributed only to stakeholder group or subgroup, rather than to individual.

Stakeholder Groups

Respondents are categorised into stakeholder groups and sub-groups (Table 5.8), repeated here for convenience:

Stakeholder Group	Stakeholder Sub-group
Owner/Operator	Airports and representative bodies
	Airlines and representative bodies
	Air Traffic Management
	Employees (Trade Unions)
Suppliers	Airframe, engine, fuel
Users	Users
Regulators	National - Government departments, National Advisory Bodies, Statutory Bodies
	Local Government
	Parliamentarians
Those Affected	Environmental Groups
	Local Community

The research specifically asks for personal, not official company views. Throughout this analysis, use of the group or subgroup name as a descriptor, means respondents from that group e.g. Operator means ‘respondents from the Operator Group’, and does not necessarily represent official views of the operator companies.

Terminology

Major sections of the Round 1 questionnaire are based on issues, policy actions, specific instruments and visions/targets, relevant to sustainable aviation. Within the sustainable development model used in this thesis (Table 3.1), these concepts have distinct meanings: targets define the vision and goals; issues arise from the systems boundary definition; policy actions are policies derived from Agenda 21; instruments are specific legal or economic measures designed and implemented to achieve the chosen target. These, or similar terms, are widely used in various forms in the literature pertaining to sustainable development (Hardi, Zdan 1997), environment (Ison, Peake et al. 2002), and sustainable aviation (Pastowski 2003), but with differing interpretations: there is no consistent definition across the literature (McLellan 2003). In the survey, respondents are able to give free format responses on all of these topics (targets, issues, policies, instruments), though it is clear that many respondents do not differentiate between these terms, and readily interchange issues, policies and specific instruments. So for instance Emissions Trading is included in the questionnaire as a specific economic instrument, but appears in responses variously as target, issue, and policy. This overlap of concepts is not regarded as problem, but is incorporated into the analysis of the free-format responses in the sections affected.

6.2 *Round 1 – Interpretation of Sustainable Aviation*

Research Objective 1 – To determine stakeholder interpretations of sustainable aviation.

Research Proposition 1.1 - There is no agreement on the meaning of sustainable aviation.

Questions are included in Round 1 questionnaire Section 4 'Visions of Sustainable Development' (Appendix 3) and derived at Section 5.4.2. The section starts with general questions on vision and progressively narrows the questioning to ask for goals and quantified targets.

6.2.1 Visions of Sustainable Aviation

Question. Do you have a personal vision of any aspect of sustainable aviation in the UK? Yes, No or Not sure

A high number of respondents give no response to the question i.e. they make no choice from the drop-down menu (Table 6.1). There is no technical problem with the question (the choices appear correctly) and it seems unlikely that respondents are unable to use the format of the drop-down choice question: several later questions in this format are answered without difficulty. It appears that many respondents either do not understand what is meant by a vision of sustainable aviation, or if they do understand the concept, are unwilling to state that they do not have such a vision.
26 respondents (35% of the survey) claimed that they do have a vision of sustainable aviation.

	Yes	No	Not sure	No response
Do you have a vision?	26	4	3	42
Percentage	35	5	4	55

Table 6.1 Respondents with Vision of Sustainable Aviation

Question. In your vision of sustainable aviation, how should the following aspects change compared with current levels in the UK?

- ***Number of flights***
- ***Greenhouse gas emissions from aircraft***
- ***People affected by daytime aircraft noise***
- ***People affected by aircraft noise at night (23.00-07.00)***
- ***Employment benefits of airports***

A general pattern emerges (Figure 6.1) of a desire for increases in the beneficial aspects of civil aviation while at the same time reductions in the disbenefits.

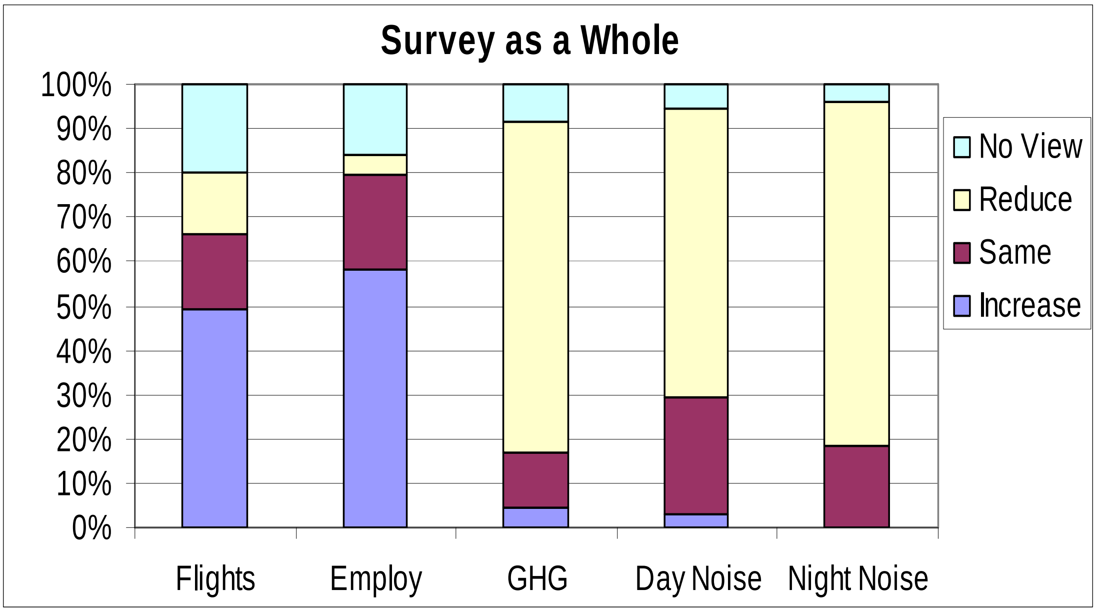


Figure 6.1 Visions of Sustainable Aviation – Survey as a Whole

There are marked variations between stakeholder groups on this overall vision. Respondents from Operators (Figure 6.2) display very strong vision of increased flight numbers (77%) and airport employment (100%), but have somewhat mixed views on the disbenefits. A majority expect greenhouse gas emissions to reduce (59%) but 22% of airline respondents expect GHG emissions to increase. Many of those expecting increased flights also, rather inconsistently, expect reduction in GHG emissions: few operator respondents actually equate increased flights with increased emissions. On noise issues there are also mixed views; a majority of airport respondents expect reductions in day noise (54%) and night noise (69%): by contrast, of airline respondents, only 22% expect reductions in day noise, and 33%

expect night noise reductions: the majority of airline respondents expect noise to stay the same (day noise 67% and night noise 56%).

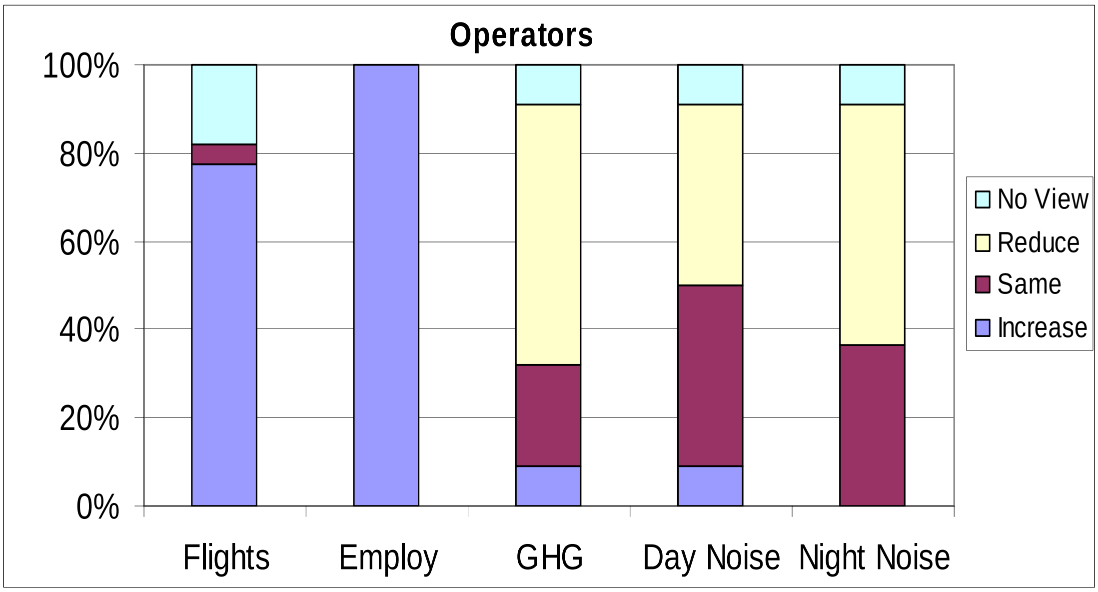


Figure 6.2 Visions of Sustainable Aviation – Operators

Compared with the operator respondents, Regulators (Figure 6.3) have a stronger vision of reducing disbenefits: for GHG emissions 83% expect reductions; for day noise 74%; for night noise 91%. Regulators less commonly expect growth in flights (30%) and increasing employment benefits (33%).

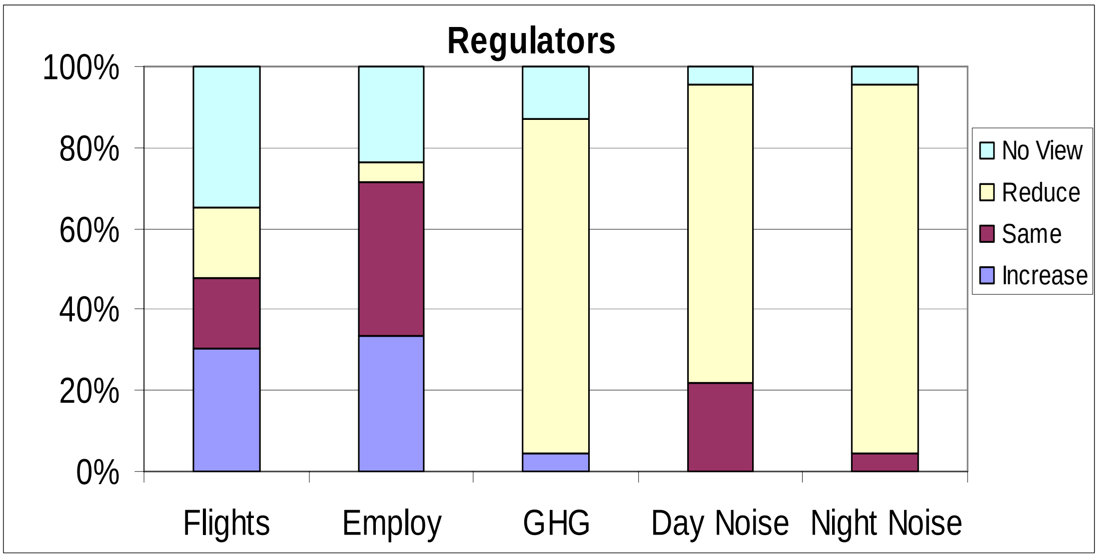


Figure 6.3 Visions of Sustainable Aviation – Regulators

Respondents from Those Affected (Figure 6.4) follow a similar pattern to Regulators, though are more consistent in their expectations of reduction in the disbenefits: for GHG emissions, 94%; for day noise, 94%, and for night noise 100% expect reductions. Only 18% of Those Affected have a vision of increased flights.

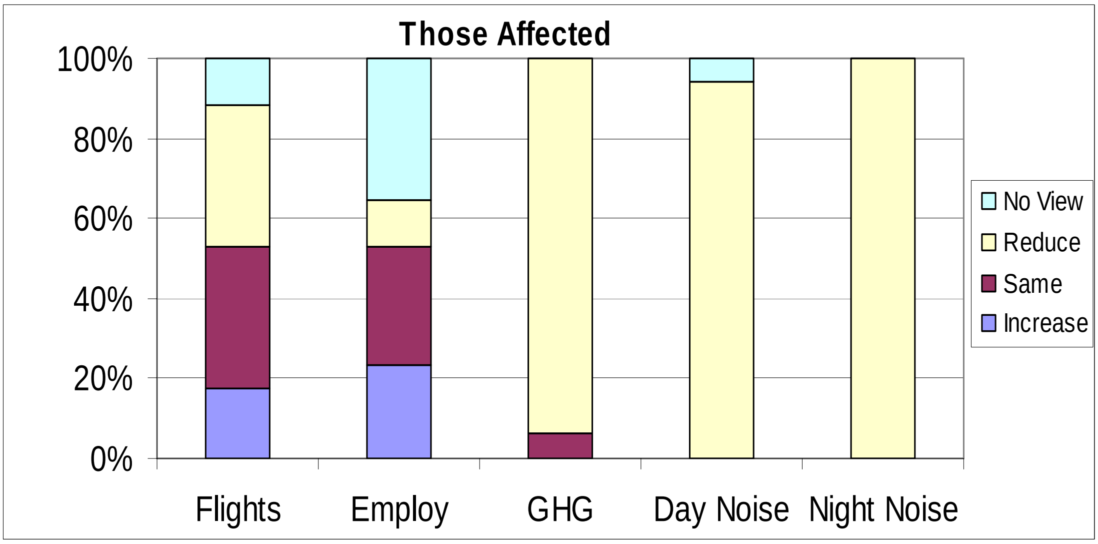


Figure 6.4 Visions of Sustainable Aviation – Those Affected.

Commentary

The most commonly stated pattern is of increased air transport activity, and simultaneously decreased disbenefits (GHG emissions and noise), but there must be some question on the realism of this pattern. It has been argued that environmental benefits gained from technology improvements to aircraft will be outweighed by the forecast growth of air traffic volumes (Johnson 2003b). Most of the additional flights will utilise existing aircraft, only a small proportion from new more efficient equipment.

The responses of stakeholder groups tend to be led by the interests of each group. Within the industry, the great majority of Operators and Suppliers expect increases in air transport activity (flights), and thus increases in airport employment, though there are mixed expectations on reduction of disbenefits. Outside the industry, the great majority of Those Affected and Regulators wish to see reductions in the disbenefits, and have mixed expectations on flight numbers: certainly some in these groups would expect that flight numbers should be restricted in order to achieve reductions in disbenefits.

The single area where there is some measure of agreement across the stakeholder groups is that of night noise: no respondents expect an increase; the great majority expect a decrease, with some operators seeing no change.

The overall conclusion is that few respondents claim to have a vision of sustainable aviation. On the five aspects included in the survey (flights, airport employment, GHG emissions, day and night noise), there is significant divergence in the future expectations of different stakeholder groups.

Question. What other aspects are included in your vision of sustainable aviation?

Thirty one respondents (41%) offer a total of 70 aspects of their vision. These are free format responses and consequently use a range of terminology with differing emphases. They range from very specific points to rather generalised topics, and not all can be readily categorised. They are analysed into general topics to obtain a pattern of responses (Table 6.2).

Local air quality	7
Surface Transport	6
Cost of flying	5
Demand Management	5
Aircraft technology	4
Economic Benefits	4
Environment (general – unspecific)	4
Social benefits	4
Airport infrastructure	3
Land use	2
Equal treatment with other industries	2
Access to LHR from UK regions	2
Airport Waste	1
Airport use of resources	1
Public safety zones	1
ATM efficiency	1
Atmospheric Science	1
Renewable fuel	1
Regulatory framework	1
Local environmental footprint	1
Emissions Trading	1
Tax hypothecation	1
Unable to categorise	6
Aspects included survey - Noise 2, GHG 4	6
Total	70

Table 6.2 Visions of Sustainable Aviation - Additional Aspects

A wide range of topics (in addition to the five included in the survey) is suggested as part of respondents' vision of sustainable aviation, and there is no predominant topic. The references to local air quality frequently mention EU air quality standards, and surface transport comments emphasise provision of public transport to replace cars. Comments on cost of flying generally express a view of higher cost as a restraint on growth, while demand management includes a range of growth restraints, not specifically cost based. Aircraft technology includes improvements in both fuel consumption and noise. From this survey it would seem that there is little agreement on what topics should be included in a sustainable aviation vision in addition to the five in the survey.

6.2.2 Targets for Sustainable Aviation

Question. Do you have any quantified targets, goals or limits for any future aspect of civil aviation?

If yes, would you please define these targets?

It is notable that a high number of respondents make no choice from the drop-down menu (see Table 6.3). There is no technical problem with the question (the choices did appear correctly) and it seems unlikely that that respondents are unable to use the format of the drop-down choice question; several later questions in this format are answered without difficulty. Respondents who do not respond to the question do not specify any targets. It would appear that many respondents are unwilling to actually state that they do not have any targets.

	Yes	No	No response
Number with targets	19	24	32
Percentage respondents %	25	31	43

Table 6.3 Respondents with Targets for Sustainable Aviation

The targets mentioned by respondents are analysed by target topic and by quantified or unquantified (Table 6.4). Quantified' means that the target has some form of absolute or relative value or target date assigned. Un-quantified indicates merely a directional or aspirational target without any meaningful values. For instance:

- Quantified – '5.2% reduction on 1990 by 2008-12, 60% reduction by 2050'
- Un-quantified – 'aviation should play its part in achieving a sustainable concentration of GHGs in the atmosphere'

The number of respondents suggesting targets is low – 19 (25% of the survey), and the number of targets is also low – 43 targets. The suggested targets tend to be concentrated in a relatively small number of issues – greenhouse gas emissions, noise, surface transport, local air quality, aircraft technology – and these correspond well to the most important issues for sustainable aviation (Section 6.3 below).

The actual targets suggested are very variable. For aviation greenhouse gas emissions there is little consistency in the targets, though a number of themes emerge: inclusion in the Kyoto protocol; inclusion in an emissions trading scheme; stabilisation or no increase in emissions; overall reductions; site specific targets. The noise targets are rather more consistent: World Health Organization (WHO) guidelines on community noise; phase out of night flights. Local air quality targets consistently refer to EU air pollution standards. The most commonly repeated specific targets are WHO Guidelines for community noise, and EU air pollution standards. Apart from these two, the targets are diverse, and no individual target is mentioned more than once.

	Targets Mentioned		
Topic	**Total**	**Quantified**	**Un-quantified**
Greenhouse gas emissions	11	5	6
Noise	6	5	1
Surface Transport	6	3	3
Local Air Quality	4	4	0
Aircraft Technology	4	2	2
Growth in flights	3	3	0
Hybrid targets/ indicators	3	0	3
Land Use	1	0	1
Payment of external costs	1	1	0
Poverty/unemployment reduction	1	1	0
Phase out old aircraft	1	1	0
Airport Infrastructure	1	1	0
ISO Accreditation	1	0	1
Totals	43	26	17

Table 6.4 Sustainable Aviation Targets

Question. Why do you believe that your vision and goals are appropriate?
18 respondents gave reasons for their visions. These are very variable, with no consistent theme.

6.2.3 Proposition

Research Objective 1 – To determine stakeholder interpretations of sustainable aviation.

Research Proposition 1.1 - There is no agreement on the meaning of sustainable aviation.

The research findings are:

- Few respondents state that they have a vision.
- On five aspects of vision in the questionnaire (flights, airport employment, GHG emissions, day noise and night noise) there are:
  - widespread general expectations of increasing benefits and decreasing disbenefits
  - diverging expectations between stakeholder groups
- There is no overall agreement on what should constitute a vision of sustainable aviation
- Few respondents have targets for sustainable aviation
- There are no commonly agreed targets or goals for sustainable aviation

From this research there is no evidence of a common understanding or interpretation of the meaning of sustainable aviation amongst this group of respondents.

The research findings support the research proposition.

6.3 *Round 1 – Sustainable Development in Aviation*

Research Objective 2 – To determine stakeholder views of the most important factors for sustainable development in civil aviation.

Research Propositions –

2.1 There is some agreement on the most important issues relevant to sustainable development in civil aviation

2.2 There is little agreement on the most important policy actions relevant to sustainable development in civil aviation

Questions are included in Round 1 Questionnaire (Appendix 3) at Section 1 (Issues) and Section 2 (Policy Actions).

Respondents are asked to indicate how important specified issues are for sustainable development in aviation, suggest other issues they consider important and make general comments. For policy actions, the questions are similar to issues with the addition of a question asking respondents to rank up to 5 most important policies.

6.3.1 Issues for Sustainable Development

Question: Please indicate how important you think each of the following issues is to the sustainable development of civil aviation: (Very high, High, No view, Low, Not relevant).

A list of 21 issues in random order (Section 5.4.2. and Appendix 3)

Responses are assigned a score of 5 → 1 (very high → not relevant) and the importance is calculated from the average score.

For the survey as a whole the highest rated issue is Aircraft greenhouse gas emissions (Table 6.5). Of the next four priorities, three (Aircraft fuel efficiency, Use of aviation fuel, Number of Flights) are related to Aircraft GHG emissions, and the other (Surface transport emissions) contribute to the overall issue of atmospheric pollution. The following three issues are local airport disbenefits: Local air pollution, Aircraft noise and Land use for airports are all ranked, on average, higher than important. Thus the most important issues external to the civil aviation system are identified as: emissions from aircraft, emissions from surface transport, local air pollution, aircraft noise and land use. The most important issues internal to civil aviation are seen as aircraft fuel efficiency, use of aviation fuel and the number of flights.

	Survey as a whole	Average	Number	SD
1	Aircraft GHG Emissions	4.7	75	0.8
2	Aircraft fuel efficiency	4.5	75	0.6
3	Use of aviation fuel	4.4	75	0.8
4	Surface transport emissions	4.4	75	0.8
5	Number of flights	4.4	73	0.9
6	Local air pollution	4.3	75	0.8
7	Aircraft noise	4.3	75	0.8
8	Land Use	4.1	75	0.9
9	Airport Emissions	3.9	75	1
10	Depletion of oil reserves	3.9	74	1.2
11	Passenger safety	3.8	75	1.5
12	Airport Employment	3.7	75	1.1
13	Airport Use of resources	3.6	75	1.1
14	Regional Equity	3.4	74	1.1
15	Airport Waste	3.3	75	1.1
16	Aircraft Disposal	3.1	74	1.1
17	Community Accident Risk	3.1	74	1.3
18	Passenger health	2.9	75	1.3
19	Aircrew health	2.8	75	1.2
20	Spread of disease	2.7	75	1.2
21	Poverty reduction	2.6	75	1.2

Table 6.5 Sustainable Development Issues – Survey as a Whole

There is a high level of consistency on the most important issues across the major stakeholder groups (Operators, Regulators, Suppliers and Those Affected). The eight most important issues for the survey as a whole are included in the highest priorities by each stakeholder group, though with slightly different rankings (Table 6.6). Operators rate aircraft fuel efficiency as highest priority, but give slightly lower priority to Number of flights, with higher priority for Aircraft noise and Passenger safety. Suppliers give a significantly lower priority to Surface Transport emissions. Regulators and Those Affected closely reflect the pattern of the survey as a whole. However, Those Affected tend to generally assign somewhat higher importance to issues, and rate more issues as ‘important’ than the other groups, including depletion of oil reserves and airport resource use.

	Operators	Average	Number	SD
1	Aircraft fuel efficiency	4.7	24	0.7
2	Aircraft GHG Emissions	4.5	24	0.9
3	Aircraft noise	4.4	24	0.7
4	Local air pollution	4.3	24	0.6
5	Airport Employment	4.3	24	0.7
6	Surface transport emissions	4.3	24	0.9
7	Use of aviation fuel	4.3	24	0.9
8	Passenger safety	4.2	24	1.2
9	Number of flights	4.1	23	0.7

	Suppliers	Average	Number	SD
1	Aircraft GHG Emissions	4.8	6	0.4
2	Aircraft fuel efficiency	4.5	6	0.5
3	Aircraft noise	4.5	6	0.5
4	Use of aviation fuel	4.2	6	1.2
5	Land Use	4.0	6	0.6
6	Local air pollution	4.0	6	1.1

	Those Affected	Average	Number	SD
1	Aircraft GHG Emissions	5.0	17	0.0
2	Use of aviation fuel	4.8	17	0.4
3	Number of flights	4.8	16	0.4
4	Local air pollution	4.7	17	0.5
5	Land Use	4.5	17	0.5
6	Surface transport emissions	4.5	17	0.5
7	Aircraft fuel efficiency	4.3	17	0.6
8	Aircraft noise	4.4	17	0.7
9	Airport Emissions	4.4	17	0.9
10	Depletion of oil reserves	4.2	17	1.1
11	A/P Use of resources	4.1	17	1.0

	Regulators	Average	Number	SD
1	Aircraft GHG Emissions	4.7	25	0.7
2	Number of flights	4.4	25	1.0
3	Surface transport emissions	4.4	25	0.8
4	Aircraft fuel efficiency	4.4	25	0.5
5	Local air pollution	4.3	25	0.7
6	Use of aviation fuel	4.3	25	0.9
7	Aircraft noise	4.2	25	1.0
8	Land Use	4.1	25	0.8
9	Airport Emissions	4.0	25	1.0

Table 6.6 Sustainable Development Issues – Stakeholder Groups

For the survey as a whole, the lowest priority is Poverty Reduction, with an average score of 2.6 – somewhere between no view and unimportant. This view is consistent for all the major stakeholder groups.

Health related issues are given widely differing importance – Local air pollution and Aircraft noise are high priority (as noted above), but other health related issues are given low importance. For the survey as a whole, Passenger health, Aircrew health, Spread of disease by air transport, are all given average scores less than 3, with community accident risk just over 3.1 and passenger safety 3.8 (approaching important). Respondents' comments may give some explanation –

> *Have given a low mark to those which are self-imposed (eg pilots' passengers health risks) but High where aviations disadvantages are imposed on 'innocent bystanders'.*
>
> *Difficult to answer - some issues are very important, but are marked low, as they are being adressed (sic) or are not really an issue - but they would be very important if they were.*

Even though the health issues may be intrinsically important, while they remain under control or of low incidence, they are not regarded as important issues by respondents. Waste disposal issues (Aircraft disposal and Airport waste) are also given low priority (3.1 and 3.3 respectively), though some residents respondents regard water runoff as very important.

While there is an overall consensus on the most important issues as noted above, on some issues there are significant variations between stakeholder groups, e.g. Passenger Safety and Depletion of oil reserves (Table 6.7). Generally, respondents outside the industry are more concerned about oil depletion than those within.

Passenger safety			Depletion of oil reserves		
Stakeholder Subgroup	**Rank**	**Average Value**	**Stakeholder Subgroup**	**Rank**	**Average Value**
Parliamentarians	1	5.0	Parliamentarians	5	4.4
Users	1	5.0	Local Groups	10	4.4
Trade Unions	5	4.6	Trade Unions	9	4.2
Airlines	6	4.1	Environmental Groups	8	4.2
Airports	9	4.0	Local Regulators	11	3.9
Suppliers	8	3.8	Users	9	3.7
National Regulators	10	3.8	Suppliers	10	3.7
Local Groups	15	3.3	Airlines	11	3.6
Environmental Groups	17	2.9	National Regulators	11	3.5
Local Regulators	20	2.4	Airports	15	3.4

Table 6.7 Sustainable Development Issues – Significant Variations

Question. Are there any other issues that you believe are important for, or not relevant to, the sustainable development of civil aviation?

Forty six respondents (61%) suggest a total of 90 issues which they consider relevant. These are free format responses and use a range of terminology with differing emphases. They range from very specific points to rather generalised topics, and not all can be readily categorised. There is considerable overlap in these responses between issues for sustainable aviation and policy actions or instruments. The responses are analysed into general topics (Table 6.8) and grouped as:

- In questionnaire as Issues
- In questionnaire as Policy Actions or Instruments
- Mentioned once only
- General topics

The first two groups are considered in other parts of this analysis, Issues at section 6.3.1 and Policies at section 6.3.2.

Of the other topics, the most frequently mentioned are: National economic issues and Social issues. Twelve respondents raised national economy (16%), eleven as a positive aspect i.e. the national economic benefits, contribution, impact and one as a negative aspect i.e. negative impact on tourism jobs. These respondents are unevenly split amongst stakeholder groups: Operators 5; Suppliers 3; Those affected

2; Regulators 2. Respondents regard National economy as a high importance with an average score of 4.66. Ten respondents mentioned social benefits or social justice with varying emphases, giving an average importance of 4.2.

These two issues do not arise specifically from the systems analysis of the aviation system (Chapter 4) but do arise strongly from respondents. The Rio Principles do not specifically refer to national economies, and in the analysis, many economic effects are regarded as related to demand systems (Section 4.3.3). Neither do Rio Principles specifically include ‘social benefits’ though there is reference in Principle 8 to ‘improved quality of life’: it is debatable whether these two concepts are synonymous. Again, in the analysis (Section 4.3.3), the potential benefits are regarded as flowing from the various demand systems. These two issues are taken forward for consideration in developing indicators (Section 6.6).

The next most popular topics, Demand Management/cost of air transport, integrated transport/tourism, Airport Infrastructure, are more akin to policies and are covered in section 6.3.2.

Question - Do you have any comments on any of the above issues?

Twenty respondents made a range of very variable comments on the issues. In general responses defend the particular interests of the stakeholder though one airport respondent suggests the industry displays:

> *a general apathy towards this subject and blocking actions to minimise disruption to current business*

There is some evidence from a regulator of lack of clarity of the scope of sustainable development:

> *Need to distinguish between sustainability issues and public health issues.*

Sustainable Aviation – Other Issues	Number
Included in Questionnaire as Issue	
Health Policies	5
World regions	2
Aircraft noise	1
Surface Transport implications	4
Waste	2
GHG emissions/ Climate change	2
Total	**16**
Included as Policy or Instrument	
Public education	2
Efficiency of Air Traffic Management	4
Atmospheric research	3
International co-operation (ICAO)	2
Aircraft efficiency	1
Stakeholder engagement	1
Integration of policy	1
Limitation of GHG emissions	1
Emissions Trading	3
Tax treatment	2
Total	**20**
Issues Mentioned once	
Demand	1
Ensure different modes of travel compete fairly	1
Human health impacts (plus and minus)	1
Land use around airports	1
Terrorist security threat	1
Regional distribution of air traffic (UK)	1
Industry rhetoric on sustainability not matched by deeds	1
Introduction of efficient financial measures	1
Local decision making overridden by financial strength of airline operators	1
Supply chain issues	1
Total	**10**
Other issues	
National economic issues	12
Social issues	10
Demand Management/cost of air transport	7
Integrated transport/tourism	4
Airport Infrastructure	3
Agreement (on issues/solutions)	3
Ease of use of air transport	3
Ownership (of air transport operators)	2
Total	**44**

Table 6.8 Sustainable Development Issues – Other

6.3.2 Policy Actions for Sustainable Development

Question. Please indicate how important you think each of the following policy actions is to the sustainable development of civil aviation: (Very high, High, No view, Low, Not relevant).
A list of 17 policy actions in random order (Section 5.4.3. and Appendix 3)

Responses are assigned a score of 5 → 1 (very high → not relevant) and the importance is calculated from the average score.

Survey as a whole

For the survey as a whole, little pattern or consistency emerges from the ranking of policies (Table 6.9). For example, policies that would apply direct constraints to the absolute level of external disbenefits are ranked 4 (Limit on GHG emissions) and 14 (National noise levels). Policies that would affect the internal efficiency of the civil aviation industry are ranked 1 (Improve fuel efficiency of new aircraft), 10 (Improve efficiency ATM) and 15 (Accelerate phase-out of old aircraft).

Rank	Survey as a whole	Av	Number	SD
1	Improve fuel efficiency of new aircraft	4.5	74	0.7
2	Effective Environmental Legislation	4.3	75	0.9
3	Integration at policy level	4.2	75	0.8
4	Limit on GHG emissions	4.2	75	1.1
5	EIA For all civil aviation activities	4.2	74	0.8
6	UK CASS	4.1	75	1.0
7	Pay full external environmental costs	4.1	75	1.1
8	Community participation	4.0	75	0.9
9	Public education	4.0	75	1.1
10	Improve efficiency of ATM	3.9	75	0.9
11	Renewable fuel	3.9	75	1.1
12	ICAO program for sustainable aviation	3.8	75	1.1
13	Atmospheric research by civil aviation sector	3.7	75	1.0
14	National noise levels	3.7	75	1.2
15	Accelerate phase-out of old aircraft	3.7	75	1.1
16	Carbon sinks (e.g. forests)	3.1	74	1.3
17	Spreading benefits to socially deprived areas	2.9	74	1.3

Table 6.9 Sustainable Development Policies – Survey as a Whole

On the highest and lowest ranked policies there is a level of consistency across stakeholder groups. The highest ranked policy (Improve fuel efficiency of new aircraft) has the lowest standard deviation (0.7), and is the one policy which all stakeholder groups regard as important or very important.

The lowest ranked (Spreading benefits to socially deprived areas) is the only policy with an overall score less than 3.0 (not important), and is ranked in the bottom 3 by all the major stakeholder groups. This ranking has a standard deviation of 1.3 showing a wide range of opinions.

For other policies, there are wide differences in the levels of importance between stakeholder groups (Table 6.10).

Operators

Operators tend to favour internal efficiency measures and attach less importance to policies which may limit external disbenefits or may reduce demand (Table 6.10): highest ranked policies are efficiency related, i.e. Improve fuel efficiency of new aircraft, and Improve efficiency of Air Traffic Management; external limits are lower ranked, 11 – Effective environmental legislation, 13 – Limit on GHG emissions, 14 – Pay full external environmental costs, 17 – National noise levels.

The pattern is similar between airports and airlines, but with some notable variations in emphasis. Airlines rank Renewable Fuel as third in importance, airports 12th: airlines rank Accelerate Phase out of Old Aircraft as a low priority (rank 14 with an average score of 3.0) while airports rank this as high importance (rank 6 with a score of 4.2). In each case the high priority reflects the stakeholder interests: airlines would like to see renewable fuel; airports would like to see newer quieter aircraft. The lower priority may reflect perceived expenses for the stakeholder: airports see additional infrastructure costs in renewable fuel; airlines see additional costs in phasing out old aircraft. The general pattern of responses reflects sectional interests.

Suppliers

Suppliers place improvements to Aircraft fuel consumption and ATM efficiency as highest priority (Table 6.10). However, unlike operators, some policies which would apply external constraints are given high priority by the respondents from suppliers (3 – Effective environmental legislation, 6 – National noise levels, 8 – Limit on GHG emissions). Suppliers' lowest priority policy is Renewable fuel with an average score of 2.5. This is in some contrast to the views of airline respondents who rank this third. The supplier group includes respondents from suppliers of aviation fuel and aero engines, who give low priority to renewable fuel. It is likely that a different fuel would be perceived as against their sectional and company interests.

	Operators	Av	Num	SD			Suppliers	Av	Num	SD
1	Improve fuel efficiency of new aircraft	4.5	24	0.7		1	Improve fuel efficiency of new aircraft	4.5	6	0.5
2	Improve efficiency ATM	4.3	24	0.6		2	Improve efficiency ATM	4.3	6	0.5
3	Renewable fuel	4.1	24	0.9		3	Effective environmental legislation	4.2	6	0.4
4	EIA for all civil aviation activities	4.0	24	0.9		4	Integration at policy level	4.2	6	0.8
5	UK CASS	4.0	24	1.2		5	EIA for all civil aviation activities	4.0	6	0.0
6	Integration at policy level	4.0	24	0.8		6	National noise levels	4.0	6	0.6
7	Public education	4.0	24	1.0		7	Atmospheric research by civil aviation sector	3.8	6	1.0
8	Community participation	3.9	24	1.0		8	Limit on GHG emissions	3.8	6	1.6
9	ICAO program for sustainable aviation	3.8	24	1.0		9	Public education	3.3	6	1.5
10	Atmospheric research by civil aviation sector	3.7	24	0.9		10	Pay full external environmental costs	3.7	6	0.8
11	Effective environmental legislation	3.7	24	1.2		11	ICAO program for sustainable aviation	3.7	6	1.4
12	Accelerate phase-out of old aircraft	3.7	24	1.1		12	Community participation	3.5	6	0.8
13	Limit on GHG emissions	3.6	24	1.2		13	UK CASS	3.5	6	1.0
14	Pay full external environmental costs	3.5	24	1.1		14	Carbon sinks (e.g. forests)	3.0	6	1.3
15	Spreading benefits to socially deprived areas	3.4	24	1.4		15	Accelerate phase-out of old aircraft	3.0	6	1.3
16	Carbon sinks (e.g. forests)	3.2	24	1.1		16	Spreading benefits to socially deprived areas	2.5	6	1.2
17	National noise levels	3.1	24	1.2		17	Renewable fuel	2.5	6	0.8

Table 6.10 Sustainable Development Policies – Operators and Suppliers

	Regulators	Av	Num	SD			Those Affected	Av	Num	SD
1	Effective environmental legislation	4.5	25	0.8		1	Limit on GHG emissions	5.0	17	0.0
2	Improve fuel efficiency of new aircraft	4.5	24	0.6		2	Pay full external environmental costs	4.9	17	0.2
3	Pay full external environmental costs	4.4	25	0.9		3	Effective environmental legislation	4.8	17	0.4
4	Limit on GHG emissions	4.4	25	0.9		4	Integration at policy level	4.6	17	0.8
5	Integration at policy level	4.3	25	0.7		5	EIA for all civil aviation activities	4.6	16	0.8
6	UK CASS	4.2	25	0.9		6	National noise levels	4.4	17	1.0
7	EIA for all civil aviation activities	4.2	25	0.8		7	Improve fuel efficiency of new aircraft	4.3	17	0.9
8	Community participation	4.2	25	0.6		8	Community participation	4.3	17	0.8
9	Improve efficiency ATM	4.0	25	0.7		9	UK CASS	4.3	17	1.0
10	ICAO program for sustainable aviation	3.9	25	1.2		10	Public education	4.2	17	0.8
11	National noise levels	3.8	25	1.2		11	Renewable fuel	4.1	17	1.2
12	Public education	3.9	25	1.2		12	Atmospheric research by civil aviation sector	3.9	17	1.0
13	Renewable fuel	3.8	25	1.1		13	Accelerate phase-out of old aircraft	3.9	17	1.1
14	Accelerate phase-out of old aircraft	3.7	25	1.1		14	ICAO program for sustainable aviation	3.6	17	1.2
15	Atmospheric research by civil aviation sector	3.6	25	1.2		15	Improve efficiency ATM	2.9	17	1.1
16	Carbon sinks (e.g. forests)	3.4	25	1.3		16	Carbon sinks (e.g. forests)	2.6	16	1.4
17	Spreading benefits to socially deprived areas	2.7	25	1.3		17	Spreading benefits to socially deprived areas	2.5	16	0.9

Table 6.11 Sustainable Development Policies – Regulators and Those Affected

Regulators

Regulators (Table 6.11) rank aircraft efficiency as important (ranked second with a score of 4.46), but otherwise consistently place as most important, those policies which would apply external constraints (1 Effective environmental legislation, 3 Pay full external environmental costs, 4 Limit on GHG emissions). Integration (Integration of environment and development in civil aviation policy making) is ranked fifth by Regulators.

Those Affected

Those Affected display a similar pattern to Regulators with policies that place limits on emissions or demand being ranked highest (Table 6.11): 1 Limit on GHG emissions, 2 Pay full external environmental costs, 3 Effective environmental legislation and 6 National noise levels. Two policies introducing environmental considerations into aviation decision making are ranked 4 & 5 (Integration at policy level, EIA for all aviation activities). Improve fuel efficiency of new aircraft is placed seventh with a score of 4.3 – still important, but lower ranking than other policies.

Question. Are there any other policy actions that you believe are important for, or are not relevant to, the sustainable development of civil aviation?

Twenty eight respondents (37%) suggest a total of 48 policies, which they consider relevant. The responses are analysed into general topics to obtain a pattern (Table 6.12). Most of these responses (32) are already included in the questionnaire as issue, policy or instrument, though in many instances the respondent suggests a slightly different view or a very particular action. Of the six respondents who mentioned Aviation Fuel Tax at this point, five considered it to be important or very important; one considered it not relevant.

The general heading of Demand Management was mentioned by five respondents, advocating a range of options including rail as an alternative to air transport, managing growth (of aviation) and encouraging UK holidays. There were various policy options on airport infrastructure - Additional runway capacity, Efficient use of existing infrastructure, Development of offshore airports, two general policy options for technological development, and two banning night flights. A number of other policies were mentioned once. No other policies emerge strongly from this analysis.

Sustainable Aviation – Other Policy Actions	**Number**
Included in Questionnaire as Policy	
Efficiency of Air traffic Management	1
Atmospheric research	2
Payment of full external costs	5
National Noise levels	2
Aircraft efficiency	1
Accelerate Phase out of old aircraft	1
Community Participation	1
Carbon Sinks	1
Limitation of GHG emissions	2
Total	**16**
Included in Questionnaire as Instrument	
VAT	1
Emissions Trading	4
Aviation fuel tax/ Tax treatment	6
Total	**11**
Other Policies	
Demand Management	7
Surface Transport measures	3
Airport infrastructure	3
Technology	2
Night Flights Ban	2
EU sustainability strategy for civil aviation	1
Independent research on Health effects	1
Ownership (of ATM Facilities)	1
Comment on emphasis of Questions	1
Total	**21**

Table 6.12 Sustainable Development Policies – Other

Question. In your opinion, which are the most important policy actions needed to move towards sustainable aviation? Please rank up to five policy actions.

Respondents may prioritise up to five policies. The response is free format; there is considerable variation in the number of policies given, and the range of policies selected. Sixty two respondents (83%) gave some response to this question, specifying from 1 to 5 policy priorities (Table 6.13). Thirteen respondents did not make a response, concentrated in the airlines and parliamentarian subgroups: in the airline subgroup, 4 out of 10 (40%) did not reply: in the MPs subgroup 5 out of 8 (62%).

Number of priorities	Respondents	
	Number	%
5	37	49
4	9	12
3	9	12
2	5	7
1	2	3
0	13	17

Table 6.13 Sustainable Development Policy Priority – Responses

As well as specifying the policies included in the questionnaire, respondents feel free at this point to introduce some instruments (included later in the questionnaire) and a range of other policies reflecting their personal convictions, some very specific, others rather general. For analysis purposes the responses in this section are grouped into policies or instruments included in the questionnaire (Appendix 3), and a number of general policy groups to cover respondents' suggestions:

- Demand management
- Local environmental footprint
- Airport infrastructure/sites
- Integration of transport/environmental/sustainability policies
- National and regional economic issues
- Technology
- Voluntary measures
- Surface transport policies

The nominated policies are assigned a weighting according to their ranking, priority 1 weighted 5, through to priority 5 weighted 1, and these weights are accumulated to give an overall score for the individual policy (Table 6.14).

Respondents mentioned thirty two different policies, instruments or policy groups (Table 6.14).

Rank	Policy, Policy Group or Instrument	Weight	Number	Average Priority
1	Pay full external environmental costs	91	21	1.7
2	Limit on GHG emissions	87	25	2.5
3	Effective Environmental Legislation	62	17	2.4
4	Emissions Trading	58	13	1.5
5	Demand management	45	13	2.5
6	UK CASS	44	14	2.9
7	National noise levels	42	14	3.0
8	Improve fuel efficiency of new aircraft	41	14	3.1
9	Public education	39	12	2.8
10	Improve efficiency ATM	37	11	2.6
11	ICAO program for sustainable aviation	31	8	2.1
12	Technology	25	7	2.4
13	Community participation	24	11	3.8
14	Surface transport	22	11	4.0
15	EIA For all CA activities	22	9	3.6
16	Renewable fuel	19	6	2.8
17	Tax on aviation fuel	17	5	2.6
18	Atmospheric research by CA sector	16	4	2.0
19	Integration at Policy level	16	5	2.8
20	Integrated policies (transport/sustainability)	15	4	2.3
21	Local environmental footprint	12	7	4.3
22	Voluntary measures	12	3	2.0
23	National/ regional economy	11	5	3.8
24	Airport infrastructure/sites	11	4	3.3
25	Accelerate phase-out of old aircraft	9	5	4.2
26	Spread benefits to socially deprived areas	7	2	2.5
27	Depletion of Oil Supplies	7	2	2.5
28	Carbon sinks (e.g. forests)	5	2	3.5
29	VAT	4	1	2.0
30	Noise charges	4	1	2.0
31	Health Policies	3	1	3.0
32	Regional equity	2	1	4.0
31	Dual Till	2	1	4.0

Weight = Sum of (number of mentions X priority weighting (5-1))

Average Priority = 6 – (Weight/Count)

Table 6.14 Sustainable Development Policy Priority – Survey as a whole

Survey as a whole

Two policies (Pay full external environmental costs and Limit on GHG emissions) stand out as the most frequent choices by a significant margin. There then follows a second group of two policies (Effective Environmental Legislation and Emissions Trading) ranked 3 and 4, but very close in the weightings. Of these, Emissions Trading is mentioned fewer times, but given higher priority when mentioned. There is then a third group of six policies ranked 5-10, but with weightings rather close together. The ranking of these six should perhaps be regarded with some caution since a single response could change the relative ranks. Thereafter, support for each policy progressively reduces. Notably, Community Participation and Surface Transport Policies both receive a significant number of mentions, but at rather low priority.

The strong emphasis of the list is towards policies external to the industry, which may introduce limitations on demand or on output of emissions and noise. The highest ranked policy is internalisation of external costs, which may be expected to increase costs and thus limit demand. The following three are all concerned with external controls on emissions or other environmental impacts.

Low in the priority list but worthy of note are two suggested policies concerned with Oil Depletion:

> *to ring fence oil supplies for aviation*
>
> *to prevent poil (sic) being used for barby doll manufacture or any other nugatory use*

These do represent some recognition of aviation's dependence on potentially reducing oil supplies.

Stakeholder Groups

The emphasis on policies which lead to external demand management or to limits on emissions and noise is reflected, with some differences of emphasis, throughout the major stakeholder groups except for the operator group (Table 6.15). The most favoured policies in the operator group are concerned with internal efficiency and sustainability strategy. Policies to limit emissions and noise are ranked 6 and 7, and policies which may limit demand e.g. internalisation of external costs, demand management, are ranked 16 and 17 respectively.

Rank	Policy, Policy Group or Instrument	Weight	Count	Average Priority
1	Improve fuel efficiency of new aircraft	26	7	2.3
2	UK CASS	23	6	2.2
3	Public education	20	5	2.0
4	Improve efficiency ATM	20	6	2.7
5	Emissions Trading	20	4	1.0
6	Limit on GHG emissions	16	5	2.8
7	National noise levels	12	3	2.0
8	Technology	11	3	2.3
9	Surface transport	10	5	4.0
10	Renewable fuel	10	3	2.7

Table 6.15 Sustainable Development Policy Priority – Operators

6.3.3 Comparison of Importance and Priority

The survey explores respondents' views of the importance of policy actions in two ways. Respondents are asked to:

- Indicate levels of importance of a large number of policies
- Prioritise a small number of their most important policies

Survey as a Whole

For the survey as a whole, the highest priority policies from the two questions are significantly different (Table 6.16). When simply asked to judge the importance of policies, all respondents agree that improved efficiency (of new aircraft) is important. However, when asked to choose between the priorities of policies, then respondents strongly favour policies which apply economic constraints or external limits: efficiency measures are given lower priority.

Importance		**Priority selection**	
	Policy		**Policy**
1	Improve fuel efficiency of new aircraft	1	Pay full external environmental costs
2	Effective Environmental Legislation	2	Limit on GHG emissions
3	Integration at Policy level	3	Effective Environmental Legislation
4	Limit on GHG emissions	4	Emissions Trading
5	EIA For all civil aviation activities	5	Demand management

Table 6.16 Sustainable Development Policies Importance v Priority – Survey

Operators

For operator group respondents, the results from the two questions correspond more closely (Table 6.17). Highest priority is given to policies supporting efficiency improvement and voluntary internal procedural changes.

Importance		**Priority selection**	
	Policy		**Policy**
1	Improve fuel efficiency of new aircraft	1	Improve fuel efficiency of new aircraft
2	Improve efficiency ATM	2	UK CASS
3	Renewable fuel	3	Public education
4	EIA for all civil aviation activities	4	Improve efficiency ATM
5	UK CASS	5	Emissions Trading

Table 6.17 Sustainable Development Policies Importance v Priority – Operators

6.3.4 Propositions

Research Objective 2 – To determine stakeholder views of the most important factors for sustainable development in civil aviation.

Research Propositions –

2.1 There is some agreement on the most important issues relevant to sustainable development in civil aviation.

2.2 There is little agreement on the most important policy actions relevant to sustainable development in civil aviation.

Proposition 2.1. For Issues, the research findings are that:

- There is good agreement on the most important issues (Section 6.3.1)
- Two other issues were raised: National Economy, Social Impacts

This research provides good evidence that there is a consensus amongst stakeholders on the most important issues for sustainable aviation.

The findings of this research support the research proposition.

Proposition 2.2. For Policy Actions, the research findings are that:

- There is little agreement across stakeholder groups on the most important policies (Section 6.3.2/3)
- Policy priorities generally favour the interests of the stakeholder group

The findings of this research support the research proposition. The implications of the differences are explored at section 6.5 and 6.6.

6.4 *Round 1 – Reasons and Orientations*

Research Objective 3 – To determine why the observed actions of the civil aviation industry diverge from the principles of sustainable development.

Research Propositions –

3.1 - There is a low level of understanding of sustainable development.

3.2 – Commercial/financial pressure dominates in civil aviation organisations.

3.3 – Institutional orientations preclude sustainable development in civil aviation.

3.4 – Organisational policies preclude sustainable development in civil aviation.

3.5 – The legal framework precludes sustainable development in civil aviation.

Proposition 3.1 (Understanding of sustainable development) is assessed as a combined analysis of Round 1 & 2 responses at Section 6.9.

Questions relating to Proposition 3.2 (commercial/financial pressure) are included in Round 1 questionnaire Section 5 (Appendix 3) and analysed at Section 6.4.1. Questions relating to Proposition 3.3 (Institutional orientations) are included in Round 1 questionnaire Section 3 (Appendix 3) and analysed at Section 6.4.2. Proposition 3.4 is assessed by document analysis of company policies (Section 6.4.3) and Proposition 3.5 by analysis of the regulatory framework (Section 6.4.4).

6.4.1 Commercial Pressures

Question. Your views on sustainable aviation may be influenced by many different factors that can be difficult to reconcile. Some of these factors are arranged on scales below. Please locate your position on each of the scales by selecting the appropriate box.

My views are more influenced by ---	2	1	0	1	2	**My views are more influenced by ---**
Employment benefits	☐	☐	☐	☐	☐	Airport/airline profitability
Employment benefits	☐	☐	☐	☐	☐	Climate change
Employment benefits	☐	☐	☐	☐	☐	Aircraft Noise
Airport/airline profitability	☐	☐	☐	☐	☐	Climate Change
Airport/airline profitability	☐	☐	☐	☐	☐	Aircraft Noise
Climate change	☐	☐	☐	☐	☐	Aircraft Noise

Responses are given a weighting as indicated on the scale (0-2). On this basis the highest possible aggregate value for a respondent would be 12, if the respondent marked a value 2 box on every scale. The highest possible value for an individual factor would be 6 i.e. three value 2 marks. Only positive scores are counted.

The positive response for each factor may be taken as an indicator or a measure of the relative importance of that factor, and the sum of the positive responses as an indicator of how strongly this set of factors influences the respondents. The average positive responses are calculated for each factor, for the survey as a whole and for each major stakeholder group (Figures 6.5 - 6.8).

The overall reported influence of the factors varies significantly across the stakeholder groups (Figure 6.5). Out of a possible maximum level of 12, the average for the survey as a whole is 6.8: respondents from suppliers report being less influenced by the factors, with a level of less than 4.7, whilst Those Affected have a level of 8.3. Analysis of stakeholder sub-groups reveals further differences: airport respondents (Figure 6.8) report a rather lower level of influence (4.3) whereas the community subgroup has the highest level at 9 (Figure 6.7).

The influence of particular factors is also reported to vary significantly between stakeholder groups. For the survey as a whole (Figure 6.5), climate change is the largest single factor (average 3.2), followed by aircraft noise (2.0), airport employment (1.1) and Airline/airport profitability (0.4).

This general pattern can be seen in the Regulator and Those Affected stakeholder groups. There is some variation within the Regulator group (Figure 6.6): climate change is a strong influence throughout this group, being particularly strong on the national regulators subgroup; local authorities and MPs give more emphasis to aircraft noise than do the national regulators; local authorities may be expected to be influenced by the prospect of airport employment, but in this survey the influence was rather low (0.8).

In Those Affected group (Figure 6.7), the influence of the factors is stronger and more polarised: the community subgroup places strong and almost equal emphasis on climate change and aircraft noise (4.7 and 4.3 respectively) and gives no consideration for either airport employment or airport/airline profitability.

The Operator stakeholder group (Figure 6.8) displays a somewhat different pattern: airport employment (2.2) is rated as a more significant influence than climate change (1.7); aircraft noise and company profitability are placed as more minor influences at a similar level (0.9 and 0.8 respectively). Within the operator group (Figure 6.8), the Trade Union respondents understandably place strong emphasis on airport employment (4.0) and airline respondents suggest that they are very little influenced by considerations of aircraft noise (0.2).

The objective of the question is to establish whether commercial pressures dominate in civil aviation organisations i.e. how important is airport and airline profitability as an influence?

Throughout the survey airport/airline profitability is reported as a relatively minor factor. For the survey as a whole this factor rates a positive average level of 0.4, though the level varies across the stakeholder subgroups (Table 6.18). From Those Affected group, and the Local Authority regulator sub-group, no respondents assigned any positive value to the airport/airline profitability factor. The influence of this factor is stated as low for suppliers, national regulators, airports and MPs. Only trade union and airline respondents report this as a significant influence, and then at the fairly low levels of 1 and 1.5 respectively (with 6 as a maximum possible score).

It is understandable that respondents outside the civil aviation organisations (i.e. Regulators, Those Affected) should assign low influence to this factor, since they are not responsible for, or dependent upon, the success of an airport or airline. It is less understandable that respondents within airport and airline companies should apparently be so little influenced by the need for company profitability. It may be that in recent years, at least airports in the UK have had few problems in achieving profitable operations, and respondents from both airlines and airports are not directly responsible for economic performance of the enterprise.

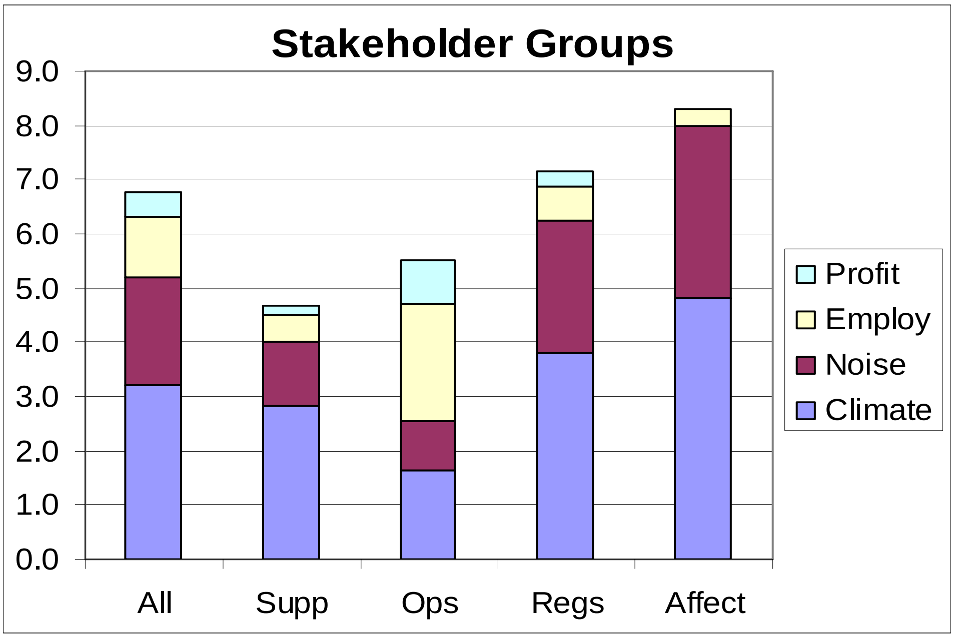


Figure 6.5 Influencing Factors – Major Stakeholder Groups

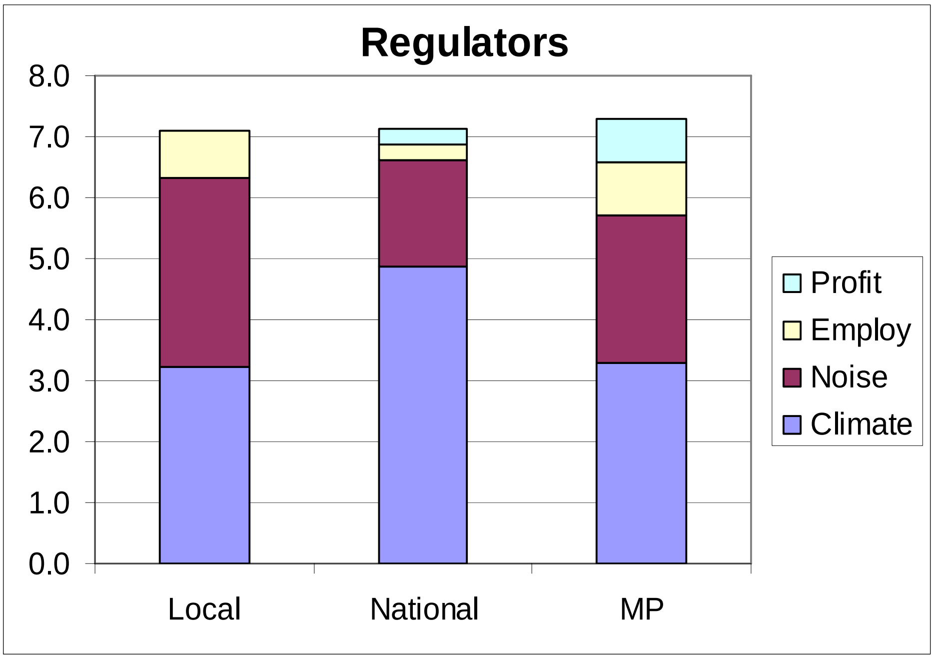


Figure 6.6 Influencing Factors – Regulator Sub-Groups

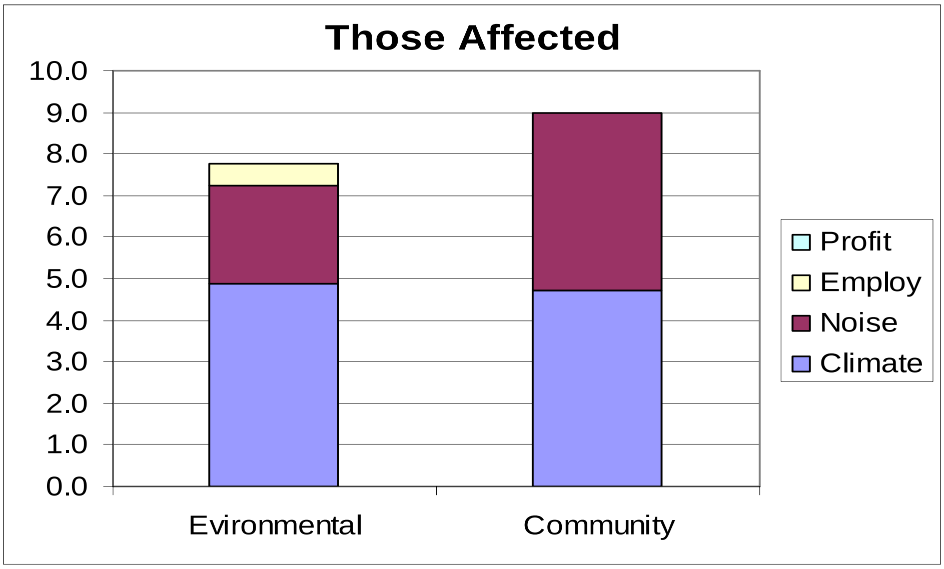


Figure 6.7 Influencing Factors – Those Affected Sub-Groups

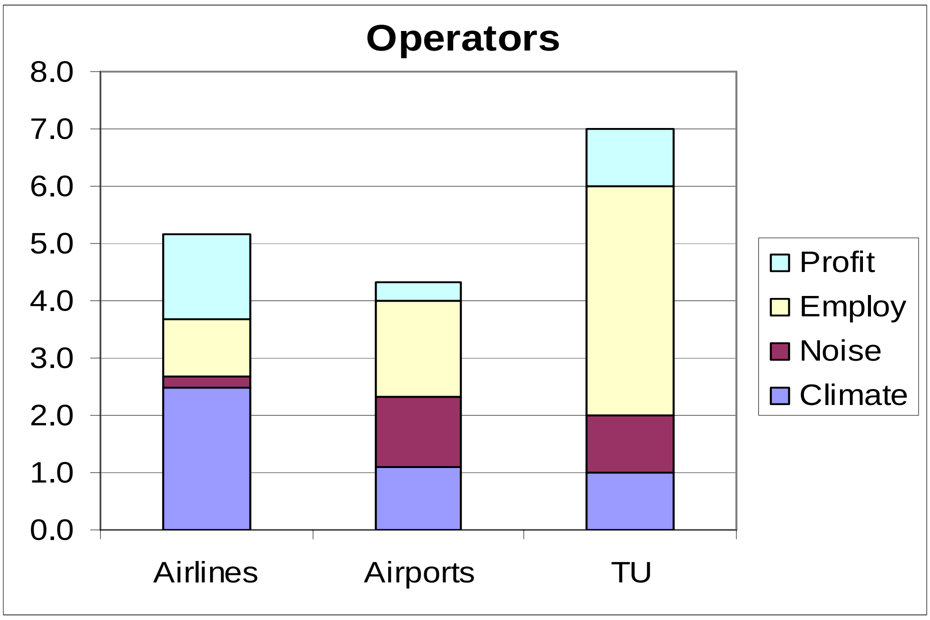


Figure 6.8 Influencing Factors – Operator Sub-Groups

Stakeholder subgroup	**Factor – Airport/ airline profitability**
Those Affected	0.0
Local Authorities	0.0
Suppliers	0.2
National Regulators	0.3
Airports	0.3
MPs	0.7
Trade Unions	1.0
Airlines	1.5

Table 6.18 Influencing Factors – Airport/Airline profitability

6.4.2 Institutional Orientations

Question. Please indicate your level of support for the following potential instruments for change: Strongly support, Support, No view, Oppose, Strongly oppose:

- ***VAT on air travel***
- ***Noise charges on aircraft***
- ***Aviation emissions trading***
- ***Tax on aviation fuel***
- ***Legal limits on aviation greenhouse gas emissions***
- ***Dual till accounting at airports (avoiding cross-subsidy of retail and aeronautical activities)***
- ***Legal compensation for air and noise pollution***
- ***Legal limit on day and night noise levels at airports***
- ***Runway slot auctions***
- ***Legal restriction on the use of aviation fuel***

Responses are assigned a score of +2 (strong support) to -2 (strong opposition), showing support as a positive value, opposition as negative. Zero indicates a neutral view. The levels of support are calculated from the average score for each instrument, for the survey as a whole and for each stakeholder subgroup.

The results for the whole survey (Table 6.19) mask wide variances between the different stakeholder groups and sub-groups and are not representative of the views of any stakeholder group.

Rank	Survey as a whole	Average	Number	SD
1	Emissions Trading	1.0	75	1.0
2	Legal noise limit	0.9	75	1.0
3	Noise Charges	0.8	74	1.2
4	Legal limit on GHG emissions	0.7	73	1.3
5	Compensation for air/noise pollution	0.4	72	1.2
6	Dual till accounting	0.3	74	1.2
7	Tax on aviation fuel	0.2	75	1.7
8	Runway slot auctions	0.1	74	1.2
9	VAT	0.1	75	1.5
10	Limit use of aviation fuel	-0.3	74	1.2

Table 6.19 Support for Instruments of Change – Survey as a Whole

The differences between stakeholder groups show in two respects: the overall level of support for the instruments and the ranking of the instruments.

Levels of support are shown numerically for each stakeholder subgroup (Table 6.20), using two measures: overall average of all respondents and all instruments, and the number of instruments supported i.e. instruments with an average positive response.

Stakeholder Sub-group	Average support level	Instruments supported
Airlines	-0.7	1
Suppliers	-0.1	4
Airports	0.1	5
MPs	0.4	7
National Regulators	0.7	9
Local Authorities	1.0	10
Environmental groups	1.3	10
Local Community	1.5	9
Maximum possible	**2**	**10**

Table 6.20 Support for Instruments of Change – Stakeholder Subgroups

There are widely differing levels of support for these instruments of change. Support levels vary from opposition by airline respondents, progressively increasing support from suppliers, airports and regulators, through to strong support from Those Affected. The number of instruments actually supported by each stakeholder group correspondingly increases from 1 by airlines to 10 by local authorities and environmental groups.

At the two extremes of the scale, airline respondents opposed every instrument for change, except emissions trading; local community respondents supported every instrument for change, except emissions trading. The diverse views on emissions trading are discussed below.

The different patterns of support or opposition between stakeholder groups (Figures 6.9 – 6.11) are perhaps more significant than support levels for specific instruments. Operators, particularly respondents from airlines and suppliers, display widespread opposition to the instruments. There is opposition to economic instruments and to limits on GHG emissions, some support for noise charges and noise limits (except airline respondents), and strong support for emissions trading.

Comments from Airline respondents indicate that they would be unable to support policies or instruments which may affect demand for air transport. It would seem that Emissions Trading is seen as an instrument that will not affect demand (see below).

By contrast, the Regulator group shows a general pattern of support, at varying levels, for most of the suggested instruments. There is some limited opposition to VAT and to a limit on aviation fuel use. Local authority respondents reported support for all instruments. Comments by local authority respondents indicate that they would be prepared to support any measures which may moderate the growth of air traffic (all local authority respondents have an airport in their area). Those Affected, Environment and Community groups, show a pattern of support or strong support for all instruments.

The differing levels of support for particular instruments are illustrative. Tax on aviation fuel evokes, variously, very strong support or very strong opposition, from the different stakeholder groups (Table 6.21): Those Affected and local authority respondents give very strong support; National Regulators and MPs moderate support; respondents from within the industry, Airlines, Airports and Suppliers, record strong opposition.

Attitudes to emissions trading vary considerably (Table 6.22) with very strong support from Airports, Suppliers and National regulators each ranking it their highest support. There is some support from the other sub-groups except for Local Community respondents who, on average, are neutral.

Emissions Trading is a type of ‘cap & trade’ system which places upper limits on the amount of emissions and allows the trade of a restricted number of permits to produce emissions (Ison, Peake et al. 2002). If the total level of emissions is to be reduced, then it may be expected that, over time, the number of available permits will progressively reduce, thus making permits more expensive. Emissions Trading should thus limit the total emissions of greenhouse gases, and this overall limit may restrict the ability of air transport to expand.

It is understandable that national regulators and environmental groups should therefore support the overall objectives of an emissions trading scheme. It is less clear why emissions trading attracts such support from industry stakeholders, and no support from local groups. The support of industry stakeholders seems inconsistent with their opposition to GHG limit and the other instruments which may limit growth.

Respondents' comments vary from expressing some doubts on the efficacy of emissions trading through to disbelief in the principle:

> *(Emissions) Trading is supported if designed well (focus on radiative forcing, not just CO2 (sic), and stringent target) but has the ability to be weak as well - given the delay until 2008 at the earliest before being introduced we reserve judgement until we see the detail, but support in general*
>
> *In absolute terms, aviation emissions should reduce. The picture is complicated by trading which would allow emissions from the sector to grow but overall remain compatible with UNFCCC commitments.*
>
> *Emissions trading is dishonest, disreputable and conceals the damage caused*

It is not intended here to explore the possible effect of an emissions trading scheme: this is a highly complex and political issue and is dependent on the level of emissions permits caps and porosity to imported permits. There seems a widespread expectation among industry respondents that emissions trading (at least in the early parts of the scheme) would not set onerous caps on emission, and would have little impact on civil aviation. There may be an expectation of a benign effect on aviation, allowing increased aviation emissions at the expense of other transport sectors or other industries.

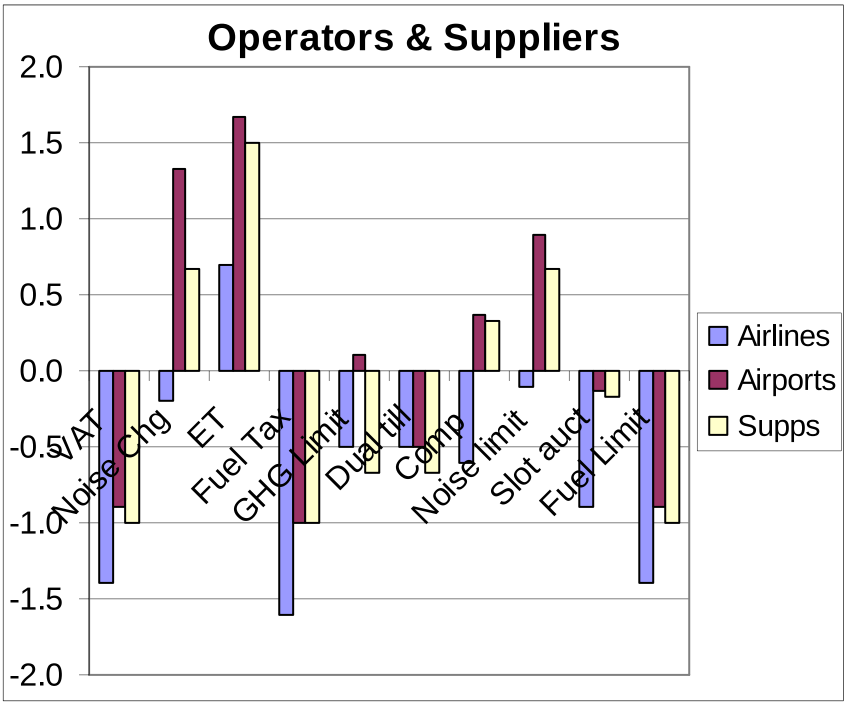


Figure 6.9 Instruments of Change – Operators & Suppliers

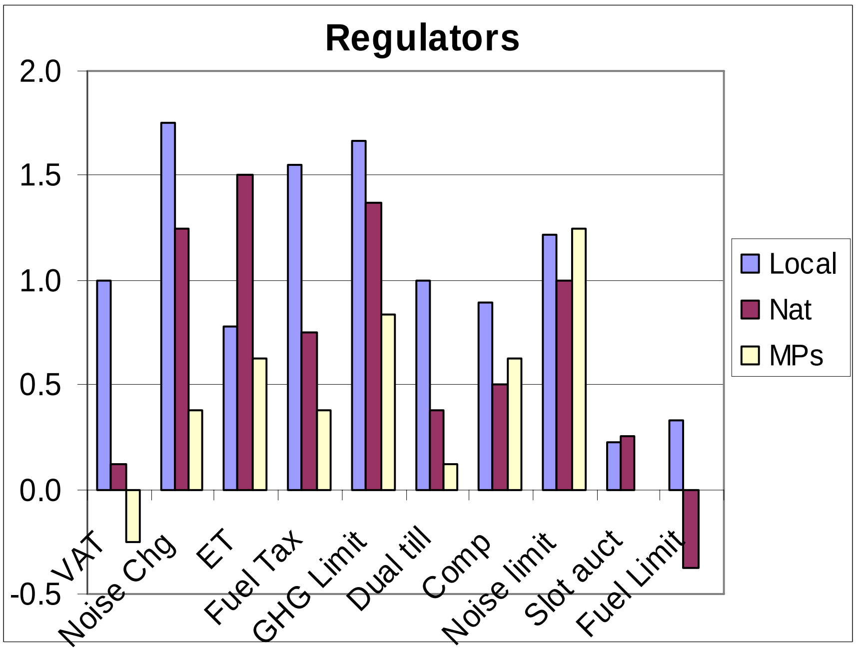


Figure 6.10 Instruments of Change – Regulators

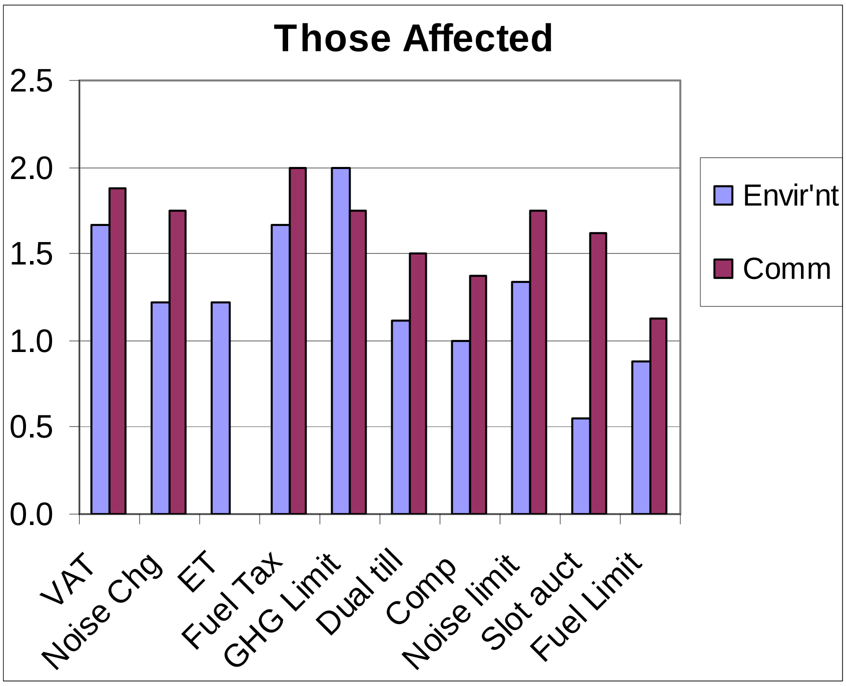


Figure 6.11 Instruments of Change – Those Affected

Stakeholder Sub-group	Support	Relative Rank
Local Community	2.0	1
Environmental groups	1.7	3
Local Authorities	1.6	3
National Regulators	0.8	5
MPs	0.4	6
Airports	-1.0	10
Suppliers	-1.0	9
Airlines	-1.6	10

Table 6.21 Aviation Fuel Tax – Support by Stakeholder Subgroup

Stakeholder Sub-group	Support	Relative Rank
Airports	1.7	1
Suppliers	1.5	1
National Regulators	1.5	1
Environmental groups	1.2	3
Local Authorities	0.8	8
Airlines	0.7	1
MPs	0.6	3
Local Community	0.0	10

Table 6.22 Emissions Trading – Support by Stakeholder Subgroups

Question. Are there any other potential instruments for change that you support or oppose?

Thirty respondents mention forty one other instruments. Responses are free format and some are general policies rather than specific instruments. The majority are repetitions of issues or policies raised in the earlier sections, or variations on the instruments included in the questionnaire.

A small number of instruments are mentioned that are relevant to aviation:

- Product labelling: information on emissions to be included on tickets, websites etc – mentioned once
- Air Passenger Duty (APD) – various modifications – mentioned 4 times
- En-route emissions charge – mentioned 3 times
- End duty free – mentioned once

The first of these – Environmental product information – is identified as an action from the analysis of civil aviation and Agenda 21, but is combined into the general policy of Public Information (section 5.4.2.3), and thus does not appear as a specific action or instrument in the questionnaire. Few other specific instruments were suggested by respondents, and there is little pattern of any widespread support for particular instruments.

Sustainability Levels

The sustainability spectrum (Pearce 1993), discussed at sections 2.2.2, Table 2.1 and at 5.4.2.4, proposes levels of sustainability from very weak to very strong. Pearce describes sustainability levels in terms of the use of various economic incentives and regulatory instruments, which can be related to survey instruments, and the response values (Table 6.23).

Aviation fuel tax is chosen as the indicative economic incentive instrument: thus very weak sustainability is indicated by lack of support for, or opposition to, aviation fuel tax; support indicates weak sustainability. Regulatory instruments are used to assess strong or very strong sustainability: strong sustainability is indicated by a strong support for legal limits on GHG emissions (a macro environmental standard from Pearce); very strong sustainability by strong support for a limit on aviation fuel use (regulatory limit on resource take). The latter two sustainability labels (strong and very strong) are only assigned when respondents positively indicate strong support for the relevant instrument. The responses from each stakeholder group are analysed according to these criteria and mapped onto the sustainability spectrum (Figure 6.12).

Sustainability Label	Use of Instruments (from Pearce)	Criteria	Response Value
Very weak	None – Free Market	Aviation Fuel Tax – no support or opposition	0, -1, -2
Weak	Economic instruments	Aviation Fuel Tax - Support	+1, +2
Strong	Macro-Environmental standards	Limit on GHG emissions - Strong support	+2
Very Strong	Minimise resource take	Limit on aviation fuel use - Strong support	+2

Table 6.23 Sustainability Spectrum – Support for Instruments of Change
Source: Author

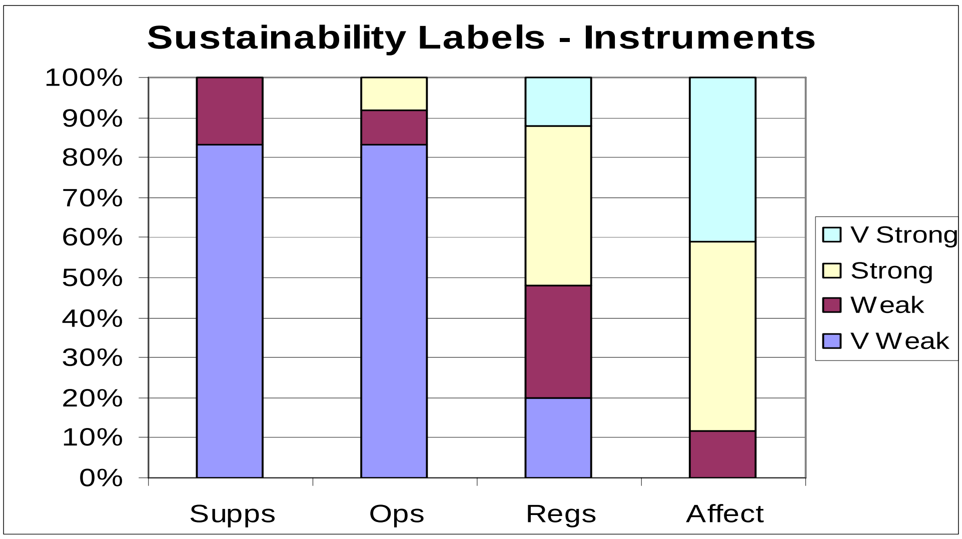


Figure 6.12 Sustainability Labels from Support for Instruments of Change

On the sustainability spectrum, respondents from Suppliers and Operators are predominantly in the very weak area (Figure 6.12), Regulators are mixed, indicating a range of views from very weak to very strong and Those Affected show a tendency towards the strong and very strong sustainability labels.

6.4.3 Organisational Policies

The Delphi Study examined the personal views of stakeholders, which may not necessarily reflect organisational views. Proposition 3.4 seeks to examine the organisational policies of airlines and airports, particularly for those organisations from which there is a corresponding input from a survey respondent, requiring a document analysis of published policies. The approach to document analysis borrows techniques from content analysis (Berelson 1952, Carney 1972, Weber 1993).

6.4.3.1 Approach to Document Analysis

The relevant documents are the published sustainability or environmental policies and reports as appropriate. There is little commonality in the documentation of sustainability issues in the organisations examined; document descriptions, formats, contents and the terminology vary widely. The following coding system is intended to clarify this variability and set appropriate rules for analysing the diverse documents. The recording units used in this analysis are based on policy, vision, goals, targets, and themes.

Policy. The highest level measure is the existence and publication by the organisation of a relevant document covering sustainability and/or environmental policies. Some organisations are known to be developing such policies, but, if at the time of the research the document has not been published, it is assumed not to exist. The range of document names includes:

- Sustainability Policy/Report
- Environmental Policy/Report
- Corporate Responsibility Policy/Report

Vision. The characteristics of a vision (section 3.4.3) are:

- Frame of reference for change
- Reflecting community/ organisational values
- Desired position to achieve

A vision is recorded where:

- The organisation states it has a vision
- A statement appears with some of the above characteristics
- A number of goals appear, which together constitute a vision statement

Goals. The characteristics of goals (section 3.4.3) are:

- More specific definition of vision
- Particular sustainability issues
- Desired direction or level of change
- Applicable to specific domain – e.g. industrial sector or company

Goals are recorded where there are statements with the general characteristics above. They may be called goal, objective, policy, commitment. Goals may be expressed at a general level covering more than one sustainability issue and may remain unquantified.

Targets. Targets as envisaged in the Bellagio Principles (Hardi, Zdan 1997), are expected to reflect the sustainability goals, refer to the scale of the sustainability issue and be quantified. In practice, organisations may set operational or management targets, which may not directly relate to the absolute scale of the sustainability issue. Targets are recorded where the organisation specifically uses the word 'target' to define some aspect of its sustainability effort. Where the organisation does not use the word 'target' but for instance talks of 'actions' or 'initiatives', then these are not recorded as targets. The different types of targets are recorded as:

- Quantified target – a target for the external scale of the issue, quantified in level and timescale.
- Procedural target – a target related to some operational or management procedure – such targets may have some quantification, but do not apply directly to the scale of the sustainability issue.

Themes. A theme in this exercise is defined as an expression of view on a subject category (see below). This may be an expression of support or opposition, desirability, undesirability, prediction or hope that the subject category should move in a certain direction. In some cases the overall direction may have to be derived from the effect of management actions or targets. Normally, themes are interpreted as a directional view on the category, and the direction of the support can be classed as increase or decrease.

Category. In this exercise, the research question concerns the relationship of organisational policies to sustainable development issues. Thus categories will be the issues relevant to sustainable development in aviation. Direction is interpreted as support for increase or decrease in the level of the category – the sustainability issue.

The research establishes a set of sustainability issues for civil aviation prioritised by Delphi Round 1 respondents (Section 6.3.1). The list forms the basis for subject categories for the document analysis. In addition certain local airport issues, which feature in airport environmental statements, are included. The full category list is:

- Aircraft GHG Emissions
- Use of aviation fuel
- Aircraft fuel efficiency
- Surface transport emissions
- Local air pollution
- Number of flights
- Aircraft noise
- Land Use
- National Economy
- Social Benefits
- Airport (ground site) emissions
- Water quality
- Waste
- Other issues

6.4.3.2 Findings – Airlines

Data is derived from the policies of British Air Transport Association (BATA 2005), and two airlines, British Airways (BA 2005) and Virgin Atlantic (Virgin Atlantic 2005). Of the ten airlines represented by respondents to the survey, only two have published environmental statements at the time of the research (early 2005). These are rich in goals but have few quantified targets (Table 6.24). Other airline respondents indicated that company policies are in preparation.

Both airlines are strongly committed to improved fleet fuel efficiency (Table 6.25), and in this respect support sustainable development principles. The highest priority of survey respondents (aircraft emissions) is not addressed and other concerns are unclear or missing from the policies. The airline policies do not address the sustainable development concerns of survey respondents except in terms of eco-efficiency of aircraft.

	Representative organisation	AL1	AL2
Policy statement	N	Y	Y
Vision	Y	Y	N
Goals	0	12	11
Targets	0	3	2

Table 6.24 Sustainable Development Policies – Airlines

Category/Theme	Representative organisation	AL1	AL2
Aircraft GHG Emissions	Unclear		Measure
Use of aviation fuel			
Aircraft fuel efficiency		Improve	Improve
Surface transport emissions			Evaluate
Local air pollution	Unclear		
Number of flights			
Aircraft noise	Unclear		Measure
Land Use	Increase		
National Economy (benefits)	Increase		
Social Benefits			
Ground site emissions		Reduce	Review
Water quality			
Waste			Monitor
Employee safety		Improve	Improve

Table 6.25 Sustainable Development Themes – Airlines

6.4.3.3 Findings - Airports

Data is taken from the environmental policies or reports published by UK airports (BAA 2005a, Birmingham Airport 2005, Bristol Airport 2005, LBIA 2005, London City Airport 2005, Manchester Airport 2004).

Most airports identify few specific targets (Table 6.26), but tend to rely on more generalised goals. AP1 (BAA) and AP6 (Manchester) have very large numbers of self declared targets: these are further analysed to ‘quantified’ and ‘un-quantified’. Each airport has 20 quantified targets i.e. defined, stated measures. The remainder (55 and 129 respectively) are unquantified, and tend to be directional or procedural in nature, often relating to the introduction of internal management processes. Other airports provide similar, though shorter, commentary on their internal activities, but tend to present this as management practice rather than as targets. These two airport companies may have set out to give an impression greater than the actual substance of the content.

	AP1	AP2	AP3	AP4	AP5	AP6
Policy statement	Y	Y	Y	Y	Y	Y
Vision	Y	Y	Y		Y	Y
Goals	5	29	7	16	7	26
Targets	75	4	1	4	2	149

Table 6.26 Sustainable Development Policies – Airports

The nature of the targets requires examination. Targets are frequently expressed as reductions compared with 'Business as Usual' (BAU), as internal operational procedures, or as comparisons with a previous year. 'Business as usual' means the nominal projected consumption or impact, based on existing efficiency levels and forecast increases in passenger numbers. Thus targets are to improve on BAU with some form of operational efficiency improvement. Procedural targets relate to some operational aspect e.g. the proportion of aircraft adopting a particular flying technique (like continuous descent approach), or the proportion of passengers using public transport. While such efficiency improvements and procedural changes are undoubtedly desirable, they do not in themselves set any target for a change in the external impact. The improvement target may be rather modest, and while efficiency or effectiveness may improve, the total external impact may actually increase owing to increased activity levels. Where airports use these types of target setting, the total external impact on consumption, emissions, noise or waste arisings, normally remains un-stated and may be difficult to derive.

A third method of target setting is to compare with a previous year. One airport has a target not to exceed 1992 noise levels; noise has reduced since that date, due to the use of quieter aircraft, though this data is not provided. Thus the target actually represents a potential increase in noise levels.

There are clear patterns from the theme analysis (Table 6.27). Although airports handle all aviation fuel, none report volumes used, or consequent aircraft emissions. Most airports have procedural targets to increase public transport use, but most remain unclear on the overall effect on ground transport emissions. Similarly, most have some operational initiative on aircraft noise, but remain unclear on total noise generation. All airports are committed to increase the proportion of waste recycling as required by their local authorities, but most are unclear on total waste arisings: only one airport makes a positive commitment to reduce total waste. Air quality and water pollution are largely defined by legislative instruments and airports are committed to operating within the law.

Category/Theme	AP1	AP2	AP3	AP4	AP5	AP6
Aircraft GHG Emissions						
Use of aviation fuel						
Aircraft fuel efficiency						
Surface transport emissions	Unclear	Unclear	Unclear	Increase	Reduce	Increase
Local air pollution	Legal limits	Legal limits		Legal limits	Reduce	Legal limits
Number of flights						
Aircraft noise	Unclear	Unclear	Unclear		Reduce	Increase
Land Use	Increase	Increase				
Social Benefits	Improve	Improve				
National Economy						
Ground site emissions	Increase	Reduce		Reduce		Reduce
Waste	Increase recycle	Increase recycle	Reduce	Increase recycle	Increase recycle	Increase recycle
Water Quality	Legal limits	Legal limits			Maintain	Legal limits

Table 6.27 Sustainable Development Themes – Airports

Airline and airport policies concentrate on internal efficiency improvements (for airlines, fuel consumption and aircraft emissions, for airports, site emissions, surface transport emissions, and waste recycling) and in this respect support sustainable development principles. The policies in general do not address the overall consumption or impact of the operation, and no airline or airport addresses the issue of total aircraft greenhouse gas emissions, identified as the most important issue by respondents to this survey. In these respects, the policies must be judged as not addressing sustainable development principles.

6.4.4 Legal Framework

A full analysis of the legal and regulatory framework is included at section 4.3.12. (Tables 4.9,4.10 and 4.11). The regulations are assessed on a proposed scale of support for sustainable development in Chapter 7.

6.4.5 Propositions

Research Objective 3 – To determine why the observed actions of the civil aviation industry diverge from the principles of sustainable development.

Research Propositions –

3.1 – There is a low level of understanding of sustainable development.

3.2 – Commercial/financial pressure dominates in civil aviation organisations.

3.3 – Institutional orientations preclude sustainable development in civil aviation.

3.4 – Organisational policies preclude sustainable development in civil aviation.

3.5 – The legal framework precludes sustainable development in civil aviation.

Proposition 3.2.

From this research, there is little evidence that the stakeholders consulted considered company profitability to be a significant factor in influencing their views of sustainable aviation. Proposition 3.2 is not supported by this research.

Proposition 3.3.

In this research, respondents from organisations within the civil aviation business:

- Display significant opposition to many instruments for change
- Are assessed as being weak or very weak on the sustainability spectrum

From this research there is good evidence that institutional orientations would preclude sustainable development in civil aviation organisations.

The research findings support the research proposition.

Proposition 3.4.

Organisational policies of airlines and airports support sustainable development in terms of efficiency improvements, but fail to address or leave unclear the total external impact of operations. Organisational policies may not actively preclude sustainable development, but neither do they actively support it, with the exception of eco-efficiency of aircraft.

The research findings partially support the research proposition.

Proposition 3.5.

The findings of the analysis at section 4.12 are that in certain respects the UK legal framework is contrary to the principles of sustainable development.

The research findings support the research proposition.

6.5 *Round 1 – Explore Differences*

The above sections (6.2 to 6.4) analyse responses from the Delphi Round 1 questionnaire in some detail. This section explores differences to bring out the underlying reasons (Linstone, Turoff 1975). The section concentrates on stakeholders' views on sustainable development in aviation – the importance of issues and policy actions. These are explored to assess differences between stakeholder groups and secondly, the relationship to the principles of sustainable development as expressed in the Rio Declaration and Agenda 21.

6.5.1 Sustainability Issues and Stakeholder Groups

The responses on the importance of issues are analysed at section 6.3.1. There is widespread consensus amongst stakeholders on the most important and least important issues for sustainable aviation (Tables 6.5 and 6.6), though on certain issues e.g. passenger safety and oil depletion, there are differences between the stakeholder subgroups (Table 6.7).

6.5.2 Issues and Sustainable Development Principles.

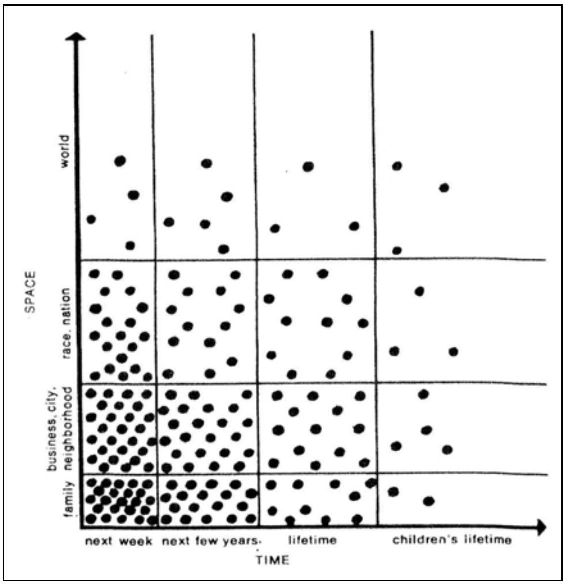
The view of sustainable development from Rio Declaration and Agenda 21 is strongly anthropocentric, and environmental protection, while extremely important, is seen as an enabler to the central objective, and thus becomes integral to all development. The Rio declaration sets out a number of principles with Human Health at Principle 1, Equitable Development at Principle 3, and Poverty Reduction at Principle 5: Agenda 21 Environmental dimension is actually entitled 'Conservation and Management of Resources For Development'.

Respondents' views from Delphi Round 1 appear to present a rather different balance (Section 6.3.1), showing environmental issues as the most important concern, with human health and equitable development given rather lower priorities. Responses give a strong emphasis to environmental aspects, primarily the global issue of greenhouse gas emissions, and secondly the local issues of air pollution and noise. Efficiency of new aircraft is given high priority by all stakeholder groups and is clearly associated with the issue of greenhouse gas emissions.

Relatively lower priority is given to health related issues (Safety, passenger & aircrew health, spread of disease), regional equity, and poverty reduction. In these respects, survey responses diverge from the balance of the Rio Declaration.

6.5.3 Issues and Human Perspectives

The differences in balance between questionnaire responses and Rio Declaration may be better understood when considered against a model of Human Perspectives (Figure 6.13).



Although the perspectives of the world's people vary in space and in time, every human concern falls somewhere in the space-time graph. The majority of the world's people are concerned with matters that effect only family or friends over a short period of time. Others look farther ahead in time or over a larger area – a city or a nation. Only a very few people have a global perspective that extends far into the future.

Figure 6.13 Human Perspectives – Space Time Graph

Source: (Meadows 1972)

Meadows suggests:

> *Every person approaches his problems, wherever they occur on the space-time graph, with the help of models. A model is simply an ordered set of assumptions about a complex system.*
>
> (Meadows 1972) *p20*

Thus people with differing models may be expected to select differing concerns (or issues).

The space-time graph provides a useful framework against which to map the issues considered in the questionnaire. In this mapping, issues are given a unique number (1-21) following the questionnaire sequence (Table 6.28). An issue is generally assigned to the lowest appropriate time/space level even though it may affect longer time or higher space levels. For instance, 6 – Number of flights, is shown at a local level even though it is also a national and global issue; 7 – Regional Equity, is shown as a current issue, but may well continue into the future; 21 – Aircraft Emissions is shown as a current concern even though the effect may be intergenerational due to the long timescale of CO_2 in the atmosphere (Pachauri 2005). Those issues concerned with local airport disbenefits (noise pollution) are shown at neighbourhood level.

	Issue	**Time**	**Space**
1	Aircraft fuel efficiency	Next few years	Business
2	Poverty reduction	Next few years	Nation
3	Passenger health	Next few years	Nation
4	Aircrew health	Next few years	Nation
5	Land Use	Next few years	Neighbourhood
6	Number of flights	Now	Neighbourhood
7	Regional Equity	Now	World
8	Aircraft noise	Now	Family/Neighbourhood
9	Passenger safety	Next few years	Nation
10	Aircraft Disposal	Lifetime	Nation
11	Surface transport emissions	Now	Nation
12	Local air pollution	Now	Family/Neighbourhood
13	Use of aviation fuel	Next few years	Neighbourhood
14	Airport Waste	Next few years	Neighbourhood
15	Depletion of oil reserves	Children's Lifetime	World
16	Airport Use of resources	Next few years	Neighbourhood
17	Airport Emissions	Now	Family/Neighbourhood
18	Airport Employment	Next few years	Neighbourhood
19	Spread of disease	Next few years	World
20	Community Accident Risk	Next few years	Neighbourhood
21	Aircraft GHG Emissions	Now	World

Table 6.28 Sustainability Issues by Space and Time

The issues input to the questionnaire show a wide spread across the space time graph (Figure 6.14A). The important issues for stakeholder groups tend to concentrate on those issues closer in time and space: responses for Operators and Those Affected are shown at Figure 6.14 B & C. For Those Affected, issues concerned with local disbenefits (aircraft noise, air pollution) are placed at the family level. These mappings show a good correlation to Meadows' Theorem i.e. that people are generally concerned with local and short term issues. The one exception is aircraft GHG emissions – a global issue which has received very wide acknowledgement and publicity and is clearly well recognised by respondents of this survey.

A) Issues included in Questionnaire				
World	7, 21	19		15
Race/ Nation	11	2, 3,4, 9	10	
Business, City Neighbourhood	6, 8, 12, 17	1, 5, 13, 14, 16, 18, 20		
Family				
	Next Week	Next few years	Lifetime	Children's Lifetime
B) Operators – High importance Issues				
World	21			
Race/ Nation	11			
Business, City Neighbourhood	6, 8, 9, 12	1, 13, 18		
Family				
	Next Week	Next few years	Lifetime	Children's Lifetime
C) Those Affected – High importance Issues				
World	21			15
Race/ Nation	11			
Business, City Neighbourhood	6	1, 5, 13, 16		
Family	8, 12, 17			
	Next Week	Next few years	Lifetime	Children's Lifetime

Figure 6.14 Sustainability Issues – Mapped in Space Time Graph

6.5.4 Policy Actions and Stakeholder Groups

Responses on the importance of policy actions are analysed in detail at section 6.3.2, showing significant differences between stakeholder groups. The emphases of the policy preferences may be illustrated by exploring the characteristics of the policies.

Internal or External:

- Internal – a policy developed and applied by the civil aviation industry
- External – external regulatory or economic measure

Limit or Procedural:

- Limit – may lead to some limitation on demand, growth, emissions or noise
- Procedural – sets directions or procedural changes, which may be beneficial, but do not in themselves apply any limits on demand, emissions or noise

The characteristics are assigned for each policy in the questionnaire (Table 6.29).

- Internal 9 (53%), external 8 (47%)
- Limit 4 (24%), procedural 13 (76%)

Internal/external policies are well balanced, reflecting the range of actions from Agenda 21. The low number of limit policies reflects the tendency of Agenda 21 to set directional policies rather than define specific limits.

Policy	**Internal/ External**	**Limit/ Procedural**
Public education	External	Procedural
EIA for all civil aviation activities	External	Procedural
Improve efficiency of ATM	Internal	Procedural
Atmospheric research by civil aviation	Internal	Procedural
Renewable fuel for aviation	Internal	Procedural
Effective environmental legislation	External	Limit
Pay full external environmental costs	External	Limit
National noise levels	External	Limit
ICAO program for sustainable aviation	Internal	Procedural
Improve fuel efficiency of new aircraft	Internal	Procedural
Spreading benefits of aviation to socially deprived areas	External	Procedural
Accelerate the phase-out of old aircraft	Internal	Procedural
Community participation	External	Procedural
Investment in carbon sinks (e.g. forests)	Internal	Procedural
UK civil aviation sustainability strategy	Internal	Procedural
Integration at policy level	Internal	Procedural
Limit on greenhouse gas emissions	External	Limit

Table 6.29 Characteristics of Questionnaire Policies

To assess stakeholder preferences, the ten policies selected as most important are analysed against the above characteristics for the survey as a whole and for stakeholder groups (Table 6.30). The whole survey broadly reflects the above balance of characteristics, but prefers a larger proportion of external policies.

Respondents from operators choose policies predominantly internal to the aviation sector and all procedural: there are no policies which may be seen as applying any limitation to the demand or any quantified limit on environmental impact. The highest priority is given to internal efficiency measures.

Respondents from other stakeholder groups show a more balanced approach, closely reflecting the balance shown in Table 6.29, though Those Affected prefer slightly more external and limit policies.

Stakeholder Group	**Internal/External**		**Procedural/Limit**	
	Internal	**External**	**Procedural**	**Limit**
Whole Survey	4	6	7	3
Operators	7	3	10	0
Suppliers	4	6	6	4
Regulators	5	5	7	3
Those Affected	3	7	6	4

Table 6.30 Characteristics of Selected Policies

6.5.5 Policies and Sustainable Development Principles

Sustainable development is seen by the UN as a process of change (section 2.2.2), to be achieved through a wide range of actions identified in Agenda 21. Economic, regulatory, efficiency and participation actions are seen as complementary in Agenda 21 which advocates a balanced approach to the use of the wide range of policies and instruments for change.

Preferred Policies

Operators

Respondents from operators have a personal vision of increasing flights and employment i.e. of increasing volumes of air transport – reflecting the published visions of the Operator Companies (section 6.4.3). Respondents from operators emphasise efficiency improvements (Section 6.3.2, Table 6.10) and oppose economic and regulatory instruments which may reduce demand or affect activity levels (Section 6.4.2). They favour internal efficiency improvements, and voluntary procedural policies. These respondents show opposition to policies and instruments which are perceived to apply economic constraints on growth or restrictions on environmental outputs.

Essentially, respondents from operators show support for eco-efficiency measures – a narrow subset of the range of actions advocated in Agenda 21.

Those Affected

Respondents from Those Affected have a personal vision of decreasing environmental impacts (GHG emissions and Noise), but have no decision making influence, and rely upon external economic and legal constraints to deliver their vision. Thus, their preferred policy actions are economic measures in an attempt to limit demand, and regulatory limits on environmental impacts. The emphasis is on regulatory, external policies.

Regulators

Regulators support a balance of regulatory, efficiency and economic policies. The emphasis remains on environmental policies.

The preferred models for mitigation are very different:

Operators

- growth – no economic restraints
- environmental impacts mitigated by efficiency and voluntary measures

Those Affected

- growth limited by economic instruments
- environmental impacts mitigated by regulatory measures

Regulators

- growth and environmental impacts moderated by a combination of measures (efficiency, economic and regulatory)

Divergence from Sustainable Development Principles

A number of specific policy actions assigned relatively low priority by respondents would appear to be inconsistent with Agenda 21.

ICAO Program for sustainable development

This is derived directly from Chapter 38 of Agenda 21

> *All relevant agencies of the United Nations system should adopt concrete programmes for the implementation of Agenda 21.*
>
> (UN 1992a) *Chapter 38.8(b)*

An ICAO Program would appear very important for two reasons;

- It is a direct mandate from Agenda 21
- ICAO is the international regulator for civil aviation.

The action is given relatively low importance by the respondents to this survey (average score of 3.8 and ranked 12 out of 17).

Renewable fuel

It would seem that if greenhouse gas emissions are the major concern, then development of a renewable fuel should logically be assigned a high priority. For the survey as a whole this is given an average score of 3.9, so is close to being regarded as 'important', but is ranked 11 out of 17 policy actions. There is some variation between stakeholder groups: respondents from environmental groups rank this as their fourth most important policy and Airlines their third most important; by contrast, Airports and Suppliers show little enthusiasm for renewable fuel (ranked twelfth) and least important respectively).

Spreading benefits to socially deprived areas

Sustainable development principles place high priority on poverty reduction. For the survey as a whole this policy is given lowest priority – consistent with the relatively low priority given to the issue of Poverty Reduction (Section 6.3.1 Table 6.5).

6.6 *Round 2 – Selection of Factors*

6.6.1 Basis for Selection

The analysis of the civil aviation system (Chapter 4) yields 21 potential issues and 17 policies, which are used as input to the Delphi study Round 1. These are now reduced in number to derive a useable set of indicators: authors suggest the number of indicators should be 'limited' or 'manageable' (Hens, De Wit 2003, Hodge, Hardi 1997, UN 2001). Others suggest that selection is based on expert stakeholder choice (Bell, Morse 1999, Mitchell, May et al. 1995), though offer little detailed advice on how to make the selection.

In this research, the selection is made by prioritising responses from the Delphi Round 1. There is no prescriptive level of the number of factors to be selected nor any definitive method of making the selection. The general approach adopted is to select factors scored at an average of 4 or above (important → very important), but application of this criterion may be achieved in a number of ways:

a) Importance level >= 4.0 for the survey as a whole
b) Importance level >= 4.0 for a particular stakeholder group
c) Percentage of respondents choosing an importance level of 4 or 5
d) For policies, the priority chosen by respondent
e) Other issues or policies suggested by respondents

Those factors scoring over 4 (important → very important) for the survey as a whole are selected, but this criteria may not validly reflect the views of all stakeholder groups i.e. factors strongly favoured by some respondents may not on average score 4. On the other hand, to select all factors scoring 4 or above for a particular stakeholder group may introduce a bias towards that group – particularly significant for Those Affected, who gave high importance to more policies than other groups. Thus factors between 3.5 and 4 are examined, and the proportion of respondents choosing 4 or 5 importance level across the survey is used as a secondary selection criteria.

The priority selection of policies (section 6.3.2, Table 6.14) does not give a reliable selection process, since for any policy, there is great variability in the number of respondents. Other factors strongly suggested by respondents are taken into account.

6.6.2 Selection

Issues. Issues with an average importance for the survey as a whole of 4.0 or greater are selected, i.e. the first eight issues in Table 6.31.

The next issue – Airport Emissions – has an average importance of 3.91 and is thought important by 75.7% of respondents. Both counts are significantly lower than the top eight, and represent a valid point to cease the selection. Thus the ninth and lower ranked issues will not be selected for Round 2 questionnaire.

Two other issues were identified by a significant number of respondents: National economic benefits and Social benefits (Section 6.3.1). These did not originally appear from the sustainability analysis, but do emerge from the stakeholder review, and will thus be included in the short list. National economic benefits is taken to include generation of jobs and Airport Employment is selected.

Rank	Issues	Av	% Important or Very Important
1	Aircraft GHG Emissions	4.67	92.0
2	Aircraft fuel efficiency	4.49	97.3
3	Use of aviation fuel	4.40	90.7
4	Surface transport emissions	4.37	91.9
5	Local air pollution	4.35	93.2
6	Number of flights	4.36	87.7
7	Aircraft noise	4.31	91.9
8	Land Use	4.07	85.1
9	Airport Emissions	3.91	75.7
10	Depletion of oil reserves	3.88	72.6
11	Passenger safety	3.76	68.1
12	Airport Employment	3.67	65.8
13	A/P Use of resources	3.56	63.5

Table 6.31 Issues with Average Importance greater than 3.5

Policies. Policies with an average importance for the survey as a whole of 4.0 or greater are selected, i.e. the first eight policies in Table 6.32.

Public education. The average importance level (3.96) is very close to 4.0, and 80% of respondents chose important or very important for this policy, equal to the policy ranked at seven. This policy is selected.

Improve efficiency ATM. The average importance is 3.91 and 78.7% selected important or very important, close to levels already included (80.0%), so this is included. There is a gap of 6.7% between this and the next lower rank (Renewable Fuel). Thus this is taken as the break point to cease the selection. No other policies were strongly suggested by respondents (Section 6.3.2).

Rank	Policies	Av	% Important or Very Important
1	Improve fuel efficiency of new aircraft	4.47	93.2
2	Effective Environmental Legislation	4.27	86.7
3	Integration at Policy level	4.24	86.7
4	Limit on GHG emissions	4.24	82.7
5	EIA For all CA activities	4.22	90.5
6	UK CASS	4.11	82.7
7	Pay full external environmental costs	4.11	80.0
8	Community participation	4.00	81.3
9	Public education	3.96	80.0
10	Improve efficiency ATM	3.91	78.7
11	Renewable fuel	3.87	72.0
12	ICAO program for sustainable aviation	3.80	65.3
13	Atmospheric research by CA sector	3.72	69.3
14	National noise levels	3.72	66.7
15	Accelerate phase-out of old aircraft	3.71	65.3

Table 6.32 Policies with Average Importance greater than 3.5

Issues	Policies
Aircraft GHG Emissions	Improve fuel efficiency of new aircraft
Aircraft fuel efficiency	Effective Environmental Legislation
Use of aviation fuel	Integration at Policy level
Surface transport emissions	Limit on GHG emissions
Local air pollution	EIA For all CA activities
Number of flights	UK Civil Aviation Sustainability Strategy
Aircraft noise	Pay full external environmental costs
Land Use	Community participation
National Economy	Public education
Airport Employment	Improve efficiency of ATM
Social Benefits	

Table 6.33 Factors included in Round 2 Questionnaire

Issues	Policies
Airport Emissions	Renewable fuel
Depletion of oil reserves	ICAO program for sustainable aviation
Passenger safety	Atmospheric research by CA sector
A/P Use of resources	National noise levels
Regional Equity	Accelerate phase-out of old aircraft
Airport Waste	Carbon sinks (e.g. forests)
Aircraft Disposal	Spreading benefits to socially deprived areas
Community Accident Risk	
Passenger health	
Aircrew health	
Spread of disease	
Poverty reduction	

Table 6.34 Factors excluded from Round 2 Questionnaire

6.6.3 Potential Indicators

The purpose of this section is to suggest potential indicators for stakeholder review in Round 2 Questionnaire (Appendix 5). Some factors may be measured in different ways, so alternative potential indicators are offered. WLU (Workload unit) is a measure of combining passenger and freight activity equivalent to 1 passenger or 100 kgs freight.

In several cases a suitable indicator is not obvious and stakeholders are asked to suggest an indicator.

Gross Domestic Product. Agenda 21 suggests that measures such as Gross National Product (GNP) and Gross Domestic Product (GDP) are not suitable indicators, and recommends that an environmental accounting system should be developed. In the lack of such an accounting system, indicators based on contribution to GDP are suggested.

Issue	Potential Indicator(s)
Aircraft GHG Emissions	GHG emissions from civil aircraft
Aircraft fuel efficiency	Fuel used/WLU km GHG emissions/WLU km
Use of aviation fuel	Aviation fuel used
Surface transport emissions	GHG emissions from surface access vehicles
Local air pollution	Number of days air quality standards exceeded
Number of flights (Consumption and volume)	Number of flights performed Passenger-kilometres & freight tonne-kilometres WLU-kilometres performed
Aircraft noise	Noise maps/noise contours Population exposed to aircraft noise
Land Use	
Airport employment	Local economic benefits - value of airport jobs Energy ratio of economic benefits (gross energy consumption/ unit of economic benefit)
Economic Benefits – National	Positive GDP contribution Negative GDP contribution Energy ratio of GDP contribution
Social Benefits	

Policy	Potential Indicator(s)
Improve fuel efficiency of new aircraft	Performance of new aircraft compared with ACARE targets
Effective Environmental Legislation	Extent to which environmental legislation is applied to civil aviation activities
Integration at Policy level	Degree of integration of environment & development in aviation policy making
Limit on GHG emissions/ Emissions Trading	Progress towards aviation in an emissions trading scheme (EETS) *If aviation is included in EETS:* Total emissions within scheme - before and during EETS Aviation emissions before and during EETS
EIA For all CA activities	Extent to which EIA is applied to civil aviation activities
UK Civil Aviation Sustainability Strategy (CASS)	Progress towards UK CASS Number of agreed goals for sustainable development for UK civil aviation
Pay full external environmental costs	Proportion of external environmental costs paid by civil aviation in environmental taxes
Community participation	Degree of community participation in aviation environmental decisions
Public education	Progress toward environmental product information for air transport consumers e.g. adverts, websites, tickets
Improve efficiency ATM	

Table 6.35 Suggested Indicators for Round 2

Energy Ratio. The two indicators based on energy ratio – Energy ratio of GDP contribution and Energy ratio of local economic benefits – are suggested for a number of reasons. Round 1 responses include calls to treat civil aviation equally with other industries:

> *Consistant (sic) treatment across transport modes*
> *equal treatment to other industries*
> *Greater competition on a more level playing field*

There were also suggestions that hybrid indicators are needed:

> *maximising the number of jobs per person affected in the 65 LDEN contour, same for economic impact, ie we should be moving to hybrid indicators*

There would seem to be a desire for indicators that can both relate different dimensions of sustainability and compare different transport and industrial sectors. Indicators based on energy ratio have previously been proposed at different levels: The UK strategy 'A Better Quality of Life' indicator A2 (Energy efficiency of economy) (DEFRA 1999); industrial sector level (Intensity of energy use) (UN 2001); aviation sector (ATAG 2002). The later UK Strategy 'Securing The Future' (DEFRA 2005a) omits indicators based on energy ratio.

Agenda 21 calls for the identification of unsustainable consumption patterns at Chapter 4.10. Indicators based on energy ratio may help to identify unsustainable consumption patterns, may enable some comparisons with other industry sectors and are thus included in the suggested indicators.

UK Civil Aviation Sustainability Strategy (CASS). A project to develop a UK Civil Aviation Sustainability Strategy took place during the research (Sustainable Aviation 2005). Questions on CASS are omitted from the Round 2 Questionnaire.

6.7 *Round 2 – Purpose of Indicators*

Objective 4 – To explore stakeholder views on the purpose and scope of sustainable development Indicators for civil aviation.

Research Proposition 4.1 - There will be general agreement on the purpose and scope of sustainable development indicators for civil aviation.

Questions are included in Delphi Round 2 questionnaire section 2 (Appendix 5).

6.7.1 Purpose of Indicators

Question. Sustainable development indicators for civil aviation should be designed to:

- ***Inform the decisions of national government policy makers***
- ***Inform the decisions of local government policy makers***
- ***Inform the decisions of airline & airport managers***
- ***Inform the decisions of air transport consumers – freight users and passengers***
- ***Provide public information***

Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree

Responses are assigned a score of 5 → 1 (strongly agree → strongly disagree) and the agreement level was calculated from the average score. The support level for each purpose reflects the perceived importance of the decision maker. Respondents tend to largely agree with the suggested purposes for sustainable development indicators, giving high average scores for all the purposes.

For the survey as a whole (Table 6.36), there is very strong agreement that indicators should be designed to inform the decisions of National Government and of Airline/Airport Managers, showing that these decision makers are regarded as most important in sustainable development issues. There is support for the other purposes (Inform local authorities, Provide public information and Inform consumers), though at a more moderate level.

The different stakeholder groups generally follow a similar pattern (Table 6.36). There is however, some variation on the importance given to Inform decisions of local government: respondents from airports give this the lowest rank (3.8), causing this to be lowest ranked in the Operator group; respondents from National Regulators also place this lowest with a score of 3.9. By contrast, respondents from local regulators place this purpose second in the rankings with a score of 4.5. There is clearly some difference in views of the relevance of local authority decision makers: respondents from airports and national regulators suggest lowest importance, local regulators placing much higher importance on their own decisions.

	Survey as a whole	**Av**	**Number**	**SD**
1	Inform decisions of national government	4.7	43	0.5
2	Inform decisions of airline/airport managers	4.5	43	0.6
3	Inform decisions of local government	4.2	43	0.8
4	Provide public information	4.1	43	0.7
5	Inform consumers	4.0	43	0.7

	Operators	**Av**	**Number**	**SD**
1	Inform decisions of national government	4.5	13	0.5
2	Inform decisions of airline/airport managers	4.5	13	0.5
3	Provide public information	4.2	13	0.6
4	Inform consumers	4.2	13	0.7
5	Inform decisions of local government	4.2	13	0.9

	Regulators	**Av**	**Number**	**SD**
1	Inform decisions of national government	4.7	14	0.5
2	Inform decisions of airline/airport managers	4.5	14	0.8
3	Inform consumers	4.1	14	0.8
4	Inform decisions of local government	4.1	14	0.9
5	Provide public information	4.1	14	0.5

	Those Affected	**Av**	**Number**	**SD**
1	Inform decisions of national government	4.9	10	0.3
2	Inform decisions of airline/airport managers	4.6	10	0.5
3	Inform decisions of local government	4.5	10	0.5
4	Provide public information	4.4	10	0.7
5	Inform consumers	3.9	10	1.0

Table 6.36 Purposes of Indicators

Question: Other purposes – please specify. Respondents are asked to suggest other purposes for civil aviation sustainable development indicators.

Seven respondents suggest other purposes (Table 6.37). Four suggested that indicators should inform the decisions of a variety of international institutions. The most frequently mentioned purpose is to inform the decisions of the European Union. It is perhaps notable that no respondents specifically mention informing decisions of ICAO (the closest is a general reference to International Agencies). It would appear that amongst this set of stakeholders there is little expectation that ICAO should play a significant role in sustainable development of aviation.

Other purposes	
Inform decisions of EU	4
Inform decisions of World Bank	1
Inform decisions of IMF	1
Inform decisions of Manufacturers	1
Inform decisions of International Agencies	1
International comparisons and use in negotiations	1
Template for sustainability indicators in other sectors	1
To allow growth in the most sustainable way.	1

Table 6.37 Additional Purposes for Indicators

6.7.2 Scope of Indicators

Question. Sustainable development indicators for civil aviation should provide information about:

- ***Social and economic aspects***
- ***Environmental aspects***
- ***Public participation***
- ***Regulatory arrangements***
- ***Effect of programmes for change***
- ***Progress towards agreed targets***

Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree.

Responses are assigned a score of 5 → 1 (strongly agree → strongly disagree) and the agreement level is calculated from the average score. The average scores may be taken as an indication of the relative importance attached to the different types of information by respondents.

The responses are dominated by a strong emphasis on the need for environmental information; all respondents either agree or strongly agree (Table 6.38). For the survey as a whole, there is then a set of information types receiving moderate support: Progress towards targets, Social & Economic aspects, Effect of programmes for change.

	Survey as a whole	**Av**	**Number**	**SD**
1	Environmental aspects	4.84	43	0.4
2	Progress towards targets	4.47	43	0.8
3	Social & Economic aspects	4.30	43	0.8
4	Effect of programmes for change	4.26	42	0.8
5	Regulatory arrangements	3.86	43	0.9
6	Public participation	3.60	42	0.9

	Operators	**Av**	**Number**	**SD**
1	Environmental aspects	4.85	13	0.4
2	Social & Economic aspects	4.77	13	0.4
3	Progress towards targets	4.31	13	0.9
4	Effect of programmes for change	4.08	13	1.0
5	Regulatory arrangements	3.69	13	0.9
6	Public participation	3.54	13	1.1

	Regulators	**Av**	**Number**	**SD**
1	Environmental aspects	4.86	14	0.4
2	Progress towards targets	4.43	14	0.9
3	Effect of programmes for change	4.36	14	0.6
4	Regulatory arrangements	4.00	14	0.6
5	Social & Economic aspects	4.00	14	1.0
6	Public participation	3.43	14	0.5

	Those Affected	**Av**	**Number**	**SD**
1	Environmental aspects	5.00	10	0
2	Progress towards targets	4.90	10	0.3
3	Effect of programmes for change	4.40	10	0.8
4	Regulatory arrangements	4.20	10	1.0
5	Social & Economic aspects	4.20	10	1.0
6	Public participation	3.90	10	1.0

Table 6.38 Scope of Indicators

For the stakeholder groups there is a marked difference in the importance of information on Social & Economic aspects: respondents from Operators rank this second in importance, giving very strong support with an average score of 4.8

(Table 6.38); respondents from Regulators and Those Affected groups agree that the information is needed, but rank it fifth, with a lower level of support (average 4.0 and 4.2 respectively).

Least supported is information about Regulatory arrangements and Public Participation. For the survey as a whole, these receive average scores less than 4, showing less than overall agreement that these are needed. For each stakeholder group, the ranking of these information types is similar, though there is some difference in the perceived need; Operators score these somewhat lower than the overall average, Those Affected somewhat higher (Table 6.38).

Other Information. Respondents are asked to suggest other information types that may be provided by sustainable development indicators for civil aviation, in addition to those included in the survey. Four respondents answer this question (Table 6.39), three suggesting comparative information, and one suggesting some form of local balance between airport benefits and disbenefits. There is an emphasis on using the indicators for comparison within and outside the civil aviation industry.

Other information types	
Benchmark data	1
Comparison with other transport modes	1
Performance of individual airlines	1
Name and shame those who fail to meet targets	1
Local balance of airport benefits and disbenefits	1

Table 6.39 Additional Scope of Indicators

6.7.3 Explore Differences

Differences between Stakeholders

On the purposes of sustainable development indicators there is widespread consensus. The single difference is that the role of local authorities is regarded as high importance by the local authorities themselves and lower importance by national regulators and airports.

On the information required for indicators, there is consensus between stakeholder groups, though respondents from Operators give greater importance to Social & Economic information, possibly because they perceive this as including data on beneficial aspects of air transport.

Comparison with Sustainable Development Principles

Purposes

Indicators should inform decision makers at all levels from consumer to national decision makers (UN 1992a) and respondents generally agree with this. There is however moderate support for information for Local Government, Consumers and Public Information, whereas Agenda 21 places heavy emphasis on the role of local initiatives, consumer choices and public participation.

Respondents also suggest an additional purpose – to provide information for international decision makers – which is consistent with Agenda 21.

Information Types

Indicators should cover the whole range of Agenda 21 dimensions and chapters. Respondents suggest that information about regulatory arrangements and public participation are not well supported (average <4), a view not consistent with sustainable development principles.

The reasons are not entirely clear from the research. It is likely that respondents are influenced by the common understanding of sustainable development as three dimensions (social, economic and environmental), and therefore have a lower appreciation of the institutional dimension which covers regulatory and participation arrangements.

6.7.4 Proposition

Objective 4 – To explore stakeholder views on the purpose and scope of sustainable development indicators for civil aviation.

Research Proposition 4.1 - There will be general agreement on the purpose and scope of sustainable development indicators for civil aviation.

This research confirms the proposition.

6.8 *Round 2 – Stakeholder Indicator Selection*

Objective 5 – To obtain stakeholder views on suggested indicators of sustainable development for civil aviation.

Research Proposition 5.1 There will be some agreement on which indicators should be used to assess progress towards sustainable development in civil aviation.

Questions are included in Delphi Round 2 questionnaire section 3 (Appendix 5).

Question. Are the following sustainable development indicators : Needed, Suitable: Yes, No, No View

The list of indicators is derived in section 6.6.3 above and arranged in five categories: consumption, local issues, economic issues, change, and institutional arrangements derived in section 5.4.3.

6.8.1 Approach to Analysis and Selection

Analysis of Responses

The following tables show for each suggested indicator, the number and percentage of respondents who consider the indicator is needed (Yes), not needed (N), or have no view (NV).

Selection of Indicators

There is no prescriptive method of selecting indicators, though there are numerous possible approaches. Some are based on mathematical support levels:

- Select if a specified percentage of respondents vote ‘needed’
- Select the most popular (a specified number)
- Reject the least popular (a specified number)
- Reject if a specified percentage of respondents vote ‘not needed’

All the approaches depend on setting essentially arbitrary levels. The resultant indicator set could potentially have a number of drawbacks: multiple similar indicators; it may not include important indicators; it may not reflect views of all stakeholder groups; may not have a balance between different types of indicator (e.g. the indicator groups in the questionnaire). Authors suggest (Mitchell, May et al. 1995) that the selection should be based on the objectives of the indicator users. In this project the stakeholder groups have different objectives, so this criteria in itself, does not offer a firm basis for selection, but does suggest that the objectives of the different stakeholder groups should be reflected in the selection.

In practice each different indicator group presents different selection issues. It is thus necessary to consider each group of indicators separately, taking into account the nature and relationship of the indicators and the stakeholder views. For each group the selection process should take account of:

- Nature and relationship of indicators
- Stakeholders' view of the importance of the factor (from Delphi Round 1)
- Stakeholders' view of the need for the suggested indicator
- Views of different stakeholder groups

6.8.2 Consumption & Efficiency Indicators

This category includes alternatives to assess attitudes to different indicators.

Suggested Indicator	Yes	N	NV	%Yes	%No	%NV
Aircraft GHG Emissions	40	2	1	93	5	2
Fleet GHG Efficiency	37	4	2	86	9	5
Fuel Used	32	6	4	74	14	9
Number of flights	31	9	2	72	21	5
PassKms/ TonneKms	31	10	1	72	23	2
Fleet Fuel Efficiency	29	9	3	67	21	7
WLU Kms	26	12	3	60	28	7

Table 6.40 Consumption & Efficiency Indicators – Overall Support

Aircraft GHG emissions receives the strongest support of all indicators (Table 6.40). From the comments received, there is a widespread feeling that this indicator should include the radiative forcing factor discussed at section 4.3.5. Respondents specifically refer to the IPCC factor of 2.7 (IPCC 1999), being unaware of later research suggesting a lower ratio around 1.9 (Sausen, Isaksen et al. 2005).
Two respondents comment that GHG emissions are proportional to fuel consumed:

> *GHG emissions are almost entirely a function of fuel used, and the development of an "aircraft efficiency parameter" very controversial.*
>
> *CO2 (sic) and fuel use are directly proportional*

Indicators for fuel used and GHG emissions are selected.

For fleet efficiency, respondents prefer indicators based on GHG emissions to those based on fuel: Aircraft GHG emissions receives more support than Fuel used; Fleet GHG efficiency is more strongly supported than Fleet Fuel efficiency.

The indicators measuring volume of performance i.e. Flights, passenger kilometres performed (PassKms), are thought necessary by over 70%, but more than 20% of the respondents consider that they are not needed.

WLU Kms performed (Work Load Unit) is included in the survey as a potential consumption indicator, capable of integrating passenger and freight transport. This received a relatively low level of support: 60% considered this needed and 56% suitable. Respondents are uneasy about the use of Work Load Unit (WLU):

> *second and third are confusing (PASS KM & WLU KM)*
>
> *I have said Yes to WLU-Kms Performed and the related question re Aircraft Fleet Efficiency, but I have resservations(sic) becauuse(sic) of concerns about whether outside the industry people will be able to understand the concept(s).*
>
> *WLU should be replaced with revenue tonne KM as this is already an established measure within the industry.*

Revenue tonne (10 times WLU) replaces WLU in the efficiency indicator. There is little variation in the rankings of the indicators between the major stakeholder groups (Table 6.45). Respondents from the operator group place the consumption indicator (PassKms/TonneKms) somewhat higher than other groups.

Selected indicators:

- GHG emissions from civil aircraft
- Aviation fuel used
- Passenger kilometres & freight tonne kilometres performed
- Aircraft fleet efficiency – GHG emissions/revenue tonne km performed

These four indicators include the three highest ranked in each major stakeholder group (Table 6.45).

6.8.3 Local Airport Impacts

Suggested Indicator	Yes	N	NV	%Yes	%No	%NV
Noise Maps	37	3	1	86	7	2
Surface Access GHG	37	4	1	86	9	2
Air Quality	35	7	1	81	16	2
Noise Population	34	6	1	79	14	2

Table 6.41 Local Impact Indicators – Overall Support

There is very high support for the indicators and little opposition. The noise indicators (maps and population) are defined in the EU directive on Environmental Noise (EU 2002) and it follows that they should be considered as an integrated indicator. There is, however, a separation in their ranking, Noise Population receiving less support than Noise Maps. A small number of respondents (3) in the operator and user stakeholder groups support noise maps as an indicator but not population exposure.

Those Affected give stronger support to all Local Airport indicators and place air quality as their highest priority (100%). Otherwise, there is little variation between the rankings from stakeholder groups (Table 6.45).

Eleven respondents (26%) suggest other indicators. Eight are variations of, or comments upon, indicators for noise, air quality and airport disbenefits. Other respondents suggest indicators for waste arisings, water quality and site emissions, also widely used in airport environmental policies (Section 6.4.3). These are omitted from the questionnaire since they are accorded lower priority in the Round 1 survey (section 6.6).

Selected Indicators:

- Noise Maps
- Noise Population
- Surface Access GHG
- Air Quality
- Waste arising
- Water quality
- Airport site emissions

6.8.4 Economic Indicators

Suggested Indicator	Yes	N	NV	%Yes	%No	%NV
GDP Positive contribution	35	2	5	81	5	12
Jobs Value	32	3	6	74	7	14
GDP Negative contribution	30	4	8	70	9	19
GDP Energy Ratio	16	11	14	37	26	33
Jobs Energy Ratio	15	13	13	35	30	30

Table 6.42 Economic Indicators – Overall Support

Analysis of Responses

There are somewhat differing levels of support for Positive and Negative contributions to GDP (Table 6.42). Regulators and Those Affected stakeholders give these two indicators the same levels of support. Differences are in the operator and supplier stakeholder groups and may reflect a preference to measure the positive, with some reluctance to measure negative aspects.

Indicators based on energy ratio are not well supported, with less than 40% support and over 60% against or no view. One respondent suggests the energy ratio indicators are not fully understood:

> *Not sure what is meant by the energy ratio indicator.*

Another respondent records no view on the need for these indicators but does seem to support the concept of a benefits/energy ratio:

> *Econmic (sic) benefits would need to be evaluted (sic) to an agreed standard against environmental costs to be worthwhile.*

Others support the need to compare across industries, but state these indicators are not needed:

> *Compare all above indicators for aviaiton (sic) industry with comparable figures for other industries using same landmass as airports, such as manufacturing and service industries*

> *Need to relate aviation contributions to other industries/modes of transport!*

While the energy ratio indicators do not take into account landmass, they are the only indicators suggested that would offer any comparison with other industries.

Respondents from the Regulators group tend to give somewhat lower support for the economic indicator category; there is little variation in the rankings between stakeholder groups (Table 6.45).

Selection of Indicators

Respondents support the use of GDP and Value of Airport Jobs. Indicators based on Energy ratio of economic benefits are not supported by the stakeholders.

Thus the indicators selected are:

- Contribution to Gross Domestic Product GDP
- Local economic benefits: value of airport jobs

6.8.5 Change Programmes

Suggested Indicator	Yes	N	NV	%Yes	%No	%NV
ACARE Targets	37	2	3	86	5	7
Aviation EETS Emissions	34	3	4	79	7	9
Progress towards Emissions trading scheme	32	7	2	74	16	5
Total EETS Emissions	29	6	5	67	14	12

Table 6.43 Change Programme Indicators – Overall Support

There is strong support for an indicator(s) to measure progress towards ACARE targets (Table 6.43).

The indicator, Aviation emissions under EETS, is the same indicator as Aircraft GHG Emissions, tracked through the period of EETS. Respondents show less enthusiasm for an indicator of Total Emissions under an EETS scheme: this is a valid indicator for National Governments within the Emissions Trading scheme, but is beyond the scope of aviation.

There is little variation in the support or rankings between stakeholder groups.

Selected:

- ACARE Targets
- Progress towards aviation in Emissions Trading scheme

6.8.6 Institutional Arrangements

Suggested Indicator	Yes	N	NV	%Yes	%No	%NV
External Costs paid	36	5	1	84	12	2
Environmental Impact Assessment	33	5	4	77	12	9
Product Information	31	3	7	72	7	16
Community Participation	29	7	5	67	16	12
Environmental Legislation	27	10	4	63	23	9
Integration	25	12	4	58	28	9

Table 6.44 Institutional Indicators – Overall Support

Analysis

This group indicators receives the lowest support (Table 6.44) except for the energy ratio indicators. It would seem that there is some reluctance to measure institutional aspects, and some doubt as to how the aspects can be measured:

> *It's difficult to say whether these indicators are appropriate as the measurement is vague.*
>
> *Integration too hard to measure; Degree of community participation very difficult to measure.*
>
> *Community participation is possibly an indicator, but how is it to be measured?*

There is widespread support for an indicator to measure the proportion of external costs paid by aviation (84% say this is needed), but also some opposing views:

> *The 3rd suggestion above assumes that taxes are a good instrument for addressing impacts - many would disagree in an aviation context.*
>
> *FURTHER TAXES ON AVIATION SHOULD BE AVOIDED.*
>
> *The external cost argument only works where payment can offset impacts. If taxes do not or cannot stimulate improved performance or remediation (eg if more efficient aircraft are not available yet) there is no point in imposing them.*

Support for the other proposed indicators progressively reduces (Table 6.44). Indicators for Environmental Legislation and Integration receive low support. This is not consistent with the responses to Delphi Round 1 where policies requiring Effective Environmental Legislation and Integration are strongly supported (Section 6.3.2). Those Affected give greater support than other groups for indicators in this category.

Selection

Selection of indicators is based on the level of support for the survey as a whole and from any specific stakeholder group.

An indicator based on External Costs paid by aviation is strongly supported overall (84%) by all stakeholder groups: Select.

An indicator based on Use of EIA (Environmental Impact Assessment) is well supported overall (77%), though is ranked fourth by the operator group: Select.

An indicator based on Product Information receives 72% support and is ranked second or third by all the stakeholder groups: Select.

An indicator based on Community Participation is ranked fourth overall with 67% support. This indicator is ranked third by respondents from the operator group and is selected on this basis: Select.

Indicators based on Environmental Legislation and Integration receive low levels of support, some increase in opposition and are consistently ranked fifth or sixth by all the stakeholder groups. On this basis these indicators are not selected.

Selected:

- External Costs Paid
- Environmental Impact Assessment
- Product Information
- Community Participation

Indicator	Whole Survey	Operators	Regulators	Those Affected
Consumption & Efficiency Indicators				
Aircraft GHG Emissions	1	1	1	1
Fleet GHG Efficiency	2	3	2	3
Fuel Used	3	4	4	2
Number of flights	4	5	5	4
PassKms/ TonneKms	5	2	6	6
Fleet Fuel Efficiency	6	7	3	7
WLU Kms	7	6	7	5
Local Airport Aspects				
Noise Maps	1	2	2	3
Surface Access GHG	2	1	1	2
Air Quality	3	3	4	1
Noise Population	4	4	3	4
Economic				
GDP Positive contribution	1	1	2	1
Jobs Value	2	2	1	3
GDP Negative contribution	3	3	3	2
GDP Energy Ratio	4	4	4	5
Jobs Energy Ratio	5	5	5	4
Change Programmes				
ACARE Targets	1	2	1	3
Aviation EETS Emissions	2	1	2	4
Progress towards ETS	3	4	3	2
Total EETS Emissions	4	3	4	1
Institutional Arrangements				
External Costs	1	1	2	1
Environmental Impact Assessment	2	4	1	3
Product Information	3	2	3	2
Public Participation	4	3	4	4
Environmental Legislation	5	5	6	5
Integration	6	6	5	6

Table 6.45 Indicator Rankings – Category & Stakeholder Group

6.8.7 Other Aspects

Question: Would you like to suggest potential sustainable development indicators for:

Improving efficiency of Air Traffic Management

Social benefits of Aviation

Airport Land Use

Improving Efficiency of ATM. Seventeen respondents (40%) suggest indicators for ATM efficiency. Most are based on a single internal aspect of ATM e.g. stacking, taxiing, use of continuous descent approach, and some suggest performance targets for ATM providers e.g. manning levels, use of direct routing. One respondent suggests that efficiency of ATM would be captured within overall fleet efficiency measures.

Social Benefits of Aviation. Eighteen respondents (42%) suggest indicators. Responses are very mixed; two respondents query the term 'benefits', preferring impacts (including disbenefits); two believe that social benefits are very important but cannot suggest indicators; one believes social benefits of aviation are 'clear'. The most common suggestion with seven occurrences is some form of indicator based on a socio/economic analysis of passengers. There are two suggestions of poverty reduction, one in the UK and one in developing countries. Other suggestions cover a wide range of aspects with no repeated indicators.

Accepting that benefits are derived by passengers from air transport, then the socio-economic analysis effectively reflects the social spread of benefits. In sustainable development terms, this is a measure of equity within the population. Thus this indicator is taken as social equity.

Airport Land Use. Eighteen respondents (42%) offer a wide range of suggestions. There are two suggestions each for indicators based on land area, passengers/unit area, car parks/passenger, noise contours, planning procedures. In addition there are individual suggestions of indicators based on comparison with other industries, area of commercial use, biodiversity, public transport, surface transport.

6.8.8 Stakeholder Indicator Selection

Twenty two indicators are selected by stakeholders (Box 6.1).

Consumption & Efficiency
Aircraft GHG Emissions
Aviation fuel used
Volume of Air transport
Aircraft GHG efficiency
Local Airport
Noise Maps
Noise Population
Surface Access GHG
Air Quality
Waste arisings
Water quality
Airport site emissions
Economy
GDP
Airport Jobs – value
Change Programmes
ACARE targets
Emissions Trading scheme
Institutional
External costs paid
Environmental impact assessment
Product information
Community participation
Others
ATM efficiency
Social Equity
Land Use

Box 6.1 Stakeholder Indicator Selection

Nineteen factors are classed by stakeholders as relatively lower priority and not included in the stakeholder indicator selection (Box 6.2). All factors come from Round 1 responses except the last two factors (Round 2).

Factor
Depletion of oil reserves
Passenger safety
Airport use of Resources
Regional Equity
Aircraft Disposal
Community Accident Risk
Passenger health
Aircrew health
Spread of disease
Poverty reduction
Renewable fuel
ICAO program for sustainable aviation
Atmospheric research by CA sector
National noise levels
Accelerate phase-out of old aircraft
Carbon sinks (e.g. forests)
Spreading benefits to socially deprived areas
Effective Environmental Legislation
Integration of Environment and Development

Box 6.2 Factors not selected by Stakeholders

6.8.9 Proposition

Objective 5 – To obtain stakeholder views on suggested indicators of sustainable development for civil aviation.

Research Proposition 5.1 There will some agreement on which indicators should be used to assess progress towards sustainable development in civil aviation.
The proposition is confirmed by this research.

6.9 *Understanding of Sustainable Development*

Objective 3 – To determine why the observed actions of the civil aviation industry diverge from the principles of sustainable development.

Research Proposition 3.1 – There is a low level of understanding of sustainable development.

Stakeholder responses are analysed by the importance of issues and policies (section 6.3) and selected indicators (section 6.8). Those factors selected by stakeholders as indicators (Box 6.1 and 6.2), are related to the sustainable development principles (Table 6.46 and 6.47).

The selected factors (Table 6.46) tend to be dominated by environmental issues (including noise and air quality), and include economic and social benefits, reflecting the accepted understanding of sustainable development: the social, economic and environmental dimensions. Selected policies tend to be related to operational efficiency.

Principle/Agenda 21	**Selected Indicator**
Principle 1 Health	Noise Maps
	Noise Population
	Air Quality
Principle 2 Economic	GDP
Principle 3 Equity	Social Equity (from social benefit)
Principle 5 Poverty	Airport Jobs – value
Principle 7 Conserve Ecosystem Chapter 9 Atmosphere	Aircraft GHG Emissions
	Surface Access GHG
	Waste arisings
	Water quality
	Airport site emissions
	Emissions Trading scheme
Principle 8 / Chapter 4 Consumption	Aviation fuel used
	Volume of Air transport
	Aircraft GHG efficiency
	ACARE targets
	ATM efficiency
	External costs paid
Principle 10 Participation	Product information
	Community participation
Principle 17 EIA	Environmental impact assessment
	Land Use

Table 6.46 Selected Factors related to Sustainable Development Principles

The omitted factors (Table 6.47) include a number of issues related to Health, Equity, Integration, and Poverty (Principles 1,3,4,5 respectively), and a range of policies related to implementing change (Renewable fuel, environmental legislation, ICAO program). Some fundamental principles of sustainable development (Health, Equity, Integration, Poverty and Change Consumption Patterns) are accorded relatively lower priorities as are Means of Implementation (Environmental Legislation and ICAO Program).

There is good evidence from this research to suggest that some respondents have an incomplete understanding of the meaning of sustainable development or consider that some principles are less relevant to civil aviation.

Overall the research findings support the research proposition.

Principle/ Agenda 21	**Omitted Factor**
Principle 1 Health	Passenger safety
	Community Accident Risk
	Passenger health
	Aircrew health
	Spread of disease
	National noise levels
Principle 3 Equity	Regional Equity
	Depletion of oil reserves
Principle 4 Integration	Integration of Environment and Development
Principle 5 Poverty	Poverty reduction
	Spreading benefits to socially deprived areas
Principle 7 Conserve Ecosystem	Aircraft Disposal
Principle 8 Change Consumption	Renewable fuel
	Accelerate phase-out of old aircraft
	Airport Resources
Principle 11 Environmental Legislation	Effective Environmental Legislation
AG 21 Chap 9 Protect Atmosphere	Atmospheric research by CA sector
	Carbon sinks (e.g. forests)
AG 21 Chap 38 & 40	ICAO program for sustainable aviation

Table 6.47 Omitted Factors related to Sustainable Development Principles

6.10 *Summary*

6.10.1 Research Findings

The survey explores stakeholder representatives' personal attitudes to sustainable development in civil aviation. Stakeholders are drawn from Operators, Suppliers, Users, Regulators and Those Affected. Delphi Round 1 covered visions of sustainable aviation, important issues and policy actions for sustainable development in aviation, and explored respondents' reasons for their views. The survey of personal attitudes is complemented by an analysis of published company policies (Section 6.4.3) and the regulatory framework (Section 4.12).

There is no evidence from this survey of any common or shared understanding of the term 'Sustainable Aviation' (Section 6.2). Few respondents have a personal vision of, or quantified targets for, sustainable aviation. On five aspects of a future vision (number of flights, airport employment, GHG emissions, day noise and night noise), there are diverging expectations between stakeholder groups.

There is widespread consensus amongst stakeholder groups on the issues relevant to sustainable development in aviation (Section 6.3.1).

There are divergent views on which policy actions should be adopted (Section 6.3.2): respondents from Operators and Suppliers favour efficiency improvements and voluntary procedural measures; respondents from Those Affected favour external policies designed to constrain demand and apply environmental limits; respondents from Regulators favour a mixture of policies, voluntary and statutory, efficiency, constraint and limits. These differences reflect the conflicting interests of the stakeholders.

There are widely varying levels of support for economic and legal instruments of change (Section 6.4.2). Respondents from Airlines oppose all potential instruments except emissions trading. Other stakeholder groups offer varying levels of support for instruments of change, up to strong support from some respondents from Regulators and Those Affected.

From this survey there is no evidence that commercial pressures influence the views of respondents (Section 6.4.1). For respondents from airports and airlines this may be regarded as a counter-intuitive conclusion.

The research indicates that institutional orientations in operator and supplier organisations mitigate against sustainable development (section 6.4.2): organisational policies support sustainable development principles only in terms of eco-efficiency (section 6.4.3): the UK legal framework does not support sustainable development principles in certain aspects (section 4.3.12 and 6.4.4).

There is agreement with the purposes for sustainable development indicators derived from Agenda 21, except that information for consumers and public information are considered relatively less important (section 6.7).

The stakeholder indicator selection is derived (Section 6.8, Box 6.1). Certain sustainable development principles and actions are given relatively lower priority by stakeholders (Section 6.8.9).

There is evidence that respondents have a limited understanding of sustainable development (section 6.10).

In the findings of this research, and in the earlier analysis of civil aviation (Chapter 4), there is no evidence of application of three fundamental principles – the Polluter Pays Principle, the Precautionary Principle, or Integration (of Environment and Development).

6.10.2 Implications of Research Findings

Institutional attitudes to Sustainable Development

The Rio Declaration defines the principles of sustainable development and Agenda 21 advocates a balanced approach to the use of the wide range of policies and instruments for change (section 2.2.3). Economic, regulatory, efficiency and participation actions are seen as complementary to achieving changes in favour of sustainable development.

The analysis at Chapter 4 suggests that safety is institutionalised into the civil aviation regulatory framework and operational procedures. Safety is integrated into all developments and safety costs are internalised. Efficiency, in terms of technical eco-efficiency of new aircraft is strongly supported by the industry. In these respects civil aviation supports the principles of sustainable development.

In other respects, there is evidence from the research and the previous analysis (Chapter 4), that opposition to other aspects of sustainable development is institutionalised in the organisations and regulatory framework of civil aviation.

Oil Dependence

The exploration of visions (Section 4.4 and 6.2) reveals a widespread expectation amongst respondents from Operators and Suppliers of increasing volumes of air transport which, with current technology, is dependent on oil-derived kerosene. From observers of the oil industry, there is a view of potentially reducing oil supplies (Peak Oil explored in section 4.3.4). It is not entirely clear how these views of increasing aviation and reducing oil may be reconciled, though views are emerging on oil dependency:

- Easier to substitute bio fuels into surface transport (Farmery 2003).
- Aviation will be the last user of oil (Beesley 2003).
- May be necessary to ‘ring fence’ oil for aviation use (Survey Respondent Section 6.3.2).

There is, perhaps, an emerging expectation that aviation will have the privilege of using an increasing proportion of a potentially reducing oil supply.

Augmentation of Selected Indicators

The survey of stakeholder views leads to a selection of indicators preferred by stakeholders (Box 6.1) and identification of a number of factors given lower priority (Box 6.2). The latter is a combination of factors with low priority at Round 1 – the exploration of sustainable development in civil aviation at section 6.3, and Round 2 – the choice of indicators at section 6.8. These factors need to be considered in a process to augment the stakeholder selection with sustainable development principles, described in Chapter 7.

CHAPTER 7 Construct Sustainable Development Indicators

7.1 *Introduction*

The objective of Chapter 7 is to select and construct indicators of sustainable development in civil aviation, using the five step indicator selection methodology at Figure 3.5.

Section 7.2 describes selection of indicators, based on the stakeholder selection (Box 6.1), and augmented by sustainable development principles (Step 3 of methodology). At section 7.3, each indicator is constructed, defining the measurement and transformation of data (Step 4 of methodology). Section 7.4 undertakes a quality review of the whole indicator set (Step 5 of methodology), against the criteria derived from Agenda 21 (Table 2.2), and a comparative review of other indicator sets.

7.2 *Select Indicators*

7.2.1 Approach to Indicator Selection

Basis of Selection

Indicators are selected on the basis of the stakeholder selection derived from the Delphi study (Box 6.1), augmented by sustainable development principles. Stakeholders tend to place priority on factors within their areas of concern (Meadows 1972) (Section 6.5.3), and may place less emphasis on wider aspects. Thus some factors, identified in the original analysis (Chapter 4) as relevant to sustainable development principles, are not included in the stakeholder selection (Box 6.2). The factors are reconsidered against sustainable development principles and may augment the indicator set.

Augmentation Criteria

A number of criteria will be used to assess whether the factors not selected by stakeholders should augment the indicator set:

- Relevance to principles of sustainable development
- Significance of external impact of the factor
- Relevance to, or responsibility of, the civil aviation system

7.2.2 Augment Indicator Set

Each factor not selected by stakeholders (Box 6.2) is assessed against the criteria above. Factors are presented in the sequence of Box 6.2.

7.2.2.1 Factors included in the Indicator Set

Passenger safety. Principle 1 – discussed at Section 4.3.10. Safety is a fundamental principle of sustainable development and a critical issue for civil aviation.

Regional Equity. Principle 3 – discussed at Section 4.3.3.4. Intra-generational equity is a fundamental principle of the Rio Declaration and of Agenda 21.

Aircraft Disposal. Principle 7 – discussed at Section 4.3.6. Disposal of materials in aircraft will become an increasing problem and is within the responsibility of the civil aviation industry.

Renewable fuel for aviation. Principle 8 – discussed at Section 4.3.4. In the long term some alternative renewable fuel is required for civil aviation to remove dependence on oil, and to address the issue of greenhouse gas emissions.

ICAO program for sustainable aviation. Agenda 21 Chapters 38 & 40 – discussed at Section 4.5.5. Agenda 21 defines a specific role for United Nations agencies, which include ICAO, to develop 'a concrete program for implementing Agenda 21'.

National noise levels. Principle 1 and Agenda 21 Chapter 6 – discussed at Section 4.3.11 and 4.5.2. National noise criteria is included as a specific action in Agenda 21.

Effective Environmental Legislation. Principle 11 – discussed at Section 4.3.12. The stakeholder review considers this issue very important, but too difficult to measure. This is one of the fundamental means of implementation of sustainable development.

Integration of Environment and Development at Policy Level. Principle 4 – discussed at Section 4.3.12. This is a fundamental principle of sustainable development and is highly relevant to the civil aviation system.

7.2.2.2 Factors not included in indicator set

Depletion of oil reserves. Principle 3 – discussed at Section 4. 3.4. Civil aviation depends on oil, and is one of many industries contributing to oil depletion. Indicators showing depletion of oil reserves are necessary, and are the responsibility of the energy sector and national governments, outside the scope of aviation. A view of oil reserves is included in the indicator for Renewable fuel for aviation.

Airport use of Resources. Principle 8 – discussed at Section 4.3.7. Energy use is covered by Airport site GHG emissions. There may be local issues of water supply, but these are not specific to airports.

Community Accident Risk. Principle 1 – discussed at Section 4.3.11. This is included in the overall aviation safety system and is not selected as a sustainable development indicator. Indicators or assessments of community risk may be required for other purposes.

Passenger health. Principle 1 – discussed at Section 4.3.10. Risks are monitored and are currently considered to be low. Indicators are part of public health systems rather than aviation.

Aircrew health. Principle 1 – discussed at Section 4.3.9. Risks are monitored and are currently low. A sustainable development indicator is not required.

Spread of disease. Principle 1 – discussed in section 4.3.10. Monitoring new diseases is the function of the international health systems (WHO 2005). Any required indicator is within the remit of health systems rather than aviation.

Poverty reduction. Principle 5 – discussed at Section 4.3.9. Poverty reduction is a fundamental principle of sustainable development. Agenda 21 places the responsibility with national governments, rather than on specific industrial sectors. It is not appropriate to include this in the civil aviation indicators.

Atmospheric research by Civil Aviation sector. Agenda 21 Chapters 9 and 35 – discussed at section 4.4 and 4.5. There remains a range of scientific uncertainty on the effect of high altitude emissions, primarily from aircraft, and there is an argument that civil aviation should be proactive in resolving these uncertainties. However, Agenda 21 places the responsibility for research on Governments (with co-operation from the private sector). Therefore, Atmospheric research is not included as a civil aviation indicator.

Accelerate phase-out of old aircraft. Agenda 21 Chapter 4 – discussed at Section 4.5.3. This is a major contributor to efficiency improvement along with many other factors. Aircraft fleet efficiency is included as an indicator and is expected to capture all effects of improved fleet efficiency and use, including fleet replacement.

Carbon sinks. Agenda 21 Chapter 9 – discussed at Section 4.5.4. The issue of carbon capture and carbon sequestration is regarded as outside the direct scope and responsibility of the civil aviation sector.

Spreading benefits to socially deprived areas. As poverty reduction above.

Factors included	**Factors not included**
Passenger safety	Depletion of oil reserves
Regional equity	Airport resources
Aircraft disposal	Community accident risk
Renewable fuel for aviation	Passenger health
ICAO programme for sustainable aviation	Aircrew health
National noise levels	Spread of disease
Effective environmental legislation	Poverty reduction
Integration of environment and development at policy level	Atmospheric research by CA sector
	Accelerate phase-out of old aircraft
	Carbon Sinks
	Spreading benefits to socially deprived areas

Table 7.1 Augmentation of Indicator Set

7.2.3 Indicator Set

Indicators, previously grouped in categories from Delphi Round 2 questionnaire, are now grouped by the four dimensions of sustainable development (Table 7.2).

Dimension	Agenda 21 Chapters
Social	3, 5, 6, 7, 36
Economic	2, 4, 33, 34
Environmental	9–22
Institutional	8, 23–32, 35, 37, 38, 40

Table 7.2 Dimensions of Sustainable Development
Source: United Nations (UN 1996).

Chapter 4 of Agenda 21, included in the Economic dimension, is concerned with changing consumption patterns; thus the Economic dimension will include certain consumption based indicators, which in other categorisations may not be classed as Economic. Indicators related to aviation fuel use are categorised as consumption indicators in Chapter 4. Indicators related to GHG emissions and to efficiency improvements in GHG emissions are categorised as part of Chapter 9 (Protection of Environment). The augmented indicator set, grouped into the four dimensions is shown at Table 7.3.

Agenda 21 Chapter		Indicator
SOCIAL Dimension		
3	S1	Airport jobs
3	S2	Regional equity
3	S3	Social equity
6	S4	Passenger safety
6	S5	Air quality
6	S6	Airport noise
6	S7	National noise levels
ECONOMIC Dimension		
2	Ec1	Aviation GDP
4	Ec2	Aviation fuel used
4	Ec3	ACARE targets
4	Ec4	ATM efficiency
4	Ec5	Volume of air transport
4	Ec6	External environmental costs paid
4	Ec7	Product information
4	Ec8	Renewable fuel for aviation
ENVIRONMENTAL Dimension		
9	En1	Aircraft GHG emissions
9	En2	Aircraft fleet efficiency
9	En3	Emissions Trading Scheme
9	En4	Surface access GHG
9	En5	Airport site GHG emissions
10	En6	Land use
18	En7	Airport water quality
21	En8	Airport waste arisings
21	En9	Aircraft disposal
INSTITUTIONAL Dimension		
8	I1	Effective environmental legislation
8	I2	Integration of environment and development
23	I3	Community participation
37	I4	Environmental impact assessment
38,40	I5	ICAO program for sustainable development

Table 7.3 Augmented Indicator Set

7.3 *Construct Indicators*

7.3.1 Approach to Indicator Construction

Characteristics. The essential characteristics of sustainable development indicators are summarised at section 2.4.3 (Smith 2002): simple, widely credible, easily understood by policy makers and the public. These characteristics will guide the construction of indicators in the following sections.

For each indicator, Name, Description and Technical construction are defined.
Description: a brief description of the indicator content and purpose.
Technical construction varies and may include as appropriate:

- Level – the physical or logical scope at which the indicator may be used
- Scale and units
- Format – e.g. absolute, relative/ ratio, trend, performance, target
- Source data and data availability
- Data transformation or calculation
- Presentation – description, numeric, diagram

Indicator Groups. An indicator may include several presentations to illustrate relevant aspects: absolute value, rate, efficiency etc.

Source data availability. An assessment is made of how readily available is the basic data needed to populate the indicator.

- Yes – data is in the public domain
- Commercial – data is commercially available
- Partial – data is partially available. Data may be published by some, but not all airports or airlines, or may be presented in inconsistent ways
- Known/not published – data is recorded within the industry, but may not be routinely published e.g. aviation fuel use by airport or airline
- Not known – data is not routinely measured or calculated: research or survey is needed to establish the data, e.g. airport jobs, community participation

Populate indicators. Where data is available, the indicator is populated and, if possible, trends are determined. Where data is not readily available or is incomplete, this thesis does not undertake the research needed to establish the data.

7.3.2 Social Dimension Indicators

Indicators included in this group are:

Agenda 21 Chapter	Indicator	
3	S1	Airport jobs
3	S2	Regional equity
3	S3	Social equity
6	S4	Passenger safety
6	S5	Air quality
6	S6	Airport noise
6	S7	National noise levels

7.3.2.1 S1 – Airport Jobs

Description

Number and value of airport jobs – input to local decision-making.

Comments

There is currently no published definition of the term 'airport jobs'. For the purposes of local decision-making this should include all airport related jobs, not simply the definition of air transport in National Accounts, and may validly include the associated retail, catering, and hotel activities on an airport site.

A proposed working definition would therefore be:

- Air transport activities included in National Accounts (SIC62 airlines, SIC6323 airport activities and air traffic control). These may be on or off site e.g. some airport offices may be located off the airport.
- Retail, catering, and hotel activities at airport site(s) as defined in PPG13.

The proposed definition includes airport related employment at remote sites, and excludes any non-airport related jobs on the airport site e.g. business parks within the airport site. Data on jobs is published by some airports, though not necessarily to a common standard. The value of jobs (i.e. total salaries) is not normally available.

A previous study (OEF 1999) needed to commission surveys of major airports to estimate airport employment.

The indicator does not include the indirect impacts on employment or trade through the airport i.e. the effects of people and goods transported. Some impacts may have a positive effect on regional or national employment, others negative e.g. imbalance in tourism, and are regarded as indicators for the associated demand systems (Section 4.3.3).

Technical Construction

Level	Airport
Units	Number of jobs (full time equivalent), value of jobs
Format	Absolute value
Source Data	Airport reports or commissioned surveys
Availability	Partial
Presentation	Graph of annual figures to show trend

7.3.2.2 S2 – Regional Equity

Description

The consumption rate of civil aviation services in world regions.

Comment

Consumption of air transport may be expressed in a number of ways, e.g. number of passengers and freight, or passenger kilometres and freight-tonne kilometres. The former is simpler and better understood outside the industry, the latter is a better measure of actual performance and is well established within the industry. ICAO World of Air Transport offered both measures until 2002 (ICAO 2003). From 2003 statistics are published in units of passenger kilometres (ICAO 2005), which is therefore selected as the indicator unit.

Technical Construction

Level	International
Units	Passenger kilometres performed/ person for each world region
Format	Ratio
Source Data	ICAO Airline Traffic Forecasts and Financial Trends (ICAO 2005) United Nations Population Division (UN 2002a, UN 2005).
Availability	Yes
Transformation	Passenger kilometres divided by population
Presentation	Tabular and graphical to show comparisons across regions and trend over time – Figure 4.4

7.3.2.3 S3 – Social Equity

Description

The consumption rate of civil aviation services by different social classes in the UK.

Technical Construction

Level	National
Units	Air Passengers per person for each socio-economic group
Format	Ratio
Source Data	See notes below
Availability	Commercial
Transformation	Air Passengers divided by population
Presentation	

Comment

Socio-economic Group. A number of different socio-economic classification systems are in use. The Market Research Society uses a classification system of six occupational groupings (MRS 2003), the familiar A,B,C1,C2,D,E groups. From 2001, the UK Office National Statistics uses a revised classification - National Statistics Socio-economic Classification (NS-SEC) for all official statistics and surveys (ONS 2001). This consists of eight classes with the highest split to two sub-groups.
Data for this indicator will be derived from passenger surveys, and previous surveys have used the MRS classification. It is appropriate to continue to use the MRS classification.

Source Data Availability

Population of socio-economic groups: population of each classification are available from the UK Census, though not published on the census website.
Consumption by socio-economic group: statistical information from passenger surveys. Many organisations carry out passenger surveys: Airlines, Airports, Civil Aviation Authority, but most of this data is regarded as commercially sensitive and is not published, according to the Parliamentary Office of Science and Technology (POST 2000). The Civil Aviation Authority does undertake a continuing programme of passenger surveys at London and regional airports, including data on socio-economic group. This data is available from the CAA.

Accumulation: Analyses of air passengers by socio-economic group are normally carried out each year at selected airports. A full analysis of all UK air passengers is not known to be available. This indicator cannot be readily populated from public data.

7.3.2.4 S4 – Passenger Safety

Description

Overall safety of the aviation system for all reasons.

Technical Construction

Level	National
Units	Passengers carried/ passenger fatality
Format	Ratio
Source Data	For UK – Annual Abstract of Statistics 2005 Table 15.27 (ONS 2005). Published annually – updated every 5 years.
Availability	Yes
Presentation	Graph – logarithmic scale Figure 7.1

Units – Safety rates may be expressed in many different units e.g. aircraft stages/ fatal accident, passenger kms/fatality. The ratio fatalities/passenger is considered simplest from an external perspective.

Source Data – ONS data (Figure 7.1) covers fixed wing scheduled passenger air transport by UK operators, including accidents and fatalities for aircrew and passengers but excluding third party fatalities.

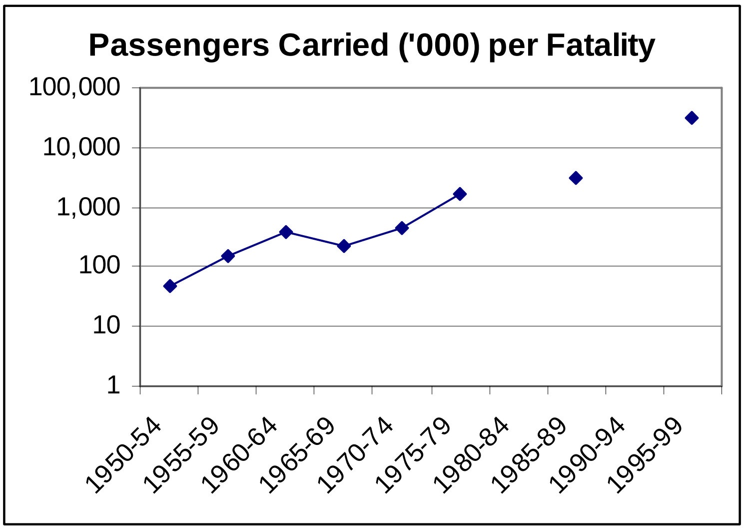


Figure 7.1 UK Aviation Safety

Source: Office of National Statistics (ONS 2005).

7.3.2.5 S5 – Air Quality

Description

Achievement of air quality standards defined by the European Union (EU 1999) and implemented by the UK Government.

Technical Construction

Level	Airport
Units	Number of times air quality exceedences are recorded
Format	Absolute value
Source Data	Airport and local authority reports. These are mandated by the EU directive
Availability	Yes
Presentation	Annual figures provide trend analysis over time

7.3.2.6 S6 – Aircraft Noise

Description

Assessment of aircraft noise levels covering daytime and night time noise, noise contours and number of people affected.

Comment

The EU directive relating to environmental noise (EU 2002) defines that noise maps and the population exposed to noise, should be produced for airports with over 50,000 movements per year from 2007. The directive defines the noise contour levels for day and night, computation methods, and public availability. At airport level, the indicator is based on the minimum day and night noise contours specified in the directive. At national level, the indicator can show trends in noise contours and total population affected.

Technical Construction - Airport

Level	Airport
Units	Noise contour maps for: • Day/evening/night – L_{den} 55dB noise contour • Night – L_{night} 45dB noise contour Data for each noise contour: • Graphical contour maps • Contour area in square kilometres • Population exposure – number of people within contour levels
Format	Maps and data as absolute value
Source Data	Airport environmental reports
Availability	Partial. Not currently available in a consistent format Available by June 30th 2007 by EU Directive (EU 2002)
Transformation	None
Presentation	Trend analysis: Graphical presentation of annual contour area and population Separate presentation for day/evening/night and for night

Technical Construction - National

Level	National – includes airports covered by EU directive
Units	For each noise contour (L_{den} 55dB and L_{night} 45dB): Total contour area and population exposed Airports with increased noise contours: Number of airports, list of airports Change in contour area and population exposed Airports with decreased noise contours: Number of airports, list of airports Change in contour area and population exposed
Format	Absolute values
Source Data	Airport environmental reports
Availability	Not currently available in a consistent format. Available by June 30th 2007 by EU Directive (EU 2002)
Transformation	Accumulation from airport indicators
Presentation	Annual report

7.3.2.7 S7 – National Noise Levels

Description

To report national criteria for safe permitted noise levels.

Technical Construction

Level	National
Units	Nominal scale Yes or No – national criteria exist or not
Source Data	National legislation
Availability	Yes

Comment

Currently, the UK has not adopted any criteria for community noise. This indicator is included in the Regulatory Framework Indicator (Section 7.3.5.1).

7.3.3 Economic Dimension Indicators

Indicators included in this group are:

Agenda 21 Chapter	Indicator	
2	Ec1	Air Transport GDP
4	Ec2	Aviation fuel used
4	Ec3	ACARE targets
4	Ec4	ATM efficiency
4	Ec5	Volume of air transport
4	Ec6	External environmental costs paid
4	Ec7	Product information
4	Ec8	Renewable fuel for aviation

7.3.3.1 Ec1 – Air Transport GDP

Description

Contribution of air transport to National Gross Domestic Product

Explanatory notes – Gross Domestic Product (GDP)

GDP is a method of measuring national income and may be calculated by three methods (Ison 2000):

- Income approach – accumulating the income earned by individuals and corporations
- Output approach – accumulating the value added of the output from the various sectors of the economy
- Expenditure approach – totalling the expenditure of various agents in the economy

The United Kingdom National Accounts (The Blue Book) are published annually by the Office of National Statistics (ONS 2006d). The Blue Book uses the Output approach of value added, to provide an analysis by broad industrial sector – agriculture, manufacturing, construction, transport and so on – based on a system of industrial classifications.

Industrial Classifications

The industrial classifications used in the Blue Book derive from EU Regulation in 1992 for common use across the EU, implemented in the UK by the UK Standard Industrial Classifications (SIC) and progressively updated to UK SIC(2003) (ONS 2003). The system defines 13 sections (A-O, omitting J,L), of which section I 'Transport and Communication', covers Land Transport, Water Transport, Air Transport (SIC62), and Supporting Activities for Transport (SIC63), Post & Telecommunications. SIC63 is further split by a four digit code to support activities for different transport modes; SIC6323 defines airport and air traffic control activities.

Definition of Air Transport

Within the standard industrial classification used across the EU, air transport is defined as the sum of SIC62 (Airlines) and SIC6323 (Airport operation and Air Traffic Control activities).

A previous study suggested a different definition (OEF 1999). The study regarded the definition of air transport used in the National Accounts as 'narrow' and chose to include airport retail, catering and hotels as part of the aviation industry. Thus the OEF study calculated aviation industry contribution to GDP as the sum of:

- SIC62 (Airlines) – from official figures for 1998
- SIC6323 (Airports and ATC) – estimated from figures for 1995
- Airport retail, catering and hotels – estimated from employment surveys

The expansion of the official definition of air transport contribution to GDP is not explicitly justified by the OEF study, but merely stated as a fact. The expanded definition does reflect the local concentration of retail, catering, and hotel activities on an airport site, but in the National Accounts these activities are already counted in other sections: section G – Wholesale and Retail Trade, and Section H – Hotels and Restaurants. It may be argued that their inclusion in Air Transport is a form of double counting.

Nevertheless the redefinition seems to be widely accepted. The study is extensively referenced e.g. UK Government – Airports Consultation Paper (DfT 2002), Aviation White Paper (DfT 2003b), many authors (RCEP 2002, Sewill 2005, Whitelegg, Cambridge 2004), and industry sources (BATA 2005, Sustainable Aviation 2005).

There are thus two definitions in use:

- ‘Air transport’ – UK National Accounts
- ‘Aviation Industry’ as suggested by Oxford Economic Forecasting

For the purposes of this study the definition used in the National Accounts is adopted i.e. SIC 62 + SIC 6323.

Technical Construction

Level	National
Units	£m Gross Value Added of air transport
Format	Absolute value
Source Data	UK National Accounts (see Table 7.4)
Availability	Yes
Transformation	Estimate of SIC 6323 (below)
Presentation	GVA of Air Transport is shown as absolute value, as a proportion of total GDP, as an activity ratio (GVA/passenger), and as energy intensity (GVA per tonne aviation fuel) Annual values for each are presented numerically and graphically to show trends over time

Comment

Source of Data (Table 7.4): The Blue Book (ONS 2006d) shows National Accounts to the level of the 13 industrial classifications above. Further analysis to the two digit SIC Codes (e.g. SIC 62 Airlines, SIC 63 Supporting Activities) is published in United Kingdom Input-Output Analyses (ONS 2006c).

The lower levels of SIC (4 digit SIC codes) are not normally published. The Annual Business Inquiry (ABI) (ONS 2006a) shows activities to the level of SIC 4 digit codes (i.e. including SIC 6323 Airports), but this data only covers a proportion of the UK economy. To calculate an approximate total value for SIC6232, the ABI value of SIC6232 must be increased by the proportion of SIC63 reported in ABI to UK Input-Output Analyses.

Data	Source	Reference	Date range
GDP	Blue Book 2006 Input-Output Analyses	(ONS 2006d) (ONS 2006c)	1992 – 2004 1992 – 2004
SIC 62	Input-Output Analyses	(ONS 2006c)	1992 – 2004
SIC 6323	Annual Business Inquiry	(ONS 2006a)	1995 – 2004

Table 7.4 Contribution to GDP – Data Sources

Populate GDP Indicator

GDP calculations based on the above assumptions and sources are shown in tabular format at Tables 7.5 and 7.6 and graphically at Figure 7.2. All figures are Gross Value Added at basic prices. Data is available from 1995 for both Airline sector (SIC62) (Table 7.6) and Supporting air transport activities (SIC 6323) (Table 7.5), though for the latter, the early figures (1995 and 1996) may be unreliable because of the low proportion reported through ABI.

Since 1995, the total absolute contribution of Air Transport to GDP has increased (Figure 7.2 Chart A) but less rapidly than total GDP (Figure 7.2 Chart B). As a proportion of GDP, the Air Transport contribution peaked in 1997/8 and has since gradually reduced (Figure 7.2 Chart C). The contribution from Airlines follows a similar pattern (Table 7.6): the contribution from Supporting activities peaks as a percentage of GDP somewhat later (Table 7.5). The ratios of GVA per passenger (Figure 7.2 Chart D) and GVA per tonne of aviation fuel (Figure 7.2 Chart E) show declining trends.

The general perception is that air transport continues to make an increasing contribution to the UK GDP. This research confirms that the absolute value of the contribution is increasing, but suggests that the proportion of GDP is reducing. It is possible that the changes in GDP contribution may be an effect of the financial performance of low cost carriers, though this is not specifically explored by the research. Further research may be required to more fully explain the trends in aviation’s GDP contribution.

1	2	3	4	5	6	7
Year	SIC63	SIC63 from ABI	ABI % of SIC63	SIC6323 from ABI	SIC6323 Adjusted	SIC 6323 % GDP
1995	11,117	4,579	41	1,078	2,617	0.41
1996	12,212	8,726	71	1,272	1,780	0.26
1997	13,117	10,698	82	1,783	2,186	0.30
1998	14,454	12,269	85	2,242	2,641	0.35
1999	15,128	13,897	92	2,428	2,643	0.33
2000	15,889	14,150	89	2,544	2,857	0.34
2001	16,353	15,585	95	3,082	3,234	0.37
2002	16,844	15,935	95	2,751	2,908	0.31
2003	17,752	17,058	96	3,002	3,124	0.32
2004	18,703	20,493	110	3,157	2,881	0.30

Table 7.5 Contribution to GDP – Supporting Air Transport Activities – SIC 6323

Source:

Col 2 – UK Input-Output Version 2005, Table 1.40 (pp 48-9) line 97

Col 3 – UK Annual Business Inquiry Section I, SIC63

Col 5 – UK Annual Business Inquiry Section I, SIC6323

1	8	9	10	11	12
Year	GDP - All industries	SIC62 - Airlines	SIC62 – % GDP	Air Transport GDP- col 6+9	Air Transport % GDP
1992	546,142	2,987	0.55		
1993	574,825	3,499	0.61		
1994	607,854	3,816	0.63		
1995	639,115	4,253	0.67	6,870	1.07
1996	680,477	4,791	0.70	6,571	0.97
1997	720,624	5,146	0.71	7,332	1.02
1998	763,690	5,255	0.69	7,896	1.03
1999	800,611	5,105	0.64	7,748	0.97
2000	840,979	5,586	0.66	8,443	1.00
2001	882,793	5,177	0.59	8,411	0.95
2002	930,297	5,239	0.56	8,147	0.88
2003	985,558	5,654	0.57	8,778	0.89
2004	1,044,165	6,089	0.58	8,970	0.89

Table 7.6 Contribution to GDP – Airlines and Total Air Transport

Source:

Col 8 – Blue Book 2005 Table 2.3 Page 110

Col 9 – UK Input-Output Version 2005, Table 1.40 (pp 48-9) line 96

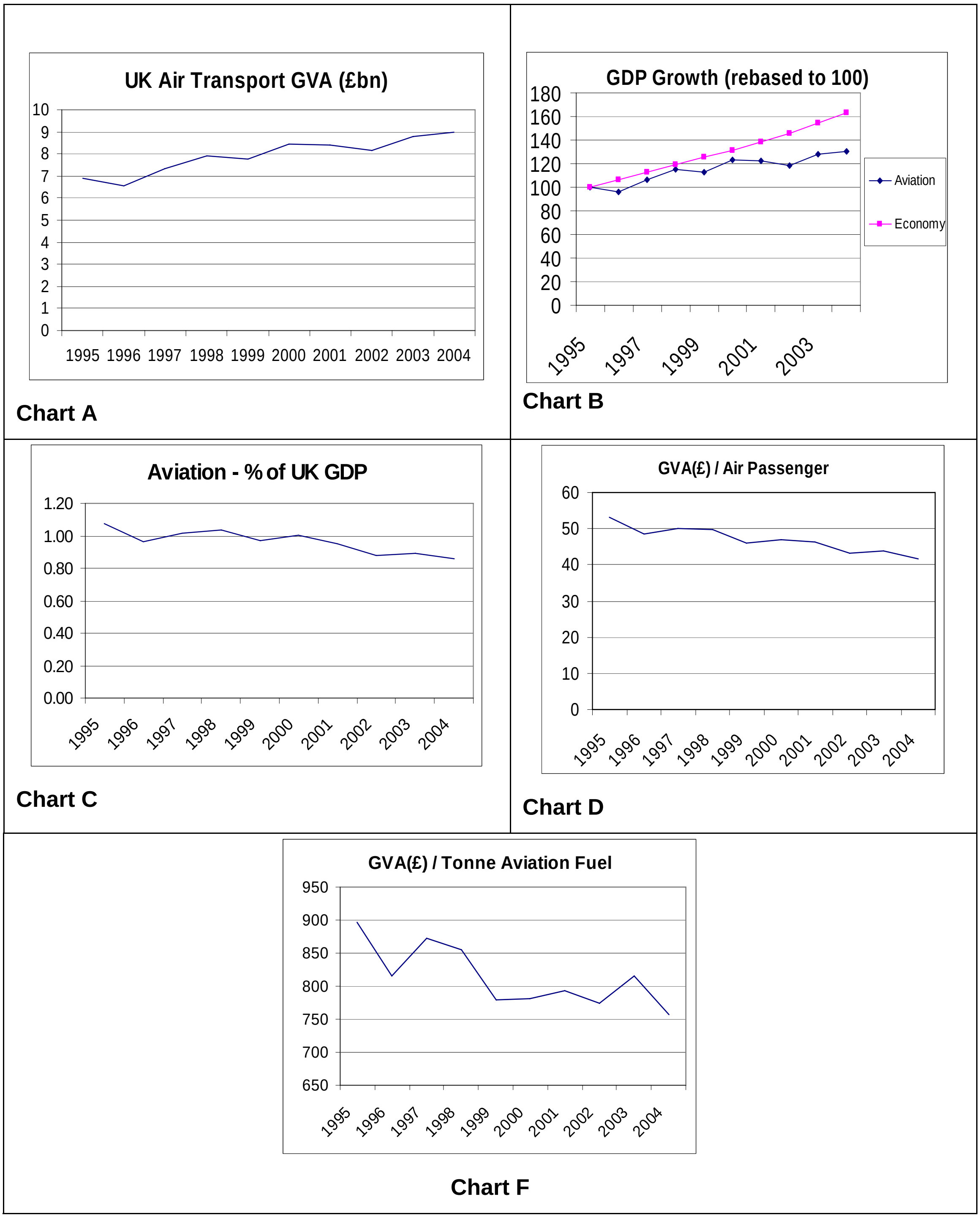


Figure 7.2 Contribution to UK GDP from Air Transport

7.3.3.2 Ec2 – Aviation Fuel used

Description

The weight of aviation fuel used. Provides base data for calculation of GHG and efficiency indicators.

Technical Construction

Level	Airport, Airline, National, International
Units	Tonnes of aviation fuel/year
Format	Absolute value
Airport and airline	
Source Data	Weight of aviation fuel used – measured at airport
Availability	Not published
Transformation	Accumulation of aviation fuel used for calendar year
Presentation	Graphical presentation to show trend over time – data not available
National UK	
Source Data	Aviation fuel delivered – Digest of United Kingdom Energy Statistics (DUKES) (DTI 2006b) (Chart 3.1.2)
Availability	Yes - Includes Military and General Aviation
Presentation	Tabular or graphical to show trends over time (Figure 7.3)
Global	
Source Data	Year 2002 – (Eyers, Norman et al. 2004)
Availability	Yes for 2002
Transformation	Complex modelling based on number of flights
Presentation	176 m tonnes

Airline and airport fuel use is not reported. UK deliveries of aviation fuel are reported through DUKES (DTI 2006b). Global aviation fuel use is not routinely published but is estimated from specific projects (Eyers, Norman et al. 2004).

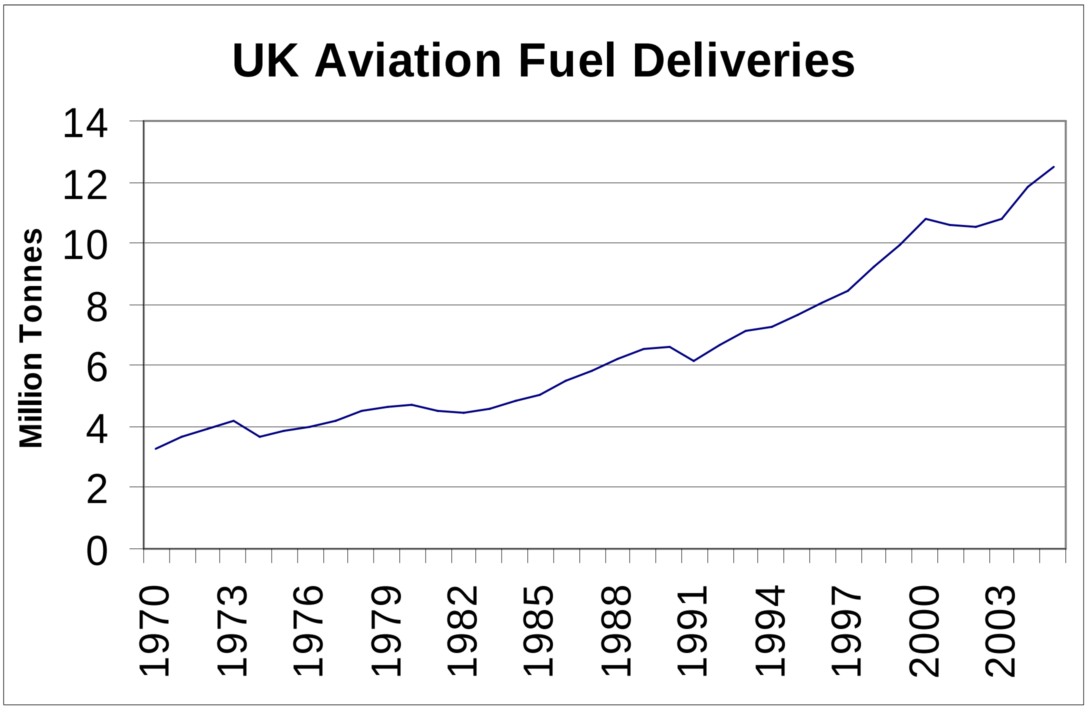


Figure 7.3 UK Aviation Fuel Deliveries

Source: DUKES (DTI 2006b)

7.3.3.3 Ec3 –ACARE Targets

Description

The progress towards ACARE targets – to indicate the relative performance of new aircraft in terms of fuel economy and noise.

Technical Construction

Level	New aircraft
Units	CO_2 emissions/seat km, NOX emissions/seat km, Noise levels
Format	Absolute value and ratio of performance of new aircraft compared with year 2000 new aircraft Using certificated values for similar aircraft on similar sector lengths
Source Data	Manufacturers' certification data
Availability	Yes

Comment

ACARE suggests that some savings will come from improvements to ATM procedures, covered by the ATM inefficiency indicators (Ec4).

7.3.3.4 Ec4 – ATM Efficiency

Description

Measure(s) of the delays and inefficiency of air traffic management procedures.

ATM inefficiency includes takeoff ground delays, additional en-route distance, and arrival holding delays. Each aspect should be measured, though a composite indicator is inappropriate. Separate indicators are used for airport delays and en-route distance.

The unit may be any convenient unit to express delays. It may be argued that the delays should be expressed as excess fuel burn, though this overlaps with the fleet efficiency indicator. The indicator should be consistent over time to demonstrate trends.

En-route Delays

Eurocontrol proposes a Route Inefficiency Indicator (Elliff, Celikel et al. 2004), which calculates relative route length compared with the direct route. This is estimated by sampling studies (Chesneau, Fuller et al. 2003) covering intra-European flights. Flights to or from areas outside Europe, and over flights are not considered by the Eurocontrol studies. The Eurocontrol indicator expresses the inefficiencies as additional percentages of route distance, flight duration and fuel burn.

Technical Construction

Level	International
Units	Additional distance, duration, fuel
Format	Ratio - % greater than direct route
Source Data	Eurocontrol (Elliff, Celikel et al. 2004) 2001 - (Chesneau, Fuller 2002) 2002 - (Chesneau, Fuller et al. 2003) 2003 - (Fuller, Hustache et al. 2004)
Availability	Yes
Presentation	Tabular/ graphical presentation to show trend over time (Table 7.7)

Inefficiency indicator (%)		2001	2002	2003
Route	Under 400 kms	10-12%	8.9%	10%
	Over 400 kms	8%		
Duration			13.5%	14.8%
Fuel		8%	9.6%	9.5%

Table 7.7 Eurocontrol Inefficiency Indicator

Source: Eurocontrol

Approach Holding patterns

Technical Construction

Level	Airport
Units	Total hours aircraft spend in holding pattern approaching the airport
Format	Absolute value
Source Data	Airport air traffic control records
Availability	Data is not published by UK airports
Presentation	Annual figures provide trend analysis over time

7.3.3.5 Ec5 – Volume of Air Transport

Description

The total consumption of air transport services performed including passengers and freight. The indicator gives a measure of overall consumption: used for trend analysis, national and regional comparisons.

Comment

There are several potential measures: flights, passengers, freight-tonnes uplifted, passenger-kilometres, freight-tonne kilometres. A composite unit (tonne-kilometres performed) is in wide use within the industry, combining passenger and freight (one tonne is equivalent to one tonne freight or 10 passengers). The measures related to distance are necessary within the industry to calculate technical fleet efficiency. Outside the industry, the incidence of an air transport journey may be more relevant than the length. Thus the preferred unit is passenger numbers and freight uplifted: these are selected for the UK. For world regions, ICAO have not published passenger numbers since 2003, relying now on passenger kilometres, which is selected as the unit for world regions.

Technical Construction

Level	Airport, airline, national, international
Units	UK – Passengers, freight tonnes uplifted World Regions – Passenger kilometres
Format	Absolute value
Source Data	UK airports, individual and aggregated: UK Civil Aviation Authority Airport statistics (CAA 2006) World regions: ICAO Airline Traffic (ICAO 2006a)
Availability	Yes
Presentation	Graphical presentation shows trend over time (Figures 4.2 & 7.4)

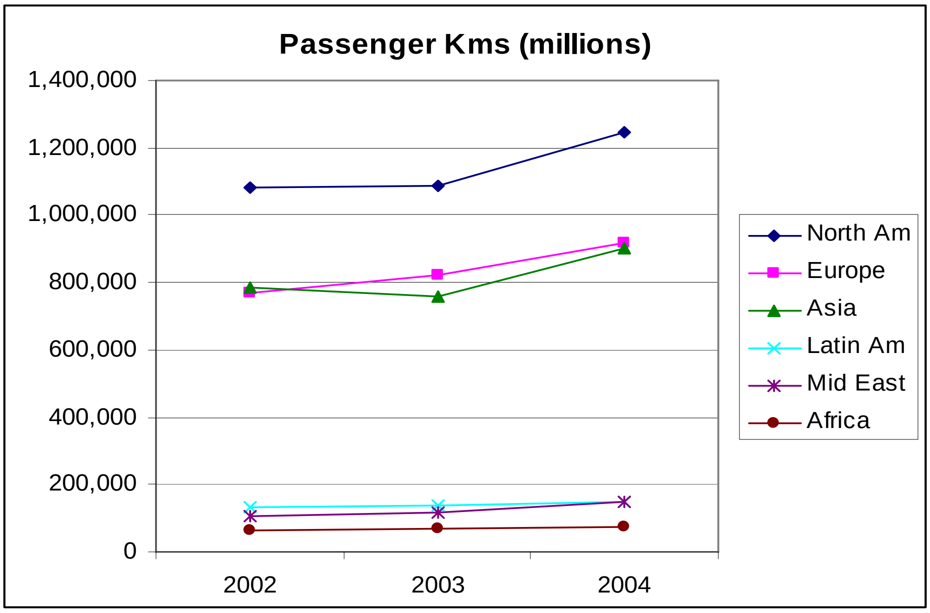


Figure 7.4 Air Transport – World Regions

Source: ICAO

7.3.3.6 Ec6 – Environment Related Charges

Description

To indicate progress towards environmentally sound pricing in civil aviation.

Comment

In the questionnaire (Appendix 5), this indicator is described as 'Payment of full external environmental costs': it is derived from the Agenda 21 action to move towards 'environmentally sound pricing' – discussed at section 4.5.3, which covers both external environmental costs and environmental incentives.

There is little agreement on the pricing of external environmental impacts, either in terms of the effects considered or the values assigned. The UK Department for Transport suggests three effects, climate change, noise and local air quality (DfT 2003a), INFRAS suggests six environmental impacts (Schreyer, Schneider et al. 2004), the CE Delft study for CfiT (CFIT 2003, Wit, Davidson et al. 2003) suggests four. The likely external cost of carbon is widely debated: the DfT uses £70/ tonne of carbon, based on estimates of 'most probable' climate effects, no account of catastrophic climate change and a discount rate of 3%, while recognising a sensitivity range from £35-£140/tonne; INFRAS suggests up to €140/ tonne; Delft CE quotes a range of studies up to $440/tonne. The studies use differing methodologies and prices for other costs; generally INFRAS tends to be higher than DfT. Others suggest that property values should be taken into account in calculating external costs of airports (Button 2003).

The indicator is based on the value of environmental charges, rather than the debated value of external costs. The indicator has two aspects: a measure of current environment charges, and future initiatives to move towards environmental charging.

The Blue Book states:

> *An environmental tax is defined as a tax whose base is a physical unit (or a proxy of it) that has a proven specific negative impact on the environment. By convention, in addition to pollution-related taxes, all energy and transport taxes are classified as environmental taxes.*
>
> (ONS 2006d) *p279*

In UK aviation, there are no taxes based on a physical unit with negative environmental impact e.g. climate change (fuel or emission charges), aircraft noise or air quality. By convention, air passenger duty (APD) is classified as an environmental tax (ONS 2006d), a view disputed by some in Government (Morley 2005). The charges are shown at Table 7.8.

Technical Construction **– Current Charges**

Level	National
Units	£M paid in environmental charges
Format	Absolute value and ratio of GVA
Source Data	UK Environmental Accounts table 13.7 (ONS 2006d).
Availability	Yes
Transformation	None
Presentation	Tabular or graphical to show trends over time (Table 7.8)

Year	APD (£M)	Environment based tax	Aviation GVA (£M)	% of GVA
1995	339	0	6,870	4.9
1996	353	0	6,571	5.4
1997	442	0	7,332	6.0
1998	823	0	7,896	10.4
1999	884	0	7,748	11.4
2000	940	0	8,443	11.1
2001	824	0	8,411	9.8
2002	814	0	8,147	10.0
2003	781	0	8,778	8.9
2004	856	0	8,970	9.5
2005	909	0		

Table 7.8 UK Aviation Environmental Taxes & Charges

Source: UK Environmental Accounts Table 13.7 (ONS 2006d).

Future Initiatives

The European Emissions Trading scheme may apply charges to a proportion of emissions. At this time, there are no other serious initiatives in Europe to apply environmental charges to air transport.

7.3.3.7 Ec7 – Environmental Product Information

Description

To assess progress towards providing environmental product information for civil aviation services and products (discussed at section 4.3.9).

Comment

Environmental product information can be made available in a number of different forms and, as far as can be determined, there is no existing scale to assess the ease of availability. A potential scale is suggested in the ladder in Figure 7.5.

Rung	Description	Comment	UK Status
8	Legal requirement	Legal Requirement	
7	Goods transported by air	Standard definition, voluntary presentation	
6	Travel Advertisements		
5	At point of purchase		
4	Websites – standardised		
3	Websites – non-standard	No standard	X
2	Academic or company literature		
1	Not available		

Figure 7.5 Ladder of Environmental Product Information

Source: Author.

The first three levels are characterised by having no standard for the calculation of the environmental impact of a flight, nor of presentation.

Level 1: Not Available. Environmental information for flights is not defined or calculated.

Level 2: Academic or company literature. Environmental information for flights may be available in academic or company publications. There may be debate about the calculation and presentation. The information is not readily accessible to the public.
Level 3: Websites – non-standard. Environmental information for flights is available to the public through websites from airline or environment bodies. There is no standard method of calculating environmental impact, nor of presentation. Different websites offer different, potentially conflicting information.

Levels 4-8: Aviation environmental data is calculated and presented to a common standard.

Level 4: Websites – standardised. A standardised method of calculating and presenting environmental impact of flights is agreed, covering passengers and freight. Data is calculated and presented to a common standard. Data is available through websites. Airline websites provide data for all the airline's routes.
Level 5: At Point of Purchase. Environmental information is available to an air transport user at the point of purchase. This applies to passengers and freight purchases by whatever means, internet, telephone or physical purchase.
Level 6: Travel Advertisements. Environmental information is included in flight advertisements.
Level 7: Goods transported by air. Environmental information is made available at the time of purchase of goods which have been transported by air.
Levels 5-7 could be implemented by industry agreement or by legal requirement.
Level 8: Legal requirement.

Technical Construction

Level	National
Units	Ordinal scale Figure 7.5
Format	Subjective assessment of level on scale
Source Data	Regulatory framework
Availability	Yes
Presentation	Annual review of position on ordinal scale

UK Civil aviation is currently at level 3 of the proposed ladder – environmental information is available through company and NGO websites, but not in a standardised manner (Section 4.5.3.2).

7.3.3.8 Ec8 – Renewable Fuel for Aviation

Description

To illustrate civil aviation dependence on oil and the time to develop an alternative renewable fuel.

Technical Construction

This is a rather disparate family of indicators. Dependence on oil is illustrated by global oil flows, oil price and estimated reserves.

Years to develop renewable fuel

Renewable fuel for aviation remains a somewhat remote concept (Lee 2003), and even if oil becomes more scarce, there may perhaps be more possibility of generating liquid aviation fuel from solid hydrocarbon sources than from renewables (IPCC 1999). A more optimistic view estimates that commercial jets may be able to use a proportion of bio fuel by 2018 (Simões, Schaeffer 2005). Any estimate of the timescale for renewable fuel for civil aviation is speculative, though a timescale of less than 30 years for commercial replacement seems unlikely.

Oil reserves: Oil reserves may be expressed as the years remaining of current proved reserves at current annual production rate (the R/P Ratio) (BP 2006), shown at Figure 4.6 Chart D. The pattern of R/P has been variable, showing a falling trend over the last few years. The R/P ratio cannot take account of future changes in reserves, production technology or production rates, and, if production rates decline, then R/P may increase and could present a misleading picture.

Oil price: annualised price for crude oil is taken from BP Statistical Review of World Energy (BP 2006). Prices are averaged over the year from different markets. There has been considerable increase in price in 2005/6, not yet shown in the BP review.

Oil flows: global oil production is taken from BP Statistical Review (BP 2006).

Trend analysis: over a long period the estimates may illustrate how the relationship between oil dependency and renewable fuel develops (Table 7.9).

Year	2000	2001	2002	2003	2004	2005
Renewable Fuel (years)	> 30	> 30	> 30	> 30	> 30	>30
Oil R/P (years	40.8	41.8	43.2	42.3	40.8	40.6
Oil price ($/Barrel)	32.8	27.3	27.3	30.6	39.6	54.5
Oil Production (m tonnes)	3,614	3,594	3,572	3,706	3,865	3,895

Table 7.9 Renewable Fuel and Oil Reserves

7.3.4 Environmental Dimension Indicators

Indicators included in this group are:

Agenda 21 Chapter	Indicator	
9	En1	Aircraft GHG Emissions
9	En2	Aircraft Fleet Efficiency
9	En3	Emissions Trading Scheme
9	En4	Surface Access GHG
9	En5	Airport site GHG Emissions
10	En6	Land Use
18	En7	Airport water quality
21	En8	Airport waste arisings
21	En9	Aircraft disposal

7.3.4.1 En1 – Aircraft GHG Emissions

Description

Estimate of aviation greenhouse gas emissions. To illustrate trend in civil aviation and enable inter sector comparison.

Comment

Aircraft emissions for commercial service aircraft can be calculated from fuel burn: each tonne of aviation fuel produces 3.15 tonnes of carbon dioxide (DfT 2003a).

The major radiative forcing component of aircraft emissions derives from CO_2, with additional effects from other gases (Section 4.3.5). The total radiative forcing effect is still in doubt (IPCC 1999, Sausen, Isaksen et al. 2005). There is some difficulty therefore in designing an indicator: should the indicator reflect emitted CO_2, or the estimated total radiative forcing effect? Many survey respondents favour the latter (section 6.8.2), suggesting the radiative forcing factor of 2.7 from IPCC (IPCC 1999), being unaware of the lower RF factor from later research (Sausen, Isaksen et al. 2005). However, if the radiative forcing factor is used, then some uncertainty is introduced, and the indicator is in danger of diverging from the essential indicator characteristics (section 7.3.1): simple; widely credible; easily understood by policy makers and the public. The indicator would no longer be simple, may not be entirely credible, and is not easily understood – at least by the public. Therefore, the indicator is based on direct CO_2 emitted rather than total radiative forcing. An alternative presentation, to show CO_2 RF equivalent (CO_2 x 1.9) may be shown. The total radiative forcing factor remains an important aspect, and is expected to be considered by climate scientists in estimating total effect on atmospheric change.

Technical Construction

Level	Airport, Airline, National, International
Units	M Tonnes CO_2
Format	Absolute value
Airlines and airports	
Source Data	Aviation fuel used, from airport and airline reports
Availability	Not published
Transformation	Direct CO_2 = Fuel weight X 3.15 CO_2 RF equivalent = Fuel weight X 3.15 X 1.9
Presentation	Graphical to show trends over time – data not available
National UK	
Source Data	Aviation fuel delivered – Digest of United Kingdom Energy Statistics (DUKES) (DTI 2006b) (Chart 3.1.2)
Availability	Yes
Transformation	As airport/airline
Presentation	Tabular or graphical to show trends over time (Figure 7.6)
Global	
Source Data	Year 2002 - (Eyers, Norman et al. 2004)
Availability	Yes (for 2002)
Transformation	Complex modelling based on number of flights
Presentation	553m tonnes

Source Data

Data Availability for Airlines and Airports: Fuel weights are not available for UK airports and airlines. It is not possible to calculate the indicator at the level of airport or airline. UK Sustainable Aviation (Sustainable Aviation 2005) has identified ‘Total Direct CO_2 Emissions from individual companies’ as an indicator, and contributing airlines may be expected to publish this data, though it is not clear when.

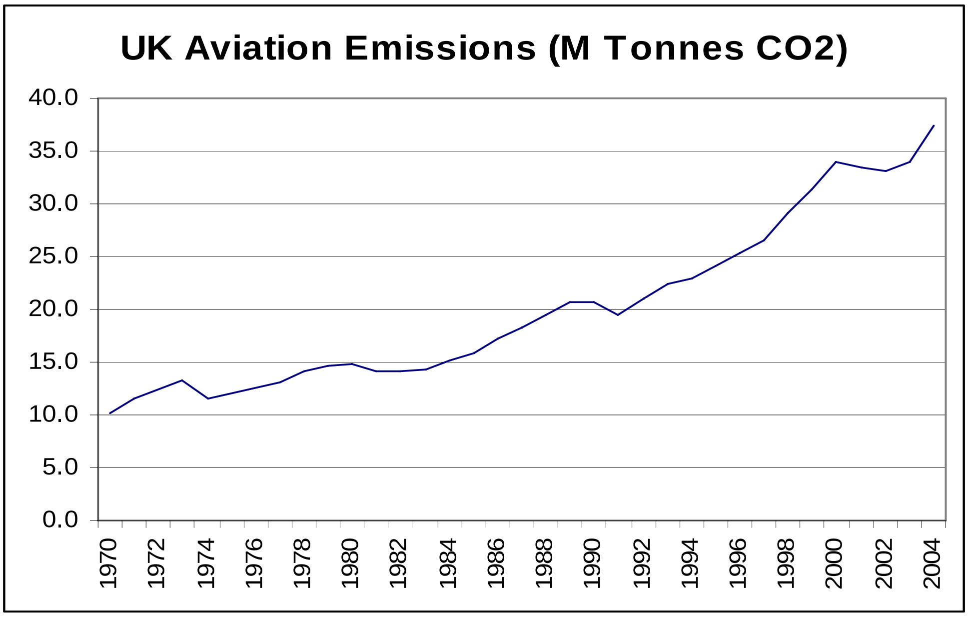


Figure 7.6 UK Aviation CO_2 Emissions

Source: Derived from Digest of United Kingdom Energy Statistics Table 3.1.2 (DTI 2006b).

7.3.4.2 En2 – Aircraft Fleet Efficiency

Description

The overall efficiency of an airline fleet.

Comment

Fleet efficiency may be expressed as fuel efficiency, or emissions efficiency. The UK Sustainable Aviation Strategy prefers the former (Sustainable Aviation 2005): survey respondents prefer the latter (section 6.8.2). Fuel efficiency is selected, though the presentation can also include CO_2 by multiplying by a factor of 3.15, the weight of CO_2 from burning a unit of fuel (DfT 2003a).

Fleet activity can be expressed as passenger kms + freight tonne kms or a composite unit incorporating passenger and freight, revenue tonne kilometre (10 passengers or I tonne freight). The latter unit is suggested by survey respondents, is adopted by the industry as the basis for an efficiency indicator (Sustainable Aviation 2005), and is adopted here.

Technical Construction

Level	Airline, National, International
Units	Kilograms fuel/ tonne kilometre
Format	Efficiency ratio
Source Data	Airline environmental reports
Availability	Partial
Transformation	Airline –Total fuel/total tonne kilometres for airline fleet in a year. National – sum of fuel/sum of tonne kilometres for all national registered airlines
Presentation	Graphical presentation to show trend over time

Source data availability: the basic data (fuel usage) is not normally published by airlines. There appears to be little consistency amongst airlines on publication of calculated fleet efficiency figures, though British Airways (BA 2005) publishes fuel efficiency and Virgin (Virgin Atlantic 2005) publishes both fuel and CO_2 efficiency.

The UK Sustainable Aviation Strategy (Sustainable Aviation 2005) has a commitment that contributing airlines will develop a common reporting system for fuel efficiency by the end of 2005. It is not clear when and for what period statistics will actually be published.

7.3.4.3 En3 – Aviation Emissions Trading Scheme

Description

Time for aviation to join the European Emissions trading scheme.

Technical Construction

Level	International (EU)
Units	Years (before aviation is included in emissions trading scheme)
Format	Subjective estimate
Source Data	UK Government/ EU
Availability	Yes
Presentation	Tabular or graphical presentation over time (Table 7.10)

Source data: the data is a forecast or estimate and varies over time. The UK Government view is that the earliest date is 2008 (DfT 2003b). This view has not been formally revised by UK Government but EU officials confirm that 2008 is not now possible (Compton 2005). There are suggestions that aviation may not be included until after 2012 (Dimas 2005).

Year estimate made	2003	2004	2005
Estimated year to join	2008	2008	2012

Table 7.10 Aviation Emissions Trading Scheme

7.3.4.4 En4 – Emissions from Surface Access Vehicles

Description

Carbon dioxide emissions from vehicles used for access to airport, including journeys by passengers, staff, freight and supplies to airport site and remote sites.

Technical Construction

Level	Airport, National
Units	Tonnes CO_2 per year
Format	Absolute value
Source Data	Airport traffic surveys
Availability	Not known
Presentation	Tabular or graphical presentation to show trends over time

Comment

Source data for this indicator is not routinely available. Specific surveys are required for airport site and remote sites, to establish vehicle numbers, consumption band and journey length. Fuel consumption band could be based on vehicle type (Upham, Mills 2005), or for UK registered cars, the Vehicle Excise Duty bands (DVLA 2006).

Calculation: for each fuel consumption band

- Extrapolate number of vehicles – survey periods to year
- Multiply by average journey length
- Calculate emissions
- Accumulate consumption bands

Further research is needed to design and implement traffic surveys on a routine basis.

7.3.4.5 En5 – Ground site GHG emissions

Description

Total carbon dioxide emissions from energy usage on airport site or airline ground activities, including on-site fuel consumption, offsite power generation, all vehicles.

Technical Construction

Level	Airport, Airline
Units	Tonnes
Format	Absolute value
Source Data	Airport and Airline environmental reports – energy inventory
Availability	Partial
Presentation	Tabular or graphical presentation to show trend over time

Most major airports and airlines publish an energy inventory, though some regional airports and smaller airlines may not. Some airports report only emissions per passenger (BAA 2005a, LBIA 2005, Manchester Airport 2004) rather than total emissions..

7.3.4.6 En6 – Airport Land Use

Description

Land for airport construction - loss of landscape, habitat and heritage.

Technical Construction

Level	Airport, National, International
Format	Quantitative and qualitative indicator
Units	Number of hectares of existing and planned land use. Qualitative: assessment of proposed loss of physical and natural landscape, habitat and heritage
Source Data	In UK – Airport Master Plans
Availability	Partial – Airport Master Plans available during 2006

7.3.4.7 En7 – Airport Water Quality

Description

Indicates discharged water quality by measuring the level of compliance with water quality discharge consents.

Technical Construction

Level	Airport
Units	Percentage compliance with water discharge consents
Format	Target – 100% compliance
Source Data	Airport environmental reports
Availability	Partial. Not consistently reported by all UK airports
Transformation	Number of days discharge consents are exceeded as percentage, measured across all outfalls over a calendar year
Presentation	Tabular or graphical presentation to show trend over time

7.3.4.8 En8 – Airport Waste Arisings

Description

Total waste arisings by disposal method – recycled, re-use, power generation, landfill.

Technical Construction

Level	Airport
Units	Tonnes of waste – Total arisings annually for each disposal method
Format	Absolute value
Source Data	Airport reports
Availability	Partial
Presentation	Tabular or graphical presentation to show trends over time

Data is reported by some airports, though not all. Many airport environmental reports show the proportion of waste recycled, rather than total volumes.

7.3.4.9 En9 – Aircraft Disposal

Description

Disposal strategy for aircraft at end of life, and for removed parts.

Technical Construction

For new aircraft the indicator covers the existence and effectiveness of a disposal strategy, for the aircraft at end of life and for removed parts.

Level	International
Units	Ordinal scale - strategy exists or not - Yes or no
Format	Subjective assessment
Source Data	New aircraft certification
Availability	Yes

Currently there is no requirement for manufacturers or airlines to consider aircraft disposal. If such a disposal strategy existed then an effectiveness indicator could include proportion by weight of aircraft and engines which can be recycled or reclaimed. Aircraft Disposal is included in the Regulatory Framework Indicator (I1).

7.3.5 Institutional Dimension Indicators

Indicators included in this group are:

Agenda 21 Chapter	Indicator	
8	I1	Regulatory Framework
8	I2	Integration of environment and development
23	I3	Community participation
35	I4	Atmospheric research by CA sector
37	I5	Environmental impact assessment
38,40	I6	ICAO programme for sustainable aviation

7.3.5.1 I1 – Regulatory Framework

Terminology

In previous chapters, the term Effective Environmental Legislation is used. This is subsumed into the more general indicator, Regulatory Framework, which now includes a range of sustainable development aspects: Safety, Integration, Participation, EIA, ICAO Programme as well as environmental issues.

Description

To illustrate how well the regulatory framework supports sustainable development principles.

Comment

The indicator is designed to cover regulatory aspects relevant to sustainable development, discussed in Chapter 4, Section 4.3.12.

- Integration of environmental protection and development: Principle 4 and Agenda 21 Ch 8.
- Public participation: Principle 10 and Agenda 21 Ch 23.
- Environmental product information: Principle 10 and Agenda 21 Ch 4.
- Effective environmental legislation: Principle 11 and Agenda 21 Ch 8.
- Compensation: Principle 13.
- Environmental Impact Assessment: Principle 17 and Agenda 21 Ch 8.
- International legal instruments: Principle 27 and Agenda 21 Ch 39.

Sustainable development principles depend on different types of regulation: environmental legislation including standards, limits and management objectives (Rio Declaration Principle 11, Agenda 21 Chapter 9-22); procedural legislation e.g. for integration, compensation, participation, EIA. The regulatory framework is a key component of the above aspects, but there is no precision on the regulatory scope or effectiveness, nor is there any recognised scale to assess effectiveness. An ordinal scale of support levels for sustainable development is proposed (Table 7.11), against which both environmental and procedural legislation may be assessed.

<table>
<tr><td>6</td><td>Institutionalised</td><td rowspan="3">Levels of Strong support</td></tr>
<tr><td>5</td><td>Quantified standards</td></tr>
<tr><td>4</td><td>Mandatory application</td></tr>
<tr><td>3</td><td>Partial/ Discretionary application</td><td rowspan="3">Levels of Token support</td></tr>
<tr><td>2</td><td>Voluntary or self regulation</td></tr>
<tr><td>1</td><td>Measurement</td></tr>
<tr><td>0</td><td>No legislation</td><td>No Support</td></tr>
<tr><td>-1</td><td>Exemption from legislation</td><td rowspan="2">Levels of opposition</td></tr>
<tr><td>-2</td><td>Separation of development and environmental protection</td></tr>
</table>

Table 7.11 Ladder of Regulatory Support for Sustainable Development
Source: Author.

The levels on the scale relate only to enacted legislative measures: at any level there may also be in effect economic incentives and political pressures which are not considered in the scale. The levels on the scale are not necessarily progressive: it is possible to mix legislation at different levels.

Levels of opposition are characterised by legislation which in some way obstructs progress towards sustainable development.

Level (-2): indicates a separation of development and environment embodied into law e.g. The Transport Act 2000 (UK Government 2000) lays duties on the Secretary of State to further the interests of airlines and airports, but defines no corresponding environmental duties.

Level (-1): indicates an actual protection or exemption built into the law e.g. noise effects of civil aviation are exempted from nuisance law (UK Government 1982).

Level 0: there is no specific legislation on the issue. Absence of legislation absolves the industry from any legal responsibility e.g. Emission of greenhouse gases.

Levels of Token support are characterised by legislation which is partial in coverage or applies no mandatory limits.

Level 1: Measurement – Legislation defines effects to be measured. The EU directive on Environmental Noise (EU 2002) defines community noise levels to be measured and how these are to be calculated.

Level 2: Voluntary – The legislation provides mechanisms for applying environmental limits, but application depends on the voluntary agreement of the polluting company. An example is the use of the UK Planning law (UK Government 1990a) to apply environmental limits. In the UK, at the time of a planning application, a local authority and an airport may reach a voluntary agreement on operational or environmental limits, which then become legally binding.
Other examples may arise by vesting regulatory powers in the operator. The UK Civil Aviation Bill 2005 (UK Government 2005) includes provision to generate noise control schemes and, in its form at the third reading on 10 October 2005, vests the authority in airports. This may be regarded as a form of voluntary self-regulation by airports.

Level 3: Partial/ Discretionary – The legislation is not comprehensive in its coverage.
Partial: The legislation requires statutory conditions, but the scope of the regulation is limited, e.g. use of environmental impact assessments (EIA). UK regulations require an EIA for runways and major terminal extensions (ODPM 2003a) at airports with a runway over 2100 metres. Other airport developments fall under General Permitted Development Order (UK Government 1995b) and do not require planning consent or EIA.
Discretionary: Legal controls may be applied on a discretionary basis by an external authority. Examples are the UK Civil Aviation Act section 78 (UK Government 1982) and Transport Act 2000 section 39 (UK Government 2000), both of which vest discretionary powers in the Secretary of State to apply limits on airport noise and

emissions. The former powers are used at three London airports (Heathrow, Gatwick and Stansted); the latter powers have not been exercised.

The levels of Strong legislation are characterised by a comprehensive application and quantified targets.

Level 4: Mandatory. The legislation specifies external conditions with comprehensive and statutory application. Levels of discretionary application are removed. The legislation may typically include:

- Statutory application, non–discretionary
- Unambiguous definition of environmental issue
- Independent external regulatory agency e.g. in the UK, the Environment Agency
- Access powers (for measurement and inspection etc.)
- Penalty system

An example is the UK Environmental Protection Act (UK Government 1990b).

Level 5: Quantified Standards. The legislation is implemented by external application of statutory, quantified performance standards, which may apply to different aspects of environmental protection:

- Limits on input or output flows e.g. consents for permitted concentrations of pollutants in water outflows (UK Government 1990b)
- Limits on an environmental quality e.g. air quality standards (EU 1999)

To be effective, pollution limits will normally be quantified and designed to reduce or limit environmental damage.

Level 6: Institutionalised. Performance standards are internally institutionalised in every aspect of operations. An example is Safety (Chapter 4 Section 4.3.10) which is fully integrated into civil aviation processes from policy making to routine operation.

Technical Construction

Level	National
Format	Ordinal scale - Table 7.11
Units	Subjective assessment of level on scale
Source Data	UK legislation
Availability	Yes
Presentation	Tabular (Table 7.12). Review every 5 years

Topic	Legislation/ Regulation	Level
Safety	ICAO SARPS & National Regulations	6
Air Quality - EU	EU Directive 1999/30/EC	5
Airport Water Quality	Water Act 1998 S107-110 & Environmental Protection Act 1990 S145	5
Airport Waste	Planning regulations	4
EIA – Airport Infrastructure	EU Directive 97/11/EC & GPDO (UK SI 1995 No. 418)	3
Aircraft Noise (UK)	Civil Aviation Act 1982 S78	3
Aircraft Noise (UK)	Transport Act 2000 S39	3
Air Quality - UK	Transport Act 2000 S39	3
Participation	Civil Aviation Act 1982 S35	3
Aircraft Noise (UK)	Town & Country Planning Act 1990 S106	2
Aircraft Noise (UK)	Civil Aviation Bill (2005)	2
Aircraft Noise (EU)	EU Directive 2002/49/EC	1
A/C GHG Emissions	None	0
Aviation Fuel Used	None	0
EIA – Airspace	None	0
National Noise Criteria	None	0
Product Information	None	0
Compensation	None	0
Aircraft Disposal	None	0
Airport Site GHG	None	0
Surface Access GHG	None	0
ICAO Programme	None	-1
Aircraft Noise (UK)	Civil Aviation Act 1982 S76	-1
Aircraft Noise (UK)	Environmental Protection Act 1990 S79	-1
Policy Integration	Transport Act 2000 S1	-2

Table 7.12 Civil Aviation Regulatory Framework

7.3.5.2 I2 – Integration of Environment and Development

Description

Assess the legal provisions for integrating environmental protection and development.

Technical Construction

The level of integration of environmental protection and development is extremely difficult to measure and, as far as is known, no scale exists for this. The indicator is a qualitative description of the current state (Section 4.3.12.4). It is argued (VanderZwagg 1995) that integration at a Government level may be embodied in the legal process. Integration is included as one aspect of the Regulatory Framework Indicator (I1) above.

7.3.5.3 I3 – Community Participation

Description

An assessment of the level of Community Participation in airport environmental decisions.

Technical Construction

Level	Airport
Units	Ordinal scale proposed – Arstein's Ladder of Citizen Participation (Arnstein 1969)
Format	Subjective assessment of level on scale
Source Data	UK legislation
Availability	Not known
Transformation	Tabular (Table 7.12). Review every 5 years

Comment

Community participation in an airport's environmental decision making may be assessed on Arnstein's Ladder of Citizen Participation. The level of participation may be assessed by survey of the local community, members of the Airport Consultative Committee or other concerned groups (Grimley 2001). The legislation affecting participation is enacted at a national level and is included in the Regulatory Framework Indicator (I1) above.

7.3.5.4 I4 – Environmental Impact Assessment

Description

The extent of application of Environmental Impact Assessment (EIA) in civil aviation developments.

Technical Construction

Level	National
Format/ Units	Qualitative assessment
Source Data	UK Legislation
Availability	Yes
Presentation	Tabular (Table 4.12). Review every 5 years.

The use of EIA for civil aviation development is analysed at section 4.3.12, Table 4.12. EIAs are required for airport infrastructure only for runways, runway extension, new or major terminal extensions, and not required for new aircraft, or airspace agreements. EIA regulations are included as one aspect of Indicator I1 (Regulatory Framework).

7.3.5.5 I5 – ICAO Programme for Sustainable Development

Description

To show the existence and effectiveness of an ICAO programme to implement Agenda 21.

Technical Construction

Level	International
Units	Ordinal scale – Yes/ No – strategy exists or not
Format	Subjective assessment
Source Data	ICAO Resolutions
Availability	Yes
Presentation	Review every 5 years

Currently ICAO does not have a concrete programme for implementing Agenda 21 (section 4.3.12.), as required within Agenda 21. If such a programme existed then it may be necessary to introduce further indicators to assess its effectiveness. This indicator is included as an element in the Regulatory Framework Indicator (I1) above.

7.4 *Review Indicator Set*

7.4.1 Summary of Indicator Set

The full set of 29 proposed indicators is shown at Table 7.13, to illustrate for each indicator the units, level, and source data availability. Table 7.14 shows the indicators by level – airport, airline, national, international.

7.4.2 Quality Assurance

Quality assurance criteria from Agenda 21 are derived in section 2.4.6. The dimensions of sustainable development follow the UN definition (Table 7.2).

Characteristics of Indicator Sets	
Scope	Four dimensions – social, economic, environmental, institutional. All relevant chapters of Agenda 21
Scale	Local, national, international
Targets	Decision makers – international, national, local government, company managers, consumers. Public information
Type	Driving force, state, response

The type of indicator is assessed from the viewpoint of the civil aviation system:

- State: an indicator measuring the current status of an aspect of civil aviation
- Driving Force: outputs from civil aviation system and impacts on other systems
- Response: an indicator of policy, economic, legal or institutional aspects, which could affect the behaviour of the civil aviation system or demand systems

In addition, the data availability of the proposed indicators is summarised at Table 7.15. National and International indicators are largely concerned with the institutional and legal arrangements: information to populate these indicators is readily available. At airline and airport levels, data to populate the indicators is generally of an operational nature, and there is considerably less transparency and consistency in data availability.

	Indicator	Scale/ units	Source data Availability	Airport	Airline	National	Inter-national
	SOCIAL						
S1	Airport Jobs	Number and value of airport jobs	Partial	X			
S2	Regional Equity	Passenger km/person by world region	Yes				X
S3	Social Equity	Passengers/person by socio-economic group	Commercial			X	
S4	Passenger Safety	Million passengers/fatality	Yes		X	X	X
S5	Air Quality	Number of exceedences of EU directive	Yes	X			
S6	Aircraft Noise	Noise contour maps, area (square kms) Number of people in area	Partial	X			
S7	National Noise Levels	Nominal scale – Y/N	Yes			X	
	ECONOMIC						
Ec1	GDP	Gross Value Added £bn	Yes			X	
Ec2	Aviation Fuel Used	Tonnes	Not published	X	X		
			Yes			X	X
Ec3	ACARE Targets	Certificated performance	Yes				X
Ec4	ATM Inefficiency	En-Route - % additional distance, time, fuel	Yes				X
		Holding patterns - Hours in holding pattern	Not published	X			
Ec5	Air Transport Volume	UK Airport Passengers & Freight, World Regions Passenger-kms	Yes	X	X	X	X
Ec6	Environment Related Charges	Total environmental charges	Yes			X	
Ec7	Environmental Product Information	Ordinal scale – subjective	Yes			X	
Ec8	Renewable Fuel	Years to renewable fuel	Yes				X

Table 7.13 Indicator Summary

	Indicator	Scale/ units	Source data Availability	Airport	Airline	National	Inter-national
	ENVIRONMENTAL						
En1	Aircraft GHG Emissions	Tonnes carbon dioxide	Not published	X	X		
			Yes			X	X
En2	Aircraft Fleet Efficiency	Kg carbon dioxide / Tonne-km performed	Partial		X	X	
En3	Emissions Trading Scheme	Years before Aviation in scheme	Yes				X
En4	Surface Access GHG	Tonnes carbon dioxide	Not known	X			
En5	Ground site GHG emissions	Tonnes carbon dioxide	Partial	X	X		
En6	Airport Land Use	Hectares, Qualitative assessment	Partial	X			
En7	Airport Water Quality	Annual % compliance with consents	Partial	X			
En8	Airport Waste Arisings	Annual Tonnes waste	Partial	X			
En9	Aircraft Disposal	Disposal strategy	Yes				X
	INSTITUTIONAL						
I1	Regulatory Framework	Ordinal scale – subjective	Yes			X	
I2	Integration of Environment and Development	Ordinal scale – subjective	Yes			X	
I3	Community Participation	Ordinal scale (Arnstein's Ladder)	Not known	X			
I4	Environmental Impact Assessment	Ordinal scale – subjective	Yes			X	
I5	ICAO Programme for Sustainable Development	Nominal scale – Y/N	Yes				X

Table 7.13 Indicator Summary (Cont)

AIRPORT INDICATORS		**AIRLINE INDICATORS**	
	Social		**Social**
S1	Airport Jobs	S4	Passenger Safety
S5	Air Quality		
S6	Airport Noise		
	Economic		**Economic**
Ec2	Aviation Fuel Used	Ec2	Aviation Fuel Used
Ec4	ATM Efficiency (holding patterns)	Ec5	Air Transport Volume
Ec5	Air Transport Volume	Ec7	Product Information
	Environmental		**Environmental**
En1	Aircraft GHG Emissions	En1	Aircraft GHG Emissions
En4	Surface Access GHG	En2	Aircraft Fleet Efficiency
En5	Airport site GHG emissions		
En6	Airport Land Use		
En7	Airport Water Quality		
En8	Airport Waste Arisings		
	Institutional		
I3	Community Participation		

NATIONAL INDICATORS		**INTERNATIONAL INDICATORS**	
	Social		**Social**
S3	Social Equity	S2	Regional Equity
S4	Passenger Safety	S4	Passenger Safety
S7	National Noise Levels		
	Economic		**Economic**
Ec1	GDP	Ec2	Aviation Fuel Used
Ec2	Aviation Fuel Used	Ec3	ACARE Targets
Ec5	Air Transport Volume	Ec4	ATM Efficiency (en-route)
Ec6	Environment Related Charges	Ec5	Air Transport Volume
Ec7	Environmental Product Information	Ec8	Renewable Fuel
	Environmental		**Environmental**
En1	Aircraft GHG Emissions	En1	Aircraft GHG Emissions
En2	Aircraft Fleet GHG Efficiency	En3	Emissions Trading Scheme
		En9	Aircraft Disposal
	Institutional		**Institutional**
I1	Regulatory Framework	I5	ICAO Programme for Sustainable Development
I2	Integration of Environment and Development		
I4	Environmental Impact Assessment		

Table 7.14 Indicator Sets – Airport, Airline, National, International

		Data Availability				
Data level	Number	Yes	Commercial	Partial	Known/not published	Not known
Airports	13	2		6	3	2
Airlines	6	2		2	2	
UK National	13	11	1	1		
International	11	11				

Table 7.15 Proposed Indicators – Data Availability

The proposed indicator set includes the four dimensions of sustainable development (Table 7.16), covering aspects of 13 out of 40 Agenda 21 Chapters. There is a balance of driving force, state and response indicators (Table 7.17), and a mix of indicators at different levels (Table 7.18) reflecting the different sources of information and varying decision makers.

7.4.3 Comparative Review

While it is not the initial purpose to compare the indicator set derived in this thesis with other sets, two other aviation related sets of indicators have been produced during the timescale of this research – one by Eurocontrol (Elliff, Celikel et al. 2004), the other as part of the UK Sustainable Aviation Strategy (Sustainable Aviation 2005). The quality assurance criteria are used to assess the characteristics of these two indicator sets. The indicator sets from Eurocontrol and UK Sustainable Aviation display a more limited spread across Agenda 21, reflecting only 5 and 6 chapters of Agenda 21 respectively (Table 7.16), having few institutional indicators. Both sets include few Response indicators (Table 7.17) and the UK Sustainable Aviation set has fewer international indicators than the other two sets.

The Eurocontrol set is defined as 'Indicators of Sustainable Growth', rather than 'Sustainable Development' and the methodology allows stakeholders to consider only three dimensions – the social, economic and environmental impacts of the aviation sector on society in Europe (Elliff, Celikel et al. 2004). There is no reference directly to sustainability principles, and the methodology adopted may be judged to effectively remove options for deriving Institutional or Response indicators.

The UK Sustainable Aviation Strategy places high reliance on voluntary initiatives by the industry and takes a narrow view of sustainability, based essentially on efficiency improvements. There is little recognition of a need for institutional or legal changes, and the proposed indicator set has only two institutional Indicators (lists of organisations endorsing voluntary codes of practice), and two Response indicators based on the ACARE targets.

The Eurocontrol and UK Sustainable Aviation show relatively low numbers of Environmental indicators. Noise and Local Air Pollution appear in Agenda 21 Chapter 6 as Health issues and are thus categorised in the Social dimension rather than Environmental.

	Eurocontrol		**Sustainable Aviation**		**This Thesis**	
	Number	%	Number	%	Number	%
Dimensions						
Social	7	33	6	35	7	24
Economic	9	43	6	35	8	27
Environmental	3	14	3	18	9	31
Institutional	0	0	2	12	5	17
Other	2	9	0	0	0	0
Total Indicators	21		17		29	
Agenda 21 Chapters	5	12	6	15	12	30

Table 7.16 Indicator Quality Assurance – Dimensions and Agenda 21 Chapters

	Eurocontrol		**Sustainable Aviation**		**This Thesis**	
	Number	%	Number	%	Number	%
Type						
Driving Force	9	43	4	24	8	28
State	12	57	11	65	11	38
Response	0	0	2	12	10	34
Total Indicators	21		17		29	

Table 7.17 Indicator Quality Assurance – State, Driving Force, Response

Scale	**Eurocontrol**	**Sustainable Aviation**	**This Thesis**
Airport	6	7	13
Airline	4	3	6
National	12	7	13
International	5	2	11

Table 7.18 Indicator Quality Assurance – Scale

7.5 *Summary*

Twenty-nine indicators are selected and constructed in this thesis. There is a spread across the four dimensions of sustainable development and aspects of twelve of the forty Chapters of Agenda 21 are covered. The indicator set has a mix of state, driving force and response indicators, and of different levels – airport, airline, national and international. At the airport and airline data, much of the data required to populate these proposed indicators, is not readily available (Table 7.15).

The indicators suggest no current initiatives to change the regulatory frameworks for civil\ aviation in favour of sustainable developments, though there are two significant change initiatives – the ACARE eco-efficiency targets for new aircraft, and the proposed inclusion of aviation in the European Emissions Trading Scheme.

CHAPTER 8 Conclusions and Further Research

8.1 *Overview*

This chapter reviews the outcomes of the thesis in relation to its stated aims and objectives, and summarises the research findings. The contributions to knowledge are assessed and an extensive range of potential further research is identified. Contribution of this research to the sustainability debate is discussed.

8.2 *Aims and Objectives*

The aim of this thesis has been 'To derive indicators of sustainable development in civil aviation'. This overall aim has been met: a proposed set of 29 indicators has been developed.

The thesis developed two procedures designed to assist operational implementation of sustainable development principles in an industrial sector: a sustainable development model (described at Box 3.1), and a methodology for indicator selection (described at Figure 3.5). The procedures were designed to assist in operationalising sustainable development. The first provided a rigorous and holistic model to assess an industrial system against sustainable development principles. The second offered a transparent and strongly participative process for indicator development. Both related directly to the full scope of the Rio Declaration and Agenda 21, and incorporated quality assurance checks against the original requirements of sustainable development principles. These procedures were then applied to the civil aviation system, though they may be generally applicable in other industrial sectors. Stakeholder participation in indicator selection was achieved by a Delphi study of UK civil aviation stakeholders. The objectives of this survey were: to determine stakeholder interpretations of sustainable aviation; to determine stakeholder views of the most important factors for sustainable development in civil aviation; and to determine why the observed actions of the civil aviation industry diverge from the principles of sustainable development.

In Chapter 5, survey questionnaires were designed, based on research propositions in turn derived from the stated research objectives. The survey results were analysed in detail at Chapter 6, and summarised at section 6.10. The research objectives of the survey have been met. The major findings of the thesis are summarised in the following section.

8.3 *Findings and Key Results*

From the literature review at Chapter 2, the thesis accepted the anthropocentric interpretation of sustainable development, and adopted the premise that sustainable development represents a journey of changing social attitudes and technology through time. The Rio Declaration and Agenda 21 were taken respectively as the definitions of sustainable development principles and recommended actions.

The research suggested that, amongst UK civil aviation stakeholders, there was no consensus on the meaning of sustainable aviation. There was a consensus amongst these stakeholders, on the issues of concern, but considerable disagreement on the policies which should be adopted to move towards sustainable developments in aviation. Although there was disagreement on desirable policies, stakeholders showed a good level of agreement on their choice of indicators of sustainable development in aviation. Stakeholders tended not to support indicators showing institutional aspects – regulation and participation.

The research indicated that civil aviation stakeholders displayed a limited understanding of the meaning of sustainable development, and gave responses broadly in support of their own sectional interests. This was consistent with Meadows' theorem of human perspectives (Meadows 1972).

Attitudes amongst industry stakeholders tended to fall within the very weak sustainability category on Pearce's Sustainability Spectrum (Pearce 1993).

The research proposed a set of 29 indicators of sustainable development in civil aviation. The indicator set fared well against quality assurance criteria derived from Agenda 21: this indicator set covered the four dimensions of sustainable development including institutional indicators, had a balance of indicator types (state, driving force and response), and a mix of indicators targeted at the range of decision makers – from consumer to international decision maker.

In addition to the set of sustainable development indicators, a number of other findings emerged from the thesis.

The assessment of civil aviation against sustainable development principles at Chapter 2 included a review of oil supplies. There emerged the prospect that the potential for reducing supplies of conventional oil (Peak Oil), and the increasing demand for aviation fuel, may lead to a physical restriction of the supply of aviation kerosene. There was evidence from the research that, amongst industry stakeholders, there was an emerging expectation that civil aviation may need to take an increasing share of potentially decreasing oil supplies.

The research also revealed widely differing approaches in civil aviation to different aspects of sustainable development. Safety may be viewed as one aspect of sustainable development: the analysis suggested that safety is institutionalised in civil aviation. Efficiency improvements of new aircraft and operations were strongly supported. In other respects, there was evidence to suggest that a level of non-sustainability was institutionalised in the regulatory and operational organisations of civil aviation: ICAO has no programme for the implementation of Agenda 21; in the UK, environmental protection and development are separated in civil aviation law, rather than integrated; there was widespread opposition from industry stakeholders to regulatory or economic instruments in favour of sustainable developments.

8.4 *Contributions to Knowledge*

The thesis makes five distinct contributions to knowledge, presented here in order of the thesis, rather than any inference of significance.

The Sustainable Development Model. The model is designed to provide a means of documenting an industrial system or sector purely in terms of sustainable development, and is based on treating sustainable development as an information system. The model relates the full scope of the industrial sector directly to the full range of sustainable development principles, including institutional aspects and implementation arrangements, frequently omitted from other methodologies.

Methodology to Derive Indicators of Sustainable Development. The methodology is distinguished from other methodologies in several respects:

- it relates directly to sustainable development principles and actions
- it covers all principles, including means of implementation
- it does not preclude certain types of indicator
- it is transparent and fully justified
- it incorporates a quality assurance process against original requirements of sustainable development indicators.

The methodology also incorporates a strong participative element, using a Delphi study to seek views from industry stakeholders.

Attitudinal survey. Views on sustainable developments in civil aviation are changing rapidly. The Delphi study offers a current view of the attitudes of relevant UK stakeholders, and establishes an attitudinal baseline for future comparison.

Indicator set. The thesis proposes a set of indicators of sustainable development in civil aviation. It is suggested that these are currently valid indicators, though, over time, there may be a need to expand or modify the scope of the indicators.

Regulatory assessment. The indicator to assess the regulatory framework proposes a new scale – the Ladder of Regulatory Support for Sustainable Development. This scale has been developed from an analysis of UK civil aviation regulatory framework, but in principle should be applicable to other sectors or, potentially, at a national level. As far as can be determined, no similar scale has previously been proposed or used. The represents a significant advance in the ability to assess progress in regulatory support for sustainable development.

8.5 *Evaluation of Research*

Methodological Approach

The thesis is based on a systems approach to operationalising sustainable development in an industrial environment.

Sustainable development within an industrial context is regarded as an information and decision making system, though a system which must operate over a long timescale, and which will itself evolve. Thus the research developed a Sustainable Development Model (Chapter 3 Box 3.1), designed to describe the component parts of such an information system. This model is well founded in systems theory. The scope of the model covers the full range of sustainable development principles and actions including means of implementation, and the whole operational system (industrial sector or operation), including changes to regulatory and economic frameworks.

The model provides a template to identify and describe the range of tangible, or ‘hard’ system components needed for the implementation of sustainable development. There are of course less tangible aspects necessary to bring about change, such as the moral imperative, political will and public support, which are not identified in the systems model and thus not explicitly considered in the thesis. The Sustainable Development Model has been developed in this thesis and used once to analyse the civil aviation system: at this stage the model may be regarded as a prototype.

Amongst the components identified in the Sustainable Development Model is information – Indicators of Sustainable Development, and a revised methodology to derive indicators has been developed. This methodology was designed specifically to meet requirements derived from an exploration of sustainable development principles (summarised at Box 2.3). It is thus well founded on sustainable development principles and incorporates a quality assurance review of the resultant indicators. The Indicator Selection Methodology has been developed in this thesis and used once to analyse the civil aviation system: at this stage the model may be regarded as a prototype.

Both the Sustainable Development Model and the Indicator Selection Methodology depend on a comprehensive analysis of the operational system (civil aviation in this thesis) against sustainable development principles. The analysis (at Chapter 4) employs a systematic approach, based on Checkland's Systems Typology, to analyse the civil aviation system. The systems approach provides a comprehensive view of the civil aviation system, well suited to the analysis required. This is however, not the only systems view of civil aviation: many other valid systematic views may be derived for different purposes.

Attitudinal Research

The research into stakeholder views (Chapters 5 and 6) employed well established techniques (Delphi study), and used electronic communications extensively. The electronic surveys matched the working practices of respondents, who now routinely use e-mail. The survey achieved a good coverage of major UK stakeholders, including respondents from the major airlines and airports. There was relatively little input to the survey from representatives of user organisations and air traffic management. The survey was restricted to UK stakeholders and therefore did not cover the views of regulators in European Union and ICAO.

8.6 *Contributions to Sustainability Debate*

Having presented the findings and key results of the research, it is now possible to show how they may be used to inform the sustainability debate with regards to civil aviation. This section focuses on aspects relevant to civil aviation in each of the four dimensions of sustainable development: social, economic, environmental and institutional.

The approximate position of Agenda 21 is mapped at Figure 8.1 against the Sustainability Spectrum (Pearce 1993), previously discussed at section 2.2.2. In this mapping, the use of economic instruments is shown to be equivalent to weak sustainability, while references in Agenda 21 to regulatory limits, maximum levels or the scope of regulation (albeit with appropriate political caveats), are taken to be equivalent to a 'macro-environmental standard', thus tending towards strong sustainability.

The position of civil aviation on the Sustainability Spectrum, based on this research, is shown in Figure 8.2 and is mapped generally in the very weak area of the spectrum, described by Pearce (1993) as unfettered free enterprise, with the exception of eco efficiency and passenger safety, respectively in the weak and strong areas. The findings may be viewed as a reasonable representation of the views of industry stakeholders (Section 5.5.4).

Social Dimension – Equity & Health

The analysis of air transport consumption rates (section 4.3.3) across world regions shows a current pattern of inequity (Indicator Ec5, Figure 7.4), that is projected to increase in future (Figure 4.4). The analysis suggests that, when assessed across world regions, development of air transport is moving away from the principle of Equitable Development (Principle 3), though this trend reflects wider economic developments.

<table>
<tr><th>Sustainability Label
Rio Declaration & Agenda 21</th><th>Very Weak</th><th>Weak</th><th>Strong</th><th>Very Strong</th></tr>
<tr><td>Social Dimension – Regional Equity</td><td></td><td></td><td>---------</td><td></td></tr>
<tr><td>Social Dimension – Human Health:</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aircraft Noise</td><td></td><td colspan="2">------------------</td><td></td></tr>
<tr><td>Passenger safety</td><td></td><td>----------</td><td></td><td></td></tr>
<tr><td>Economic Dimension - Change consumption patterns:</td><td></td><td>----------</td><td></td><td></td></tr>
<tr><td>Economic incentives</td><td></td><td>----------</td><td></td><td></td></tr>
<tr><td>Improve eco-efficiency</td><td></td><td>----------</td><td></td><td></td></tr>
<tr><td>Renewable fuel</td><td></td><td>----------</td><td></td><td></td></tr>
<tr><td>Environmental Dimension – Protect Atmosphere</td><td></td><td colspan="2">------------------</td><td></td></tr>
<tr><td>Institutional Dimension:</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Integrate environment and development in decision making</td><td></td><td colspan="2">------------------</td><td></td></tr>
<tr><td>Environmental legislation</td><td></td><td colspan="2">------------------</td><td></td></tr>
</table>

Figure 8.1 Sustainability Spectrum – Agenda 21

Sustainability Label **Civil Aviation**	Very Weak	Weak	Strong	Very Strong
Social Dimension – Regional Equity	----			
Social Dimension – Human Health:				
Aircraft Noise	---			
Passenger safety			----------	
Economic Dimension - Change consumption patterns:				
Economic incentives	--			
Improve eco-efficiency		----------		
Renewable fuel	-----			
Environmental Dimension – Protect Atmosphere	---			
Institutional Dimension:				
Integrate environment and development in decision making	---			
Environmental legislation	---			

Figure 8.2 Sustainability Spectrum – Civil Aviation

Agenda 21 suggests national noise criteria. The research shows that civil aviation respondents place this as their least important policy (section 6.2.3) and few airline respondents expect noise reductions (section 6.2.1). This would suggest that community noise is not of great concern to the industry respondents, and initiatives to improve the noise climate may not therefore arise from the industry of its own volition. The UK legal exemption of aircraft noise from nuisance law (section 4.3.11

and 4.3.12) removes legal pressures from the industry, and may therefore act as a barrier to progress towards sustainable developments in this respect.
Safety is institutionalised in civil aviation, managed by a form of ‘self-regulating’ safety system (section 4.3.10) with overall (macro) safety standards: for these reasons passenger safety is categorised as strong sustainability in this illustration. Respondents did not assign great importance to the issue, merely accepting that safety is not currently a great problem. The prevailing safety culture may be regarded as equating to or even exceeding the requirements of sustainable development.

Economic dimension – Change consumption patterns

The objective of sustainable development (Agenda 21 Chapter 4) is to ‘reduce and eliminate unsustainable consumption patterns’ using a range of policies: increased efficiency, environmentally sound pricing, renewable energy, public education.

The research indicates that civil aviation stakeholders oppose the use of economic instruments to support environmentally sound pricing, and which may reduce consumption of air transport (sections 6.3.2 and 6.4.2). Development of renewable fuel is supported by airline respondents, receives only moderate support from airport respondents and is not supported by supplier respondents (section 6.3.2). In Agenda 21, improved efficiency is seen as a means of ***reducing*** consumption (Agenda 21 Chapter 4.18). Civil aviation respondents, while strongly supporting increased eco-efficiency, oppose policies which may limit aviation growth (section 6.3), and envisage increased volumes of air transport (section 6.2). Clearly, industry respondents do not view improved efficiency as a means of reducing consumption, rather as a contribution to cost reduction, which may stimulate demand and increase overall consumption. Thus, while the action of improved eco-efficiency may appear consistent with Agenda 21, the actual effect on overall consumption of civil aviation is contrary to sustainable development objectives.

Overall, it can be seen that the objective of reducing unsustainable consumption is not supported by civil aviation. On the evidence of this research, any realistic measures to change consumption patterns can only arise from outside the industry.

Environmental Dimension – Protect Atmosphere

The Agenda 21 objective is to ‘to limit, reduce or control’ harmful emissions from transport. This research suggests that civil aviation respondents are ambivalent on this issue. There is wide agreement that greenhouse gas emissions (GHG) from aviation are very important (section 6.3.1) – indeed, the most important sustainability issue facing civil aviation. Most operator respondents expect an increased number of flights and many of these respondents, rather inconsistently, also expect a reduction in GHG emissions: few operator respondents actually equate increased flights with increased emissions (section 6.2.1). At the same time, operator respondents display strong opposition to controls on emissions (section 6.3.2 and 6.4.2) and to economic measures designed to curb demand (section 6.4.2).

Overall, this research shows that industry respondents recognise the importance of aviation GHG emissions but oppose any measures to curb their growth. The implications are that realistic measures to curb aircraft emissions are unlikely to arise from within the industry, and may depend on external intervention.

Institutional Dimension

Rio Declaration Principle 4 states 'In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it', placing integration as a fundamental and overarching principle. The research shows an ambivalent view on integration: while civil aviation respondents support the policy of integration (section 6.3.2), they do not wish its application to be measured (section 6.8.6). However, extant UK civil aviation legislation embodies a separation of development and environment in the duties of the Secretary of State for Transport (section 4.3.12.), effectively mitigating against an integrated aviation policy in the UK. This represents a barrier to sustainable development within civil aviation in the UK.

Effective environmental legislation is seen by the Rio Declaration (Principle 11) as a fundamental aspect of sustainable development. Airline and airport respondents place a low priority on the need for further environmental legislation (section 6.3.2).

Changes in Favour of Sustainable Development

The changes required to move civil aviation towards sustainable development are well illustrated in Figures 8.1 and 8.2. Two aspects (improved eco-efficiency and passenger safety) are already supported by civil aviation: both of these aspects are in the interests of the industry; the former (eco-efficiency) is used to increase, rather than reduce, consumption as envisaged by Agenda 21.

In other respects, the research suggests that the industry is institutionally opposed to changes in favour of sustainable development (section 6.10.2). This opposition is displayed in the institutional orientations (section 6.3.2 and 6.4.2) and extends to the legal framework under which civil aviation operates (section 4.3.12 and Indicator I1). Industry respondents support voluntary changes of an internal and procedural nature, promoting internal efficiency and avoiding any external limits (section 6.5.4). The implications of the research and analysis are that it remains unrealistic to expect substantive change towards sustainable development to originate from the industry.

In the social dimension, regional consumption of air transport reflects wider economic developments. In order to move towards equitable development, measures to change consumption of air transport (e.g. economic incentives) would need to be differentially applied across world regions so as to selectively depress demand in the current high consuming regions (primarily North America and Europe), while allowing consumption increases in some parts of the less developed world, particularly Africa.

In the economic dimension, sustainable development has an objective to make trade and environment mutually supportive (section 4.5.3), and UK Government policy aims for reduced energy intensity in the national economy (section 4.3.3.3). For UK civil aviation, the energy intensity, measured as aviation's direct contribution to GDP, shows an increasing trend (Indicator Ec1 at Figure 7.2), i.e. less economic contribution arises for each unit of energy consumed (tonne aviation fuel), and the industry's performance appears contrary to the UK Government policy. Thus, within the UK, there may be national economic reasons to apply some form of environmental charge to redress this trend.

In the environmental dimension, the overriding need is for a specific limit on aviation greenhouse gas emissions, or a macro-environmental limit including aviation. The former is strongly opposed by civil aviation (section 6.3.2). Inclusion of aviation in the EU emissions trading scheme is strongly supported by respondents (section 6.4.2), though is still some years from implementation. It remains to be seen how effective the scheme will be in reducing aviation emissions: there is clearly an expectation amongst industry respondents that the scheme will not adversely affect aviation growth, and thus may not reduce aviation emissions.

The growth of air transport consumption (and thus aviation greenhouse gas emissions) has hitherto relied upon adequate supplies of oil-derived kerosene at moderate prices. The examination of oil supplies (section 4.3) suggests the possibility of continued elevated oil prices and potentially a reducing supply. There is an emerging expectation from the industry that aviation will take a greater share of a reducing oil supply (6.10.2). An elevated oil price may itself have some impact on aviation growth, and at some time in future, a shortage of raw material (oil) may present a significant external constraint, potentially limiting consumption of air transport and accelerating the development of alternative fuels or technologies.

In the institutional dimension, Agenda 21 Chapter 8 specifies the need to provide a regulatory framework to ensure legal integration of environment and development in policy making, a fundamental aspect of the implementation of sustainable development. Within the UK, this requires amendments to (at least) the Transport Act 2000, to place environmental protection duties on the Secretary of State for Transport, equivalent to his existing duties to protect the interests of air operators. Such a change of Ministerial duties should result in an integrated aviation policy, and other legal changes (e.g. airport noise limits). This change needs to be part of a wider reassessment to legally incorporate environmental protection into Ministerial duties for all Government Departments as required by the Integration Principle. There is no public indication that the current UK Government acknowledges the need to adjust Ministerial duties in this respect.

Summary

In summary, the research suggests that the aviation industry does not recognise, and cannot accept, a need to reduce air transport consumption advocated by Sustainable Development principles. Initiatives from civil aviation are limited to efficiency improvements, which contribute to lowering the real cost of air transport, in turn translated into increased consumption. The industry recognises the great concerns on aviation GHG emissions, but seems incapable of applying internal limits, or accepting external measures to limit emissions. In these respects, the civil aviation industry is institutionally oriented against sustainable developments.

Initiatives to move towards sustainable development seem unlikely to originate from within the civil aviation, but pressures may arise outside the industry, potentially from economic initiatives (e.g. to increase GDP contribution/unit of energy), from macro-environmental limits (e.g. aviation in an emissions trading scheme), or potentially from physical raw material limitations caused by reducing oil supplies.

8.7 *Further Research*

Further research is suggested in six distinct areas.

Methodology Research

Sustainable Development Model. The thesis proposes a sustainable development model which has been applied in this instance to the civil aviation system. It is expected that the approach may validly be used for other industrial sectors, though it is acknowledged that, in many ways, this remains a prototype model. There is therefore scope for further research to refine the Sustainable Development Model and to apply the model to other industrial sectors.

Methodology to Derive Indicators of Sustainable Development. Similar comments apply here as for the Sustainable Development Model. The indicator methodology has been applied to civil aviation, but could be applicable to other sectors. There is therefore scope for further research to refine the methodology and to apply it to other industrial sectors.

Ladder of Regulatory Support for Sustainable Development. The thesis proposes a novel scale for assessment of the regulatory framework – the Ladder of Regulatory Support for Sustainable Development which has been used in this instance to assess civil aviation regulation in the UK. The scale may be regarded as a prototype at this stage. Further research is required to refine the scale, apply it to other industrial sectors and to relate the scale to Pearce's Sustainability Spectrum.

Research in Attitudes

There is a need to ascertain attitudes of stakeholders on a wider scale. Research on attitudes to sustainable development in civil aviation is required to include regulators in European Union and ICAO, civil aviation stakeholders in other countries, air transport consumers and the general public in UK. Attitudes to the environmental impacts of aviation are rapidly changing. Future research may be required to assess these changing attitudes over time.

Indicator Data

Three indicators are suggested for which data is not currently derived – UK social equity, surface access emissions, and community participation. There is a need for research to derive methodologies capable of producing data on a routine basis to enable continuing assessment of these indicators.

Explanation of Indicator results

The indicator of aviation contribution to GDP, measured as Gross Added Value (GVA) is populated by data from the UK National Accounts. The data indicates that Civil Aviation contribution to GDP is increasing in absolute terms, but reducing as a proportion of total National GDP. The ratios of GVA per passenger and GVA per tonne of aviation fuel show declining trends. These trends have not been examined in the research, though they may represent the financial impacts of the increase in low cost carriers. Further detailed research is required to fully explain these trends.

Assurance of Existing Sustainable Development Strategies

There currently exists a range of sustainable development strategies, at international, national, and industrial sector levels. In general, these strategies are not assessed against the Sustainability Spectrum. Sustainable development indicators proposed as part of these strategies are in general not subject to any quality assurance check against the sustainable development principles.

Further research is required to relate sustainable development strategies to the Sustainability Spectrum, and to develop a quality assurance check for sustainable development indicators.

Kerosene supplies

There is a suggestion that, as production of conventional oil declines and projected demand for aviation fuel expands, there may be a physical shortage of aviation fuel. Further research is required on potential scenarios for oil supply and aviation growth to assess this prospect.

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Appendix 1 – Rio Declaration

REPORT OF THE UNITED NATIONS CONFERENCE ON
ENVIRONMENT AND DEVELOPMENT*

(Rio de Janeiro, 3-14 June 1992)

Annex I

RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT

The United Nations Conference on Environment and Development,

Having met at Rio de Janeiro from 3 to 14 June 1992,

Reaffirming the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972, a/ and seeking to build upon it,

With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people, Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system,

Recognizing the integral and interdependent nature of the Earth, our home,

Proclaims that:

Principle 1

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Appendix 1 – Rio Declaration (cont)

Principle 6

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

Principle 7

States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 8

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

Principle 9

States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10

Environmental issues are best handled with participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 11

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and development context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

Appendix 1 – Rio Declaration (cont)

Principle 12

States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Appendix 1 – Rio Declaration

Principle 13

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14

States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Principle 16

National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Principle 18

States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

Appendix 1 – Rio Declaration (cont)

Principle 19

States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

Principle 20

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

Principle 21

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

Principle 22

Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

Principle 23

The environment and natural resources of people under oppression, domination and occupation shall be protected.

Principle 24

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

Principle 25

Peace, development and environmental protection are interdependent and indivisible.

Principle 26

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27

States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

Appendix 2 – Agenda 21 Chapter Headings

Chapter
1. Preamble
SECTION I. SOCIAL AND ECONOMIC DIMENSIONS
2. International cooperation to accelerate sustainable development in developing countries and related domestic policies
3. Combating Poverty
4. Changing consumption patterns
5. Demographic dynamics and sustainability
6. Protecting and promoting human health conditions
7. Promoting sustainable human settlement development
8. Integrating environment and development in decision making
SECTION II. CONSERVATION AND MANAGEMENT OF RESOURCES FOR DEVELOPMENT
9. Protecting the atmosphere
10. Integrated approach to the planning and management of land resources
11. Combating Deforestation
12. Managing fragile ecosystems: combating desertification and drought
13. Managing fragile ecosystems: sustainable mountain development
14. Promoting sustainable agriculture and rural development
15. Conservation of biological diversity
16. Environmentally sound management of biotechnology
17. Protection of the oceans, all kinds of seas…..
18. Protection of the quality and supply of freshwater resources
19. Environmentally sound management of toxic chemicals
20. Environmentally sound management of hazardous wastes
21. Environmentally sound management of solid wastes and sewage-related issues
22. Safe and environmentally sound management of radioactive wastes
SECTION III. STRENGTHENING THE ROLE OF MAJOR GROUPS
23. Preamble
24. Global action for women towards sustainable and equitable development
25. Children and youth in sustainable development
26. Recognizing and strengthening the role of indigenous people in their communities
27. Strengthening the role of non-government organisations
28. Local authorities initiatives in support of Agenda 21
29. Strengthening the role of workers and their trade unions
30. Strengthening the role of business and industry
31. Scientific and technological community
32. Strengthening the role of farmers
SECTION IV. MEANS OF IMPLEMENTATION
33. Financial resources and mechanisms
34. Transfer of environmentally sound technology, cooperation and capacity building
35. Science for sustainable development
36. Promoting education, public awareness and training
37. National mechanisms and international cooperation for capacity building in developing countries
38. International institutional arrangements
39. International legal instruments and mechanisms
40. Information for decision making

Appendix 3 – Delphi Survey Round 1 Questionnaire

P M Grimley
Department of Civil and Building Engineering
Loughborough University
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p.m.grimley@lboro.ac.uk

Sustainable Aviation Survey

Your views on the meaning of sustainable aviation will be appreciated. Please note that all responses will be confidential.

Please complete this form electronically. You may use the cursor or tab key to work through the document. For multi-choice questions, please select only one option.

---

1. Issues Relevant to Sustainable Aviation

The following is a list of issues that may be relevant to sustainable development of the civil aviation industry.

Please indicate how important you think each of the following issues is to the sustainable development of civil aviation:	Level of importance				
	Very high	High	No view	Low	Not relevant
Aircraft fuel efficiency	☐	☐	☐	☐	☐
Civil aviation contribution to poverty reduction	☐	☐	☐	☐	☐
Airline passenger health (e.g. DVT)	☐	☐	☐	☐	☐
Aircrew health (e.g. cancer risk from radiation)	☐	☐	☐	☐	☐
Land for airport construction - loss of landscape, habitat and heritage	☐	☐	☐	☐	☐
Volume of air transport – total number of flights	☐	☐	☐	☐	☐
Varying levels of air transport use in different regions of the world	☐	☐	☐	☐	☐
Aircraft noise	☐	☐	☐	☐	☐
Airline passenger safety	☐	☐	☐	☐	☐
Disposal of redundant aircraft	☐	☐	☐	☐	☐
Emissions from surface transport to airports	☐	☐	☐	☐	☐
Local air pollution from airports	☐	☐	☐	☐	☐
Use of aviation fuel	☐	☐	☐	☐	☐
Waste material from airports (solid and liquid)	☐	☐	☐	☐	☐
Depletion of oil reserves	☐	☐	☐	☐	☐
Use of resources (energy; water) by airports	☐	☐	☐	☐	☐
Emissions from airport sites	☐	☐	☐	☐	☐
Employment at airports	☐	☐	☐	☐	☐
Spread of disease by air transport (e.g. SARS)	☐	☐	☐	☐	☐
Risk of aircraft accident to airport community	☐	☐	☐	☐	☐
Greenhouse gas emissions from aircraft	☐	☐	☐	☐	☐

Appendix 3 – Delphi Survey Round 1 Questionnaire (cont)

Are there any other issues that you believe are important for, or not relevant to, the sustainable development of civil aviation?	Level of importance Very high	 High	 No view	 Low	 Not relevant
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

Do you have any comments on any of the above issues?

---

2. Policy Actions toward Sustainable Development of Aviation

The following is a list of potential policy actions that could be adopted in support of sustainable development of aviation. Some are not the direct responsibility of the civil aviation industry, so please give your view of the **importance** of the policy**,** rather than the responsibility.

Please indicate how important you think each of the following policy actions is to the sustainable development of civil aviation:	Level of importance Very high	 High	 No view	 Low	 Not relevant
Public education on sustainability of air transport	☐	☐	☐	☐	☐
Environmental impact assessment for all civil aviation activities	☐	☐	☐	☐	☐
Improve efficiency of air traffic management	☐	☐	☐	☐	☐
Sponsorship of atmospheric research by civil aviation sector	☐	☐	☐	☐	☐
Development of renewable fuel for aviation	☐	☐	☐	☐	☐
Effective environmental legislation for civil aviation	☐	☐	☐	☐	☐
Payment of full external environmental costs by civil aviation	☐	☐	☐	☐	☐
National maximum noise levels for airports	☐	☐	☐	☐	☐
ICAO program for sustainable aviation	☐	☐	☐	☐	☐
Improve fuel efficiency of new aircraft	☐	☐	☐	☐	☐
Spreading benefits of aviation to socially deprived areas and unemployed people	☐	☐	☐	☐	☐
Accelerate the phase-out of old aircraft	☐	☐	☐	☐	☐
Community participation in airport environmental decisions	☐	☐	☐	☐	☐
Investment by civil aviation in carbon sinks (e.g. forests)	☐	☐	☐	☐	☐
UK sustainability strategy for civil aviation	☐	☐	☐	☐	☐
Integration of environment and development in civil aviation policy making	☐	☐	☐	☐	☐
Limitation of greenhouse gas emissions from civil aviation	☐	☐	☐	☐	☐

Appendix 3 – Delphi Survey Round 1 Questionnaire (cont)

Are there any other policy actions that you believe are important for, or are not relevant to, the sustainable development of civil aviation?	Very high	High	No view	Low	Not relevant
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

(Level of importance)

In your opinion, which are the most important policy actions needed to move towards sustainable aviation? Please rank up to five policy actions.

1st policy –
2nd policy –
3rd policy –
4th policy –
5th policy –

Why do you think these policy actions are the most important?

---

3. Specific Instruments for Change

There has been considerable debate about specific potential changes that may be applied to the civil aviation industry – either economic or legal instruments. Please indicate your level of support for the following potential economic and legal changes. Please add other changes that you consider relevant in the final section of the table.

Please indicate your level of support for the following potential instruments for change:	Strongly support	Support	No View	Oppose	Strongly oppose
VAT on air travel	☐	☐	☐	☐	☐
Noise charges on aircraft	☐	☐	☐	☐	☐
Aviation emissions trading	☐	☐	☐	☐	☐
Tax on aviation fuel	☐	☐	☐	☐	☐
Legal limits on aviation greenhouse gas emissions	☐	☐	☐	☐	☐
Dual till accounting at airports (avoiding cross-subsidy of retail and aeronautical activities)	☐	☐	☐	☐	☐
Legal compensation for air and noise pollution	☐	☐	☐	☐	☐
Legal limit on day and night noise levels at airports	☐	☐	☐	☐	☐
Runway slot auctions	☐	☐	☐	☐	☐
Legal restriction on the use of aviation fuel	☐	☐	☐	☐	☐

Are there any other potential instruments for change that you support or oppose?	Strongly support	Support	No View	Oppose	Strongly oppose
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

What are the reasons for your views on economic and legal instruments?

Appendix 3 – Delphi Survey Round 1 Questionnaire (cont)

4. Vision of Sustainable Aviation

A vision of sustainable aviation may cover a single aspect of the future development of civil aviation, or may include several aspects.

Do you have a personal vision of any aspect of sustainable aviation in the UK? Please select

In your vision of sustainable aviation, how should the following aspects change compared with current levels in the UK?	Increase	Stay the same	Reduce	No view
Number of flights	☐	☐	☐	☐
Greenhouse gas emissions from aircraft	☐	☐	☐	☐
People affected by daytime aircraft noise	☐	☐	☐	☐
People affected by aircraft noise at night (23.00-07.00)	☐	☐	☐	☐
Employment benefits of airports	☐	☐	☐	☐
What other aspects are included in your vision of sustainable aviation?				
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐

Do you have any quantified targets, goals or limits for any future aspect of civil aviation? Please Select

If yes, would you please define these targets?
Note – Your targets should be quantified and may be expressed as absolute or relative levels, growth rates or a desired standard. Targets may apply to a company, airport, or to the UK as a whole. If possible, please include the timescale of your targets.

What aspect does the target apply to?	What is the value of the target?
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐

Why do you believe that your vision and goals are appropriate?
☐

5. Major Factors Influencing your Views

Your views on sustainable aviation may be influenced by many different factors that can be difficult to reconcile. Some of these factors are arranged on scales below. Please locate your position on each of the scales by selecting the appropriate box.

My views are more influenced by ---	2	1	0	1	2	**My views are more influenced by ---**
Employment benefits	☐	☐	☐	☐	☐	Airport/airline profitability
Employment benefits	☐	☐	☐	☐	☐	Climate change
Employment benefits	☐	☐	☐	☐	☐	Aircraft Noise
Airport/airline profitability	☐	☐	☐	☐	☐	Climate Change
Airport/airline profitability	☐	☐	☐	☐	☐	Aircraft Noise
Climate change	☐	☐	☐	☐	☐	Aircraft Noise

Are there any other major factors that influence your vision of sustainable aviation?

☐

6. General

Your name ☐

Organisation ☐

Position in organisation ☐

If you are prepared to take part in a follow up telephone interview, please provide a contact telephone number - ☐

Would you like to receive a summary of the results of this survey? Please Select

Would you be prepared to take part in a follow up survey on sustainable development indicators for civil aviation? Please Select

Does your organisation have policies covering sustainable development or a vision of sustainable aviation? Please Select

If so, will you please provide the Website reference(s) – or send a copy by email to p.m.grimley@lboro.ac.uk or hardcopy to the address in the document heading. ☐

Are there any other comments you would like to make on any aspect of this survey?

☐

Thank you for completing this survey

Please save the completed questionnaire and send a copy as an e-mail attachment to ---
p.m.grimley@lboro.ac.uk

Appendix 4 – Delphi Round 1 Generic Letters

Appendix 4 contents

Round 1 Cover Letter – Sample

Dear XXXX

Thank you for agreeing to take part in the Sustainable Aviation survey when we spoke at XXXX on XXXX. The questionnaire form is attached. If possible a response by (+14 Days) would be very much appreciated.

Loughborough University is currently undertaking research into the views of key civil aviation stakeholders on sustainable aviation in aviation. The aim of the research is to provide an insight into the understanding of sustainable aviation and from this to derive a set of proposed sustainable development indicators for airports. A wide range of aviation stakeholders is taking part in the survey, including people in airlines, airports, community and environment groups and government bodies.

We would be very grateful if you would take the time to complete this important survey. We are interested in your personal views. The survey does not ask for any business confidential information or technical detail, but seeks to establish personal attitudes to sustainable aviation. The contents of the questionnaire will be kept confidential and information identifying the respondent will not be disclosed. We would be pleased to forward to you a summary of the results of the survey in due course.

The form is designed to be completed and returned electronically. Please save a copy of the attached questionnaire, complete the form and return as an email attachment to p.m.grimley@lboro.ac.uk. Should you prefer, the questionnaire may be printed, completed and returned by post to the address below. If you take this option, then please respond 'Yes' or 'No' to the drop-down boxes marked 'Please select' and you may need to use a separate sheet for the free format responses.

Thank you for your time in responding to the survey.

Yours sincerely

Paul Grimley

Mr P M Grimley
Department of Civil and Building Engineering
Loughborough University
Leicestershire
LE11 3TU
Tel: 01509 263171 ext XXXX
Mobile XXXX

Appendix 4 Round 1 Chase Letter 1 – Sample

Dear XXXX
Some time ago you agreed to complete a short questionnaire on Sustainable Aviation, but I don't yet seem to have received a reply. Could I ask you when you will be able to complete the form please? A response in the next week would be very much appreciated - could I suggest by Monday October 4 if possible. For your convenience, I attach a further copy of the questionnaire to this note.

Thank you very much for your time and assistance.

Regards

Paul Grimley
Mr P M Grimley
Department of Civil and Building Engineering
Loughborough University
Leicestershire
LE11 3TU

Tel: 01509 263171 ext 4682
Mob: XXXX

Round 1 Chase Letter 2 – Sample

Dear XXXX
May I apologise for raising this matter again - some time ago you agreed to complete a short questionnaire on Sustainable Aviation, but I've not yet received a response.

It would be extremely valuable to have your input to the survey, and I look forward to receiving your completed questionnaire. Effectively though, input to the survey will need to close by the end of October. Could I therefore ask whether you could return a completed questionnaire by the end of the month? If it is not possible for you to make a return by this date, then perhaps you could let me know and I will be able to adjust my records.

For your convenience, I attach a further copy of the questionnaire to this note.

Thank you very much for your time and assistance.

Regards

Paul Grimley

Mr P M Grimley
Department of Civil and Building Engineering
Loughborough University
Leicestershire
LE11 3TU

Tel: 01509 263171 ext XXXX
Mob: XXXX

Appendix 4 Round 1 Summary Cover Letter – Sample

Dear XXXX

Last year, you took part in a survey from Loughborough University on the understanding of sustainable aviation; may I thank you again for completing the questionnaire. The survey received a very good response from a wide range of civil aviation stakeholders. As agreed, I now attach a summary of the findings.

When you completed the last survey, you kindly agreed to take part in a second survey on sustainable development indicators for civil aviation. This follow-up survey is almost ready, and I expect to be able to send you the questionnaire in the next few days.

If you would like any further information on any aspect of this research, please contact me.

Yours sincerely

Paul Grimley

Mr P M Grimley
Department of Civil and Building Engineering
Loughborough University
Leicestershire
LE11 3TU

Tel: 01509 263171 ext XXXX
Mob: XXXXX

Appendix 4 Round 1 Summary Report

Loughborough University

Sustainable Aviation Survey – October 2004

Summary Report of Findings

1 Introduction

A survey of stakeholder views on important factors for sustainable aviation took place in September/October 2004 as part of a PhD research project on Sustainable Development Indicators for Airports. This report provides a summary of the survey findings.

75 respondents took part in the survey, from the following groups of organisations:

Operators – Airports, Airlines, Air Traffic Management, Trade Unions
Suppliers – Airframe, Engine, Fuel
Users – Air transport user organisations
Regulators – National Government, Local Government, Parliamentarians
Those Affected – Environmental Groups, Residents' Groups

Respondents were asked to give personal views; the survey findings do not necessarily represent organisational policy. In this report any reference to a stakeholder group (e.g. airlines) means 'respondents from airlines'. Replies from user, trade union and air transport management organisations were few in number, and findings from these groups are not normally presented separately.

2 Management Summary

Few respondents had any clear vision of, or quantified targets for, sustainable aviation (section 2). There was widespread agreement between respondents from the different stakeholder groups on the most important issues facing sustainable aviation (section 3).

There was divergence of view between the stakeholder groups on the important policies to move toward sustainable aviation (section 4); respondents from operators and suppliers tended to favour internal efficiency and voluntary policies; respondents from regulators and those affected gave more importance to policies involving external regulation or limitations.

Differences were more marked on the levels of support for potential legal and economic instruments. Respondents from airlines supported only emissions trading and opposed other instruments. Other stakeholder groups showed progressively stronger support; respondents from airports and suppliers supported several instruments; regulators and those affected supported most or all of the instruments.

Appendix 4 Round 1 Summary Report (Cont)

3 Visions and Targets

Vision – 35% of respondents said they had a vision of sustainable aviation. 65% said they had no vision, or did not respond.

Respondents were asked how they saw aspects of civil aviation in the UK changing in future. Overall, the most popular response pattern was that the number of flights and airport employment should increase, whilst at the same time greenhouse gas emissions, day noise and night noise should reduce. There were significantly differing emphases between stakeholder groups.

There was very strong expectation of increases in flight numbers amongst respondents from operators and suppliers, whilst regulators and those affected were much less inclined to support increase in flights.

On daytime noise, operators were equivocal – evenly balanced between noise staying the same and reducing.

On night time noise, no respondents expected increases; there was widespread expectation of reductions across all stakeholder groups, though a majority of respondents from airlines expected night noise to stay the same.

Targets – 26% of respondents said they had targets for sustainable aviation and 16% of respondents mentioned quantified targets. A wide range of different targets was suggested; the most frequently mentioned specific targets were World Health Organisation guidelines on community noise, and EU limits on air quality.

4 Issues

Respondents were asked to give their view of the importance of a range of issues. Responses were given a score of 1→ 5 (very unimportant → very important). Thus an average of 3 represented a neutral view, 4 important, 5 very important.

For the survey as a whole, the following issues were given an average response of greater than 4, i.e. important to very important. The issues are in rank order.

1	Aircraft greenhouse gas emissions
2	Aircraft fuel efficiency
3	Use of aviation fuel
4	Emissions from surface transport to airports
5	Local air pollution
6	Number of flights
7	Aircraft noise
8	Land Use

There was a high level of consistency in these priorities across the major stakeholder groups (operators, regulators, suppliers and those affected). The same eight issues were included as the highest priorities by respondents from each stakeholder group – though there were slightly different rankings. Suppliers gave a somewhat lower priority to ‘Surface transport emissions’, and operators slightly lower priority to ‘Number of flights’.

Appendix 4 Round 1 Summary Report (Cont)

Health related issues were generally given low priorities (with the exception of Local air pollution and Aircraft noise), as were waste disposal issues. The lowest priority overall was given to 'Poverty reduction'.

Respondents from user and trade union groups showed some variation from the general pattern: Users gave 'Passenger safety' as most important issue, and tended give lower importance to local airport issues (noise, air pollution, land use); Trade union respondents gave 'A/c fuel efficiency' and 'Aircrew health' as most important.

5 Policies

Respondents were asked to give their view of the importance of a range of policies. Responses were given a score of 1→ 5 (very unimportant → very important). Thus an average of 3 represented a neutral view, 4 important, 5 very important.

For the survey as a whole, the following policies were given an average response of greater than 4, i.e. important to very important. The policies are in rank order.

1	Improve fuel efficiency of new aircraft
2	Effective Environmental Legislation
3	Integration at Policy level
4	Limit on greenhouse gas emissions
5	EIA For all CA activities
6	UK CASS
7	Pay full external environmental costs
8	Community participation

Over 90% of respondents agreed that 'Improve fuel efficiency of new aircraft' was important or very important, making this the highest average score. However, for other policies, there was a wide divergence of views between different stakeholder groups. Policies with an average response of greater than 4 (important to very important) are shown below in rank order for the major stakeholder groups:-

Operators

1 Improve fuel efficiency of new aircraft
2 Improve efficiency ATM
3 Renewable fuel
4 EIA for all CA activities
5 UK CASS
6 Integration at policy level
7 Public education

Suppliers

1 Improve fuel efficiency of new aircraft
2 Improve efficiency ATM
3 Effective environmental legislation
4 Integration at policy level
5 EIA for all CA activities
6 National noise levels

Regulators

1 Effective environmental legislation
2 Improve fuel efficiency of new aircraft
3 Pay full external environmental costs
4 Limit on greenhouse gas emissions
5 Integration at policy level
6 UK CASS
7 EIA for all CA activities
8 Community participation

Those affected

1 Limit on Greenhouse Gas emissions
2 Pay full external environmental costs
3 Effective environmental legislation
4 Integration at policy level
5 EIA for all Civil Aviation activities
6 Improve fuel efficiency of new aircraft
7 National noise levels
8 Community participation
9 UK CASS
10 Public education
11 Renewable fuel

Appendix 4 Round 1 Summary Report (Cont)

Respondents from operators and suppliers gave highest priority to internal system efficiencies (aircraft fuel consumption and ATM efficiency), and gave relatively lower priority to policies which may apply external constraints. On the other hand, respondents from regulators and those affected tended to give greatest importance to policies which would lead to external limits – either legislative (environmental legislation, limit on greenhouse gas emissions) or economic (payment of environmental costs).

In general, respondents from operators and suppliers assigned lower levels of importance to the policies than did regulators and those affected.

6 Specific Instruments

Respondents were asked their level of support for a range of possible economic and legislative instruments. There were wide differences in support for the instruments between and within stakeholder groups.

Airlines – Respondents from airlines reported moderate support for Emissions trading and varying levels of opposition to all other instruments.

Airports and Suppliers – Respondents showed strong support for Emissions trading, and support Noise charges, Legal noise limit, moderate support for Compensation for air/noise pollution, and varying levels of opposition to the other instruments.

Regulators – Overall, respondents showed strong support for Legal limit on greenhouse gas emissions, Legal noise limit, Noise charges, Emissions trading. There was moderate support for all other instruments except 'Legal restriction on the use of aviation fuel'. For respondents from Local Authorities, the highest priority was Noise limits and for MPs highest priority was Noise charges, whereas respondents from the National regulators subgroup placed these noise related policies below Emissions trading and Limit on greenhouse gas emissions.

Those Affected – Environmental and Local Community – There was very strong support for Legal limit on greenhouse gas emissions, Tax on aviation fuel, VAT; there was strong support for all other instruments, except Emissions trading which received moderate support.

In general, respondents from operators and suppliers expressed lower levels of support for legal and economic instruments than did regulators and those affected.

7 Next Steps

We would like to thank everyone who took part in this survey.

The findings from this survey will be used as a basis for a follow-up survey on potential sustainable development indicators for airports.

P M Grimley, Department of Civil and Building Engineering, Loughborough University
p.m.grimley@lboro.ac.uk

Appendix 5 – Delphi Survey Round 2 Questionnaire

Loughborough University

Sustainable Development Indicators for Civil Aviation

Your views on sustainable development indicators for civil aviation are important to this research. All responses will be confidential.

Please complete this form electronically using the tab key or cursor to work through the document. For multiple choice questions, please select only one option.

1. Identification

Your name ☐

Would you like to receive a summary of the results of this survey? Y/N

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2. Purpose of sustainable development indicators

This section explores the purpose of sustainable development indicators for civil aviation. Please indicate how strongly you agree or disagree with each statement.

Sustainable development indicators for civil aviation should be designed to:	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Inform the decisions of national government policy makers	☐	☐	☐	☐	☐
Inform the decisions of local government policy makers	☐	☐	☐	☐	☐
Inform the decisions of airline & airport managers	☐	☐	☐	☐	☐
Inform the decisions of air transport consumers – freight users and passengers	☐	☐	☐	☐	☐
Provide public information	☐	☐	☐	☐	☐
Other purposes – please specify ☐					

Sustainable development indicators for civil aviation should provide information about:	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Social and economic aspects	☐	☐	☐	☐	☐
Environmental aspects	☐	☐	☐	☐	☐
Public participation	☐	☐	☐	☐	☐
Regulatory arrangements	☐	☐	☐	☐	☐
Effect of programmes for change	☐	☐	☐	☐	☐
Progress towards agreed targets	☐	☐	☐	☐	☐
Other aspects – please specify ☐					

Appendix 5 – Delphi Survey Round 2 Questionnaire

3. What Indicators should be used?

The following are possible indicators of sustainable development in civil aviation. For each indicator please show whether you think -

- the indicator is needed
- the indicator is suitable to give the information required

3.1 Consumption and efficiency of air transport

These indicators are based on existing published measures. They may be derived at varying levels - airport site, airline, country.
Work load unit (WLU) is equivalent to 100kgs freight or 1 passenger. It may be used as a single unit to measure both freight and passenger transport.
GHG – greenhouse gas emissions.

Are the following sustainable development indicators –	Needed	Suitable
Number of flights performed	Y/N	Y/N
Passenger-kilometres & freight tonne-kms performed	Y/N	Y/N
WLU-kms performed	Y/N	Y/N
Aviation fuel used	Y/N	Y/N
GHG emissions from civil aircraft	Y/N	Y/N
Aircraft fleet efficiency – fuel used/WLU-km performed	Y/N	Y/N
Aircraft fleet efficiency – GHG emissions/WLU-km performed	Y/N	Y/N

Do you have any comments on the above indicators?
Would you like to suggest other indicators?

3.2 Local airport impacts

These indicators normally apply to an individual airport; some may be accumulated for groups of airports. Methodologies and standards for air quality, noise maps and population noise exposure are assumed to be from existing EU Directives.

Are the following sustainable development indicators –	Needed	Suitable
GHG emissions from surface access vehicles	Y/N	Y/N
Number of days air quality standards exceeded	Y/N	Y/N
Noise maps/noise contours	Y/N	Y/N
Population exposed to aircraft noise	Y/N	Y/N

Do you have any comments on the above indicators?
Would you like to suggest other indicators?

Appendix 5 – Delphi Survey Round 2 Questionnaire

Loughborough University

3. What Indicators should be used? (continued)

3.3 Economic aspects
Local economic benefits are measured as value, rather than number, of airport jobs. Energy ratio is the energy consumption to produce each unit of economic value i.e. gross energy consumption/economic worth. This may be calculated for local benefits and GDP – gross domestic product.

Are the following sustainable development indicators –	Needed	Suitable
Local economic benefits - value of airport jobs	Y/N	Y/N
Energy ratio of local economic benefits	Y/N	Y/N
Positive contribution to GDP	Y/N	Y/N
Negative contribution to GDP	Y/N	Y/N
Energy ratio of contribution to GDP	Y/N	Y/N

Do you have any comments on the above indicators?
Would you like to suggest other indicators?

3.4 Current programmes (ACARE, Emissions Trading, UK CASS)
ACARE (Advisory Council for Aeronautics Research in Europe) has established targets to reduce fuel burn, NOx emissions and perceived noise from new aircraft.

There is support from the UK Government and industry bodies for including civil aviation in a European Emissions Trading scheme (EETS).

Air Travel – Greener by Design is overseeing a project to agree a UK Commercial Aviation Sustainability Strategy (UK CASS). Should the UK CASS be agreed, further indicators to measure the effectiveness may be needed.

Are the following sustainable development indicators –	Needed	Suitable
Performance of new aircraft compared with ACARE targets	Y/N	Y/N
Progress towards including civil aviation in emissions trading scheme (EETS)	Y/N	Y/N
Should aviation be included in EETS: –		
Total emissions within scheme - before and during EETS	Y/N	Y/N
Aviation emissions before and during EETS	Y/N	Y/N

Do you have any comments on the above indicators?
Would you like to suggest other indicators?

Appendix 5 – Delphi Survey Round 2 Questionnaire

Loughborough University

3. What Indicators should be used? (continued)

3.5 Institutional and legislative arrangements for civil aviation
For some of these indicators, there is no currently known assessment criteria or measurement scale, e.g. extent of EIA or degree of integration. For these, it may be necessary to develop an appropriate measurement scale.
These indicators generally apply at a national or international level.

Are the following sustainable development indicators –	Needed	Suitable
Extent to which environmental legislation is applied to civil aviation activities	Y/N	Y/N
Extent to which environmental impact assessment is applied to civil aviation activities	Y/N	Y/N
Proportion of external environmental costs paid by civil aviation in environmental taxes	Y/N	Y/N
Degree of integration of environment & development in aviation policy making	Y/N	Y/N
Degree of community participation in aviation environmental decisions	Y/N	Y/N
Progress toward environmental product information for air transport consumers e.g. adverts, websites, tickets	Y/N	Y/N

Do you have any comments on the above indicators?
Would you like to suggest other indicators?

3.6 Other Aspects

Would you like to suggest potential sustainable development indicators for –
Improving efficiency of Air Traffic Management –
Social benefits of Aviation –
Airport Land Use –

Would you like to make any further comment on this survey? –

Thank you for completing this survey

Please save the completed questionnaire and send a copy as an e-mail attachment to ---
p.m.grimley@lboro.ac.uk

Appendix 6 – Delphi Round 2 Generic Letters

Appendix 6 contents

Round 2 Cover Letter – Sample

Dear XXX

In September /October last year you kindly completed the survey on sustainable aviation, and at that time agreed to take part in a follow-up survey on sustainable development indicators for civil aviation. I now attach the followup questionnaire. It would be most helpful if you could complete and return this by (+14 days).

The first survey showed the factors of civil aviation which stakeholders considered most important for sustainable development and a summary of the results has already been sent to you. This questionnaire takes those important factors and seeks views on whether they should be measured, and if so how. This questionnaire does not suggest any specific targets for sustainable aviation, nor advocate any particular policies; rather it explores how stakeholders think progress towards sustainable development in aviation may be assessed.

We would be very grateful if you would take the time to complete this important survey. We are interested in your personal views. The survey does not ask for any business confidential information or technical detail, but seeks to establish personal attitudes on the suitability of indicators.

The contents of the questionnaire will be kept confidential and information identifying the respondent will not be disclosed. We would be pleased to forward to you a summary of the results of the survey in due course.

The form is designed to be completed and returned electronically. Please save a copy of the attached questionnaire, complete the form and return as an email attachment to p.m.grimley@lboro.ac.uk. Should you prefer, the questionnaire may be printed, completed and returned by post to the address below. If you take this option, then please respond 'Yes' or 'No' to the drop-down boxes marked 'Please select' and you may need to use a separate sheet for the free format responses.

Thank you for your time in responding to the survey.

Yours sincerely

Paul Grimley

Mr P M Grimley
Department of Civil and Building Engineering
Loughborough University
Leicestershire
LE11 3TU

Appendix 6 Round 2 Chase Letter 1 – Sample

Dear XXX
Recently I sent you a short questionnaire on Sustainability Indicators for Aviation, which you had previously agreed to complete, but I don't yet seem to have received a reply. It would of course be extremely valuable to receive your input to this survey, and I do hope that you will be able to complete the questionnaire.

If possible a response by the end of next week - by Friday 4th March – would be very much appreciated. For your convenience, I attach a copy further of the questionnaire to this note.

Thank you very much for your time and assistance. I look forward to receiving your completed questionnaire.
Regards
Paul Grimley

Mr P M Grimley
Department of Civil and Building Engineering
Loughborough University
Leicestershire LE11 3TU

Tel: 01509 263171 ext xxx Mob: xxxx

Round 2 Chase Letter 2 – Sample

Dear XXXX

May I apologise for raising this matter again - some time ago I sent you a short questionnaire on Sustainable Development Indicators for Civil Aviation, which you had previously agreed to complete, but I have not yet received a response.

It would be extremely valuable to have your input to the survey and I would very much appreciate receiving your completed questionnaire. A summary of the survey findings will be available to respondents. I will need to close the survey during March, so if possible a response by Monday 21st March would be very much appreciated.

If however you feel unable to complete the survey, then perhaps you could let me know this, and I will be able to adjust my records.

For your convenience, I attach a copy further of the questionnaire to this note. I look forward to receiving a completed questionnaire.

Thank you very much for your time and assistance.
Regards
Paul Grimley

Mr P M Grimley

Department of Civil and Building Engineering
Loughborough University
Leicestershire LE11 3TU
Tel: 01509 263171 ext XXXX Mob: XXX

Appendix 6 Round 2 Summary Cover Letter – Sample

In March this year you took part in a Loughborough University survey on sustainable development indicators for civil aviation - part of the research work on my PhD project. May I thank you again for completing the questionnaire and apologise for the time taken to circulate the summary report - other aspects of the research conspired to delay the analysis work.

The survey responses will form part of the input to the research thesis, and I now attach a short summary of these responses. There is no intention to produce any other papers prior to submission of the thesis - planned for early 2006.

However, if you would like any further details of the work, or wish to make any other contribution to the research, then please contact me at the University Email address - p.m.grimley@lboro.ac.uk

Thank you very much for your contribution to this research.

Paul Grimley

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Appendix 6 Round 2 Summary Report

Loughborough University

Sustainable Development Indicators for Civil Aviation

Survey – March 2005

Summary Report of Findings

1 Introduction

As part of a PhD research project on Sustainable Development Indicators for Airports two surveys of stakeholder views have been carried out. The first survey, on the important factors for sustainable aviation, took place in September/October 2004. A report was issued to the 75 respondents who took part in this survey on 27th January 2005. Of these respondents, 55 agreed to take part in the second survey.

The most important issues and actions identified by respondents to the first survey were used to derive potential indicators. A second survey took place in March 2005, asking for views on the need for, and suitability of these indicators.

43 respondents replied to the second survey from the following groups of organisations:

Operators – Airports, Airlines, Trade Unions
Suppliers
Users – Air transport user organisations
Regulators – National Government, Local Government, Parliamentarians
Those Affected – Environmental Groups, Residents' Groups

Respondents were asked to give personal views; the survey findings do not necessarily represent organisational policy. In this report any reference to a stakeholder group (e.g. operators) means 'respondents from operators'. Analysis is based on the major groups – Operators, Regulators and Those affected.

2 Management Summary

Overall there was general agreement that the suggested indicators are needed. The most strongly supported indicators are related to greenhouse gas emissions or aircraft noise; an indicator of Aircraft Greenhouse Gas Emissions received the highest support of the indicators in the questionnaire (93%).

There was strong support for indicators of the local airport impacts (Noise/ People affected by noise, Surface Transport Emissions and Air Quality). Views on economic indicators were mixed, with little support for indicators based on the energy ratio i.e. the energy cost of economic benefits.

There was a mixed, though generally lower level of support for indicators suggested to assess institutional arrangements. There seems to be reluctance to assess some institutional aspects and a feeling that it is very difficult to measure certain aspects e.g. public participation, integration of environment and development.

Additional indicators were suggested based on airport waste arisings, water quality and site emissions.

3 Purpose of Sustainable Development Indicators

Purpose – Respondents were asked how strongly they agreed with a range of purposes for sustainable development indicators – to inform the decisions of National Government, Local Government, Airline/Airport Managers, Consumers, and to provide public information.

The responses were assigned a score of 1→ 5 (strongly disagree→strongly agree) and the agreement level was calculated from the average score. The agreement level for each purpose may be taken as an indication of the importance attached to the decision makers specified in the questions.

Respondents tended to largely agree with the suggested purposes for sustainable development indicators, giving high average scores for all the purposes.

For the survey as a whole, there is very strong agreement that indicators should be designed to inform the decisions of National Government (4.7) and of Airline/Airport Managers (4.5), showing that these decision makers are regarded as most important in sustainable development issues. There is support for the other purposes (Inform local authorities, Provide public information and Inform consumers), though at a more moderate level.

There is some variation on the importance given to 'Inform Decisions of Local Authorities'; Respondents from airlines give this their lowest rank with an average score of 3.8; respondents from National Regulators also place this lowest with a score of 3.9. By contrast respondent from local regulators place this purpose second in the rankings with a score of 4.5.

There is clearly some difference in views of how important local authority decision makers are to sustainable development; respondents from airports and national regulators suggest lowest importance; local regulators placing much higher importance on their own decisions.

A number of respondents suggested that indicators should inform the decisions of a range of international bodies (EU and others). No respondents specifically mentioned ICAO (International Civil Aviation Organization).

Types of Information – Respondents were asked how strongly they agreed that a range of information types should b e provided by sustainable development indicators – Social and economic aspects, Environmental aspects, Public participation, Regulatory arrangements, Effect of programmes for change, Progress towards agreed targets.

The responses were assigned a score of 1→ 5 (strongly disagree→strongly agree) and the agreement level was calculated from the average score. The average scores may be taken as an indication of the relative importance attached to the different types of information by respondents.

The responses are dominated by a strong emphasis on the need for Environmental information (4.8). Information about Targets, Social & Economic, Programmes for

Change receive moderate support. Least supported are information types about Regulatory Arrangements and Public Participation. These receive average scores of 3.9 and 3.6 respectively; a significant proportion of respondents do not agree that this type of information is needed.

4 Potential Indicators in Questionnaire

Respondents were asked to indicate whether they thought that a number of potential indicators were needed and suitable as sustainable development indicators.

Consumption and Efficiency of Air Transport

Aircraft GHG Emissions was the single most supported indicator with 93% of respondents saying the indicator is needed.

Where there were alternative indicators based on GHG emissions or fuel used, there is a clear preference towards the GHG based indicators; Aircraft GHG emissions receives more support than Fuel used, GHG efficiency is more strongly supported than Fuel efficiency.

The indicators measuring volume of performance i.e. Flights, Pass/Kms performed, are considered necessary by over 70%, but more than 20% of the respondents considered that they are not needed.

WLU (Work Load Unit) kms performed was suggested as an combined unit to measure both passenger and freight transport. 60% considered this is needed and 56% suitable. Respondents were uneasy about the use of this unit (WLU) because it may be confusing and is not well known outside the industry.

Local Airport Impacts

There is very high support for these indicators and little opposition. The indicators based on Noise maps and Population exposed are given different levels of support (86% and 79% respectively) though logically they are linked. A number of respondents from the operator and user groups do not support the Population based indicator. This may be indicative of slight reluctance to acknowledge the number of people affected by aircraft noise as a valid indicator.

Economic Aspects

There was considerable comment about the use of GDP as an indicator – some expressing support, some doubt. GDP Positive was supported by 81% of respondents and GDP Negative by 70%. Again, logically, both the positive and negative aspects should be counted. The difference derives from a number of respondents from the Operator and Supplier groups who did not support use of GDP negative. This may be indicative of a preference to measure positive aspects, with a slight reluctance to measure negative aspects.

There is little support for the use of energy ratios as indicators; GDP Energy Ratio received 37% support, and Jobs Energy Ratio 35%.

Change Programmes

There is strong support for indicator(s) to measure progress towards ACARE targets (86%), though some consider that an indicator of the number of aircraft in service achieving ACARE targets is preferable. An indicator of progress towards including aviation in Emissions Trading (EETS) was supported by 74% of respondents.

Appendix 6 Round 2 Summary Report (cont)

The indicator Aviation emissions under EETS is the same indicator as Aircraft GHG Emissions, tracked through the period of EETS.

Institutional Arrangements

Overall, this category of indicators received the lowest support for need and suitability.

Proportion of External Environmental Costs paid received 84% support; Extent of EIA (Environmental Impact Assessment) 77%; Progress towards Environmental Product Information 72%. Other suggested indicators (extent of Public Participation, Environmental Legislation and Integration of Environment and Development in Policy) received lower levels of support with a number of comments on the difficulty of measuring these.

It would seem that there is some reluctance to measure many institutional aspects and some doubt as to how these aspects can be measured.

5 Additional Indicators

Respondents were asked if they would like to suggest other indicators of sustainable development in addition to the indicator proposed in the questionnaire.

Additional indicators based on airport waste arisings, water quality and site GHG emissions were suggested. These issues were given relatively low priority in the first survey and had consequently been omitted from this questionnaire.

Suggested indicators for ATM (Air Traffic Management) tended to be based on the use of specific procedures or techniques e.g. stacking, taxiing, continuous descent approach.

Indicators suggested for social benefits tended to be based upon some form of socio/economic analysis of passengers.

Suggested indicators for airport land use tended to be based on the area of land, or some measure of effectiveness of land use e.g. passenger throughput/area or car park area/passenger throughput. There were no references to the use of remote locations e.g. off-airport car parks.

6 Next Steps

We would like to thank everyone who took part in this survey.
The results of this survey will become part of the research information for the PhD thesis. There is no intention to issue further papers prior to the completion of the PhD.

If you would like further information on this project or associated work please contact:
P M Grimley,
Department of Civil and Building Engineering,
Loughborough University,
LE11 3TU
p.m.grimley@lboro.ac.uk

Appendix 7 – Indicator Characteristics

The following gives a sample of indicator characteristics suggested by authors.

United Nations (UN 2001). Indicators should be primarily national in scope;

- Relevant to assessing sustainable development progress
- Understandable, clear and unambiguous to the extent possible
- Within the capacities of national Governments to develop
- Conceptually sound
- Limited in number, but remaining open-ended and adaptable to future needs
- Broad in coverage of Agenda 21 and all aspects of sustainable development
- Representative of an international consensus, to the extent possible
- Dependent on cost effective data of known quality.

Harger and Meyer (Harger, Meyer 1996)

- The final indicators should be as simple as possible
- Scope: the indicators should cover the whole spectrum of human activities related to economy and environment but overlap amongst particular indicators should be as small as possible
- Quantification: the elements should be readily measurable
- Assessment: the elements should be capable of being monitored to establish performance trends
- Sensitivity: the chosen indicators should be sensitive enough to reflect important changes in environmental characteristics
- Timeliness: frequency and coverage of the elements should be sufficient to enable timely identification of the performance trends

Bellagio Principles (Hodge, Hardi 1997)

- Limited number of indicators or indicator combinations
- Standardizing measurement wherever possible to permit comparisons
- Comparing indicator values to targets, reference values, ranges, thresholds, or direction of trends as appropriate

Anderson (Anderson 1991)

- Information readily available
- Relatively easy to understand
- Measurable
- Measure something important
- Timely
- Capable of comparisons
- International comparability

Mitchell (Mitchell, May et al. 1995)

- Relevance and scientific validity
- Sensitivity to change across space or groups
- Sensitivity to change over time
- Consistency of data, comprehensible
- Appropriate data transformation
- Measurable data
- Possible target or threshold values

Spangenberg (Spangenberg, Pfahl et al. 2002)

- Independent
- Indicative
- General
- Robust
- Sensitive

Environmental Protection Agency (US EPA 1996)

- Focuses on results (i.e. outcomes, such as number of illnesses caused, not activities or outputs, such as tons emitted)
- Isolates transportation's share of the impact
- Provides a useful level of detail to the intended audience
- Is stated in comparable units (allowing comparison among impacts, modes, etc)
- Is in meaningful units (the quantity is compared to a standard or goal)
- Is reasonably certain

Smith (Smith 2002)

- Simple
- Widely credible
- Easily understood by policy makers and the public