



THE CONCEPT OF AIRPORT ENVIRONMENTAL CAPACITY

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Acronyms and Abbreviations

ACC	Area Control Centre
ACCA	Association Chartered Certified Accountants
ACI	Airports Council International
AEA	Association of European Airlines
AEF	Airports Environment Federation
ANCAT	Abatement of Nuisance Caused By Air Transport
ANSP	Air Navigation Service Provider
AOP	EUROCONTROL Airport Unit
APR	EUROCONTROL Airport Programme
ASMGCS	Aircraft Surface Movement Guidance and Control System
ATS	Air Traffic Service
ATC	Air Traffic Control Service
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
BOD	Biological Oxygen Demand
BSI	British Standards Institute
CAEP	Committee on Aviation and Environmental Protection (of ICAO)
CAMACA	Commonly Agreed Methodology for Airport Airside Capacity Assessment
CANSO	Civil Air Navigation Services Organisation
CASA	Computer Assisted Slot Allocation
CDA	Continuous Descent Approaches
CFMU	Central Flow Management Unit (European Airspace)
CIM	Capacity Indicator Model
CIP	Convergence and Implementation Programme
CNS	Communications, Navigation and Surveillance
CO	Carbon Monoxide
CO ₂	Carbon dioxide
CRCO	Central Route Charges Office
dB(A)	The decibel noise unit, weighted with an 'A' filter to account for human hearing characteristics
DEFRA	UK Department for Environment, Food and Rural Affairs
DETR	UK Department of Environment, Transport and the Regions (now DEFRA)

Dp/Foo	The ICAO regulatory parameter for gaseous emissions, expressed as the mass of pollutant emitted during the landing/take-off (LTO) cycle divided by the rated thrust (maximum take off power) of the engine.
DPS	Data Processing System
DTLR	UK Department for Transport, Local Government and the Regions
EATMP	European Air Traffic Management Programme
EEA	European Environment Agency
EC	European Commission
ECAC	European Civil Aviation Conference
ECS/T	Environmental Capacity Screen/Toolkit
EPI	Environmental Performance Indicator
EU	European Union
FDPS	Flight Data Processing System
FAP	Future ATM Profile
FUA	Flexible Use of Airspace
GHG	Greenhouse Gas
GMAT	Ground Movement Analysis Tool
GRI	Global Reporting Initiative
GWP	Global warming Potential
HCS	Hydrocarbons
IATA	International Air Transport Association
ICAO	UN International Civil Aviation Organization
IPAT	Integrated Performance Analysis Tool
IPCC	UN Intergovernmental Panel on Climate Change
ISO	International Standards Organisation
kwh/s-km	Kilowatt-hours per second-kilometre
<i>Leq</i>	Equivalent sound level (long term average noise exposure)
LTO	Landing Take Off
<i>Lmax</i>	Maximum (A-weighted) sound level
MPI	Management Performance Indicators
NGO	Non Governmental Organisation
NO _x	Nitrogen Oxides (the sum of NO+NO ₂)
NPR	Noise Preferential Route
NTK	Noise Track Keeping
O ₃	Ozone
OECD	Organisation for Economic Co-operation and Development

OPI	Operational Performance Indicators
PM10	Particulate matter with a mass median aerodynamic diameter of less than 10 micrometers
ppmv	Parts per Million by Volume
ppt	Parts per trillion
PRC	Performance Review Commission
PSZ	Public Safety Zone
PTK	Passenger Tonne Kilometre
RACE	Runway Capacity Enhancement
RAMS	Reorganized ATC Mathematical Simulator
RAMSAR	Wetlands of international importance
RNAV	Area Navigation
RPKs	Revenue Passenger Kilometres
RTKs	Revenue Tonne Kilometres
SCAN-UK	The UK Sustainable Cities and Aviation Network
SIDS	Standard Instrument Departures
SSSI	Site of Special Scientific Interest
SWOT	Strengths, Weaknesses, Opportunities and Threats analysis
STARS	Standard Arrival Routes
TACOT	Automated Command Tool
TERM	Transport and Environment Reporting Mechanism
TMA	Terminal Control Area
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	US Environmental Protection Agency
US GAO	United States General Audit Office
UV	Ultra-violet radiation
VOC	Volatile Organic Compound
WHO	World Health Organisation

1. INTRODUCTION

1.1. Context

1.1.1. EUROCONTROL is the European Organisation for the Safety of Air Navigation, with 31 Member States. EUROCONTROL has as its primary objective the development of a seamless, pan-European air traffic management (ATM) system. Since congestion and capacity constraints at major European airports threaten this primary objective, emerging policies affecting airport capacity are crucial concerns for EUROCONTROL.

1.1.2. October 2002 will see the accession of the European Commission as member of EUROCONTROL. In keeping with the Commission's policy objective relating to sustainable development it is likely that this will lead to a greater emphasis being placed on the environmental performance of the European ATM System.

1.1.3. The overall capacity of the European ATM system is to a significant extent determined by the capacity of its airports and en-route sectors. Environmental issues have the potential to constrain the operation and growth of airports and therefore the overall operational capacity of the system. Given EUROCONTROL's responsibilities for forecasting and assisting the capacity enhancement of the European ATM System, EUROCONTROL has a direct interest in the implications of environmental issues for operational capacity at airports.

1.1.4. EUROCONTROL has recognised that unless airport environmental capacity is effectively managed, environmental issues will form an increasingly significant constraint on European airport development and operation. Furthermore, constraints on airport capacity affect the capacity of the European air navigation system. It is evident that air traffic capacity is becoming constrained at major European airports by environmental factors, leading to the emergence of the concept of "environmental capacity". The European Commission has expressed the view that limited environmental capacity is a potential constraint on aviation growth (Coleman, 1999).

- 1.1.5. The management of air traffic in Europe is reliant on an ATM network, which can be disrupted by knock-on effects stemming from capacity constraints in any part of that network.
- 1.1.6. Environmental capacity constraints already exist at critical nodes of the European air transport network. These have arisen primarily as a result of local political pressure, manifested by the introduction of operational restrictions (e.g. at certain times of day, or on types of aircraft); operational limits; or other controls. A number of key airports across Europe therefore have more infrastructure and operational capacity than they are able to use.
- 1.1.7. It is evident that the estimation of the true capacity of airports, airport systems, or ATM networks must include estimation of environmental capacity alongside operational capacity models.
- 1.1.8. In addition to international regulatory limits that have capacity implications for airports, local response to community and political demand have resulted in the proliferation of a heterogeneous mix of solutions and compromises across European airports. Piecemeal controls on the capacity of individual airports, by the imposition of environmental controls and restrictions, combine to cause problems in forecasting and managing airspace capacity and for airlines in planning their operations.
- 1.1.9. The concept of environmental capacity as applied to aviation is in its infancy relative to other sectors including transport, housing and water supply and treatment. There is not yet a common currency of definition, understanding and estimation among the various aviation stakeholder groups. Furthermore, until recently, air traffic management organizations have not been fully involved at a strategic level in shaping emerging policy on aviation environmental capacity. As a consequence, EUROCONTROL commissioned the Centre for Aviation, Transport and the Environment (CATE), at the Manchester Metropolitan University, UK, to undertake a study into the concept of environmental capacity as it applies to the European ATM system with a specific focus being placed on airport, rather than *en route* environmental capacity issues.
- 1.1.10. The scope of the current research study was pan-European. The literature survey component searched European and additionally North American

academic texts. It is noteworthy that the UK featured prominently in the study, as the Sustainable Cities and Aviation Network (SCAN UK) group at Manchester have been leaders in investigating environmental capacity, and the UK Government has recently conducted a national consultation that includes specific reference to environmental capacity in aviation.

1.1.11. The stakeholder dialogue component involved input from more than 100 individuals from across Europe. It also involved convening and analyzing output from 5 focus groups held in Amsterdam, Athens, London, Manchester and Salzburg. This large body of data and information was augmented by responses to a questionnaire sent to 209 ACI Europe member airports and data provided by IATA and CANSO.

1.1.12 The study was divided into two phases and the terms of reference for the study as a whole are appended (Appendix A). Phase 1 was completed on February 28 2002, and an interim report submitted concomitantly. Phase 2 was completed on July 31 2002, and this final report supersedes the interim report.

1.2. Aim

1.2.1. The primary aim of this first environmental study for EUROCONTROL Airport Unit (AOP) was to investigate and clarify the concept of environmental capacity as it applies to the European ATM and specifically as it affects the growth and development of airports within that system. A secondary aim was to develop a conceptual model and toolkit, which could estimate and assist in the enhancement, securement and management of environmental capacity at airports. The study was designed to set the context and provide input into the EUROCONTROL P6 initiative.

1.3. Objectives

To achieve the above aims the following objectives were set:

- 1.3.1. Undertake a comprehensive review of literature and research studies currently underway within industry, government and academia relating to issues directly associated with the concept of environmental capacity.
- 1.3.2. Examine the different environmental issues that have the potential to constrain growth or operational capacity, how they are defined, measured, managed and reported.
- 1.3.3. Produce a series of definition terms and indicators relating to environmental capacity and test their applicability and acceptance within air transport sector.
- 1.3.4. Develop a conceptual model for calculating the environmental capacity of an airport or airport system given basic infrastructure, operational and geographic data relating to the sites and their related ATM system. In addition, the model should be suitable for interfacing with current EUROCONTROL tools such as the Commonly Agreed Methodology for Airport Airside Capacity Assessment (CAMACA) and the Ground Movement Analysis Tool (GMAT).
- 1.3.5. Develop a toolkit (best practice checklist for use by airports, airlines and air traffic services) designed to maximise and manage the environmental capacity of the air transport system and of an individual airport and its associated air traffic management area. This toolkit should be compliant with current work of APR/RACE on best practices.

2. METHODOLOGY

2.1. Introduction

2.1.1. Project delivery involved the adoption of a variety of different methods, all of which were developed and agreed in consultation with EUROCONTROL based on the original Terms of Reference (Appendix A). These methods were:

A literature and web review;

A detailed review of specialist studies;

Attendance at conferences, workshops and seminars during the study period;

A questionnaire survey of European airports;

Analysis of an existing questionnaire survey of European airlines;

Questions to Air Navigation Service Providers

Semi-structured interviews carried out with key stakeholders;

An airports/environment expert discussion group;

Convening and leading stakeholder focus groups;

The development of a conceptual model and toolkits; and

Research into aviation Environmental Performance Indicators (EPIs).

2.2. Literature and Web Review

2.2.1. A detailed literature review was undertaken in order to examine publications and reports relating primarily to the concept of environmental capacity as applied to aviation and other transport sectors.

2.2.2. Academic journals were reviewed, and appropriate conference review papers and workshop proceedings were examined. A number of airport and airline environmental and sustainability reports were reviewed, for reference to capacity issues, as well as approach to environmental management. An internet search was undertaken to supplement the conventional literature review.

2.3. Detailed Review of Specialist Studies

Three studies of particular relevance were examined in detail:

Environmental Capacity: The Challenge for the Aviation Industry. A workshop hosted by the Sustainable Cities and Aviation Network for the United Kingdom (SCAN-UK) and held on 7th June 2000;

The Sustainable Cities and Aviation Network for the UK (SCAN-UK) first International Conference on Environmental Capacity at Airports. Held at the Manchester Metropolitan University in April 2001; and

The responses received by the UK Government Department of Transport, Local Government and the Regions in response to their consultation document, *The Future of Aviation* (DLTR, 2000). These documents were inspected at DTLR library, London, November 27 2001.

2.4. Attendance at Conferences, Workshops and Seminars During the Study Period

2.4.1. The following conferences and workshops were attended during the study period. Conference documents were reviewed and informal interviews carried out with key participants and speakers.

Demand Analysis and Capacity Management – The Air Transport Issues; Transport Studies Group, University of Westminster, London, October 24 – 26 2001.

Seminar on Aviation and Noise; Institute for Public Policy Research (IPPR) November 20 2001.

Seminar on Paying for the Environmental Costs of Aviation; Institute for Public Policy Research (IPPR) January 10 2001.

3rd Annual Aviation and Environment Conference; Euromoney, IATA Conference Centre, Geneva, January 23/24 2002.

Airport Policy and Planning Conference; Transport Studies Group, University of Westminster, London, May 2002

10th Greening of Industry Conference; Gothenburg, Sweden, June 23rd – 26th 2002.

Final Boarding Call: Air Transport, Airports and Sustainable Development, Conference; T&E and UNEP, Paris, 1st – 2nd July 2002.

2.5. Questionnaire Survey of European Airports

- 2.5.1. A structured questionnaire was prepared by CATE to be sent to European airports, an important feature of design being to maximise the response rate by making it short and easily understandable. Arrangements were made by CATE for the European Regional Office of the Airports Council International (ACI EUROPE) to distribute the questionnaire by post and through e-mail to member airports. A set of questions (see Appendix B) was agreed through discussion with EUROCONTROL.
- 2.5.2. To further encourage participation, draft covering letters from both ACI-Europe and EUROCONTROL were prepared (Appendix B) to accompany the questionnaire. These were sent out via ACI EUROPE to ensure their active support and involvement at the highest level. The letters and questionnaires were sent out to ACI members in mid-May 2002 (see covering letters, Appendix B).

2.6. Analysis of a Questionnaire Survey of European Airlines

- 2.6.1. A study carried out by MMU/CATE for the International Air Transport Association (IATA) in 2001 involved the dispatch of a questionnaire on environmental reporting to 268 IATA members. With the permission of IATA, returned questionnaires from European airlines were re-examined in the present study. Three questions were re-examined, these are reproduced in Appendix C.

2.7. Questions to European Air Navigation Service Providers

- 2.7.1. In order to address the issue from an air traffic management at airports perspective, a series of questions were sent to the Civil Air Navigation Services Organisation (CANSO), together with an invitation from EUROCONTROL to dispatch the same questions to the CANSO membership.

2.8. Semi-Structured Interviews Carried Out With Key Policy Stakeholders

- 2.8.1. A list of interviewees representative of key stakeholders involved in the debate on environmental capacity from across Europe was drawn up and agreed with EUROCONTROL. A series of eight questions were developed in consultation with EUROCONTROL. These were designed to be flexible and open-ended and were, therefore, semi-structured.
- 2.8.2. Interviews were conducted either in person or by telephone, between November 2001 and June 2002. Prior to the formal part of the interview, a briefing was carried out, based on a one-page summary.
- 2.8.3. All interviews were recorded and transcribed and the transcriptions reviewed and summarised.
- 2.8.4. Transcripts were interpreted by CATE , and notes were compared to ensure all key points were captured.

2.9. Airports/Environment Expert Discussion Group

- 2.9.1. The ACI (Europe) Environmental Strategy Committee comprises 33 environmental experts employed at European Airports. Agreement was achieved for CATE to attend a meeting of that Committee in Brussels on 15 – 16 April 2002, to present a paper outlining the environmental capacity project. As part of the meeting, a questionnaire was circulated for completion and a discussion of environmental capacity issues at airports was facilitated by CATE.

2.10. Stakeholder Focus Groups

- 2.10.1. A series of five research Focus Groups was convened. The Focus Groups were conducted in London (11 December 2001, CAA), Manchester (21 December 2001, Manchester Airport), Amsterdam (March 6 2002, Schiphol Airport), Salzburg (May 8 2002, Salzburg Airport) and Athens (June 28 2002, Athens International Airport).

2.10.2. Unsuccessful attempts were also made to convene Focus Groups at Frankfurt and Paris. The five sites chosen reflected the following characteristics:

Airport/Airport Group	Study Site Characteristics
London (BAA airports)	Major hub and other airports serving South East England. Actively managing environmental capacity constraints.
Manchester	Regional airport, actively managing environmental capacity constraints.
Amsterdam-Schiphol	Major hub. Pro-active in recognising and managing environmental capacity constraints.
Salzburg	Small regional airport. Pro-active in recognising and managing environmental capacity constraints.
Athens	Major new airport in Southern Europe. Environmental capacity constraints pre-studied and accounted for.

2.10.3. The meetings were scheduled for approximately two hours, and were facilitated by CATE. At each city, the Group comprised representatives from the airport, key local airlines, and air traffic management services.

2.10.4. A series of four questions were devised by CATE in consultation with EUROCONTROL, together with a SWOT (strengths, weaknesses, opportunities, threats) analysis on two possible future policy scenarios (Appendix D).

2.10.5. Participants were asked to consider each question for five minutes, then to discuss each question with the Group for fifteen minutes, identifying agreement or conflict. By agreement, the focus groups' discussions were not audio-recorded; written notes were taken by CATE. The SWOT analysis (not performed at all groups due to lack of time) was facilitated by CATE, and results transcribed from flip chart sheets. To encourage participants to be more open, it was agreed that for final reporting of the study, there would be no attribution to an individual or organisation for any comment, statement or opinion. Outcomes are, therefore, simply attributed to "focus groups".

2.11. Development of a Conceptual Model and Toolkits

2.11.1. The Terms of Reference for the study included a requirement to develop a conceptual model to assist the estimation of the environmental capacity of an

airport/airport system, suitable for interface with two EUROCONTROL forecasting models: the Commonly Agreed Methodology for Airport Airside Capacity Assessment (CAMACA) and the Ground Movement Analysis Tool (GMAT).

2.11.2. A study visit was made to EUROCONTROL Brussels (18/19 June 2002) to discuss assumptions, structure, inputs and outputs and obtain working demonstrations of both GMAT and CAMACA. An assessment of both models was made in relation to their potential to interface with the environmental capacity model under development.

2.11.3. A series of toolkits, intended for use in the estimation, enhancement and management of airport environmental capacity, were developed for key environmental issues currently constraining airports in Europe.

2.12. Environmental Performance Indicators Relevant to Environmental Capacity at Airports

2.12.1. A literature survey, together with a review of relevant contemporary studies and interviews with experts working in the field (industry and academics) were carried out to assess the current status of development of environmental performance indicators (EPIs) for airports and airlines. Interviews with CANSO, and selected ATC organisations were also undertaken to ascertain the status of ATM EPIs and in particular at airports.

3 KEY OUTCOMES

3.1. General Literature Review

- 3.1.1. Environmental capacity and related phrases are common currency in many areas of environmental policy development. **Environmental carrying capacity** is an ecological term, referring to the number of individuals of a given species that an ecosystem can sustain (Kidd, 1992). The carrying capacity of the Earth in context of human population growth statistics and industrialisation was the subject of a study by the Club of Rome (1972), and by many subsequent studies which took account of the trends of globalisation, increased mobility, and world development patterns (WCED, 1987, Meadows *et al* 1992). Annual updates of **key global performance indicators** in relation to carrying capacity are published by a number of bodies (Worldwatch Institute, 2002).
- 3.1.2. In the field of ecotoxicology, the study of pollutants in the environment, a parallel concept of “**environmental assimilative capacity**” is firmly established (Calow, 1992). Ecotoxicology is concerned partly with the science of establishing the ability of the environment to cope with or assimilate the impacts of human activity. Increasingly, it is also about the ability of humans to cope with or assimilate the impacts of human activity, with medical health and epidemiological studies brought to the fore. In this branch of science, the ability of the environment to receive and process pollutants or other impacts is referred to as “**assimilative capacity**”, and the ability of human populations to receive and tolerate pollutants or other impacts as the “**human assimilative capacity**”. The latter concept has been recognised for many centuries as the dictum accredited originally to the Greek Paracelsus, that “*the poison is in the dose*”. However, the “acute” dose (the dose causing rapid death) is rarely of concern to ecotoxicology; more important is the “chronic dose” which over time leads to chronic illness, or to more subtle factors such as reproductive failure or inefficiency, or reduced quality of life (Calow 1992).
- 3.1.3. Assimilative capacities avoiding chronic effects are difficult to calculate. In the field of water pollution for example, where studies are most advanced, laboratory models are often too simplistic to predict complex environmental

outcomes on the impact of chemical effluents on the receiving systems, be they physical, chemical or biological. Setting “acceptable” limits, in the field of water, air, and terrestrial impacts tends to become a political compromise based on “best guess” of chronic effects such as toxicity, reprotoxicity, carcinogenicity, persistence, and bioaccumulation factors. In the absence of scientific certainty, the “precautionary principle” is often invoked, leading to the banning of certain “suspect” substances and impacts completely, or reducing acceptable discharge levels of others.

- 3.1.4. **Tolerance limits** are increasingly based on world standards calculated and published by such agencies as the World Health Organisation (WHO), but the application of tolerance limits, being tied to the economic and social developmental stage of a state or nation, is often discretionary to a government or union of governments. Decisions must be weighed on a cost/risk basis, reviewed as scientific knowledge of the issues develops. A good example of this is aircraft noise exposure.
- 3.1.5. Quite apart from calculating environmental assimilative capacity, defining and interpreting the concept in the various fields of human activity has been problematic. Often, there has been a protracted period where a sector or activity is in denial of any environmental impact. In general, and often in the face of scientific and medical evidence and public/government lobbying, environmental impacts are recognised, and a process of management of those impacts begins. The tolerance of an impact will be related to perceived value of an activity against the risk that activity brings to human health or environmental quality.
- 3.1.6. If the continued activity is tolerated at all, the debate will shift to acceptable limits of impact, to associated timescales, and to targets and performance measures. It is the debate over these limits (and whether limits are an appropriate management tool), which will be most contentious, in context of uncertain science, and risk/benefit arguments. During such arguments, clarity of terminology is vital.
- 3.1.7. In its application to the various fields of human activity, environmental capacity rarely enjoys clarity of definition. Indeed, as Upham (2001) points out, the phrase is open to subjectivity and interpretational abuse.

- 3.1.8. Some sectors have failed to apply these rules, and as a consequence, consensus has failed to emerge on the meaning of environmental capacity, notably in housing and urban development planning (Barton, 1995).
- 3.1.9. Janicke (1997), and Fagin (2001) argue that any definition of environmental capacity is influenced by political actors and their decisions, the dimensions and appropriateness of policy, and the availability of technical knowledge and expertise. Furthermore, that the ability to identify and solve ecological problems is constituted by the strength of organized governmental and non-governmental proponents of environmental protection constrained, or enabled, by the structural framework of political action (Janicke, 1997: 8). This links into the theme of public participation and the role society can play in helping achieve environmental capacity through consensus and negotiation.

3.2 Environmental Capacity at Airports Literature

- 3.2.1. The UK-based Aviation Environment Federation (AEF) published a discussion paper on environmental capacity as it applies to airports (AEF, 2002), suggesting a system of “environmental licensing”. For AEF, larger airports would be licensed under an environmental capacity approach involving environmental, as opposed to operational limits. The paper proposes that noise, local air quality and third party safety be modelled and contour maps compiled for each airport. The contours would then be used to set limits, subject to the number of people exposed, with penalties applied for exceedances of those limits. The document notes that the actual limit values are likely to be controversial, and proposes a phased approach with short and long-term goals.
- 3.2.2. In the present context of meeting the requirements of numerous stakeholders, airports must balance local health, environmental and quality-of-life issues with wider societal, environmental and economic concerns. The concept of environmental capacity is not solely confined to the field of environmental management and has been applied widely to other policy areas. The Organisation for Economic Co-operation and Development - OECD (1994: 8)

defines environmental capacity as '*a society's ability to identify and solve environmental problems*'.

3.2.3. The detailed search of European and North American literature has demonstrated a lack of peer-reviewed publications specifically addressing environmental capacity of the air transport system. However, since 1999 the UK Office of Science and Technology (OST) through the Engineering and Physical Research Council (EPSRC) has funded the Sustainable Cities Aviation Network (SCAN-UK). This network has been responsible for carrying forward the debate on environmental capacity of the air transport system. In particular the network has organised workshops and a conference to specifically debate and discuss the capacity issue. The outcomes of these fora are available at (<http://www.scan-uk.mmu.ac.uk>) and are considered by many aviation stakeholders as the starting point for future discussions and agreements.

3.2.4. Environmental capacity was the theme of a workshop held at Heathrow Airport on June 2000 (SCAN-UK 2000). The aims of the workshop were to attempt to agree on a working definition of environmental capacity as it applies to aviation and airports. Around 40 contributors (with a UK emphasis) were present, representing academic bodies, local authorities, NGOs, airports, Government, manufacturers, consultants, airlines.

3.2.5. The workshop concluded with the adoption of a general definition that environmental capacity represents:

"the extent to which the environment is able to receive and tolerate, assimilate, or process outputs derived from air activity."

3.2.6. The workshop also identified a number of ways of reducing environmental impact, in order to maximise environmental capacity. The workshop was very successful in highlighting the issue of environmental capacity, and was the first forum to suggest a definition and the factors affecting it. However, the workshop also demonstrated that the concept could be confused with the issue of environmental management.

- 3.2.7. The SCAN-UK International Conference on Environmental Capacity at Airports in April 2001 was successful in attracting a large audience from around the world with sixteen papers being presented on a variety of issues. It is clear from the papers presented at the conference (available at <http://www.scan-uk.mmu.ac.uk/>) and from transcripts that there is a clear dichotomy of opinions and interpretations presented by stakeholders on the meaning of environmental capacity as it relates to the aviation industry. This was vividly illustrated by the views of key note speakers drawn from industry and NGOs, the former addressing mitigation of environmental consequences of industry growth, and the latter calling for measures to manage demand and restrict industry growth. Both had their own interpretations of sustainability and capacity. This characterised the discussion that took place throughout the Conference, with a variety of industry practitioners, academics, and lobbyists tending to avoid the specific topic of environmental capacity and pursuing alternative environmental themes.
- 3.2.8. Only Janic (2001) and McLellan (2001) addressed the topic in any depth. Janic attempted to combine infrastructure, operational, economic and environmental capacity in a single model, although this was conceptual rather than predictive, and it was not clear how issues such as noise could be successfully incorporated into it. McLellan reported progress on public consultation on the use of the concept at a local level at London Luton Airport. (In September 2001, the term 'environmental capacity' was adopted in the Airport Development Brief as a key policy item, LLA, 2001). Douglas (2001) also suggested that the lack of primary materials for airport construction should be considered as part of the capacity debate.
- 3.2.9. Whilst the Conference was able to highlight the growing importance of environmental capacity, there was little consensus achieved on the definition or meaning of the term.
- 3.2.10. A paper by Upham (2001) set out the theoretical issues for establishing basic research directions. Perhaps the most useful components of the paper were the highlighting of the failure by other sectors to successfully adopt environmental capacity as a concept; and a set of conditions under which the concept could be successfully applied to aviation. Definitions and indicators were not tackled in this paper.

3.2.11. A more pragmatic approach to environmental capacity had earlier been espoused by Thomas (2000). Thomas regarded environmental impacts as one of three components constraining airport capacity, alongside operational and infrastructure capacity constraints. Thus, environmental capacity is not defined directly, although the environmental component constraining capacity is recognised as:

“the impact of airport operations upon the local environment and upon the lives of residents of local communities”.

3.2.12. In conclusion, the literature search confirmed both the scarcity of aviation-related work on environmental capacity and the importance of beginning to redress that deficit. Environmental capacity was found to involve concepts from social as well as natural sciences. The importance of regulator-led dialogue with stakeholders was affirmed, specifically in terms of increasing the precision of concepts, indicators and limits.

3.3 The UK Government Consultation “The Future of Aviation” on Environmental Capacity

3.3.1. It is believed that only one European government has openly consulted on the meaning and implications of environmental capacity in aviation. In November 2000, the UK Government published a consultation paper to inform its development of a UK policy on the future of air transport. The document contained the following questions on environmental capacity.

Could the concept of environmental capacity limits be applied successfully to UK airports?

How would limits be set? and

Would these be alongside or instead of limits on passenger throughput?

3.3.2. On 12 November 2001, an interim report was released, which summarised the responses received to these specific questions (DETR, 2001):

About 60% of the 145 responses received (mainly from local councils, environmental organisations, individuals, residents' groups, and amenity societies), considered that some form of environmental capacity limit might be applied successfully to airports. Several respondents took the view that environmental capacity limits should be set alongside limits on passenger throughput, but be phased in over time to replace them. Some argued that environmental capacity limits should be applied instead of limits on passenger throughput while a number suggested that aircraft movements should be limited, based upon their environmental impacts. It is evident that a simple movement based limit could have limited benefit in terms of environmental protection if the result were to encourage the use of larger (and therefore more noisy) aircraft.

Many respondents agreed that environmental capacity limits should reflect local circumstances and by implication, be negotiated at a local level. Several identified aircraft noise and local air quality as the primary issues for consideration and that limit values could be phased in over a period of years. Others suggested limits relating to road congestion, road traffic volumes and water quality.

Some questioned whether the tools were available to establish and monitor appropriate limits and that it would be difficult to define an overall "environmental capacity limit" for an airport. However one respondent cited the February 2001 Gatwick agreement (www.baa.co.uk/main/corporate/sustainable_development) as a good example of an environmental capacity limit already in use in the UK. A variety of different mechanisms were suggested by which environmental capacity limits might be achieved. These ranged from the adoption of purely voluntary agreements between airport operators and their neighbouring communities, the development of planning agreements (such as the Section

106 agreements adopted at London-Heathrow and Manchester) or the implementation of limits as part of conditions imposed alongside planning approval. A number of respondents suggested that environmental capacity limits should be based on the environmental statements submitted with planning applications.

A few respondents from the industry sector asked why airports should be subject to such limits whilst road and rail are not, and that unilateral arrangements might penalise UK airlines. The implication of this is that agreements or frameworks for such agreements should be set at an ECAC or ICAO level. Some argued that environmental capacity limits should not be applied, as this would be inconsistent with internalising environmental costs. Finally some indicated that such limits already existed at a number of airports e.g. noise limits, limits on operating hours, noise preferential routes and ICAO limits on engine noise.

Individual responses to the consultation are tabulated in Appendix E.

3.3.3. The literature review and the review of contemporary studies underline the importance and timeliness of the present investigation. If the term environmental capacity is to be a useful part of the aviation/environment lexicon, definitional rigour is required **and** there must be wide consultation resulting in environmental capacity issues being identified, and their social, political and economic implications considered.

3.4. Questionnaire Survey of European Airports

34.1. The questionnaire in Appendix B was sent to 209 Member ACI Europe airports across Europe with the assistance of the ACI- Europe Regional office. A total of 28 responses were received and these have been summarised in the tables provided in Appendix B.

- 3.4.2. Approximately two-thirds of those airports that responded claimed to have considered the concept of environmental capacity. In general these were some of the larger airports in north-west Europe, with notable exceptions being Tallinn and Bucharest. Environmental issues considered by respondents to be potential constraints included aircraft noise, nature conservation, wastewater/sewage disposal, bird strike hazards and ground transport access. From the responses received it would appear that the environmental capacity debate is particularly well advanced in Sweden. Here, the Government is explicitly committed to the sustainable development of the air transport industry and discussions are currently underway within the Swedish CAA about a definition of environmental capacity as an ecological basis for sustainability. Meanwhile the Swedish Environmental Court and Government fix noise contours and emissions caps at several airports.
- 3.4.3. Eleven airports claim to have a working definition of environmental capacity. In some cases this was very specific, relating to particular impacts such as noise (e.g. Salzburg) or emissions (e.g. Stockholm-Arlanda) whilst at others the definition was more general and descriptive (see Appendix B).
- 3.4.4. A number of airports report having undertaken environmental impact assessment (EIA) studies specifically associated with the concept of environmental capacity. These were primarily associated with aircraft noise or local air quality, although more than one airport reported studies on wastes, water quality and energy use.
- 3.4.5. A total of 16 airports reported having undertaken formal EIA studies on all, or a major part of their operations. All were carried out during the past 10 years with the majority during the last five years. These were normally triggered by the submission of major airports development proposals and the consequential requirements for EIA under planning law.
- 3.4.6. When asked whether environmental issues currently restrict airport operations, 19 airports reported operational restrictions based upon noise, 2 reported air quality restrictions, and none considered third party risk to affect current operations. Five of the airports that responded considered land availability as a potential constraint upon future growth, with smaller numbers

referring to habitat protection, energy consumption, ground transport access, and surface/ground water quality as constraints on existing operations.

- 3.4.7. In respect of the management of such issues, operational controls and restrictions proved the most widespread in relation to aircraft noise. The adoption of fiscal measures, market based options and voluntary agreements were also reported. Noise, air quality and in some cases of land use and habitat protection, environmental constraints were regulated by a mixture of international, EU, national and regional controls.
- 3.4.8. When asked which environmental issues would likely constrain future airport growth in the short, medium and longer terms, noise, local air quality, climate change, third party risk, habitat protection and land availability were raised (in descending order of importance). Some airports also identified energy, water pollution and waste as actual or potential constraint issues.
- 3.4.9. A number of airports reported the involvement of local air traffic control services in their environmental management programmes. Their involvement was exclusively related to the control of aircraft noise, although clearly potential exists for air traffic control services to assist reductions in emissions. Twelve airports reported having established forums to enable airport operators, airlines and air traffic controllers to meet to discuss issues associated with environmental capacity.
- 3.4.10. The level of response to the questionnaire was lower than hoped for, considering the very high level support given to the initiative from within EUROCONTROL and ACI-Europe. In part this may have reflected some lack of understanding of the issue, and in part a reluctance to discuss environmental constraints as they are regarded as 'threats' to airport development. It should be noted that there was an apparent degree of inconsistency in the responses to individual questions provided by particular airports. For example, one airport reported no environmental capacity restriction was in place at their airport whilst at the same time acknowledging the existence of a 'noise budget'.

3.5. Questionnaire Survey of European Airlines

- 3.5.1. Three specific questions relating to environmental capacity were examined in data collected from an IATA Environmental Reporting Survey (Dobbie and Hooper, 2001), details of which are provided in Appendix C. The results obtained from airline respondents broadly confirmed the findings obtained from European airports.
- 3.5.2. In response to a specific question asking airlines to rank how important different issues were to the growth of the air transport industry, European airlines indicated that in general, environmental issues were of similar importance to commercial factors such as employment generation, building new alliances, and developing air route networks at their home airports. Aircraft noise disturbance and effective land use planning emerged as the primary issues of concern in the environmental field, followed by the need to reduce engine emissions.
- 3.5.3. Large and medium-sized airline companies consistently rated environmental issues as more important than smaller airlines. It is noteworthy that aircraft noise was consistently ranked of greater importance by the larger airlines, compared to intermediate and smaller companies.
- 3.5.4. Most European airlines (92%) indicated that environmental rules and regulations at airports affected their business and generated responses designed to limit exposure to operational penalties (e.g. noise charges and penalties, 89%). Approximately half of the respondents also indicated a wish to limit the possibility of litigation (56%) and/or airport/en-route charges (61%). In terms of the source of the regulatory impetus on environmental issues, national legislation is regarded as the dominant driver (97%), although local regulation was also cited in over 80% of the cases.
- 3.5.5. 82% of all respondents indicated that environmental policies/strategies had been adopted by their airlines. All large airline respondents indicated that environmental policies/strategies were in place, which was noticeably higher than for intermediate (70%) and small (61%) airlines.

3.5.6. Although this re-analysis provides some information on the general view of responding airlines to environmental issues, the specific issue of environmental capacity at airports was not addressed by the questionnaire. However, subsequent components of the study afforded particular opportunity to question airline representatives on this issue.

3.6. Semi-Structured Interviews With Key Stakeholders in the Environmental Capacity Debate

3.6.1. The list of interviewees agreed with EUROCONTROL comprised high level representatives from a wide variety of European aviation/environment stakeholders, including environmental NGOs, representatives from the airline, airport, ATM sectors and policy-makers (Table 1).

Table 1. Consultee List for Semi- structured Interviews

Name	Affiliation
John Hume (JH)	ACI Europe
Le Thi Mai (LTM)	Association European Airlines (AEA)
Tom Needham (TN)	Airport Operators Association (AoA), UK
Tim Johnson (TJ)	Aviation Environment Federation (AEF, NGO)
Mike Rossell (MR)	European Commission Directorate-General for Energy and Transport (DGTREN)
Gerard Bekebrede (GB)	Dutch Ministry of Transport
Jean-Louis Renteux (JLR)	EUROCONTROL
Paul Wilson (PW)	EUROCONTROL
Leonnie Dobbie (LD)	International Air Transport Association (IATA)
Tony Grayling (TG)	IPPR (NGO)
Hans Blokland (HB)	Member of European Parliament (MEP)
Annette Palsson (AP)	Swedish Defence Research Agency (FOI)
Beatrice Schell (BS)	Transport and Environment (NGO)
John Stewart (JS)	Transport 2000 (NGO)

3.6.2. The use of a semi-structured questioning technique facilitated discussion and allowed opinions to be expressed. There was no intention to compare the results of interviews in any detailed way.

3.6.3. However, the following table provides a summary of responses to some of the key questions presented for discussion.

Table 2 Summary of Responses from Interviewees

<p>1. The term ‘environmental capacity’ is being discussed in the aviation industry, as part of the analysis of forecast growth, supply, and demand. What do you understand by this term, and how does your organisation define or interpret “environmental capacity”?</p>
<p>Living within the environmental capacity limits of the environment in terms of air quality, in terms of noise and climate change.</p> <p>...how best a dynamic economic industrial sector such as air transport works in concert with environmental concerns.</p> <p>A proxy for a limit without any reference to what that limit might be.</p> <p>A concept which allows for a certain amount of environmental impact without overt description. There is a question as to whether or not it can be defined at all, because it is entirely dependent on the tolerance of communities.</p> <p>Anything and everything by way of airport or ATC infrastructure or the supply of infrastructure, which may inhibit or facilitate the movement of aircraft throughout the airspace and in and out of airports .</p> <p>It is an attempt I think by the industry to take on board and respond to the environmental agenda.</p> <p>For the moment we are not talking about environmental capacity, but we try to identify environmental constraints.</p>
<p>2. Have you conducted research into this issue, and if so, how was this done?</p>
<p>IPPR through a sustainable aviation policy report AEF by working with, with ACI/IATA. Scenario forecasting by the Swedish CAA Dutch government evaluation of transport economic and environmental requirements, and EIA of Schiphol airport</p>
<p>3. In relation to European airports and air traffic management, which environmental issues are already constraints to growth, and which issues will constrain future growth of the European air transport system (over a 20 year period)?</p>
<p>All interviewees put noise at the top of the list for present and future constraints. Air quality was regarded as a rising issue, and though climate change was an issue it was thought by most not to a constraint on airports capacity. Habitat protection and water issues were mentioned by some.</p>
<p>4. What role do you think your own organisation can have in shaping the debate on environmental capacity?</p>
<p>Highly varied, see transcripts.</p>

5. How can primary stakeholders, such as ATM's/airspace users/airports, work to alleviate environmental impacts? Who do you believe are the other important stakeholders who can contribute to the debate?
Groups previously under-represented from local and European debates were cited by some interviewees as trade unions, and consumers groups. Industry interviewees all felt that closer involvement by ATC organisations was a positive.
6. To what extent do you believe issues or matters of environmental capacity should be resolved through locally negotiated agreements
Respondents presented different weightings on the use of regulatory, fiscal, and voluntary measures. See transcripts.
7. Is there an <u>effective</u> international framework taking this forward, or capable of taking this forward?
Various views, see transcripts
8. How do you anticipate regulation and other policy developing across Europe over the next 20 years?
There will certainly be a common framework in Europe for dealing with noise pollution. There is already a common framework for dealing with air pollution in Europe, and UK airports need to be brought inside that. The earliest carbon trading could happen would be during the period 2008-2012, but I think that's probably optimistic. Further legislation, firstly in noise and probably in the not too distant future on emissions, plus market-based measures. I certainly think that the momentum in Europe is there in the regulatory arena. There will be more regulation, which might be pre-empted by voluntary agreements at local level or at regional level (IATA). I foresee increasing pressures on governments to regulate at very local levels, from residents concerned about noise. They are going to be more organised, more vociferous. The European Union will have to take the lead on regulation; waiting for CAEP 6 is not a viable option because CAEP 6 will be as inconclusive as CAEP 5. At ICAO level there will be in the next three years further discussions on guidelines in respect of environmental measures, focusing on noise. At European level, pressure for more regulation. At local level, enough flexibility to tune your measures so that everybody is relatively happy. I think that the legislators of Brussels will have some good days in front of them!

3.7. Airport/Environment Expert Discussion Group

3.7.1. The Airports Council International (ACI) European Environmental Strategy Committee comprises environmental experts from 37 European airports. As part of a Committee in Brussels on 16th April 2002, twenty members gave responses to five questions devised by CATE.

3.7.2 The following airports or airport groups were represented at the meeting:

Aeroportos de Portugal, Amsterdam-Schiphol, Athens, Bologna, Brussels, Bucharest, Dublin, Hamburg, London Gatwick, London Heathrow, Milan, Munich, Norwegian Air Traffic and Airport Management, Oslo, Prague, Rome, Salzburg, Spanish Airport Authority (AENA), Stockholm, Zurich.

3.7.3. A total of 15 out of the 20 airport representatives present reported that environmental capacity constraints already affected the growth of their airports, issues of concern being primarily aircraft noise, but also air quality, water pollution, third party risk, and road traffic access. A further four reported anticipating such constraints in the medium or longer term. Only one airport (Dublin) regarded capacity constraints as unlikely, although there was a possible concern in the long term over noise and waste management.

3.7.4. The majority of respondents considered that constraints at individual airports do already or could have implications for European airspace management. This was stated to be particularly the case at some major hub airports. Operational consequences of environmental constraints included; difficulties in slot allocation; scheduling problems caused by night restrictions or curfews; the proliferation of local solutions; proliferating operating rules; and reduced runway capacity.

3.7.5 Respondents listed the following factors as being the most important in terms of maximising environmental capacity:

Effective management of the environmental factors directly affecting capacity;

Legislation driving improved environmental quality standards;

EU environmental policy;

Reducing noise levels at source through the use of new technologies (aircraft, engines);

Phase out of marginally compliant Chapter 3 aircraft;

Effective land-use planning;

The adoption of abatement procedures (for noise, air quality, waste);

Co-operation between ATC, airlines and airport operators; and

Stakeholder management programmes (especially community and local government).

- 3.7.6. Sixteen of the 20 respondents reported that at their own airport, Air Traffic Control were briefed or involved in dealing with environmental issues and constraints, most in relation to noise management. Three respondents noted limited involvement, with only one noting no ATC involvement.
- 3.7.7. When asked whether the Terminal Control Area (TMA) at their own airport was at risk of losing capacity due to environmental constraints at neighbouring airports, 10 respondents reported “no” or “not presently”, with a further seven either not responding or responding “unknown”. The three airports replying “yes” were Amsterdam-Schiphol, Aeroportos de Portugal, and Prague.
- 3.7.7. Only one participant (Amsterdam-Schiphol) reported that their airport had produced any reports on environmental capacity in particular noise capacity.

3.8. Stakeholder Focus Groups

- 3.8.1. Focus groups were held in Amsterdam, Athens, London, Manchester, and Salzburg. Attempts to convene focus groups in Paris, Frankfurt and Madrid were not successful. The following is a summary of responses received against each question posed. As stated in the methodology, comments are not attributed to individuals, organisations, or sectors.

Question 1. *The term “environmental capacity” is being discussed in the aviation industry, as part of the analysis of forecast growth, supply and demand. What do you understand by this phrase, and is it useful?*

UK (Manchester and London)

- 3.8.2. At both focus groups, discussions moved from consideration of environmental capacity to consideration of the use of “environmental capacity limits”. Some participants were resistant to a fixed limit concept, concerned by their implications for operations, the difficulties of calculating and gaining political acceptance for them, and the consequences of airports ‘breaching’ their limits. It was believed that gaining consensus on limits would be difficult, and

that airport limits could have deleterious socio-economic effects, as well as potentially causing adverse environmental effects elsewhere in the air transport network. The focus group was concerned that socio-economic, regeneration and other local issues could potentially be ignored when determining environmental limits, and may be a blunt instrument in achieving developmental consensus.

- 3.8.3. Of particular concern to the group was that socio-economic factors should be included in determining environmental capacity and limits, especially in achieving the correct 'balance' between adverse environmental impacts and socio-economic benefits. For example, a cost/benefit approach could factor in the value of a job or new facility against the associated environmental disbenefit. One view was that the application of environmental limits to UK airports would only be appropriate where it was considered that the environmental costs of expansion clearly outweigh the economic benefits.
- 3.8.4. It was considered that UK policy-makers may not find the concept of environmental capacity attractive, with indications that such an approach may be too rigid, and lead to 'costs outweighing benefits'.
- 3.8.5. A key term, which came up regularly in discussion, was the concept "tolerance" of nuisance or disturbance. Participants noted that some communities are more tolerant than others, that perceptions change over time, and are subject to economic considerations. Two definitions of environmental capacity were offered (by the London focus group).

*"A point at which the marginal benefit equated to the marginal cost," and
"The form of a fixed limit."*

Amsterdam-Schiphol

- 3.8.6. Schiphol has already adopted environmental capacity as part of technical capacity, and it is implicit in its yearly capacity system. The concept was considered useful by the focus group, a key point being that environment is "upgraded" to a level comparable with traffic capacity. This concept is backed by specific Dutch regulation, where environmental capacity is defended in law as being of equal importance to technical capacity. Increased traffic volume

is possible within a given environmental limit, but it depends on aircraft type, time of day, etc. The parties involved have learned to operate within the rules and to be creative within those limits.

One definition was offered:

“Environmental capacity is the traffic volume possible within environmental load limits, depending on aircraft environmental characteristics (noise, emissions) and time distribution of traffic.”

Salzburg

In response to Question 1, the following was cited:

“Environmental factors are potentially constraints on achieving desired airport capacity. Environmental capacity is the limit of environmental tolerance. In order to secure airport capacity, sustainable airport management is required. Many environmental factors could limit capacity, but here at Salzburg, it is aircraft noise that is the important factor, as we are only 3km from city centre, and have many suburban communities. Therefore, we define noise contours, based on sound science. The City of Salzburg decrees that noise contours must decrease every year, despite increased traffic. In Europe, I see an increased environmental pressure, depending on local circumstances. The important thing is to secure environmental capacity by pro-active management. ATC is vital to this aim, especially as they are the source of technical data and expertise.”

Athens

- 3.8.7. As in the UK groups, there was some discussion as to whether the term implied an operational limit, a factor that was not acceptable to some participants.

The focus group produced two interpretations of environmental capacity.

“The ability of a specific space, which interrelates dynamically and can accept pressure from air traffic on the ground, during LTO and navigation and can affect the imposed environmental limits;”

and

“a balanced combination of operational and environmental conditions that do not exceed a specific range of values”.

Question 2. *How do you believe issues of environmental capacity should be addressed? (Use the following table as guide if you wish, but don't feel restricted by it).*

3.8.8. The following analysis of results is based on the response of twenty individuals, pooled from all five focus groups, although not all respondents tackled every issue. The number in each box gives the number of respondents in favour of each approach.

Table 3 Focus Group Responses, Controlling Environmental Capacity Issues

Issue	Respondent Number	Management Tools		Local agreements	Regulation			
		Fiscal	Operational		Regional	National	EU/ECAC	ICAO
Noise	20	13	17	11	6	9	12	13
Local air quality	16	8	6	6	8	5	11	4
Climate Change	20	10	1		1	9	12	13
Habitat protection	18	4	5	11	6	7		
Traffic	3	3		3				
Third party risk	2		2	2				

3.8.9. Analysis of these results demonstrates that there is a spread of opinion among the focus group participants on the preferred policy approach for each issue. There were no clear differences in approach proposed between the focus groups.

3.8.10. On noise, the majority supported regulation at international and European levels. There was also majority support for local agreements, operational management tools, and fiscal management tools.

3.8.11. On air quality, the majority supported regulation at the European level, with a spread of opinion on other policy measures.

3.8.12. On climate change, the majority supported regulation at international and European level, and half supported the use of fiscal management tools.

3.8.13. On habitat protection, regulation was not deemed appropriate, with local agreements considered by the majority to be the best policy instrument.

3.8.14. Two other capacity issues were raised by Focus Group participants. traffic/surface access was raised by three participants, who unanimously agreed that local agreements coupled to fiscal management tools were the appropriate approach. Third party risk was raised by two participants, who agreed that local agreements coupled to operational management tools were the appropriate measures.

Question 3. *In the past, different stakeholders have tended to address environmental issues independently. To what extent should they work more closely, and how?¹*

3.8.15. UK focus group participants agreed that in terms of certification mechanisms and environmental assessment there was room for improvement in terms of stakeholder involvement and partnership. Key stakeholders were NGOs, community groups, Environment Agency, ATC providers, airlines and airport operators. One view was that national government should override local community concerns when decisions were of national/international importance.

Question 4. *How can Air Traffic Management Services (ATMS) in Europe contribute to addressing and managing environmental capacity constraints?*

Manchester-London UK

3.8.16. A key point of weakness was that ATM were just starting to come to grips with environmental issues. One opinion was that they were not yet even 'at the party'. However, at both London and Manchester, representatives from ATC were working with airports and airlines on key issues such as noise, Noise Preferential Route (NPR) and Continuous Descent Approach (CDA).

Schiphol

3.8.17. ATC is already closely involved with the monitoring and managing of activity within noise limits.

¹ This question was discontinued for the Amsterdam, Salzburg, and Athens Focus Groups.

Salzburg

3.8.18 ATC is a vital component of such management, and we think that we represent best practice in its involvement at smaller airports.

Athens

3.8.19. The HCAA is involved in aircraft noise management. Noise abatement procedures are agreed for the Greek airports. Technology (radar, Noise Track Keeping (NTK), etc) is important in mitigating and tracking operational /environmental issues.

3.9. Strengths/Weaknesses/Opportunities/Threats (SWOT) Analysis

3.9.1. There is a general acceptance that future regulatory developments within Europe could move in one or two directions, either:

Scenario I: A regulated federal European system applying environmental capacity limits.

Scenario II: No European framework on environmental capacity, continued proliferation of local rules.

3.9.2. In order to assess the potential benefits, costs and impediments associated with the two scenarios as they apply to the issue of environmental capacity at airports EUROCONTROL requested that a SWOT analysis be undertaken, where possible, as part of the Focus Group meetings.

3.9.3. The following responses are pooled from the London, Manchester, and Amsterdam, focus groups. However, where time was constrained at Athens, no SWOT analysis was carried out.

Table 4. Focus Groups SWOT Analysis (Scenario I)

Scenario I: A regulated federal European system applying environmental capacity limits.

<p>Strengths</p> <ul style="list-style-type: none"> Level playing field Equitable for EC citizens Local air quality and noise may improve Brings clarity and consistency Avoids inter-airport competition on environmental issues Time to implement change minimised Predictability Fair competition Balance Stability 	<p>Weaknesses</p> <ul style="list-style-type: none"> Likely to require new airports, and/or sub-optimal site development Airspace complexity Increased costs, and costs of regulation. May adversely affect climate change May lead to unnecessary capacity constraints, and some airports being “over-regulated” Too strict for some, too weak for others. Not adaptable to local needs Changes take a long time
<p>Opportunities</p> <ul style="list-style-type: none"> Ease of access to airports, and more point-point services Emissions trading within capacity limits Flexible regulations Growth at local level Current regulation could be improved on A European-wide transport system view Stimulate understanding and requirements Drives creativity and technical development 	<p>Threats</p> <ul style="list-style-type: none"> USA would take over global aviation and negative competition issues with other world regions Inflexible regulations More airports Local development blocked by European level decisions Higher costs

Table 5. Focus Group SWOT Analysis (Scenario II)

Scenario II: No European framework on environmental capacity, continued proliferation of local rules.

<p>Strengths</p> <ul style="list-style-type: none"> Local certainty, acceptability and flexibility Less anarchic provided guidance is provided Bigger airports with more concentrated traffic More flexible No regulation necessary Control at national level Would allow for cultural/ 'affluence' differences in different parts of Europe (relating to environmental impact) to be reflected in local regulation/ controls 	<p>Weaknesses</p> <ul style="list-style-type: none"> Difficulties in scheduling aircraft Delays could be generated Inequitable treatment of affected local citizens New agreements affected by previous agreements. Reduced competition Business constrained by slow agreements Growing airspace capacity systems problem Wasted capacity Unfair competition within Europe Difficult for airlines to plan System trusted less More vulnerable to local pressures Incrementalism in planning decisions
<p>Opportunities</p> <ul style="list-style-type: none"> To manage the proliferation (framework required). Guidance to government. European framework, local rules Community interaction Resolve constraints by mitigation For certain airports within Europe to grow, i.e. less well regulated countries To promote responsible environmental management whilst growth occurs Resolve constraints by mitigation 	<p>Threats</p> <ul style="list-style-type: none"> Complex rules Getting the balance correct Precedent setting Airports limits reached Politicians choose most restrictive elements Under-utilising physical capacity More local NGO campaigning

3.9.4. In the UK, a slight preference was expressed for the second scenario, although neither scenario was felt to represent an ideal outcome. In Amsterdam, the first scenario was regarded as preferable, but far from ideal. A third scenario that emerged during subsequent discussion, was for a European framework allowing local rules. This was preferable to both groups.

3.9.5. A much shortened version of the SWOT analysis was carried out in Salzburg.

Scenario I: Regions would be the biggest losers. By regulating access on an environmental basis, regional hubs may be by-passed.

Scenario II: Preferable, since local situations are paramount. Of course some cohesion on rules would be preferable.

3.10. Development of a Conceptual Model and Toolkits

3.10.1. As set out by the project brief, two operational models devised at EUROCONTROL (GMAT and CAMACA) were assessed for their ability to interface with environmental capacity and management issues. Both were studied for their potential to interact with the environmental capacity model/toolkit under development.

Ground Movement Analysis Tool (GMAT)

3.10.2. GMAT is an internet-based application that uses information from the following data sources:

Airline schedules;

Flight plans; and

Movement signals/messages.

3.10.3 The tool generates information representing flights and airports, and contains messages linking to consecutive flights of each aircraft and comparing all events related to that flight.

3.10.4. The main use of GMAT is to compare predicted with actual flight activity (both ground and *en route*), and in particular to indicate delays and to some extent identify their cause. GMAT is considered to have the potential to be used as

an environmental efficiency assessment tool; and this potential is discussed in section 6.

Commonly Agreed Methodology for Airport Airside Capacity Assessment (CAMACA)

3.10.5. The CAMACA project was devised and undertaken by EUROCONTROL to investigate concerns from IATA, ACI, the EC and other stakeholders, about discrepancies between planned and actual functional capacity at airports and airspace capacity, and different interpretations of “capacity”.

3.10.6. The CAMACA model considers three elements of capacity:

Unconstrained Capacity. This is the theoretical capacity of the system in an “ideal world”.

Sustained Capacity. This is the anticipated capacity that can be achieved in the “real world”; and

Declared Capacity. This takes account of political factors that determine stated limits. (This can contain environmental factors, but does not necessarily reflect environmental capacity).

3.10.7. CAMACA can provide an estimate of airport operational capacity for unconstrained and sustained runway, apron, and taxiway capacity and produces outputs as a function of percentage arrivals. Inputs include a wide variety of infrastructure and operational variables. The model has been tested by EUROCONTROL at Brussels, Helsinki, Stockholm, Madrid and Faro airports.

3.10.8. The model was not designed to include environmental variables, but has been tested using noise/ community constraints from Brussels Airport.

3.10.9. The model is useful for the analysis of “What if” scenarios. This makes it ideal for predicting the effects of environmental capacity restrictions on operational performance of an airport. For airport planning, the best environmental/operational outcome can be tested. Environmental issues could influence a number of input parameters such as runway use configurations, airspace constraints, traffic mix, and operational restrictions. These can be tested directly.

3.10.10. The use of the model already has brought an improvement in operational efficiency at Brussels, where four additional movements per hour have been achieved by comparing declared and sustained capacity. Additionally, it prescribes an interactive stakeholder decision-making process, which gives consensus to data/model output.

3.10.11. As a strategic modelling tool, there is already a suggestion to integrate noise contour information.

Concept Model Construction

3.10.12. The present study has sought to determine which factors constitute current and potential future environmental capacity issues at airports. In order to assist airport managers to review actual or potential environmental constraints at individual airports, an environmental screen has been devised. The screen utilises a flow-chart to link two toolkit sets².

3.10.13. The first is a set of Capacity Identification Toolkits which identify whether environmental issues are currently, or have the potential to, create environmental capacity constraints. The second set is a series of individual Capacity Enhancement and Management Toolkits to assist the user to manage, enhance, or secure environmental capacity and, thus, enhanced operational capacity. The “Environmental Capacity Screen/Toolkit (ECS/T)” is presented in an appended document.

3.11. Environmental Performance Indicators

3.11.1. The current status of development of environmental performance indicators (EPIs) for airports, airlines and ANSP providers at airports was investigated through literature search and dialogue with stakeholders.

² At this stage of conceptual development, the environmental screen represents a sequential flow through the issues potentially representing environmental capacity constraint at airports in Europe. Whilst it is acknowledged that inter-relationships between environmental issues can influence management or planning decisions, and that there is potential to incorporate this complexity into the model at the next stage of development, it is recommended that the model is first tested in its current conceptual format.

Airlines

3.11.2. A recent IATA study reported that a non-standardised range of qualitative and quantitative environmental and social indicators is a feature of environmental reporting in the airline sector (Dobbie and Hooper, 2001). The use of no fewer than 120 indicators by 17 reporting airlines was noted, and there is little commonality between indicators used by different airlines. The range included a variety of different types of indicators (*absolute, productivity based, output and ratio* indicators), described by the International Standards Organisations in ISO 14031 (ISO 2000) each of which have different functions in terms of management and reporting.

Table 6. Types of ISO 14031 Indicators

Type of Indicator	Function
Absolute indicators	Data representing total quantities of resource use and waste emissions, e.g. fuel use expressed in tonnes.
Relative indicators	Where resource use/emission are related to some measure of business service provision (also known as ratio indicators), e.g. litres of fuel per revenue tonne kilometre.
Indexed indicators	These link the data to a chosen standard or baseline, e.g. per cent change in carbon dioxide against performance in a base year.
Aggregated indicators	Combine data of the same type from difference sources, e.g. carbon dioxide emissions from all transport activities.
Weighted indicators	Attempt to sum different output indicators through the use of conversion factors e.g. SAS's use of a universal environmental impact index.

3.11.3. Dobbie and Hooper (2001) examined airline EPIs relating to resource use and wastes produced in different phases of airline operations (flight, cabin, ground operations). They found that :

When the relative performance of the airlines was grouped according to EPI and ranked, a degree of consistency was observed in respect of the absolute indicators associated with flight operations. However, much less consistency was found in the ranking of corresponding indicators linked to ground operations; and

When the performance in relative EPI categories was compared (including where EPIs were linked to the same operational activity: e.g. fuel use expressed in g/RKT or g/PTK and NOx emissions in g/RTK), no consistency in the ranking of companies was observed.

3.11.4. These inconsistencies suggest that, in addition to any genuine differences in the performance of the airline concerned, other factors relating to data collection or Indicator definition may be influencing the results reported against specific EPIs.

3.11.5. Considerable variation in the specific definition of indicators is evident from the flight-based EPIs. For example, some airlines (e.g. BA, Finnair and SAS) use total emissions throughout the flight, whereas others (e.g. Air France, KLM and Swissair) confined the data to high altitude cruising and excluded the landing and take-off cycle. In another example, emissions and fuel use reported by some airlines appears to be based on calculated distances (based on Great Circle Distance) while others report actual distances flown.

Airports

3.11.6. The great variety of EPIs produced by airlines is mirrored in airport environmental reporting. Environmental reports have been produced by a number of major European airports e.g. Amsterdam-Schiphol (1998); Stansted (1998); Zurich (1999); Frankfurt (1999) and Manchester Airport (2000). Some airports have recently started to produce sustainability reports (e.g. BAA, 1999a and 1999b, Gatwick (2000), Manchester (2001)) that also take account of the social and economic benefits that balance the adverse environmental costs and emphasise commitment to local communities, which are exposed to the impacts of airport operations. Both types of report provide theme-based data in varying levels of detail, providing information about impact, ambient environmental quality, mitigation measures, resources consumed and wastes generated.

3.11.7. A review of environmental and sustainability issues being addressed by European airports (Upham, 2001a) has shown that most are concerned primarily with managing aircraft noise, local air quality and surface water quality in order to meet regulatory or locally agreed thresholds or limits. A wide variety of indicators relating to these issues have therefore been developed to facilitate management and to ensure and to report performance against target.

3.11.8. A wide variety of indicators have been developed for individual impacts. Each can offer insight into different aspects of the cause and effects of particular impacts. This can be important in terms of facilitating environmental management. However, where such data are to be used for benchmarking or modelling there is a need to reduce to a minimum number, indicators that accurately represent the overall impact.

3.11.9. As an example, Schiphol Airport selected the following as Key Performance Indicators in its 1998 report on environmental performance.

Table 7. Key Performance Indicators/Figures" Schiphol Airport (1998)

Proportion of Chapter 2 aircraft % of jet traffic	Emission (max. level in surroundings)
No. of night flights 23-06 h total traffic	NO ₂ microgrammes/m ³
Number of noise-affected houses < 35 Ku contour	CO microgrammes/m ³
Number of noise-insulated houses, different phases	Fine particles microgrammes/m ³
Number of engine running tests	Number of inhabitants within odour contour
Number of complaints about noise	Proportion of passengers in public transport %
Natural gas consumption mln m ³	Proportion of staff in public transport %
Electricity consumption mln kWh	Proportion of separated waste at source
Drinking water consumption 1,000 m ³	

3.11.10. A review of airport environmental reports shows that they lack the information necessary for meaningful and consistent comparison of environmental and sustainability performance between airports. In particular, they tend to neglect absolute data in preference for relative data that provides a better impression of environmental performance (Upham, 2001a). A non-standardised range of quantitative environmental (and to a lesser extent social) performance indicators is similarly found in airline environmental reports (Dobbie and Hooper, 2001). Non-standardisation in corporate environmental/sustainability indicators and reporting generally is a recognised barrier to comparative benchmarking (Dias-Sardinha and Reijnders, 2001).

3.11.11. As a result a number of initiatives are currently underway to develop international standardisation of benchmarking by NGOs (GRI, 2000 and 2002; ACCA, 2001); and academics (e.g. Berkhout et al, 2001, Young and Welford,

1999). At the EU level the Transport and Environment Reporting Mechanism (TERM) programme is developing such indicators for the transport sector (EEA, 2001).

3.11.12. The ACI Europe Environmental Strategy Committee has established a Working Group to research an “Airports Benchmarking Protocol”. An interim list of indicators being considered at the present time and subject to further development is provided in the following table.

Table 8. Developing Environmental Indicators for Airports (ACI, unpub. data)

	Absolute Indicator	Relative Indicator
Resources		
Energy: Heat and electricity for buildings and installations	MWh/year	KWh/TU
Fuel consumption		L/TU
Water consumption	m ³	L/TU
Use of products and raw materials (de-icing products, biocides, cleaners etc.)		
Pollution		
Emissions: Oxides of nitrogen (NO _x)	Tonnes/year	kg/TU
VOCs		
BOD		
Noise: Chapter III movements		% of total flights % under limit
Waste: Amount of waste	Tonnes/year	kg/TU
Share of recyclables	Tonnes/year	%
Mobility: User of railway station		
Number of passengers taking trains/bus per day		
Environmental Condition		
Quality results of: Water		
Air		
Soil		

Source: ACI Environmental Strategy Committee, Benchmarking Working Group (Brussels, 15-16/04/02).

3.11.13. Clearly, this is work in progress, but it already indicates the diversity of indicators being considered by the ACI Environmental Strategy Committee.

3.11.14. The UK Airport Operators Association (AoA) published an Environmental Guidance Manual for Airports in 2001 (AoA 2001) containing KPIs designed to demonstrate compliance with a key aims; inform strategy development; and provide management information and trend data. The Manual stressed that KPIs need to be simple, relevant, balanced, and meaningful and they could be divided into three categories, measuring:

Trends in total impact (eg, total energy use on a site);

Efficiency (e.g., energy use per passenger); or

Percentage achievement of targets (e.g., % completion of awareness training)

The manual went on to propose the following list of KPIs for airport use:

AoA recommended KPIs for describing airport environmental impact

Noise

Number of violations of Noise Preferential Routes (NPRs) consistent with Glossary

Number of non-compliances with Noise Abatement Procedures (by airline)

Noise level by area/aircraft type/average noise level

Number of noise-related aircraft surcharges (by aircraft type/airline)

Total number of infringements

Infringements per 10 000 departures (day or night)

Income generated from noise surcharges

Number of noise complaints/analysis of complaint nature/location

Percentage Chapter 2/quieter Chapter 3/Chapter 4

Ground Noise

Number of non-compliances with Noise Abatement Procedures (by airline)

Noise level by area/aircraft type/average noise level

Percentage of aircraft stands fitted with fixed electrical ground power

Air Quality

Yearly averages and peaks of key pollutants

Trends of key pollutant concentrations year on year

Number of non-compliances against local/national air quality standards

Climate Change

CO2 emissions per passenger

3.11.15. This list indicates the potential diversity of indicators that can be employed to describe a particular impact, and illustrates the need for agreeing a suite of key indicators that could be employed across the airport sector. Harmonisation is required if this type of information is to be used for benchmarking.

Air Navigation Service Providers (ANSP)

3.11.16. The results of this study indicate that whilst there is a good deal of activity designed to develop KPIs for airlines and airports, there has been little

published in this area for ATM. Accordingly, following informal discussions with ANSPs in Europe, the following potential EPIs were developed by the report authors as a preliminary material for discussion within the ATM community.

3.11.17. A variety of different factors associated the operation of airline fleets are under the direct influence of ATM and, therefore, can be considered as KPIs for use in this section these are presented in Tables 9,10,11.

Table 9. Noise KPIs

KPI	Unit of Measurement	Influencing Factors	Measurement
Area covered by 57 Leq contour	km ²	Adherence to. NPRs Adoption of CDA	ATC records Noise monitoring
% aircraft adopting continuous descent approaches	%	ATC enable Pilots achieve	NTK tool
Average time engine running from start to take-off roll	Minutes	CFMU Just-in-time taxi clearance Pressure from airlines to be off-stand on time to achieve punctuality statistics	SMR (part of ASMGCS) multilateralation. Observation and records
Average time runway vacated to stop engines	Minutes	CFMU	As above
% and types of aircraft given non-standard departure clearances	% A/c types	ATC tend not to vector traffic off NPR before vectoring altitude. May be beneficial to do this, allowing quicker climb, and less noise and increased r/w capacity	NTK tool
Noise contours for aircraft held in stacks	Leq _{16hr/8hr} or other low level noise indicator	Difficult to measure and interpret	No system at present
Total time aircraft held in stack	Total hours	As above	Extract and analyse trends in 'in-stack time' data field in the UKFDB

ATM service providers can have a significant influence upon fuel consumption and emissions by airlines.

Table 10. Carbon Emission KPIs

KPI	Unit of Measurement	Influencing Factors	Measurement?
Total aircraft CO ₂ emissions in national airspace	Kg	ATC Direct routing, stacking, point to point	Requires estimation
CO ₂ emissions per movement			
CO ₂ emissions per pax			
Total ground energy consumption	KW	Taxi times and engine start up times	Requires estimation
CO ₂ emissions from ground energy consumption	Kg	As above	
CO ₂ emissions caused by airborne holding	Kg	CFMU. ATC	Fuel burning/flight time
Kg CO ₂ emissions/revenue passenger km	Ratio		
Average time engine from start to take-off roll	Minutes	CFMU Just-in-time taxi clearance Handling	SMR Surface Movement Radar(part of ASMGCS multilateration. Observation and records
Average time runway vacated to stop engines	Minutes		As above

Table 11. ATM-Potential KPIs

A number of potential ATM procedures have direct environmental consequences.

KPI	Unit of Measurement	Influencing factors	Measurement?
% aircraft being given requested flight level	%	If airlines are requesting flight levels commensurate with fuel efficiency, than an ATC provider enabling the use of such levels provides lower emissions	Comparison of filed flight plan level with actual flight level. Some information from flight database, but this would not track tactical changes.
% of expedited or smooth climbs	%	Stepped climbs may need to be taken for safety reasons	Possible through radar analysis
% aircraft being given minimum track distance between city pairs or between two en route points.	Difference between actual and optimum route % Mil/Civ co-ordination	Not a reasonable measure in congested airspace, or for terminal airspace due to holding patterns. Would give environmental efficiency of routings.	Possibly compare track distance through reporting points with a measure of optimum distance.
Average Flight Inefficiency ³ (horizontal flight efficiency)	Difference between actual and optimum flight path divided by optimum flight path length	The shorter the flight, the greater the impact of arrival and departure routings (flight inefficiency varies between 10-12% for short-haul flights, and 8% for long haul flights). Achieving very high flight efficiency (very low route extensions) might mean a trade-off with operational capacity.	Measure the amount of additional fuel burned.
Fuel efficiency	Additional fuel burn per km or per passenger	Might impact on total system efficiency. Attributing climate change influences to fuel burn is problematic: e.g. time of day and altitude affect the impact of identical emissions. Terminal phases of flights can add to additional fuel burn (stacking and holding patterns, non-optimal climb and descent profiles, extended low altitude flying).	Model emissions potential at different altitudes and times of day. Measure additional fuel burn.

3.11.18. Given the fact that ATM environmental indicators appear to be in their infancy, there is an opportunity for EUROCONTROL to take a lead role in an initiative to develop a standard set of ATM related indicators for use across Europe. A discussion of the environmental factors that will impinge on the development of ATM KPIs is provided in Chapter 6.

4 ANALYSIS OF KEY OUTCOMES

4.1. Literature Survey

- 4.1.1. The survey identified a well-developed body of literature on the general theme of “environmental carrying capacity.” This concept emerged during the 1960s and 1970s, with most publications concerned with the impacts of human activity at the global level.
- 4.1.2. Since the 1980s, the science of ecotoxicology has produced a large literature on pollutants in the environment, and their implications for environmental and human health. “Tolerance limits” both for the environment and humans to receive pollution and nuisance are widespread, both in the literature and in environmental policy.
- 4.1.3. In some areas (e.g. local air quality) this has resulted in the development of fixed limits or guide values relating to critical thresholds above which adverse health effects have been shown to occur. In others, (e.g. nuisance caused by aircraft noise), regulation is designed to enable a balance to be achieved at a local level, between the adverse environmental impacts and the social and economic benefits that arise from a particular activity.
- 4.1.4. The term “environmental capacity” has been applied to a number of sectors of human activity, but according to the literature, has not been adopted with consensus in many sectors and is, in the words of one author “subject to interpretational abuse”. A clear recommendation from the literature is that if the aviation sector and its stakeholders are to use the environmental capacity concept with reasonable consensus, the following conditions must apply:

Wide consultation is necessary so that environmental capacity issues are recognised and agreed;

The social and economic implications of environmental constraints or limits need to be recognised and measured; and

Agreement is needed on the definition and interpretation of the term environmental capacity.

This is precisely what has been attempted by the current study.

³ Average Flight Inefficiency and Fuel Efficiency Indicators from PRR5. It should be noted that considerable overlap exists between these two indicators

4.1.5. The literature on the major environmental issues with the potential to constrain airports; noise, air quality, third party risk, and land use is well developed.

4.2. ACI EUROPE Airports Questionnaire

4.2.1. The response to the ACI airports questionnaire (28 out of 209) was disappointingly low. The low response rate may indicate a lack of comprehension of the concept of environmental capacity, since the majority of responses were received from airports or individuals known to be proactive in the field. It may also indicate that for some airports the concept of 'environmental capacity' may be regarded as a contentious issue, engendering a reluctance to participate. Finally, it is believed that there have been a number of questionnaires sent to European airports in the past year and this may also have reduced the response rate. Given the low number of respondents, no detailed statistical breakdown of results was attempted.

4.2.2. Approximately two-thirds of responding airports have considered the concept of environmental capacity. No two interpretations or definitions of the concept given by airports are the same (see Appendix B). Only Aeroport de Paris presented a formal definition of environmental capacity:

'The level of development of air traffic that provides economic activity with acceptable environmental impact'.

4.2.3. Eleven airports reported that they had carried out studies relating to environmental capacity. These were predominantly scenario models for noise and/or air quality, but also included linkage to operational capacity studies, and other environmental management issues. The majority of airports stated that an Environmental Impact Assessment of part or all of their operations had been undertaken in recent years. However whilst it might be expected that EIAs would address environmental capacity issues, no specific reference to this was made by respondents. Future airport environmental impact studies could usefully include an assessment of environmental capacity.

- 4.2.4. According to respondents, noise impact is the primary environmental issue restricting operations at a significant number of European airports. Other environmental issues are generally perceived by airports as being potential constraints to growth only in the medium to long term.
- 4.2.5. Air quality was not recognised as a capacity constraint by the majority of respondents, but evidence from Sweden and prescribed EU regulations suggest that it may become so in the future. In Switzerland, Zurich and Geneva airports are both subject to local emissions limits but these have not yet been reached.
- 4.2.6. Third party risk was not cited as a capacity issue by any of the respondents, but was introduced as a topic for discussion by the focus groups. Land-based capacity issues (land availability, inappropriate developments and sensitive habitats) are of major concern at some airports. De-icing of aircraft, landside traffic and water protection issues were also claimed as restricting operations at others.
- 4.2.7. A mix of noise management tools (fiscal, operational and market based options) was reported as being in use by airports. Operational restrictions were widely employed to reduce noise disturbance, driven by voluntary agreements and regulatory controls. Management of third party risk and local air quality is primarily driven by national regulation. Land use planning and habitat protection was reported as being primarily subject to regulation at a regional level. Zurich Airport cited energy and land-side issues as constraining issues, which are managed by operational and market-based tools and by voluntary agreements.
- 4.2.8. ANS providers employ a range of operational measures to manage environmental issues. A number of airports reported having established forums where ATC, airport operators and airlines meet to maximise airport environmental capacity

4.3. Questionnaire Survey of European Airlines

4.3.1. Analysis of the IATA questionnaire confirmed that key issues relating to environmental capacity (particularly aircraft noise) are recognised all by airlines. The results from this survey failed to ascertain airline attitudes toward environmental capacity however this issue was directly addressed in focus groups and interviews.

4.4. Questions To CANSO

4.4.1. CANSO has established an Environmental Task Force to develop policy and address environmental issues. Their response was focussed on noise capacity constraints and acknowledged that ANS providers have a major role to play in noise management at airports by, for example, assisting the development of approach and departure flight paths, and through effective air traffic management enabling pilots to adopt low noise approach procedures. CANSO highlighted the difficulties created by the current situation where each airport designs unique ATC procedures which create operational difficulties for airlines.

4.4.2. CANSO cited evidence that ANSPs have been instrumental in promoting co-operation at an airport level. Joint working teams of air traffic controllers, airport authorities and airline operations have resulted in successful 'environmental operations programs', leading to improved airport capacities. Examples of such action are reported from Australia, Austria, France, Germany, the Netherlands, Switzerland, and the UK.

Other issues raised in the CANSO response were:

1. Politicians regard noise as an 'airport' issue and make the mistake of drafting legislation to contain the airport's operations. In reality, managing the environment is an 'air transport system' issue, in which the system needs to operate in unison to stay within certain boundaries. Legislation should therefore be applied uniformly to the system and its players – ATM, airlines and airports.

2. Essential environmental capacity issues include:

- Noise on take-off and approach;
- Flight paths and approach angles;
- Runway selections and variations in runway use;
- Night operations;
- The impact of weather; and
- External third party safety.

3. Communications between industry and public should be improved. STARS (Standard Arrival Route) and SIDS (Standard Instrument Departure) design are often misunderstood by the public, with an understanding of aircraft performance and track-keeping being restricted to experts. Safety issues such as the influence of LVP (Low Visibility Procedures) operations, wind and Meteorological contributions on track keeping, glide slope angles, minimum speed controls, timely check lists and landing gear management are routinely misunderstood by environmental campaigners. The aviation industry has much to improve in dealing with complaints and misunderstandings raised by the public; which often considers ATM responsible for aircraft flight paths and therefore for aircraft noise.

4.4.3. CANSO proposed that EUROCONTROL should highlight the impact on safety of the current European approach to air traffic management and the environment, and focus on obtaining political support to achieve European harmonisation of environmental procedures.

4.5. Semi-structured interviews

4.5.1. As might have been expected when consulting so many individuals from such diverse stakeholders groups involved in the aviation environment debate, a wide range of responses were obtained. A summary of responses is set out in Section 5; and no further attempts have been made to abridge responses here, although they have informed later discussion.

4.6. ACI Europe Environmental Strategy Committee

- 4.6.1. The (ACI) European Environmental Strategy Committee forum, where twenty committee members gave responses to five questions, produced a valuable insight (from an airport perspective) into the current and future impingement of environmental capacity at European airports.
- 4.6.2. Seventy five percent of respondents noted current environmental capacity constraints, with all respondents noting likely or possible medium or long-term constraints. This information highlights the seriousness of environmental capacity issues as a constraint at European airports.
- 4.6.3. The issue of greatest concern was noise, but at some airports, air quality, water pollution, waste, third party risk, and road access are regarded as constraint issues.
- 4.6.4. The majority of respondents were of the view that constraints at individual airports do already, or could affect airspace management, supporting the notion that airport environmental capacity constraints affect airspace management capability.
- 4.6.5. The following issues were reported by respondents to be the most important factors in the effective management of environmental capacity constraints:

Identify which environmental issue are/will be capacity constraining;

Land use planning;

Reduce impact at source;

Abatement procedures;

Technical and social management programmes;

Collaboration between stakeholders;

EU environmental policy; and

Legislation on environmental quality standards.

- 4.6.6. To some extent, this list follows the ICAO “Balanced Approach for noise management”, but it was notable that different respondents reported different management solutions, indicating the heterogeneous approach to management of environmental capacity across Europe.
- 4.6.7. It would appear from this part of the study that ATM is well integrated into airport environmental activity, but this conclusion must be tempered by the fact that participants’ representation on the (ACI) European Environmental Strategy Committee, makes these 20 airports among the most environmentally pro-active in Europe. However, a further 11 airports from the ACI questionnaire study also reported local involvement by ATC, and CANSO in their response cited several examples of ATC involvement. This is an encouraging trend, and this “best practice” might usefully be promulgated by EUROCONTROL.
- 4.6.8. The issue of capacity being lost at one airport due to environmental restrictions at another is not common across Europe, but may be set to grow. Most respondents did not feel qualified to answer this question, indicating the need for further research, especially as it is an emerging or current problem at some airports.

4.7. Stakeholder Focus Groups

- 4.7.1. The focus groups were in general useful in allowing more depth and freedom to discussions on the issues under study. Since the local situation of each airport focus group varied, it was difficult to compare outcomes between the groups. Rather, these studies acted as place-specific “case histories” of the degree to which environmental capacity issues were addressed, and the degree to which collaboration between airport, air traffic control, and airlines takes place.
- 4.7.2. In general, some focus group participants were more informed than others on environmental capacity issues, and a variety of approaches to environmental capacity issues was observed. Participants displayed varying views and levels of enthusiasm on environmental capacity issues raised during the focus groups. One primary theme viewed unfavourably by participants was imposition of (operational) limits by third parties, whether EU, national

government, or airport. One of the more positive outcomes of the focus groups was to establish among stakeholders that environmental capacity was an issue for all parties involved, and that each has a very positive contribution to make in, enhancing, securing and managing capacity.

- 4.7.3. In general, airport personnel were acutely aware of capacity issues, whilst other participants, from airlines and ATC, displayed varying degrees of awareness and involvement in managing environmental issues.
- 4.7.4. Salzburg (small regional airport) and Schiphol (large hub airport) are highlighted as exhibiting good practice on collaboration between airlines/ATC/airports and in understanding and managing environmental capacity issues. Athens is a good example of an airport where there is excellent environmental management. Environmental capacity has barely emerged as an issue, the airport having been operating only since March 2001. Environmental impact and environmental licensing studies were completed prior to airport opening and have defined the framework of measures to be applied for at least a 10 year period.
- 4.7.5. The London BAA and Manchester airports displayed varying degrees of collaboration between airlines/ATC/airports, and furthermore, the concept of environmental capacity is creating some friction in aviation circles. It may be that the on-going UK policy review process will clarify this issue to some extent.

4.8. Summary of Individual Focus Groups

Athens

- 4.8.1. This Focus Group provided the perspective of a new, medium-sized airport, which regards environment as an important management issue, but not a constraint issue. The Environmental Department of Athens International Airport has been certified according to EN ISO 14001 since December 2000, so providing to airport authorities a comprehensive picture of environmental issues and enhancing management capabilities.

4.8.2.

The toleration of Olympic Airways' Chapter 2 fleet until recently, due to “economic slippage”, ended in 2002. Noise abatement procedures include runway preferences at night, which lead to exemptions in the case of ~10% of night-time movements. There are no noise contour restrictions, and no fiscal instruments in relation to noise performance. Nevertheless, there is restriction of departures during the period 1500-1700 from runway 03R.

4.8.3. The AIA community programme deals with enquiries and complaints, and the focus group reported little pressure from local communities. However, social and cultural factors may change, and with growth, there is potential for noise constraint to occur.

4.8.4. There is some evidence at AIA that the airline companies are not strongly affected by the airport environmental management system, and that the existing safety forum at which airports and airlines discuss noise issues might be improved to include environmental issues. There is also scope for local ATC to become more involved in noise issues. Since October 2002, monthly meetings have been taking place with HCAA to discuss noise issues.

4.8.5. The HCAA could also benefit by having a stronger forum for ATC/airport/airline/community involvement on noise and other environmental issues. (Addendum: since October 2002, monthly meetings have been taking place between AIA and HCAA to discuss noise issues).

Salzburg

4.8.6. This Focus Group provided the perspective of a small airport (1.3 mppa, Austria's largest regional airport). The local issues include proximity to a city centre, and due to spectacular mountain scenery, tourism. The airport is owned by the City of Salzburg, which has insisted on good environmental management. The main capacity issue is noise and this was recognised over ten years ago. The key to securing capacity has been technical and community noise management. ATC involvement in this process is clearly an

example of good practice, as is the interaction on this issue of airport, ATC and airlines.

4.8.7. The excellence of environmental management at Salzburg is formally accredited through both EMAS (Environmental Management and Auditing System) and ISO 14001 certification, and more importantly, in the way the system is “lived”. The Salzburg team prefer informal progress to minuted meetings and forums, and put a high value on training and encouragement throughout the staff.

4.8.8. A meeting was convened with Airlink, a private airline and flight school, operating a fleet of Cessna, Beechcraft and Piper light aircraft. These aircraft, especially those on training circuits, have been identified as a major source of noise nuisance to local communities, and Airlink is working with the airport to look at changing and alternating circuit routes to reduce disturbance.

Amsterdam

4.8.9. This focus group provided the perspective of a major airport (one of Europe’s big four) in a state which has adopted environmental capacity at airports in policy, and in law. Putting policy into practice has been extremely problematic, leading to a crisis of operational management in 1998, when capacity limits were reached and breached. In 2002, the system is agreed not to be perfect, but has achieved the following notable features:

1. The airport, airlines, and ATC must work closely together to get optimum traffic capacity. It is interesting that even where the concept is of environmental capacity enshrined in policy and law, and furthermore is thought by the industry trio to be useful and progressive, no actual definition is present. One participant offered a definition, but it was not acceptable to all.

2. All the major environmental issues listed (noise, air quality, climate change, land use) were regarded as capacity issues, along with third party risk and visual intrusion. The range of controls recommended tended to favour management tools backed by regulation.

3. ATC is already closely involved with management of environmental capacity.

4. The SWOT analysis indicated that the Dutch group did not think either scenario especially attractive, although Scenario II was marginally preferred.

London/Manchester

- 4.8.10. Discussion rapidly moved from consideration of environmental capacity to “limits”. Some participants were quite resistant to a fixed limit concept, concerned by the operational implication of limits, the difficulties of calculating and gaining political acceptance, and outcomes of limit breaching. It was agreed that gaining consensus on limits is difficult, and that airport limits could have deleterious environmental consequences on a wider scale as well as adverse socio-economic effects. Socio-economic, regeneration and local issues are potentially ignored, and limits do not necessarily solve environmental problems, and may be a blunt instrument in achieving developmental consensus.
- 4.8.11. UK policy-makers may be lukewarm to the environmental capacity concept, with indications that such a policy may be too rigid, and lead to costs outweighing benefits.
- 4.8.12. There was agreement that new metrics taking into account the wider aspects of environment/sustainability capacity were needed if the environmental concept was to mature, especially on noise issues. Any limits should be based on Key Performance Indicators (KPIs), not simply metrics currently in use.
- 4.8.13. A key interpretive word, which came up regularly, was “tolerance”. That is, some communities are more tolerant than others. Perceptions change over time, and are subject to economic considerations.

4.9. Discussion of Key Findings

- 4.9.1. The interrogative aspects of this study (questionnaires, interviews, focus groups) set out to find the answers to ask five key questions:
1. What is the meaning and definition of environmental capacity in relation to European airports?
 2. What environmental issues affect environmental capacity, and how should these issues be managed/regulated?

3. What is the role of ATM/ATC in particular, and the interaction of airport operators, airlines, airspace user and the ANSP in enhancing, securing and managing environmental capacity?
4. What are the issues shaping European policy development in respect of airport environmental capacity?
5. What are the implications for EUROCONTROL traffic forecasting designed to meet future capacity needs?

4.9.2. These issues were also considered as part of the literature review. A summary of research findings for each question is analysed and discussed below.

What is the meaning and definition of environmental capacity in relation to European airports?

4.9.3. Whilst there are few published explanations of the term environmental capacity as applied to aviation, a number of definitions or interpretations were collected under the present study. These are as follows:

The extent to which the environment (and the local community) is able to receive and tolerate, assimilate, or process outputs derived from airport activities;

The impact of airport operations upon the local environment and upon the lives of residents of local communities;

The level of an airport's operational capacity at which those deciding an airport's future agree that the adverse environmental and social dis-benefits arising from its development and operation outweigh the benefits that the airport would otherwise have brought;

The component of capacity constraint at airports or airspace described by environmental factors.

A proxy for environmental limits without any reference to what that limit might be;

A concept which allows for a certain amount of environmental impact without overt description. There is a question as to whether or not it can be defined at all, because it is entirely dependent on the tolerance of communities;

A point at which the marginal benefit equated to the marginal cost;

A flexible limit;

Environmental capacity is the limit of environmental tolerance;

Environmental and Human Toleration Capacity;

Environmental capacity is the traffic volume possible within environmental load limits, depending on aircraft environmental characteristics (noise, emissions) and time distribution of traffic;

The ability of a specific space, which interrelates dynamically and can accept pressure from air traffic on the ground, during Landing and Take – Off (LTO) and navigation and can affect the imposed environmental limits;

A balanced combination of operational and environmental conditions that do not exceed a specific range of values; and

The level of development of air traffic that provides economic activity with acceptable environmental impact.

4.9.4. There are several other interpretations of the concept, as set out in Section 5.0. Clearly, there is no current consensus on the meaning or interpretation of the term environmental capacity between different aviation stakeholders. Furthermore, there is no consensus within NGO lobby groups, nor within industry. In general, while NGO groups are in favour of applying limits, many consultees agree that if limits were decided to be appropriate, they may be operationally difficult to achieve.

4.9.5. There is unlikely to be consensus around the concept of “limits”, as they are currently understood by some industry players. Industry groups were keen that a cost-benefit element be included in any interpretation of environmental capacity.

4.9.6. There is an opportunity for EUROCONTROL to broker an Industry-wide agreed definition, or set of definitions, and many of the key stakeholders reported that they would welcome this. CATE proposes that the following definitions be considered.

The first is a generic definition: *The extent to which the natural and human environment is considered able to receive and tolerate the environmental impacts of airport activities.*

The second reflects environmental capacity as a component of operational capacity: *The component of capacity constraints at airports or their airspace that is determined by environmental factors.*

The third reflects the linkage of environmental impacts to cost/benefit analysis and sustainable development: *The extent to which adverse environmental and social impacts balance positive economic and social benefits.*

4.9.7. These interpretations are not mutually exclusive. It is recommended that they be “tested” on stakeholder groups, as could EUROCONTROL’s proposed concepts of “Airport Environmental Capacity Zone”, and “Airport Environmental ATM Zone”.

What environmental issues affect environmental capacity, and how should they be regulated and managed?

4.9.8. One of the difficulties in this study has been establishing a separation between *environmental management issues* and *environmental capacity issues*. Many airports, and some airlines and ANSPs have environmental management systems (EMS) that deal with environmental issues that are significant features of their operation. However, these issues only become “capacity” issues when constraints are active or envisaged. Additionally, management of environmental capacity issues requires a different approach (based on scenario planning) than EMS, which tends towards operational management rather than planning. The following issues have been identified by the participants in the study as being actual or potential environmental capacity constraints.

Aircraft Noise

4.9.9. Results from this study indicate that the main environmental issue relevant to airport capacity presently and anticipated over the next 20 years in Europe, is the disturbance caused to residents of communities surrounding airports by aircraft noise. The results of the airports survey undertaken in this study indicate that at present 66% of airports are already constrained by noise-related issues with an additional 13% anticipating that noise would constrain their operations in the medium to longer term.

4.9.10. A number of major airports across Europe have reached their noise capacity before having made full use of the runway and terminal infrastructure they have provided (ACI 1995, ICAO 1993). Some claim to have failed to gain planning approval for further development as a result of the noise implications of future traffic growth, despite the proven demand for air travel that exists in the regions they serve. Finally it is not uncommon for airports, particularly those which are given planning approval for further major developments, to agree or be set noise limits for all their future operations (e.g. Amsterdam-

Schiphol, London-Heathrow, Manchester, Salzburg, Stockholm-Arlanda, Stockholm-Bromma).

4.9.11. Some airports have operational limits that restrict the number or types of aircraft that can land or take-off at particular times of the day and night. Some have runway use restrictions developed specifically to address noise concerns but which reduce the operational capacity of the airport. Finally the implementation of particular operating practices such as the adoption of preferred noise routes for departing aircraft, the adoption of low noise approach procedures or action to minimise the use of reverse thrust all reduce runway operating capacity.

4.9.12. A draft report to the European Parliament in 2000 (2000/0194{COD}) stated that as many as one in three Europeans complain about noise from transport and industrial sources. The report set out an EU noise policy which included a number of proposals of significance to the air transport industry. The most important of these was a specific directive dealing with noise from aircraft near airports which will include requirements for noise action plans and targets to reduce the number of people exposed to higher levels of noise over 10-20 years. Such regulation could in the future result in capacity limits emerging for some of Europe's airports based upon noise in the same way that EU air quality legislation could constrain airport growth due to emissions.

4.9.13. There is unequivocal evidence that the auditory system can be damaged by exposure to extremely high levels of noise. However, despite considerable research into the possible non-auditory health effects of noise the results are largely contradictory and inconclusive. The broader World Health Organisation (WHO) definition of health helps to resolve this apparent paradox. This states that health is a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity. The inclusion of well-being in the definition expands the concept of health beyond clinical significance to encompass a number of effects of aircraft noise that are well known i.e. annoyance, sleep disturbance, interference with speech communication, cognitive and performance effects.

4.9.14. The problem of aircraft noise disturbance involves the complex interaction of a number of physical, biological, psychological and sociological processes

(Schultz 1978). The relevant physical factors include those which are associated with noise generation e.g. aircraft type, mode of operation and the resulting noise level. The other critical components are the human factors which include the basic biological systems of audition followed by the psychological processes that interpret these signals and can include health status, annoyance and stress (Job 1996). The further interpretation of noise disturbance can be subjected to sociological conditioning that may include factors such as socio-economic status, cultural and lifestyle differences. Finally, although individuals may complain about the 'noise' of aircraft, a variety of other factors such as fear of air accidents or disturbance from other airport activities can be the underlying cause of annoyance (Moss *et al.* 1997).

4.9.15. It is possible to model the future noise impact of traffic growth and from demographic information calculate the numbers of people who would be exposed to noise disturbance as the airport develops. This would give an indication of the potential sensitivity of a particular airport to this issue. However it should be noted that social and economic development brings with it less tolerance of disturbance such that levels of noise which are considered acceptable today will result in increased community opposition in the future.

4.9.16. A wide variety of measures have been introduced to reduce noise exposure. ICAO envisage a balanced approach to control involving land use planning, technological and operational improvements and, as mentioned above, the introduction of operational restrictions.

4.9.17. The ICAO "Balanced Approach to aircraft noise management" is a multi-step process for controlling noise on an airport-specific basis, consisting of the following phases:

Identification of an airport's specific noise problem, based on objective, measurable criteria;

Evaluation of costs and benefits of the four principle types of noise reduction measures (reduction at source, land-use management, noise-abatement operational procedures and operating restrictions); and

Selection of the measures to achieve maximum environmental benefit most cost effectively.

- 4.9.18. The balanced approach is intended to allow for transparency, by requiring consultation with stakeholders, dissemination of information and dispute resolution (ICAO, 2001: Assembly Resolution A33-7).
- 4.9.19. The process of land use planning was designed many years ago to prevent unsuitable development in areas of high noise exposure around airports. Such controls have only been introduced in recent years in some European countries and there is variation in the extent to which they are enforced in others. As a result there are major differences in the number of people exposed to higher levels of noise around different European airports.
- 4.9.20. There is no question that significant improvements have been made in aircraft engine and air frame technologies over the past 20-30 years which have dramatically reduced the level of and the area of exposure of noise generated by modern aircraft. However, it would appear that the potential for further improvement is becoming more difficult. No step change in technology is on the horizon and it can be anticipated that any such development would be exceedingly costly.
- 4.9.21. Even when new technologies have been developed, it takes many years for certification and airworthiness approval mechanisms to take effect. It then takes even longer for aircraft to progressively enter the airline fleet, if only because of the very high costs of buying or leasing new aircraft. A less costly approach would involve the retrofitting of existing aircraft with new or 'hush-kitted' engines. This has been successfully achieved in the past, although the noise benefits have been far less dramatic than those that could be achieved through replacement with new aircraft.
- 4.9.22. A wide variety of operating practices have been developed by airlines in order to reduce the noise generated by their flights. Continuous descent approaches reduce arrival noise. Quiet take-off procedures, which involve throttling back the aircraft engines once a safe height has been reached, minimize departure noise. Minimum noise routes for arriving and departing traffic can ensure that as far as possible aircraft are routed away from built up areas. On the ground, air traffic management procedures can ensure that aircraft are held in locations where noise propagation does not affect local

residents. However, as indicated above, these management practices can reduce the operating capacity of the airport.

4.9.23. At airports, purpose-built engine test facilities can contain the noise generated during ground maintenance procedures. The construction of noise mounds or walls can prevent localized noise exposure: for example, the domestic terminal at Copenhagen Airport has been designed to incorporate and act as a noise wall which protects local housing from apron noise. Another costly and major infrastructure development reported specifically to reduce noise exposure involves the realignment of runways (e.g. Schiphol) to reduce the number of people overflown by arriving and departing aircraft. In the most extreme examples, entirely new airports have been built in remote locations (e.g. Munich). Meanwhile in the UK and Netherlands serious consideration has been given to the development of new coastal or off shore locations to avoid operational constraints (especially at night) caused by aircraft noise.

4.9.24. Finally some airport operators (e.g. ADP and Schiphol) have resorted to, or are considering buying up, properties to reduce the number of people exposed to higher levels of noise, or making compensation payments in reparation for noise nuisance. This is one way of investing in environmental capacity.

4.9.25. The nuisance caused in local communities by noise and hence the level of annoyance or community opposition to future airport growth is not simply a function of the frequency and noisiness of aircraft movements. It is also affected by people's tolerance of disturbance which in turn will be influenced by issues such as affluence, attitude and lifestyle, all of which can influence expectation of quality of life. Furthermore, the community's understanding of the social and economic consequences of constraining or permitting further airport growth can influence their toleration of noise. Existing noise metrics do not take account of the fact that the residents of communities surrounding airports which serve less affluent populations are likely to be more tolerant of aircraft noise if at the same time stand to gain benefits, e.g., additional employment from the continued growth of those airports. This indicates that part of the solution to opposition caused by aircraft noise is actually action to educate and encourage tolerance through community investment as well as action to reduce noise exposure.

4.9.26. The concept of community tolerance, although understood for a number of years is now emerging more strongly in terms of airport responses to the management of noise. In this context it is possible to propose a definition of the term “Aircraft Noise Toleration Capacity” as:

‘The extent and pattern of noise exposure tolerable to local airport communities, arrived at by negotiated local settlement, informed by socio-economic analysis’.

Local Air Quality

4.9.27. After aircraft noise, local air quality was deemed to be the most significant environmental issue with the potential to constrain airport growth, with many respondents regarding this as this as a medium-term potential capacity constraint.

4.9.28. Air quality in the vicinity of an airport is determined by a number of factors. The major sources of emissions that affect local air quality, and are associated with airport operations, are road traffic, aircraft and apron activities such as refuelling. It is predicted that over the next two decades, emissions from road vehicles will fall and at that time, given the current growth in aviation and rate of technological change, aircraft may have a much more significant influence upon local air quality than is the case today.

4.9.29. At this time, only Stockholm-Arlanda, Gothenburg, Zurich and Geneva airports reported that local air quality (or local emissions) have the current potential to constrain airport operating capacity. However respondents from a number of countries indicated an expectation that local air quality would potentially constrain airport capacity in the future.

4.9.30. The European Union has developed a regulatory framework, supported by national legislation to establish air quality management zones across the Community and introduce targets and mandatory limits for local air quality. The operation of an airport and its associated infrastructure can be the most significant source of pollution in a particular locality. Modelling studies suggest that a number of major airports across Europe may fail to comply with regulatory requirements with the result that local air quality may have the potential to constrain airport growth.

4.9.31. A variety of sophisticated air quality modelling systems exist which can be used to forecast future levels of pollution from all of the relevant sources. As with the issue of noise measurement there is no consensus at the present time as to the most effective modelling tools or the best indicators with which to describe local air quality. A number of projects are under discussion (e.g. AERONET) to compare modelling tools to ensure a higher level of compatibility, and agree a common methodology and a single suite of indicators for use across Europe.

4.9.32. Airports in Sweden and Switzerland have implemented emissions related-operational charges to encourage the use of aircraft with lower emission power plants. Airside infrastructure (taxiway) developments and improvements to ground movements procedures have been implemented to reduce taxiing and holding times for aircraft. Several airports report the introduction of electric or gas powered vehicles for apron use. Finally a variety of measures have been implemented to reduce fugitive emissions arising from refuelling activities.

Third Party Risk

4.9.33. A number of consultees stated that this was an area of potential future constraint, especially if left unmanaged. Communities surrounding airports and their elected representatives are increasingly paying attention to the risk of an aircraft crashing into an urban area with the resultant loss of life on the ground. Awareness is high at airports where air accidents have occurred in the recent past (e.g. Schiphol). Accident rates tend to be higher along the approach and departure routes where air traffic is concentrated. As with noise and local air quality, the growth in air traffic is offsetting the benefits of increasing safety with the result that the risk of an air accident is likely to increase year-to-year.

4.9.34. In some countries such as the UK and the Netherlands, risk contour modelling systems are used to predict areas of high risk from air accident with regulatory controls limiting the level of societal risk that is considered acceptable. This will determine zones around airports where it is 'unacceptable' for people to live or work. Continuing growth in traffic has the potential to increase the size of these zones unless offset by improvements in

the safety performance of individual aircraft and air traffic services. Preferred noise routes designed to minimise the number of aircraft that over-fly populated areas bring additional benefits in reducing the extent of third party risk.

- 4.9.35. Where on-going traffic growth at some airports has generated growth in third party risk contours some airports are being 'obliged' to buy up and demolish houses in order to remove people from the areas of highest risk. Again it can be anticipated that public awareness and expectation will increase the priority given to dealing with third party risk in the future.

Ecological and Habitat Impacts

- 4.9.36. A number of respondents considered that ecological or habitat issues in the environment surrounding their airport could act as a constraint upon further infrastructure development. Airports cover large areas of land which can often be of considerable ecological value, particularly if they are located in a green belt surrounding a major urban conurbation. The ability of an airport to extend its boundaries or even build upon parts of its own land can be restricted by the value of the habitats threatened. This problem is most acute in parts of Europe where sites protected by national or international convention (e.g. Special Area of Conservation (SAC) and sites protected under the RAMSAR convention) have prevented or restricted airport development.

Climate Change

- 4.9.37. A number of consultees to this study considered greenhouse gas emission a potential airport constraint. However most felt that an international approach to control and management was required, based upon the protocol provided in the Kyoto Agreement on greenhouse gas emissions, and in this regard it is difficult to envisage how individual airports might be affected. A few airports (e.g. London-Heathrow) have begun the process of producing carbon or greenhouse gas emissions strategies, however while a number of consultees could envisage constraints based upon these issues, none could envisage how such regulation might be applied at a local level. One potential indirect impact of climate change could be to bring changes in patterns of tourism and hence air traffic demand.

Other Issues

4.9.38. Other issues identified as potential constraints on the operational capacity of an airport in the longer term were waste generation, energy and water availability and effluent released to water/land. Here the theoretical constraints would arise from either the ability to ensure an adequate and secure supply of utilities or to facilitate the removal and treatment of (solid and liquid) wastes. The potential costs of ensuring these services and the availability of land to enable necessary infrastructure provision were also raised.

Interrelationships between environmental impacts - tradeoffs

4.9.39. Given the inter-relationship between different environmental consequences of the operation and growth of airports, there are certain situations in which one impact has to be traded off against another.

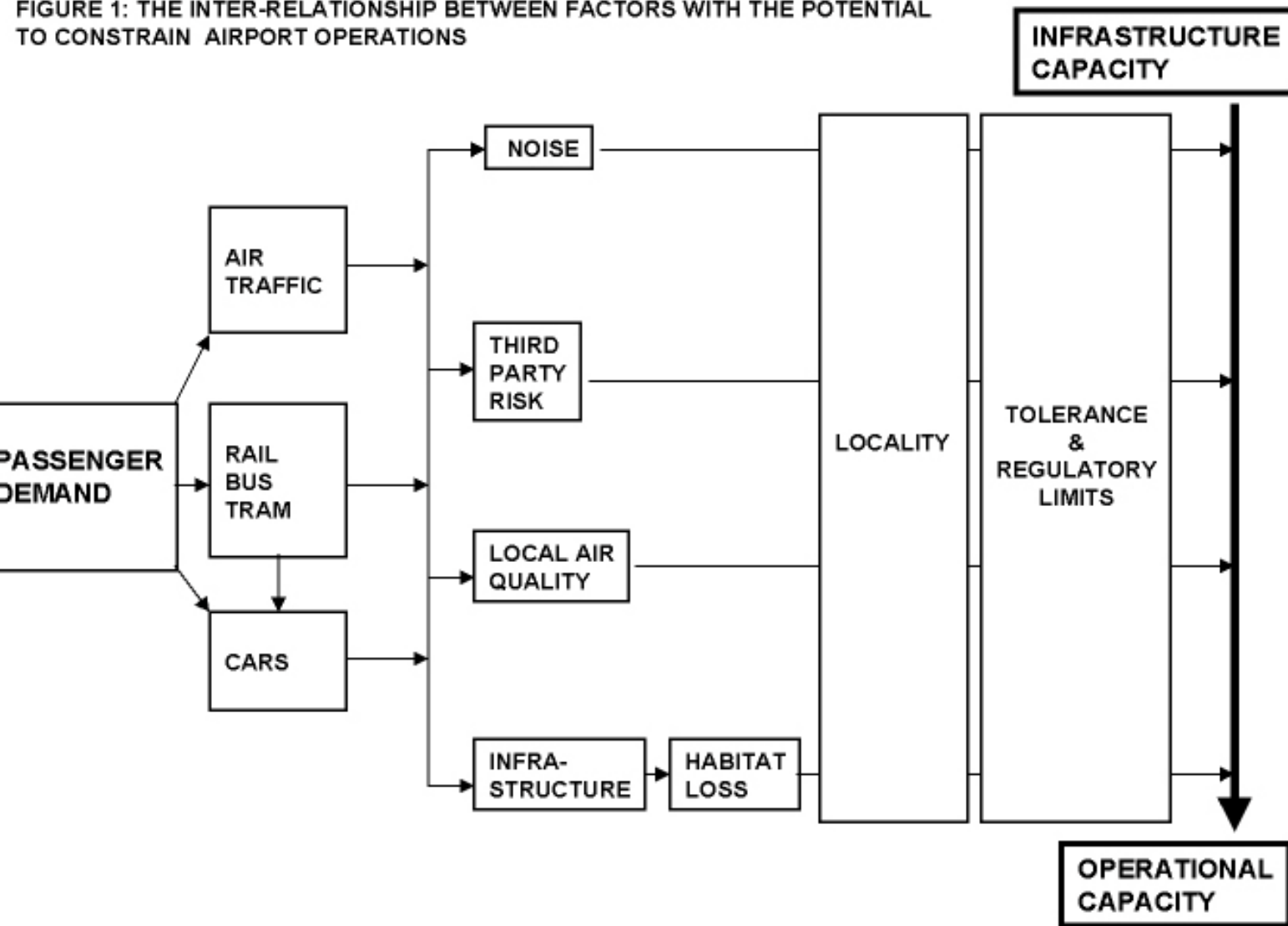
4.9.40. Figure 1 provides a schematic representation of the way in which different environmental impacts relate to each other. It also indicates the regulatory and other societal controls or restrictions that are associated with them and shows how these could reduce or restrict the operating capacity of an airport.

4.9.41. Reference to Figure 1 provides a useful way of illustrating other trade-offs. For example, local emissions arising from growing road traffic could in theory cause the air quality management zone in which the airport is located to fail to meet local air quality regulations. This constraint could be alleviated by the construction of a rail link to reduce car use, however this would require additional land-take that could be restricted by habitat protection issues in the surrounding countryside.

4.9.42. For example, the development of preferred noise routes designed to reduce community disturbance can result in departing aircraft having to fly further during the early phase of flight. This can increase fuel burn and engine emissions.

4.9.43. There may also be conflicts between the requirement at an airport to reduce fuel burn and emissions, and a requirement to minimise noise. This is already an issue at some airports.

FIGURE 1: THE INTER-RELATIONSHIP BETWEEN FACTORS WITH THE POTENTIAL TO CONSTRAIN AIRPORT OPERATIONS



What is the role of ATM/ATC in particular and the interaction of airport operators, airlines and the ANSPs in enhancing, securing and managing airport capacity?

- 4.9.44. Historically it has been airport companies that have taken lead responsibility for airport environmental impact, even though the majority of emissions arising from their operation come from their customer airlines and service partners. It has been airports that have first contact with the public, politicians and planning bodies in order to either assuage public concern about existing operations or secure approval for future growth.
- 4.9.45. Given current concerns about the adverse environmental impacts, there is now a tendency for airports to agree environmental constraints or operational targets and limits in order to secure approval for future growth. Yet the ability of airports to meet those targets is dependent upon the efforts of their airlines and ANSPs. One important finding from focus group discussions held at European airports was the suggestion that airports, airlines and air traffic service providers should liaise closely before making any public agreements of this nature so as to ensure that such commitment can be met.
- 4.9.46. Taking aircraft noise as an example, airports may introduce monitoring systems, complaints handling services, noise related operational charges and restrictions. However it is the type of aircraft operated by the airline and the way in which it is flown that is the primary determinant of the level of noise exposure caused in neighbouring communities.
- 4.9.47. Air Traffic Controllers can also have a major influence upon airport environmental impact through their management of aircraft on the ground, on approach and departure and within the wider TMA. On landing and departure, air traffic controllers working with pilots can help maximise opportunities for the adoption of quiet approach procedures, adherence to preferred noise routes, and minimal use of reverse thrust. By careful sequencing of aircraft and by selecting the least noisy aircraft to be given non-standard departure clearances, ATCO's can provide maximum flexibility within the airport operations system whilst ensuring the noise impact of operations is kept to a minimum.

4.9.48. It was evident, particularly from the focus groups held at Schiphol and Salzburg, that airports which have developed some of the most advanced thinking and procedures with regard to managing their environmental impact have also developed the greatest level of dialogue between themselves, their airlines and air traffic service providers. At some locations the airport's role is restricted to encouraging the exchange of information and expertise, at others such arrangements have been encouraged through the development and inclusion of environmental clauses in commercial contracts between the different parties.

4.9.49. The positive contribution from CANSO to this study, and the contribution of several ATM organisations, gives clear indication of the potential role that ATM providers can have in estimating and securing environmental capacity.

What are the issues shaping European policy development in respect of airport environmental capacity?

4.9.50. As might be expected, the desired approach to new policy development on capacity varied among the study consultees. However, there is some consensus that the principles of sustainable development need to underpin policy development at the European level.

4.9.51. It is widely accepted that the social and economic benefits arising from the growth of airports are significant indeed, not only in respect of European integration but also in terms of the participation of the states or regions of Europe in the global economy. The adverse environmental consequences of the continuing growth of the European air transport industry are however, very significant also. The European Community is committed to the principles of sustainable development and therefore faces a major challenge in its attempts to encourage development and mobility in a sustainable manner.

4.9.52. The demand for aviation in Europe is growing at such a pace that it is predicted to continue to outstrip the benefits that accrue from technological and operational improvements such that many of its environmental impacts have the potential to increase in the future. This same factor is putting increasing pressure upon the physical infrastructure of airports not only in terms of their ability to handle aircraft but also in terms of ground transport

access, the provision of facilities on site to handle wastes produced and also airport ability to secure more resources (energy, water etc) to ensure their operation and maintain service standards.

4.9.53. Increasing affluence, one of the major factors driving demand, also results in an increasing expectation of quality of life and a declining tolerance of environmental degradation. Growing public awareness of environmental issues and the evolving scientific understanding of the adverse social, environmental and health implications of the air transport industry will add to public concern and continue to drive environment up the political agenda. The benefits that accrue from airport development are significant but are spread across entire regions. The adverse environmental impacts are however borne by residents of communities surrounding airports. Given that unlike other forms of transport, air travel is only used comparatively infrequently, the wider public are unlikely to actively campaign for growth in the industry unless they see their own travel plans being constrained. A significant proportion are, however more likely to identify with the concerns of the airports neighbours and see aviation as a blight upon the environment. For these reasons, it is evident that future growth of airports will become increasingly difficult to achieve. This is further evidenced by:

The time taken to achieve planning approval for the fifth Terminal at Heathrow;

The difficulties encountered in achieving approval for further development at Frankfurt and in Paris;

The efforts in the Netherlands to develop an off-shore airport, and in the UK to develop a new coastal airport near London; and

The recent attempts by residents of communities surrounding Heathrow Airport to utilise human rights legislation to prevent night flying.

4.9.54. As detailed above, the disturbance caused by aircraft noise is the single most significant environmental impact which threatens to constrain airport growth and this provides a useful illustration of the challenge faced by airports. Three important factors will exacerbate the level of disturbance faced by residents of communities around airports:

The first relates to the fact that while the noise of individual aircraft movements has declined, traffic frequency has increased, with the result that the balance of nuisance at some larger airports is moving away from the disturbance caused by each aircraft to the frequency with which people are over-flown.

The second relates to the fact that given new noise certification regulations recently announced by the ICAO and the anticipated rates of growth in the industry, the noise climate around many airports is likely to deteriorate in the future, reversing a trend of improvement that has taken place over the past 20 years as Chapter 3 aircraft have replaced the Chapter 2 fleet; and

The third is linked to the fact that disturbance is a subjective issue that is related to perception or tolerance of nuisance and that this in turn declines with increasing affluence. As a result, levels of disturbance that were 'acceptable' in the past will no longer be considered so in the future.

4.9.55. Sensitivity to aircraft noise is particularly acute within Europe because of high population density, the size of the aviation industry and the fact that Europe comprises a comparatively affluent population in well-educated democracies with a high expectation of quality of life and low tolerance of nuisance. This is of major significance to the air transport industry as disturbance or increasing nuisance will lead to increased levels of community and political opposition and in turn will act as a barrier to airport growth.

4.9.56. It is clear that the growth of the air transport industry, increasing environmental pressures and increasing affluence will all drive tighter environmental regulation over a variety of fields from local air quality and noise through to wastes disposal.

4.9.57. In the field of climate change, NGOs continue to call for the imposition of taxation upon aviation fuel in keeping with the principles of the internalisation of external costs and the application of the polluter pays principle. Meanwhile airlines are considering the concepts of voluntary agreements emissions trading schemes. While it is difficult to predict how these factors will affect demand and hence airport growth it is clear that they cannot be ignored.

4.9.58. In general, most consultees felt at a European policy level, a framework or guidelines should be established on the management of environmental capacity issues at airports. This should take account of the need for fixed

limits on some issues (e.g. health related to air quality) but local flexibility on others (e.g. noise nuisance).

What are the implications for EUROCONTROL traffic forecasting designed to meet future capacity needs?

4.9.59. The capacity of the air traffic system within Europe is a function of the capacity of its airports and their associated ATM systems and also the capacity of the *en route* sector. EUROCONTROL has already developed a number of traffic forecasting and analysis systems that take account of the infrastructure capacity at different airports across Europe and existing operational constraints or restrictions (including some environmental restrictions such as night flying constraints) at those airports. However they do not yet take full account of the potential of environmental issues to constrain the ability of airports to make full use of their existing capacity in the future or to obtain approval for further infrastructure development.

4.9.60. Prior to this study it was known that certain environmental issues associated with certain airports could restrict operations or constrain growth. It is now evident that tools are required to allow these factors to be included in scenario plans to further refine the EUROCONTROL forecasting and analysis systems. This will allow both current and future infrastructure and environmental factors to be integrated into an airport forecasting system to enable far more accurate assessments to be made of the anticipated capacity of the European air transport system.

4.10. Development of New Tools for Environmental Capacity

RACE

4.10.1. The terms of reference for the present study, in particular those for the development of toolkit/conceptual model, require compliance with EUROCONTROL's current work of the Airport Operations Programme and in particular with the Guidelines on Runway Capacity Enhancement (RACE).

4.10.2. RACE is concerned with measures to enhance runway capacity, and contains a catalogue of best and recommended practices. Environment is considered in relation to available capacity, and guidelines are provided on mitigation and

best practice at some European airports. Whilst RACE considers that the runway is the most critical link of an airport's operational capacity, indirect airside environmental constraints to runway capacity and offsite issues are also considered. Case studies citing best practice on environment are Schiphol, Heathrow, and Salzburg, and community relations at Manchester.

4.10.3. A clear recommendation of RACE is the establishment of internal technical working groups at airports comprising airport operator, ANSP , and airspace users, to reduce environmental/community impact in order to achieve maximum runway capacity.

4.10.4. RACE provides useful background, case history and some useful recommendations. The current study develops the analysis of interaction of environmental, infrastructural and operational capacity issues, and is able to provide in more detail than RACE, a best practice checklist for consideration.

Modelling Environmental Capacity

4.10.5. There have been previous attempts to combine environmental and operational factors in airport development models, notably by Thomas *et al* (2001). The intention of this published model is to facilitate airport planning scenarios which avoid breaches of air quality and noise regulations. The model attempts three levels of analysis: "general", "spatial" and "spatial/temporal", and has a range of environmental indicators. To date, the model is still at a conceptual stage, and has not been tested at an airport.

4.10.6. The present study has addressed the development of a conceptual model through an alternative route. An established and tested airport operations model, CAMACA, has been investigated for its potential to incorporate environmental inputs.

4.10.7. The Environmental Capacity Screen/Toolkit (ECS/T) was designed to provide an effective screen of potential environmental capacity issues at European airports, and to provide ways of estimating and managing those issues. The model shows good promise in integrating with CAMACA, although this will require further study in order to confirm whether/how integration can occur. This would permit more effective decision making which could a) improve the

operational efficiency of the airport system and b) make environmental savings, helping to offset the effects of growth.

4.10.8. The ECS/T model has been informally tested against the five focus group airports of the present study; Manchester, Heathrow, Amsterdam, Salzburg and Athens. This very preliminary study indicates that airports might be ranked according to the degree to which they a) recognise capacity issues, and b). how they are managing/enhancing/securing capacity. The next stage would be to test the model in conjunction with CAMACA on a range of airports.

GMAT

4.10.9. EUROCONTROL have developed the GMAT model in order to calculate inefficiencies within the air traffic system, especially at airports. The model is driven by a variety of operational parameters provided by airlines, airports and their service partners such as ground handling companies. Potential exists to further develop GMAT in order to take additional inputs relating to operational parameters and thereby increase its potential for identifying weaknesses within existing operations systems at airports. It is further possible to incorporate environmental impact data into the model so as to enable the environmental consequences of delays to be assessed. This would permit more effective decision making which could a) improve the operational efficiency of the air traffic system and b) make environmental savings helping to offset the effects of growth.

4.10.10. GMAT contains parameters such as: changes in capacity due to unavailability of runway(s); preferred departing order after recovery from bad weather; early warning for late arrivals and insufficient turn-around time; ATFM slot swapping within or between airlines; and taxi times for each individual aircraft and other information relating to delays. Data obtained from local airport/airline systems is also subject to performance monitoring and represents an integral part of a central performance monitoring tool.

4.10.11. GMAT has the potential to become an internet-based environmental performance monitoring tool. Further work in identifying and testing environmental inputs will be required.

4.11. Environmental Performance Indicators

4.11.1. A highly contemporary theme of aviation/environment research concerns the development of environmental performance indicators (EPIs). This is also the case in other industry sectors, where environmental systems and reporting are emerging, and attempts at harmonising the contents of reports have begun. There is also a trend towards describing key indicators for environmental issues such as energy use and biodiversity impacts, enabling comparisons between sectors. Three types of EPI are recognised: Management Performance Indicators (MPI), which provide management information on how efforts to improve environmental performance are working; Operational Performance Indicators (OPI), which provide information about operational performance; and Environmental Condition Indicators (ECI), which provide information on environmental impact, and can be used to help an organisation understand its actual or potential environmental impacts (ISO 2000).

4.11.2. For performance indicators to have value in the management process, they must be:

Designed to meet a specific objective;

Straightforward to collect and simple to understand; and

Meaningful to the user.

4.11.3. A review of published and some unpublished environmental performance indicators (EPIs) for airlines, airports and ANSPs was undertaken. For airlines and airports, there are a large number of published EPIs, although there is little consensus on a common suite for benchmarking and subsequent use across Europe. In their present form the EPIs produced in airline and airport environmental reports do not provide a means of comparing relative environmental (or social) performance. Co-ordinated action at an industry level is required to develop consistent interpretations of agreed key performance indicators (KPIs).

4.11.4. For some issues, no suitable EPIs have yet been developed. For example, in respect of aircraft noise, whilst a variety of tools have been developed to describe noise exposure, it is far more difficult to predict how people would respond to that noise and how much they would be willing to tolerate the nuisance. The level of perceived nuisance would only in part be a function of the frequency and noisiness of aircraft movements. It would also be affected by:

Temporal factors – particularly night flying;

The variation in affluence, attitude, culture and lifestyle that affect perceptions of disturbance or annoyance;

Understanding of the social and economic consequences of constraining airport growth upon the local and regional communities they serve; and

The considerable variation in socio-economic need and the need for air route development in different regions of Europe.

4.11.5. Given the fact that the disturbance caused by aircraft noise is the single most significant environmental impact with the potential to constrain airport growth, there is a need to research further the different factors that affect tolerance and develop metrics or indicators for each to enable them to be quantified and modelled.

4.11.6. In contrast to the variety of EPIs in use by airlines and airports, there are few published ATM-related EPIs. This study has presented a preliminary list for consideration. There is an opportunity for EUROCONTROL to take a lead role in developing a harmonised suite of indicators for use across the industry and Europe.

4.11.7. Whilst standardisation is necessary, it is important that indicators are structured so that they accurately reflect the specific conditions that pertain in different member states, at different airports and in different segments of the air transport industry.

4.11.8. The process of developing ATM-environment indicators will need to consider the selection and use of data, both inside EUROCONTROL (e.g. CODA, CFMU, CRCO) and amongst its partners (e.g. ANSPs, airports, airline operators and Regulators). In the context of certain environmental impacts, such as regional air quality, particular attention would have to be paid to the

approach/departure phases of flight in addition to aircraft movements on the ground. In respect of a European or global perspective it would be necessary to take account of the entire air transport system.

4.11.9. Modelling ATM scenarios and projecting the performance indicators 5 to 15 years ahead in simulation, would permit a valid and coherent comparison of alternative strategies, would facilitate synergy between different performance indicators, and would support the decision-making process (Pomeret & Mahlich, 1997). Existing tools such as the Integrated Performance Analysis Tool (IPAT) could be used in conjunction with the CAMACA screen and GMAT tools to assess current and potential future environmental capacity constraints and assist in enhancing overall ATM system efficiency.

4.11.10. Tools such as GMAT could have a role to play in the development of ATM-related indicators. Furthermore, the optimal performance of the ECS/T model would likely be achieved through the use of agreed performance indicators in its associated toolkits.

4.11.11. EUROCONTROL's Future ATM Profile (FAP) permits simulation of a limited number of "what if" scenarios, and displays several snapshots of the performance indicators at different moments in time (e.g. 2007, 2012). FAP was the methodology used by EUROCONTROL to project performance indicators into the future, and to assess the consequences of strategic ATM options, and was subsequently used by the Performance Review Commission (PRC) in PRR5 in respect of target Performance Indicators.

5. CONCLUSIONS

- 5.1 Aviation stakeholders have acknowledged the concept of airport environmental capacity. There is little evidence of its discussion in academic and industry publications and as yet there is no common definition for the term. If the aviation sector and its stakeholders are to use the environmental capacity concept with reasonable consensus an agreement on definition and interpretation of the term is essential. Three definitions are proposed in this report.
- 5.2 The current study has clearly shown that environmental constraints are already influencing the growth and development of many European airports including a number of major nodes within the ATM system. Given EUROCONTROL's responsibility for achieving a safe, uniform, cost-effective and environmentally sustainable European air traffic management (ATM) system that meets future capacity needs, it should take an active role in the supporting or promoting policy formulation in this area.
- 5.3 The principal issues with the potential to constrain current operations or future growth are the disturbance caused by aircraft noise and local air quality. Other issues which could also constrain growth in the future include, third party risk, ground transport access and climate change.
- 5.4 A variety of different strategies may be adopted to securing environmental capacity at airports. This could be through investment in environmental management or mitigation programmes, the provision of additional infrastructure capacity, by paying compensation to local residents to tolerate nuisance or by more effective land use planning and 'buy out' programmes. A cost benefit analysis would indicate how finance would be best invested in these different approaches.
- 5.5 The study has demonstrated that the current approach to the management of environmental capacity is largely piecemeal and local, and furthermore that the issue has not yet been acknowledged at a number of airports. The focus groups were especially useful in demonstrating that there is a diversity of

opinion between airports, airlines and ATC over how this issue should be managed effectively.

- 5.6 It will not be sufficient for airports to manage their own environmental capacity issues in isolation; a clear outcome of the current research is that a Europe-wide strategy is required to secure maximum environmental capacity across the air transport network. This will best be achieved through the coordinated action of all three sectors of the industry; airports, airlines and air navigation service providers. EUROCONTROL can play an important part in such an initiative, in keeping with its aim of achieving a safe, uniform, cost effective and environmentally sustainable European air traffic management system that meets future capacity needs.
- 5.7 This study has shown that environmental impacts have the potential to constrain current operations or future growth. As a consequence it is of utmost importance that the concept of environmental capacity is included in EUROCONTROL scenario planning and forecasting.
- 5.8 Based on the results of this study, a conceptual model the “Environmental Capacity Screen/Toolkit (ECS/T)” has been developed which would be capable of estimating and assisting the enhancement of airport environmental capacity.
- 5.9 A preliminary study suggests that the ECS/T could be developed to integrate with CAMACA, thereby enabling CAMACA to incorporate environmental capacity modelling, which could serve as a common decision making tool.
- 5.10 It is evident that the potential to increase the environmental capacity of the air transport system will be enhanced through the adoption of an integrated approach by airports, airlines and air navigation services providers.
- 5.11 This study has identified the need for the development of a common suite of environmental indicators. Whilst standardisation is necessary, it is important that indicators are structured so that they accurately reflect the specific conditions that pertain in different member states, at different airports and in different segments of the air transport system.

6. RECOMENDATIONS

- 6.1 EUROCONTROL take a leading role in promoting an industry-wide agreement and interpretation of the term environmental capacity. The three definitions of environmental capacity developed in this report be taken forward for stakeholder consideration.
- 6.2 EUROCONTROL prepare guidance and training material for the airport, ATM, and airline sectors on the nature of the emerging environmental capacity problem. This should include proposals for an industry-wide approach to its management.
- 6.3 EUROCONTROL should investigate the cost/benefit of achieving capacity enhancements through different methods that include: operational enhancements; environmental management; technological improvements; infrastructure development; and third party financial compensation.
- 6.4 EUROCONTROL to further develop the Environmental Capacity Screen/Toolkit (ECS/T) and assess its potential at selected airports.
- 6.5 Further work should be undertaken to establish the feasibility of integrating CAMACA and ECS/T, and to develop additional complexity within the ECS/T itself. Furthermore, it should explore the potential of this tool to support common decision- making process on airport environmental capacity.
- 6.6 EUROCONTROL to take a lead role in developing a harmonised suite of ATM environmental performance indicators for use across the industry and Europe.
- 6.7 EUROCONTROL to examine the potential of GMAT to include a capability for identifying the environmental consequences of air traffic system inefficiencies.
- 6.8 EUROCONTROL to establish a forum for key stakeholders to debate and discuss environmental capacity and develop partnerships for maximizing capacity.
- 6.9 Subject to confidentiality issues, this report should be circulated to selected stakeholders for critical comment.

REFERENCES

ACCA (2001) *ACCA UK Environmental Reporting Awards Criteria*, The Association of Chartered Certified Accountants, London.

Downloaded from: http://www.accaglobal.com/social_environmental/era_criteria.doc

Airport Operators Association (2001) *Environmental Management at Airports: Best Practice Manual*. Airport Operators Association, London.

ACI (Europe) (1998) *Air Traffic Report 1997*. ACI International World Headquarters. London: PricewaterhouseCoopers.

Aéroports de Paris (1999) *Environnement et Partenariat*. Paris: Aéroports de Paris.

Amsterdam Airport Schiphol (1998) *Environmental Report 1998*, Amsterdam: NV Luchthaven Schiphol. Viewed on-line at <http://www.schiphol.nl> on 12/99.

BAA (1999a) *Towards Sustainability. Heathrow's Environmental, Social and Economic Performance Report 1998/99*. London: British Airports Authority plc.

BAA (1999b) *Towards Sustainability: BAA's Environmental, Social and Economic Performance Report*. London: British Airports Authority plc.

Barton, H. (1995) The Capacity to Deceive. *ECOS* 16 (3-4), 18 – 25.

Barton, H., G. Davis, and R. Guise (1995) *Sustainable Settlements. A guide for Planners, Designers and Developers*. University of the West of England and LGMB. Bristol.

Berglund, B & Lindvall, T. (eds.) (1995) "Community Noise", *Archive of the Centre for Sensory Research – Stockholm*, vol 2 (1), 86-104.

Berkhout, F., Hertin, J., Azzone, G., Carlens, J., Drunen, M., Jasch, C., Noci, G. and Olsthoorn, X. (2001) *Measuring Environmental Performance of Industry: Final Report (MEPI)*. Downloaded at: <http://www.environmental-performance.org>

British Airways plc (2001) *From the Ground Up: Social and Environmental Report 2001*.

Buchanan, C. (1963) *Traffic in Towns: A Study of the Long-Term Problems of Traffic in Urban Areas*. London: Her Majesty's Stationery Office.

Calow P. (1992). *The Principles of Ecotoxicology*. Academic Press.

Club of Rome (1972) *The Limits to Growth*. Washington DC: Potomac Associates Books).

Coleman, R.J. (1999). *Environmentally Sustainable Capacity: Airport Capacity – Challenges for the Future*, Salzburg 15 –16 April 1999 (ECAC Conference proceedings).

Department of the Environment, Transport and the Regions (DETR) *A New Deal for Transport: Better Deal for Everyone* (20.7.98)

Department of the Environment, Transport and the Regions (DETR) *The Future of Aviation: The Government's Consultation Document on Air Transport Policy* (12.12.00).

Downloaded from: www.aviation.detr.gov.uk/consult/future/12.htm

Department for Transport, Local Government and the Regions (November 2001) *The Government's Consultation Document on Air Transport Policy: A report on the response to the public consultation.*

Dias-Sardinha, I. & Reijnders, L. (2001) "Environmental Performance Evaluation and Sustainability Performance Evaluation of Organizations: An evolutionary framework", *Eco-Management & Auditing*, 8, 71-79. DOI: 10.1002/ema.152

Dobbie, L. & Hooper, P. (2001) *IATA Airline Environmental Reporting Survey*. Geneva: IATA.

ECAC/CEAC & EUROCONTROL (2001) *Study on Constraints to Growth (Vols I & II)*.

Edmonds, D and Wollenberg, E (2001) "A Strategic Approach to Multistakeholder Negotiations", *Development and Change*, 32, 231-253.

EEA (2001) *TERM 2001 – Indicators tracking transport and environment integration in the European Union*, European Environment Agency, Copenhagen: <http://www.eea.eu.int>

ENDS (2000) 303, 6 –7.

EUROCONTROL ATM 2000+ Strategy

EUROCONTROL Environmental Policy and Strategy (2001)

EUROCONTROL (2002) Commonly Agreed Methodology for Airside Capacity Assessment. Personal communication by B.Desart, 18th June 2002.

EUROCONTROL (2002) GMAT: Performance Monitoring Tool. Personal communication by M. Dentchev, 18th June 2002.

EUROCONTROL (2002) *Performance Review Report: An Assessment of Air Traffic Management in Europe During the Calendar Year 2001 (PRR5)*.

European Commission (2002) *Directive 2002/30/EC of the European Parliament and of the Council*, 26th March 2002.

European Parliament (2002) *FINAL A5-0121/2002 Report on the Joint Text Approved by the Conciliation Committee for a European Parliament and Council Directive Relating to the Assessment and Management of Environmental Noise*. PE-CONS 3611/2002 – C5 -0098/2002 – 2000/0194 ((COD)).

Fagin, A. (2001) 'Environmental Capacity Building in the Czech Republic', *Environment & Planning A*, 33, 589-606.

FHG (1999) *Horizons Environmental Statement 1999*, Flughafen Hamburg GmbH. Hamburg.

Glicken, J. (2000) 'Getting Stakeholder Participation 'Right': A Discussion of Participatory Processes and Possible Pitfalls', *Environmental Science & Policy*, 3, 305-310.

GRI (2002) *Global reporting Initiative Draft 2002 Sustainability Reporting Guidelines*, Global Reporting Initiative, Boston, <http://www.globalreporting.org/>

Grayling, T. & Bishop, S. *Sustainable Aviation 2030 Discussion Document*. IPPR (August 2001).

Hooper, P.D., Lever, M. and Stubbs, M. (1998) 'Corporate Environmental Reporting: Is the Definition of Sustainability Out There?', *Proceedings of the Business Strategy and Environment Conference*, Leeds, September 17th & 18th 1998, 86-91.

Hooper, P. & Lever, M. *Corporate Environmental Reporting in the Airline Sector: A Route to Stakeholder Empowerment*, Paper presented to the 10th Greening of Industry Conference, Gothenburg, Sweden, June 2002.

ICAO (2001) *Balanced Approach to Aircraft Noise Management* (Appendix C of Assembly Resolution A33-7).

Downloaded from: http://www.icao.int/cgi/goto_atb.pl?icao/en/env/overview.htm;env

International Standards Organisation (2000) *ISO 14031: 2000 Environmental Management – Environmental Performance Evaluation*, European Committee for Standardisation, Brussels.

ISO (2000) *ISO 14031: Environmental Management - Environmental Performance Evaluation – Guidelines*. Geneva: International Organization for Standardization.

Janić, M. (1999) 'Aviation and Externalities: The accomplishments and problems', *Transportation Research D*, 4, 3, pp. 159-180.

Janić, M. (2001) *Airport Sustainable Capacity: An Analysis of Concepts and Influencing Factors*. Paper presented to the 1st International Conference on Environmental Capacity at Airports. Manchester Metropolitan University, 2nd – 3rd April 2001.

Janicke, M. (1997) 'The Political System's Capacity for Environmental Policy' in Janicke, M. and Weidner, H. *National Environmental Policies – A Comparative study of Capacity Building*. Berlin: Springer.

Kidd, C.V. (1992). "The evolution of sustainability", *Journal of Agriculture and Ethics* 5(1), 1 – 26.

Lever, M. & Dimitriu, D. (2001) *Increasing Capacity at Airports in the Face of Noise Nuisance Perception*. London: British Airways plc.

London Luton Airport (2001) *Development Brief*. Luton: London Luton Airport.

McLellan, M. (2001) *Exploring the Concept of Environmental Capacity Through Public Consultation*. Paper presented to the 1st International Conference on Environmental Capacity at Airports. Manchester Metropolitan University, 2nd – 3rd April 2001.

Manchester Airport (2000) *Environment Report 1998-9*, Manchester Airport plc, Manchester, England.

Mason, M (1999) *Environmental Democracy*. London: Earthscan.

May, T. (1997)(2nd edition) *Social Research: Issue, Methods and Process*. Buckingham: Philadelphia Press.

Meadows et al. (1992) *Beyond the Limits: Global Collapse or a Sustainable Future*. London: Earthscan.

Moss, D, Warnaby, G, Sykes, S and Thomas, CS (1997) "Manchester Airport's Second Runway Campaign: the boundary spanning role of public relations in managing environmental organisational interaction", *Journal of Communication Management*, 2 (4), 320-334

OECD (1994) *Capacity Development in Environment*. Paris: OECD.

Pomeret, J.M. & Mahlich, S. (1997) *Piloting ATM Through Performance*. First EUROCONTROL/FAA Air Traffic Management Seminar. Saclay, France, June 17th – 20th 1997.

Rees, W. (1992) "Ecological footprints and appropriated carrying capacity: what urban economics leaves out" in *Environment and Urbanization*. Vol. 4 N°2 October. IIED. London.

SCAN UK (2000) *Environmental Capacity: The Challenge for the Aviation Industry*. Proceedings of a workshop held at Heathrow Airport, June 7th 2000.

SCAN UK (2001) Proceedings of the 1st *International Conference on Environmental Capacity at Airports*. Manchester Metropolitan University, 2nd – 3rd April 2001.

Stansted Airport Ltd (1998) *BAA Stansted Environment and Community Report*, British Airports Authority plc, London.

Thomas,C.S., Raper, D.W., Upham, P. Gillingwater, D., Yang, Y., Hinde,C. (2001). A Strategic Decision Support Tool for Indicating Airport Sustainability. *Env. Modelling and Software*. 16, 297-298.

UNEP/T&E (2002) *Final Boarding Call: Air Transport, Airports and Sustainable Development*. Proceeds of a conference held on 1st – 2nd July 2002, Paris.

Upham, P. (2001a) "A Comparison of Sustainability Theory with UK and European Airports Policy and Practice", *Journal of Environmental Management*, 63 (3): 237-248.

Upham, P. J. (2001b) "Environmental Capacity of Aviation: Theoretical Issues and Basic Research Directions", *Journal of Environmental Planning and Management*, 44, 5, 721-734.

World Commission on Environment & Development (1987) *Our Common Future*. Oxford: Oxford University Press.

Worldwatch Institute (2002). State of the World 2002: Progress Towards a Sustainable Society, Earthscan .

Young, C.W. and Welford, R. (1999) "An Environmental Performance Measurement Framework for Business", Greener Management International, vol.21, Spring, pp.30-49.

Zurich Airport Authority (1999) *Environmental Report 1999*, Zurich: Zurich Airport Authority. Downloaded at <http://www.zurich-airport.ch> 12/99.