SCAN-UK The UK Sustainable Cities and Aviation Network

Workshop Proceedings 2

Environmental Capacity
The challenge for the aviation industry

A workshop held on 7th June at Heathrow airport

SCAN-UK is an EPSRC funded network of experts from industry, government, NGO's and academia.

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INTRODUCTION

By Dr David Gillingwater
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ENVIRONMENTAL CAPACITY: The Challenge for the Aviation Industry

SCAN-UK - or to give it its full title, the 'Sustainable Cities and Aviation Network for the UK' - is a network of experts drawn from academia, industry, government (both central and local) and NGOs. Its aim is to facilitate debate and exchange information relating to the long term sustainability of the aviation industry. SCAN-UK is funded by the UK Engineering & Physical Sciences Research Council (EPSRC) and is based at Manchester Metropolitan University (MMU). It is managed as a joint project between MMU and Loughborough University and is directed by a steering group made up of individuals from the network.

SCAN-UK has identified three primary means of facilitating debate and exchanging information relating to the long term sustainability of the aviation industry: by developing a self-supporting Internet site (<http://www.scan-uk.mmu.ac.uk>), by promoting a series of day workshops - like today's - on topical themes, and by sponsoring a major international conference to be held in April 2001.

The theme of today's workshop is 'Environmental Capacity: The Challenge for the Aviation Industry'. Like its predecessor, the title and scope of this workshop was a product of the previous workshop on 'Sustainability and Air Transport' held at Manchester Airport on January 11th 2000 (proceedings of which are available from the Network Co-ordinator, Jane Walkington-Ellis, at MMU (email address: <j.walkington-ellis@mmu.ac.uk>)). We are delighted to accept BAA's invitation to host today's event at the Heathrow Visitor Centre and look forward to a thought provoking and challenging day.

The aim of today's workshop is two-fold: first, to try to pin down and agree on a working definition of environmental capacity as it applies to aviation in general and particularly to airports; and second, to help shape the role and structure of the major international conference on 'Environmental Capacity at Airports' to be held under the auspices of SCAN-UK next year (April 2-3, 2001: Manchester Metropolitan University).

The aim of this opening paper, together with the paper from Callum Thomas which follows, is to put the concept of environmental capacity into context.

In my view, environmental capacity is the 'big issue' which is staring the aviation industry in the face - and with it the industry's very future: its airlines, airports, service providers, planners, regulators and policy makers. Why? There can be few who seriously doubt that we are beginning to witness the emergence of a truly global economy, an economy which will stimulate further the demand for air travel at a time when the environmental implications of mobility are causing increasing concern. Most commentators agree that the aviation industry is expected to grow at around 5 to 7 per cent per annum for the foreseeable future. This growth will bring with it major social and economic benefits but also significant environmental impacts at both global and local levels. The key question for us is whether this growth can be accommodated without putting undue pressures on the environment's ability to assimilate its consequences and thus sustain the environment's long-term evolution.

As applied to the air transport industry, the notion of 'environmental capacity' in its most basic form means agreeing to reduce an airport's (and by definition the air transport system's) 'operational capacity' so as to ensure that aviation can function - and indeed be optimised - according to the ground rules of sustainability rather than 'operate to meet unconstrained demand'. According to this maxim, environmental capacity will always be less than operational capacity.

This concept of 'environmental capacity' as it applies to airports can be approached in at least two ways: EITHER as an airport's operational capacity *less* the sum total of the individual environmental mitigation measures already in place at that airport - even though these remain separate and largely uncoordinated (from an air transport system's perspective) OR

something much more than this! The former view may be a politically optimal solution, in the sense of striking a balance or compromise between, say, the local community around an airport and the level of aircraft operations, but it is highly doubtful whether this is or could ever lead to an environmentally optimal solution. There are four points I would like to make here regarding the search for a more environmentally optimal solution.

First, from an environmental perspective, an airport is not only a hub for aircraft operations but it is also the hub for environmental concerns about environmental capacity. If airports are thought of as inter-modal transport hubs rather than as places where aircraft take-off and land, then we might begin to get a better grasp of all the myriad of issues which focus in, on and around airports. As an example of what I mean by this, such a repositioning implies that we in the aviation industry must be prepared to accept and work with problems which are not directly our responsibility - e.g., problems to do with surface access - and thus help to find solutions to such issues.

Second, the coupling of sustainability with environmental concerns means that we must begin to question and rethink the kind of trade-offs which we have become familiar with making. Typically this means identifying and separating out politically controversial, *short-run concerns* which mainly affect quality of life (e.g., aircraft noise) from *long-term issues* which mainly affect the assimilative capacity of the environment to cope with what we are throwing at it (e.g., pollution and global warming). This means finding ways and means of rebalancing our priorities away from the former towards the latter, which is the very opposite of what we have become used to - in other words, according less weight to the here-and-now and greater weight to the future. As yet we do not in my view have either a political calculus or a currency to be able to do this.

Third, we must begin to question the viability of many (all?) of the environmental mitigation measures we have in place at and around airports in the light of the kind of argument presented in my second point. For example, many major gateway airports have long-established night curfews whose aim has been to protect local communities from excessive exposure from aircraft noise. As a result, those airports are experiencing severe operational problems associated with the so-called shoulder hours - those periods immediately before the curfew's start and end. From an environmental capacity perspective, such a curfew may be seen as a short-run, here-and-now quality of life issue - and a successful mitigation measure - but with potentially more serious long-term environmental consequences. The reason is simple. During the early morning shoulder periods, aircraft are approaching but cannot have clearance to land. Air traffic control has little option but to order those aircraft arrivals into stacks at selected points in local airspace until the curfew ends. The consequence of such a strategy is additional and not inconsiderable fuel burn and emissions - with accompanying air quality implications, which are concentrated at and under those stacks. Such a strategy may be achieving short-run success but at what long-term cost to the environment? The same sort of logic can be applied to those airports suffering from operational congestion.

Finally, by putting together the three points outlined thus far, it is possible to pose another question: Where are we to draw the boundary of our concern? Each of the points above suggest that we in the aviation industry need to think much wider than we have been used to. Much as many airport managers would like to dream of the time when their boundary of concern might coincide with the perimeter fence, reality suggests otherwise. Responsibility for the wider consequences of aviation's activities has to be recognised and accepted by everyone within the industry - especially in my view by the airlines, because it is their activities which are the primary instigators of such concerns and where their leadership (with one or two notable exceptions) has been generally conspicuous by its absence. A possible approach to tackling this so-called boundary problem might be provided by the assumptions built into the standard landing-and-take-off cycle, the LTO-cycle. There is an operational ceiling to the LTO-cycle - 3000 feet. Interestingly, it is also at this level that roughly marks the division between the surface atmosphere and the troposphere - the so-called 'boundary layer'. Taking this 3000 feet/1 km level as the limit of our concern would of course have huge ramifications because the geographical area around an airport would be significantly larger than the current boundary of concern, which is more often than not identified with the contour of intrusive aircraft noise (e.g., 55 or 57 dBA L_{eq}).

These then are my initial thoughts on the subject of the 'something much more than this' noted above - the search for a more environmentally optimal solution. In my view, the challenge facing us today is to begin this process of identifying and specifying the substance of what an environmentally optimal solution might look like. Each of us will more than likely have very different views about this, which in many cases will mean getting down to the 'bedrock' of our own assumptions and having them challenged by those with different persuasions. If we are to achieve this melding of views, each of us will need to approach the task ahead constructively - and in so doing we will be working towards a major objective of the SCAN-UK network.

Environmental capacity of airports- what does it mean?

By Professor Callum Thomas
Chair of Sustainable Aviation, Manchester Metropolitan University

INTRODUCTION

The development of any airport gives rise to significant environmental impacts relating to a wide variety of issues including noise disturbance, emissions to air, water pollution and habitat destruction. Some arise from the operation of the airport, others as a result of the impact of providing additional airport infrastructure. All have the potential to constrain future growth. This paper will consider the environmental issues that already constrain growth at many airports and those which will create constraints in the future. The way in which these factors influence airport development will be considered along with information about how environmental capacity can be maximised.

WHAT MAKES AN AIRPORT ENVIRONMENTALLY SENSITIVE ?

The environmental sensitivity of an airport is dependent upon a number of issues, the most obvious of which is its location relative to residential areas and hence the number of people who can be disturbed by its operations. Ecological constraints posed by habitats in the surrounding area can also make an airport environmentally sensitive. Many airports have developed in the green belt on the edge of major cities and towns. Within Europe in particular, undisturbed habitats are dwindling and legislation is tightening in respect of protection 'of the countryside'. This can severely limit opportunities for expansion by providing physical limits to infrastructure growth. It is clear from a number of recent planning decisions that protection of landscape and habitats is increasing in significance. These two examples illustrate the particular challenge faced by major airports throughout the world. The most popular airports with the travelling public are those which are closest to the major centres of population and therefore those which in many respects are the most environmentally sensitive.

It is possible to calculate the environmental capacity of an airport (measure the environmental sensitivity of an airport) using a variety of modelling techniques which combine environmental impact contouring with GIS mapping and terminal, apron and runway simulation models. The Aviation Research Group at Manchester Metropolitan University are currently developing such a tool to assist airport developers and managers to make more sustainable planning decisions.

THE CONCEPT OF ENVIRONMENTAL CAPACITY

The capacity of an airport can be measured in a variety of ways. Some figures quote the number of runway slots, some the terminal capacity or capacity of the apron areas. Even with a given amount of infrastructure however, the maximum number of passengers or aircraft which can be accommodated on a particular day is limited by how well the airport is operationally managed.

There is, however a third major issue which will affect both the capacity and the potential for future growth and this is the impact of the airports' operation upon the local environment and upon the lives of residents of local communities. This can manifest itself in a number of ways the most obvious of which is the disturbance caused by aircraft noise.

Aircraft noise disturbance is probably the single most important issue affecting the operation and development of airports around the world. It is related to the frequency and noisiness of aircraft movements and the proximity of communities relative to the airport's arrival and departure routes. The control and monitoring of aircraft noise are issues that have received significant attention and aircraft and engine manufacturers have made very significant technological improvements over the years. However the benefits of such action have been offset by the growth in the industry such that today, most of the world major airports have operational constraints or capacity limits based upon noise. In many cases these relate either

to restrictions upon the use of noisier aircraft, night curfews or operational limits based upon a noise budget or a noise contour.

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 grows. 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 community opposition in the future.

A critical issue for airport operators and governments alike is the need for effective land use planning which will prevent more housing being built in noise sensitive areas around airports and thereby protecting future capacity.

Air quality in the vicinity of airport is determined by a number of factors. The major source of pollution is often the motor car with aircraft emissions and apron activities (e.g. refuelling) being important also. It is predicted that over the next two decades, emissions from cars will fall dramatically in many parts of the world and at that time, given the current growth in aviation and rate of technological change, aircraft will have a much more significant influence upon local air quality than is the case today.

Although an issue of current concern in the most developed nations, it is clear that air quality limits within discrete geographical areas will be regulated by regional, national and international legislation in more and more countries in the future. The operation of an airport is often the most significant source of pollution in a particular locality. Air quality legislation has therefore the potential to constrain airport growth either by restricting aircraft movements or road traffic. The more far-sighted airports are already ensuring they have sufficient land available to develop public transport infrastructure in anticipation of the need to reduce car traffic.

A variety of very sophisticated air quality modelling systems exist which forecast future levels of pollution from all of the relevant sources. These can be used to predict the time when local air quality could constrain the growth of the airport and also the time when it will be necessary to develop public transport services to replace car access.

Communities surrounding airports and politicians are increasingly paying attention to the risk of an aircraft crashing into an urban area with the resultant loss of life on the ground. Accident rates tend to be higher along the approach and departure routes where air traffic is concentrated. The growth in air traffic is offsetting the benefits of increasing safety, with the result that the risk of an air accident is increasing on a year to year basis.

In the UK and in the Netherlands, risk contour modelling systems are used to predict areas of high risk in which it is considered ‘unacceptable’ for people to live and work. Continuing growth in traffic has the potential to increase the size of these zones. In consequence, further airport growth may be restricted or airports may be ‘obliged’ to buy up and demolish houses 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.

Airports by their very nature cover large areas of land and create a habitat which is either hostile to wildlife or a monoculture (e.g. grassland). The areas surrounding airports can, however often be of considerable ecological value particularly if the airport is located in a green belt surrounding a major urban conurbation, as is often the case. 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 have prevented or restricted airport development. The same has also been true in the US and elsewhere in the world. Given the commitments made at the Rio Earth Summit to protect biodiversity, such constraints are very likely to become more apparent in the future, even in less developed countries.

THE IMPLICATIONS OF CLIMATE CHANGE FOR AIRPORT DEVELOPMENT

Mass market civil aviation has existed for approximately 40 years and yet in this time, the industry has grown so significantly that today it is estimated that it could be responsible for 4% of greenhouse gas emissions associated with human activities. World governments have accepted that climate change is the single largest threat to the future development of human kind and in response, in 1998 at Kyoto, they agreed a strategy which will constrain and then reduce CO2 emissions over the next half century. The EU have agreed a reduction of greenhouse gas emissions of –8% over a approximately a fifteen year period. The UK government has set itself a target of –20% over fifteen years. Current predictions suggest that over this same time period, the contribution made by aviation will double. In the main this is because the rapid rate of growth of the industry is outstripping the rate of technological improvement.

Both the EU and the UK Government have acknowledged that aviation has a particular role to play and will become increasingly important in the developing global economy of the 21st Century. Both make it clear however that while they would not impose national and international targets upon individual industries, they would expect any industries failing to meet those targets to be able to prove that they were taking all reasonable action to reduce their emissions. This suggests that for aviation, 'business as usual' will not be politically acceptable.

At a global level, the issue of climate change is likely to drive very significant changes in the aviation industry over the next 10-20 years. This will manifest itself in a number of ways, but in particular it is likely to drive airports into developing as inter-modal public transport hubs that connect to an integrated public transport system. This would disassociate the link between air travel and the significant emissions of greenhouse gases that arise from cars transporting passengers to and from airports. However, this provides an opportunity for airports and airlines to begin transferring short distance air routes onto high speed rail. This can bring additional benefits in terms of hub development in that it provides more runway capacity and also extends the potential catchment area for airline customers.

Those same environmental pressures are likely to drive other changes in the industry such as efforts to maximise the load factor on aircraft, thereby reducing the fuel use and aircraft emissions per passenger kilometre.

COMMUNITY OPPOSITION TO GROWTH

The benefits of the growth and development of an airport are spread over a large geographical area, whereas the costs are borne by the residents of its neighbouring communities. Local community opposition can constrain growth and confound efforts to gain planning approval for further development. In addition to opposition arising from disturbance caused by aircraft noise, other major issues raised in complaints to airports include local air quality (the smell of aviation fuel), congestion and accidents on local roads, fear of air accidents etc.. Unless local people can see a reason to tolerate the nuisance caused by an airports operation then they will have little reason to support airport growth.

The key to managing local community opposition is to adopt a strategy which addresses the major issues of concern to them. It is import to provide information to local residents about what actions are being taken to resolve their perceived problems, to establish a system of public consultation, to publicly set targets for improvement and then implement transparent monitoring systems to show that progress is being made. In addition to minimising the adverse effects, however it is also important that airports develop strategies which seeks to maximise the social and economic benefits of their continuing growth and target them towards areas of greatest need or areas worst affected by their operation.

INFRASTRUCTURE AND ENVIRONMENTAL CAPACITY

The capacity of an airport is a function of many different factors, the first of which is the airspace which services the site. Other issues include the number of runways, the extent of

taxiway and apron development, the terminals and landside facilities and the ease of access. As has been explained above, however a number of environmental issues can constrain the growth and development. Across Europe are examples of airports that have failed to gain permission to build additional infrastructure, either as a result of the environmental impact of the development itself or as a result of the increase in traffic which would result from it.

Airport developers can in theory invest hundreds of millions of pounds in new infrastructure (e.g. a terminal) but not have the environmental capacity to allow it to be put to full use. This has also been the case at some European airports. Long term planning, coupled with an analysis of the environmental implications of potential future developments and traffic growth is the key to maximising the potential capacity of a site along with good environmental management.

MAXIMISING THE ENVIRONMENTAL CAPACITY OF AN AIRPORT

The key to maximising the environmental capacity of an airport is the integration of environmental management into the heart of the corporate business planning process. It is a characteristic of environmental issues that they can require significant short-term investment in order to ensure long term return. It is also a characteristic of airport development that the provision of additional infrastructure can take many years for approval and often results in environmental limits being placed upon their operations.

Airport operators need to begin to plan now for the long term, to visualise the ultimate runway, apron and terminal infrastructure which can be realistically anticipated for a particular site, the ground transport infrastructure likely to be needed to serve it in order to meet anticipated demand and to address environmental constraints.

They need to invest sufficient resources in environmental management and mitigation to ensure future capacity. They need to work with their service partners and where necessary enforce controls to ensure corporate environmental targets are met and that the environmental impact of the airports total operation is kept to a (commercially sustainable) minimum. Airlines wishing to develop hub operations at a particular airport may actually take a proactive approach to encouraging the development of environmental best practice in order to secure their own future.

In the long term it is to the advantage of all involved in the air transport industry that it continually strives to improve its environmental performance. Only through such action, coupled with planning for the long term that it will maximise its capacity within a climate of increasing environmental pressures.

CONCLUSION

It is certain that environmental pressures will continue to build and increasingly constrain the growth of airports. Across Europe there are already examples of airports which have reached their environmental capacity before having made full use of their infrastructure. Others in much need of additional infrastructure are failing to gain approval for further growth, either as a result of the environmental implications of the development itself or the growth in air traffic that would arise from it. Many airports which are successful in planning applications find that approval is subject to newly imposed environmental constraints normally relating to aircraft noise but increasingly involving other issues such as the risk of air accident and local air quality.

Effective environmental management and long term planning are the key to ensuring that the environmental capacity and hence the operating capacity of an airport can be maximised . However eventually there have to be limits to growth and some airports are within 10-20 years of reaching this point . For the first time in history, therefore, airport managers have to consider the concept of ultimate capacity - When will the airport cease ‘growing’ and how should it develop thereafter ?

Applying the Concept of Environmental Capacity at a Growing Airport

By Dr. Mark McLellan
Head of Environment, London Luton Airport Operations Ltd.

London Luton Airport is one of the fastest-growing UK airports, providing leisure charter; low-fare scheduled; air cargo, and business aviation services. Situated on a plateau of 235 hectares in the Chiltern Hills, and above the valley of the River Lee, the airport site is located close to the Luton-Dunstable conurbation, 45 kilometres north of London. The airport is owned by Luton Borough Council, but operated by a private sector consortium, London Luton Airport Operations Ltd. (LLAOL) under a 30 year concession agreement.

The company is committed to sustainable development of the airport, and has established a programme to match ambitious commercial plans with environmental and community performance. Currently at approximately 6mppa, it has been established that the operational capacity can easily be extended to 10mppa, and with a runway extension and other infra structural improvements, 30 mppa could be operationally accommodated.

However,can this be accommodated by the local environment and community? And from a national and global perspective, can this development be "sustainable"?

LLA has begun addressing this dilemma in a masterplan Development Brief. The document was prepared in close consultation with a working group representing surrounding local authorities and issued for full public consultation.

The Brief advocates a "capacity approach" to environmental management. Current planning permission for LLA is already subject to an agreed maximum capacity on noise emissions, based on calculated noise contours for both day time and night time.

We broadly define environmental capacity as:

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

Attempting to put this into the context of sustainable development, the World Bank in 1991 offered a number of core principles of sustainable development, which included:

"*the rate of pollution emission should not exceed the assimilative capacity of the environment".*

Therefore it follows that sustainable airport development can be attained by the non-excedence of agreed limits on environmental capacity (under the World Bank "rules") and by balancing economic, social and environmental considerations (UK Government strategy for sustainable development, 1999).

However the key words in this thesis are *"agreed"* and *"balance".* It has proven extremely difficult in the field of ecotoxicology, to *agree* acceptable emissions levels of based on sound science. Whilst it is generally agreed that the environment can assimilate certain human activities up to a certain level, and that human individuals and communities can tolerate certain levels of pollution and disturbance, defining and agreeing these levels has been problematic. Recent policy has been to agree an acceptable limit on emissions to air, water, or land, and to set goals to achieve or better this. In certain cases, the "precautionary principle" has been invoked in cases where the safe emissions limit of a substance or process has been assumed to be zero, in the absence of evidence supporting "safe" or "acceptable" levels.

The activities of airports with respect to their emissions to the environment, are in some areas covered by existing national requirements. With respect to chemical emissions to air, land and water, their "capacity" on emissions is consented and monitored by such bodies as the Environment Agency and local authority departments. Capacity on noise, surface access and land use are regulated under the planning system, and in the absence of a wider national policy on these issues at airports, local planning authorities are responsible in the first instance for *"agreeing"* or *"balancing"* limits on noise emission, traffic levels and land use changes.

At London Luton Airport, noise tolerance by local communities, local road congestion, wildlife habitat and water treatment present limits to growth potential. At other airports, a different portfolio of obstacles may be present. The issue of how capacity can be measured and set for noise, is especially controversial, and the methodology for calculating noise impact on people needs to be agreed by all concerned, prior to a study of noise impact.

An important issue for airports is that the noise burden is not likely to evenly spread, and that some communities will receive more disturbance than others. Therefore it is critical that an airport operator:

a) Minimises noise disturbance using all technological, operational, and planning devices within its power;
b) Communicates the issues to affected communities clearly and honestly;
c) Openly consults with and considers reasonable suggestions from those communities;
d) Considers mitigation and compensation for affected communities; and
e) Works within limits agreed and set by the local planning authority.

The Environmental Impact of Aero-Engines - Issues and Opportunities

By Dr Jacquetta Lee, Rolls-Royce plc

This paper discusses the history of environmental improvements in the aero-engine industry and summarises its current status. Alongside growing consumer concerns, these issues are vitally important as they effect future technological options, and influence the direction of the industry.

Rolls-Royce is a global company, and a renowned aircraft engine manufacturer. It has facilities in 14 countries, providing power for land, sea and air applications in the civil aerospace, defence, energy and marine business sections. As a global organisation, we are fully aware of the wide range of influencing factors which come in to play around the globe, in terms of legislation, culture and community development etc. More importantly, a number of the concerns currently facing aviation are being faced by other industry sectors, and it is important to learn from those who have already started to make the transition towards a environmentally and socially responsible business operations.

The impact of aviation on the planet and the atmosphere is an issue that is perceived to be increasing in importance, largely due to the success of aviation, and its continued growth. Noise, emissions and atmospheric changes are amongst the most significant environmental impacts and these issues are specifically related to the aircraft power plant.

The history of aviation is important as it helps to explain why engines are designed the way they are and some of the 'in built' attitudes of our industry, and provides us with the platform from which we can move forward. In the case of aero-engines, there are a number of design issues that need to be considered in any engine design. A range of influencing factors effect the environmental performance of aero-engines, some of these are well known, such as engine pressure and temperature effecting fuel efficiency and emissions, and fan blade design effecting noise issues. And yet others, weight for example, are often overlooked as environmental concerns.

Lower weight leads to less work required for each and every aircraft mission. As a concentrated mass, weight reduction in the engine enables further weight reduction in the structure of the aircraft. Reduction of one unit of engine weight generally saves between 1.5 and 4 units of aircraft empty weight. The lower power required for take off means less noise; the reduced fuel burn leads to emissions reductions. Today's engines are over 30% lighter than its equivalent ancestor 30 years ago. This has been achieved by two methods. Firstly, increased efficiencies and performance give enhanced thrust for a given weight of engine, and secondly, use of lower density materials has given rise to some weight savings. However, this has been offset by the use of materials designed to withstand higher temperatures, which are inevitably are of increased density, as part of the drive for increased efficiency.

Obviously important as a method of minimising the use natural resources, improvements to fuel efficiency are fundamental to reducing the overall environmental impact. Fuel burn is directly proportional to carbon dioxide emissions and is also related to other emissions. As with engine weight, there is a knock on effect on noise and emissions due to the aircraft weight being lowered due to the reduced fuel load.

Over the last 30 years, fuel consumption by engines for long range aircraft has been reduced by 35%. This has been the major influence in the reduction of approximately a 50% reduction in fuel burn per seat by the aircraft over the same period.

The efficiency results from a combination of the core thermal efficiency and the propulsive efficiency. The former has been increased by increasing both the core temperatures and pressures. The major influence on increasing propulsive efficiency has been the use of high bypass ratios. This has also had a dramatic effect on noise.

Unfortunately, high temperatures and pressures are conducive to NOx formation and this has been a cause for concern. The focus of research has been on how to achieve higher engine temperatures without paying an excessive penalty through the production of NOx. The Phase 5 combustor, for which Rolls-Royce was awarded the Queens award for Environmental Achievement, has resulted in reductions of around 40% in NOx emissions for the RB211 engine, while the state-of-the-art Trent engine has NOx emissions at 70% of the current regulation standard. Never the less, the trade-off between fuel efficiency and NOx emissions is likely to become more severe in the future

Technological developments in noise control have resulted in a 75% reduction in annoyance levels in the last 30 years, and research into noise reduction techniques is continuing. Such measures as increased bypass ratio, acoustic liners, space between rotating parts, swept fan blades and more recently, negatively scarfed intakes are all measures that can be employed to reduce noise.

Aviation has an impressive record in reducing environmental impact of noise, fuel consumption and NOx, but the question which now confronts the industry is how will we progress in the future. The growing concerns over the environmental impact attributed to aviation, and its predicted growth levels are fundamental aspects of our development. In order to illustrate the range of options open to the industry, the following definitions were developed.

- The 4 D's, Defend, Deny, Delay and Do nothing.
  The industry denies it causes an environmental concern, and/or delays doing anything about it.
- The 3 M's, Manage, Mitigate and Minimise.
  The industry controls the environmental effects of aviation where possible. This is where most of the industry is now.
- The 2 S's, Sustain and Survive.
  The industry works collectively with all affected parties to develop an industry and community wide strategy. By definition, this should be at least an international, if not global strategy.
- STOP.
  Pressure from governments, NGO's or other sources cause a significant reduction in, or even complete cessation of, air travel.

Accounting for the improvements made in engines and airframes, by 2050, the carbon dioxide emissions from aviation could be *increased* by more than 5 times what they were in 1990. The recently published report by the Royal Commission on Environmental Pollution has suggested a *reduction* in current annual carbon dioxide emissions of 60% by 2050. This is the challenge facing the industry today.

Aviation is not all bad, it does bring considerable benefits to society, and it is important to include those when considering the overall impact of aviation. Aviation plays a key role in the global economy. By value, more than one third of the world's exports are transported by air (but only ~2% by weight). Much international business is facilitated by air travel. Tourism is a very important sector of the economy, particularly in many developing nations, much of which is reliant on the availability of affordable and reliable air transport. Others would argue that the increased availability of mobility is harmful.

The fashionable way to link all these issues is using the philosophy of Sustainable Development. This concept is not readily applicable to any single activity, particularly aviation. However, the aviation industry, as a whole, must strive to achieve the optimum balance between a wide variety of sometimes-conflicting requirements. Issues that need to be considered include; uncertainty surrounding effects of aviation at altitude, local versus global concerns, legislation at local, regional and global levels, operational issues and technology developments.

Of particular interest to the engine manufacturers are the trade-offs which exist between the three fundamental concerns of the powerplant, fuel efficiency, NOx emissions and noise. These three issues often have conflicting requirements, noise can be reduced, but potentially

at the expense of increased engine weight, thus reducing fuel efficiency. Fuel efficiency can be improved by increasing operating temperatures and pressures, but this can lead to increased NOx formation. Whilst we continue to reduce all three impacts, there are clearly some choices to be made in the future as to which impacts are considered to be the more important.

If we are to meet the challenge of the future, innovative aircraft and engine designs are required to provide step improvement in performance. Potential changes include;

- The 'flying wing' offers significantly-reduced drag for high-capacity aircraft
- Contra-rotating aft fan concept can be over-wing mounted and improves SFC, weight and noise
- Pre-mixed, double-annular combustors will offer reduced NOx emissions
- All-electric aircraft offer future improvements in fuel burn and operating cost, through the elimination of hydraulic systems and their associated weight penalties.

In addition to engine and airframe improvements, operating improvements, such as reduced running on the ground, improved aircraft routing, and air traffic management systems all have their part to play.

Achieving the optimum balance for the environment as a whole requires a thorough understanding of all the issues by all sectors in the industry, including the customers. The engines are not the sole determining factor which define the environmental impact. The aircraft they are attached to, the fuel they burn and they way they are operated can all have very significant effects. Synergistic improvements in all these areas, together with the optimisation of aero engines should allow the aviation industry to continue to supply a service to its customers in a sustainable manner.

Countries with Economy in Transition- challenges and opportunities in transport system; case-study TAROM

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BACKGROUND

Countries with Economies in Transition (EIT) have had to face significant environmental challenges over the last decade. Being located in Central-Eastern Europe and Former Soviet Block (CIS), some of them are seeking to be involved in European Union integration. For them, meeting the EU environmental obligations is a requirement. They are all looking to restructure their economies, starting with their transport industries which are at the heart of this process. So, today, Accession States have a real opportunity to develop an environmentally sound transport system. This raises a number of questions :

- What can these nations learn from western European countries, in order to avoid repeating their mistakes?
- How can they integrate a local transport system into a European network, without damaging their natural landscape?
- How can they meet the required capacity with the present infrastructure?
- What are the social costs and benefits of such development ?

All these and many other questions, have to be resolved in a wide decision-making process, where the stakeholder analysis has an important role. European integration cannot take place without a common environmental policy, as geographically, all the Accession States are located within the continent of Europe. The decision-makers in policy and conservation of the environment have to focus on: legislation, planning, transparency, participation. Transparency and public participation requires a slow process and one which is new in many EITs. Such systems are more developed in Western Europe, they differ from country to country and so European NGOs have an important role to play in assisting the development of EITs.

ACCESSION STATES – PRESENT AND FUTURE

All these states are under pressure to adapt their economies to western European norms. According to the European Commission's Agenda 2000, the first countries from CEEC (Central-Eastern European Countries) could join the EU by the end of 2004. For them, the western system is the only possibility, there are no other alternatives. There is a strong need and requirement for environmental and socio-economic impact assessment. The role of local and European NGOs in sharing their experience with governmental bodies is minimal in CEEC countries as result of the fact that there is a lack of understanding at the highest level of their role or value. In order to help their development, the EIT countries must have access to, and experience of different European projects related to transport and regional development.

For instance, ISPA (Instrument for Structural Policies for pre-Accession) projects have requirements to contribute to Sustainable Development , but can't be financed with European money alone. So, countries have to set up their priorities, when they apply for such projects. Co-funding has to be organized, normally from western credit sources (e.i. European Investment Bank). The TEN (Trans-European Network) project is co-financed by multilateral banks and states themselves, but the funds cannot be spent for urban public transport, which gives the project a European dimension.

Thinking about the future, the Accession States could become world leaders in the field of sustainable mobility, they have the space and existing infrastructure to do it, they have the ability to learn from more developed countries mistakes. There is still a fear, however that the environment will get left behind as the rush to develop proceeds and as the 'system' resorts to the habits of the old-style of Government.

AVIATION SECTOR: GENERAL PERCEPTION

In this sector, opportunities and challenges are both economic and ecological. All the above mentioned states have to renew their airline fleets, as these are based on Russian built aircraft, which are on average less fuel efficient, more polluting and noisier than those used in the West . The driving factors for policy making are:

- Relieving airport restrictions
- Modernising fleet composition
- Developing commercial/financial reason
- Increasing competition
- Delivering passenger comfort
- Ensuring flight safety

The present infrastructure can't meet the traffic demand and increase in capacity is essential. Shortfalls in capacity and constrains on the efficiency of airports and the ATM system can have negative effects on:

- airline costs
- passenger convenience
- the environment
- and the potential to develop the air route networks required to serve EITs.

The environmental concerns are in minimizing the negative impact arising from the long economic lifetime of 'old technologies'. Meanwhile, the love-hate relationship between airports and their local communities has not yet developed in EITs, although increasing freedom, coupled with increasing traffic growth are likely to drive greater community opposition in the future

CASE-STUDY: TAROM – ROMANIAN AIR TRANSPORT

TAROM believes it is its duty to adopt a responsible attitude to the environment. The Company had to face the latest changes in fleet renewal, to meet competition and western airports requirements.

MODERNIZATION TRENDS

Starting with 1990, a systematic modernization program has been carried out by TAROM . The older aircraft (IL-18 ,IL-62, Tu-154, AN-24) have gradually been replaced with technologically advanced : A310, B 737-300, ATR 42. The new aircraft make a significant contribution to reducing emissions and noise levels, but the Company has only 26 aircraft, all belonging to Chapter 3. When the transition process started ('90),TAROM had 77 aircraft, 70% being Russian built, so it was quite difficult to keep all destinations in an increase competition. The example of fleet renewal and financial efforts made by the Company is a good asset for evaluation in a European aviation market.

ENVIRONMENTAL POLICY

TAROM is aware of the significant environmental issues such as: noise, emissions to atmosphere, energy saving, waste and water pollution. According to Romanian legislation on environment, a program of compliance has been set up, in order to manage the environmental impact throughout the entire Company. The policy is based on a strategy targeted to 2002. Fuel conservation is one of the main concerns of our environmental policy. Fuel burn is registered during every flight, based on the Flight Plan, and CO2 emissions are calculated, by aircraft, showing TAROM's contribution to Global Warming. In order to reduce emissions and noise disturbance the Company has implemented the process of 'phasing-out Chapter 2' aircraft, since March 2000.

CONCLUSION

Accession States need a wise aviation policy in order to meet EU requirements, the efforts required being in all sectors: airlines, airports, ATC, refueling companies, etc. They need to have a competitive system, to increase capacity, to meet the challenge of aviation growth, being aware of the safety above all and the environmental consequences of such developments. Their greatest challenge is to develop a system which brings the greatest social and economic benefits at minimal cost to the environment.

Summary of Working Group Discussions

Working groups addressed the following key questions:

- **How is local and global environmental capacity defined?**
- **What action can the industry take to increase its environmental capacity?**

In response to the above issues the following conclusions were reached:

How is local and global environmental capacity defined?

- All groups agreed that definitions of local and global environmental capacity are very distinct. A general definition was ventured, which facilitated discussion; this being: "*Environmental capacity is the extent to which the environment is able to receive, tolerate, assimilate or process outputs of air activity*".

- It was agreed that, at local level, the extent to which the environment was perceived to tolerate the outputs of air travel varied considerably. It was often the population immediately effected by the airports operation which defined the environmental capacity of the airport and this was primarily determined by noise and air pollution with little regard for other issues such as water pollution. Consequently, the levels of pollution tolerated differed from area to area and these were subjective and ephemeral.

- Definitions of environmental impact were further complicated by the number of organisations researching impact effects and producing differing results. The groups agreed that the establishment of a single independent body dedicated to monitoring the environmental impacts of all UK airports was desirable. They agreed that all factors needed to be considered not just noise and air pollution. In addition the introduction of eco-performance indicators for airports would also inform discussion.

- Accepting a subjective view of local environmental capacity it would seem preferable that the government, informed by independent data, negotiated the capacity of airports with local authorities who were better informed of the needs of the population, the local environment and the airport.

- Establishing eco-performance indicators would facilitate benchmarking. Careful monitoring was also essential if the reductions in pollution achieved by one country were not to be nullified by another country's breach of the targets. Countries currently developing air travel would find it difficult to meet environmental targets. They were recognised as being restricted by limited purchasing power hence they would be more inclined to opt for second-hand planes than the newer more eco-efficient planes; consequently they will struggle to meet pollution targets in terms of air quality and noise.

What action can the industry take to increase its environmental capacity?

- Airports increase trade and tourism both nationally and regionally however it is usually only the local community that experiences the negative effects of its operation. These are generally perceived as increases in noise, air and traffic pollution. Given the subjective nature of environmental capacity, at a local level, the groups suggested a number of ways of increasing environmental capacity:
    - Reducing the number of night flights
    - Ensuring pilots used best practice in landing and taking off (this alone can lead to big differences in noise levels)
    - Reducing the levels of stacking and holding of planes
    - Traffic management, investment in rail links
    - Integrating the airport into the community (this can be done by public meetings, school visits, local employment and investing in community projects).

- Given the subjective nature of tolerance levels to noise and air pollution it is not unreasonable to suppose that the integration into the community by investment, PR and improved community relations will enhance an airports image and perhaps increase a community's tolerance levels.

- The capacity of airports can be increased with the introduction of effective transport management systems which reduce the impact on the local community. The level of noise can often be reduced by modifying the way a pilot lands a plane and a reduction in air pollution achieved by a reducing the amount of holding and stacking of planes.

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