

MIME – Noise Trading for Aircraft Noise Mitigation

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Abstract

Airports currently use coarse constraints such as airport-wide noise budgets or simple categorisation mechanisms to control noise. Finer constraints could allow airlines to stay within them using a mixture of fleet composition, schedule, and route usage. A system of tradable, transferable noise permits could reduce the impact of this on airline business while, at the same time, enabling better overall management of airport noise.

The European Commission-sponsored "MIME" project will provide a system of transferable noise permits. Research centres on defining different candidate implementations and methods for initially allocating permits to airlines. These proposals and the performance of the market will be analysed using economic and air traffic simulations. The project is overseen by a stakeholder advisory board to ensure that the chosen system is equitable and acceptable.

MIME will also define tools for calculation of airline noise permit use and for enabling airports to decide on applicability to their situation. It will produce an analytic framework enabling airlines to understand the operation of this market and the value of such permits. The regulatory framework that would establish and govern this system and propositions for uniform implementation of the system at European airports will also be delivered.

Introduction

The problem of noise around airports has a history almost as long as that of aviation itself. Once the novelty wore off, as the number of planes increased, so did the noise, and so did the number of complaints. Public pressure has, over the years, seen the introduction of many different types of constraint at an increasing number of airports in an effort to keep both annoyance and complaints to a minimum.

These constraints are very coarse by nature, affecting all airlines similarly. Nothing is provided to allow airlines to manage their own noise budget and thereby allow them to avoid these blanket penalties on their business. Finer constraints, based on individual airlines' noise production could allow these airlines to stay within imposed noise levels using a mixture of fleet composition, schedule, and route usage.

This paper introduces a three-year European Union-sponsored project studying the introduction of a system of tradable, transferable noise permits could reduce the impact of noise limits on airline business while, at the same time, enabling better overall management of airport noise and even allowing "quiet" airlines to expand their business. First it looks briefly at current airport noise constraints. This is followed by an examination of economic methods already in use in environmental control. After a discussion of methods for translating aircraft noise into permits, the problems entailed in applying such economic methods to aircraft noise are expounded and avenues for investigation are proposed.

Environmental Noise Due to Air Transport

The negative impact of aircraft noise, in particular around airports, is increasing. More and more people suffer not only from annoyance and similar subjective effects, but recent studies indicate that intermediate and high noise levels also contribute to physiological and psychological effects that in extreme cases can cause severe health problems and even death.

The aircraft industry has launched an ambitious plan for the coming 15 years to reduce the noise emission levels from aircraft by as much as 20 dB. However, even if this goal

can be reached, reduced noise emission levels for new aircraft will have little or no influence on the total noise situation around European airports before 2025. This is due to a slow renewal rate for aircraft combined with an increase in passenger volume.

In order to stay competitive and to cope with an increasing number of neighbourhood complaints and noise-impact related constraints, airport owners will have to look for novel solutions to reduce noise emission levels.

The International Civil Aviation Organisation (ICAO) has defined a four-point "balanced approach" to mitigating for aircraft noise impact:

- Reduction of noise at source;
- Land-use planning;
- Noise-abatement operational procedures;
- Operating restrictions

This last option is intended to be used as a last resort. In fact, European Union directive 2003/30/EC requires that all other options be exhausted before operating restrictions are brought into force in EU member states. However, reduction at source needs time for aircraft fleets to be renewed, noise abatement procedures have to be developed and accepted from a safety point of view, and it is generally too late to stop people from living close to the airport - they are already there. Operating restrictions are, therefore, generally the only option available to an airport in the short term. This means that not only is increased capacity constrained by noise, that capacity is even reduced because of it. As can be seen in Table 1, these measures are very coarse instruments that enable a reduction in noise through an across-board penalisation of airport operations.

Table 1. Main airport noise-inspired restrictions (from Boeing database)

	USA	Rest of world	Total
Curfew	74	154	230
Noise limits	33	60	93
Noise quotas	13	35	48
Noise abatement procedures	197	228	425
Preferential runways	190	168	358

Stage 3 restrictions	8	44	52
APU	20	85	105
Engine run-up	184	183	367
Noise budget	4	11	15
Noise surcharges	4	124	128

As complaints grow, more and more airports are introducing one or more of these types of restriction. Figure 1. shows the evolution of the number of airports that certain types of restriction are applied at, over the last 35 years.

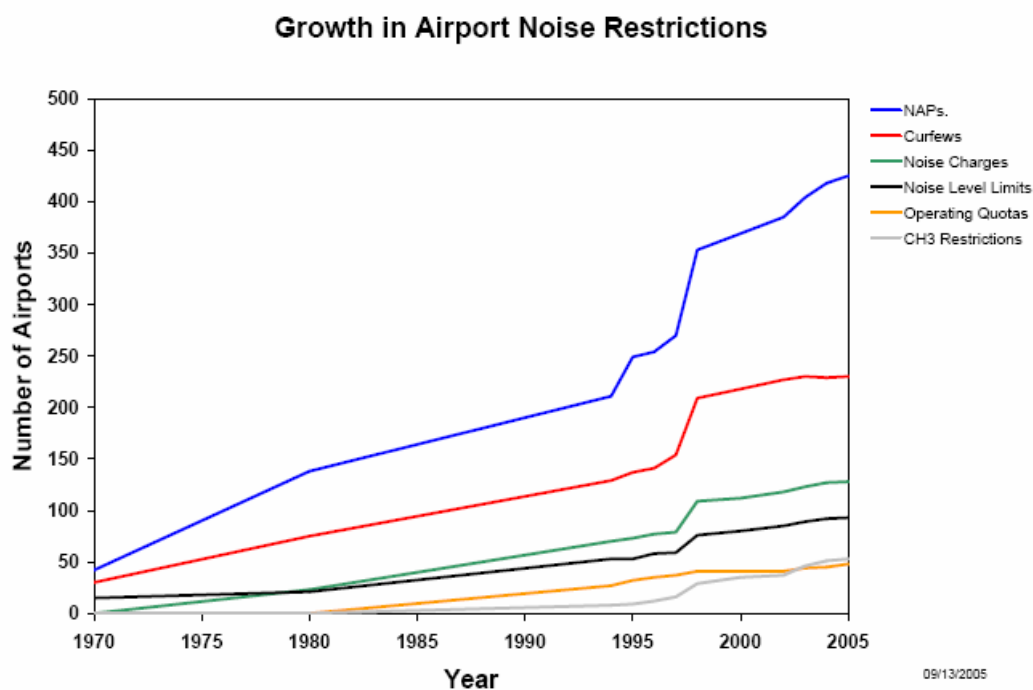


Figure 1. Evolution of six different restrictions at airports between 1970 and 2005

Whereas hundreds of millions of euros are being spent on projects aimed at reducing aircraft noise at source and more is being spent on developing noise abatement procedures, the cost of the implementation of operating restrictions on airline's balance sheets is enormous, whether the airline has put newer, quieter aircraft into service or not; whether the airline applies noise-abatement procedures or not. Operating restrictions thus affect all airlines indiscriminately. If finer constraints could be devised that break an

airport's total noise burden down into each airline's share of this burden, these airlines could manage their noise levels through fleet composition, schedule, and route usage. This could enable them to avoid restrictions and even increase their service. If this noise were tradable, airlines could sell unused noise allocations to companies that are unable to reduce their own noise to within agreed limits. Such trading possibilities would offer economic incentives for further reducing noise levels.

Market methods in environmental control

Economic measures have been used in several areas of environmental control in recent times. There are three major types of economic incentive aimed at limiting quantities of pollutant production:

- Pricing;
- Penalties for deviations from standards;
- Rationing by quantity.

These incentives can be mixed in defining an overall controlling mechanism.

Rationing by price involves assigning a charge per unit of pollutant to the producer. This is used for charging for effluent or waste disposal, for example; the producer paying a charge based on a pre-defined scale – there may be different rates for different types of waste – and thereby under a financial incentive to reduce waste. Similarly, charging for water consumption rather than applying a flat water-rate, as has been the practice in some countries, incites users to not only reduce normal usage, but to also repair leaks etc.

Fines, penalties or “non-compliance fees”, can be applied to producers violating a socially acceptable threshold. Fines are regularly applied when excess emissions, for example, are produced by an industrial complex. In air transport this mechanism is used in ensuring that aircraft stick to noise-preference routes

Rationing by quantity is a very simple instrument. Each entity in the domain/area/industry concerned is allowed to produce a certain maximum agreed amount of a given pollutant and no more. If this agreed amount is exceeded a fine can be imposed, or even some more drastic action may be taken. Some organisations or

institutions are more easily able to constrain their pollutant production than others. Over the years, therefore, the notion of these high-performing organisations' being able to sell their excess "pollutant capacity" to those who cannot meet requirements has arisen. This leads to the development of a system of marketable permits, with the total amount of pollutant allowed by all permits set to a socially acceptable level. Market-based incentives for pollution control are used to some degree today in several industries, with varying degrees of success (depending on the point of view of different players!). Examples of the application of such incentives include:

- The Lead Trading Programme in USA started in the 1980s for phasing out lead in petrol;
- Emission trading for local air-quality control in the United States. Areas not meeting local air-quality standards refuse new polluting sources unless they can be compensated by reductions at existing sources. Existing sources able to reduce emissions are awarded "credits" that can be sold to other firms, thus offsetting their mitigation costs;
- Water-pollution control in the Netherlands and in Germany.
- Tradable Water Abstraction Rights, such as in the Northern Colorado Water Conservancy District and the California Drought Water Bank
- Regional Clean Air Incentives Market RECLAIM in Los Angeles; targeted two gases, SO₂ and NO_x;
- The Ecopoint Programme in Austria is an ongoing initiative for limiting pollution and noise from truck traffic;
- The Zero Emission Vehicle Programme in California seeks to speed up the introduction of electronic vehicles
- The European Commission and European car manufacturers (ACEA) have a voluntary agreement to improve fuel efficiency of new cars by 25% relative to 1995 levels by 2008.
- Under the Kyoto Protocol, purchase of greenhouse-gas emissions permits is allowed, so countries falling below their Kyoto targets may sell the excess permits.
- CO₂ and other greenhouse-gas emissions are being addressed by the European Union Emission Trading Scheme (EU ETS), which started in January 2005. EU Member

States are required to set a CO₂ emission cap for all national companies according to pre-defined criteria, and this is then divided into a tradable annual allocation for each participating site. Initially, about 12000 large emitters are included in this trading scheme.

In concrete terms, the basic operation of a control system using marketable permits is fairly simple. Permits are issued to meet a desired measure of total impact across a specified region and are allocated to sources of impact in the region. This allocation can be free or paid for by the polluters. The number of permits allocated to a particular company can be based on criteria on previous impact or even declared future impact, or it can be the result of an auction etc. Sources that reduce impacts below the allocated number of permits will have surplus permits that may be traded between sources owned by a single enterprise, or between enterprises.

If the socially desired environmental impact is limited, available permits will be limited, and there will be a scarcity value associated with each permit. This value encourages trading of permits.

Tradable permits make departure from standards-based regulation easier than in a tax-based approach, a flexibility that enables them to be more cost effective (i.e. the marginal benefit of control is equal to the marginal cost). Additionally, this means that they do not require the regulator to have information about marginal abatement costs of pollution producers in order to set the target control level. Their great advantage over other approaches, however, is that they can be revenue neutral so that the producers don't see them as "just another tax-collection scam" – initial permits could be freely allocated up to the predefined limits and all financial transactions are between the companies themselves. Furthermore, companies that invest in less polluting equipment can either recuperate some of the costs associated with this investment by selling permits that are no longer needed, or they could hold on to these permits to cover the pollution caused by increased production. And here is the main advantage of tradable permits: whereas taxes, charges and fines restrict growth, tradable permits encourage it.

Airline-based aircraft noise modelling

For marketable permits to be applied to airline noise, it is first necessary to be able to define an airline's noise production accurately. There is currently no agreed method for doing this. There are two possibilities for determining an aircraft's, and therefore an airline's, noise output: measurement and modelling.

Permanent measurement is a costly affair. It involves the siting of several expensive microphones or microphone arrays at various locations around an airport and linking them, with radar data, to the hub of the airport noise and track monitoring system. Such systems provide very accurate measurements of the noise from aircraft flying overhead. They are generally used for monitoring residential noise levels and for ensuring that aircraft keep to designated flight paths. They are not very useful for producing "the big picture".

In general, airport-wide noise maps are produced by noise models. Airport noise modelling is defined by several internationally accepted guidance documents, of which the most recent is Doc. 29R from the European Civil Aviation Conference (ECAC). This will be used as the basis for the International Civil Aviation Organisation's (ICAO) updated Circular 205. This guidance material has been translated into noise-modelling software. Principal among the software noise models available is the US Federal Aviation Administration's (FAA) Integrated Noise Model (INM).

INM uses airport fleet details and a database of aircraft noise and performance data, together with theoretical flight profiles (height, speed and thrust) and ground-track data (generally the theoretical arrival and departure ground tracks defined for the airport) to produce analytical noise maps showing isometric contours of different noise-exposure levels. These maps do not allow sufficient accuracy for the true calculation of an airline's noise production, nor do they allow efforts taken by the airline in flying low-noise arrival and departure procedures to be taken into account.

The EUROCONTROL Experimental Centre has developed a front-end to INM called ENHANCE – the European Harmonised Aircraft Noise-Contour Modelling Environment.

ENHANCE calculates an aircraft's real ground track and flight profile from radar data. This includes estimating the thrust profile from changes in speed and height – not an easy task. Once these profiles have been calculated, they are passed to INM to produce the noise contours. 0shows an example of the outputs from INM and from ENHANCE. These diagrams are for illustration purposes only. They are not based on equivalent traffic nor do they cover equivalent time periods. They do, however, show how ENHANCE takes the true dispersion of the real aircraft into account in its calculations.

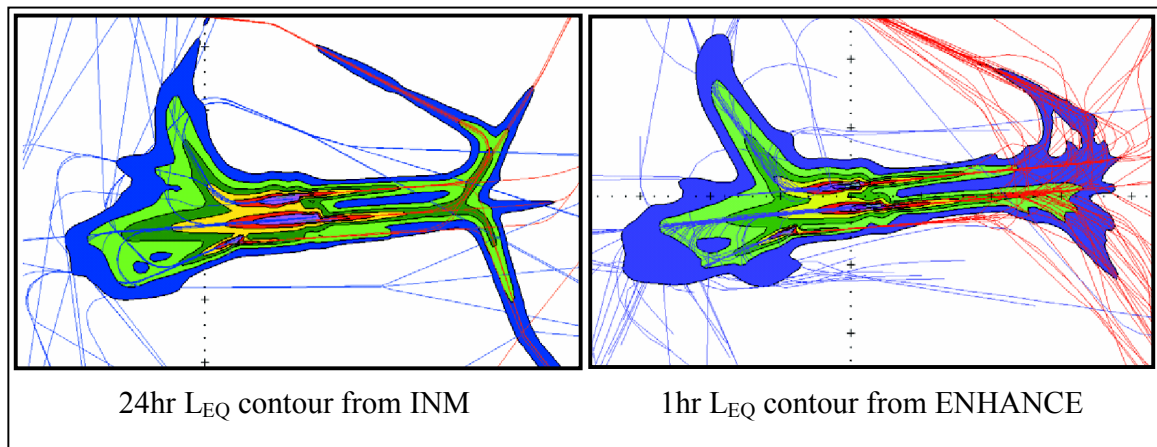


Figure 2. Airport noise contours using INM and ENHANCE

Each colour on these diagrams represents a different L_{EQ} noise level. Blue: 45dB; Pale green: 50db; dark green: 55dB; etc.

Having such a tool available enables the production of noise contours on a flight-by-flight basis, and therefore on an airline-by-airline basis. This is a calculation easily performed by INM by simply running it separately for each airline's movements.

Creating a tradable aircraft noise-permit system

In Figure 3. a day's traffic at an international airport has been thus modelled and the number of movements for each airline has been plotted against the surface area of the 55dB L_{EQ} contour calculated for these movements.

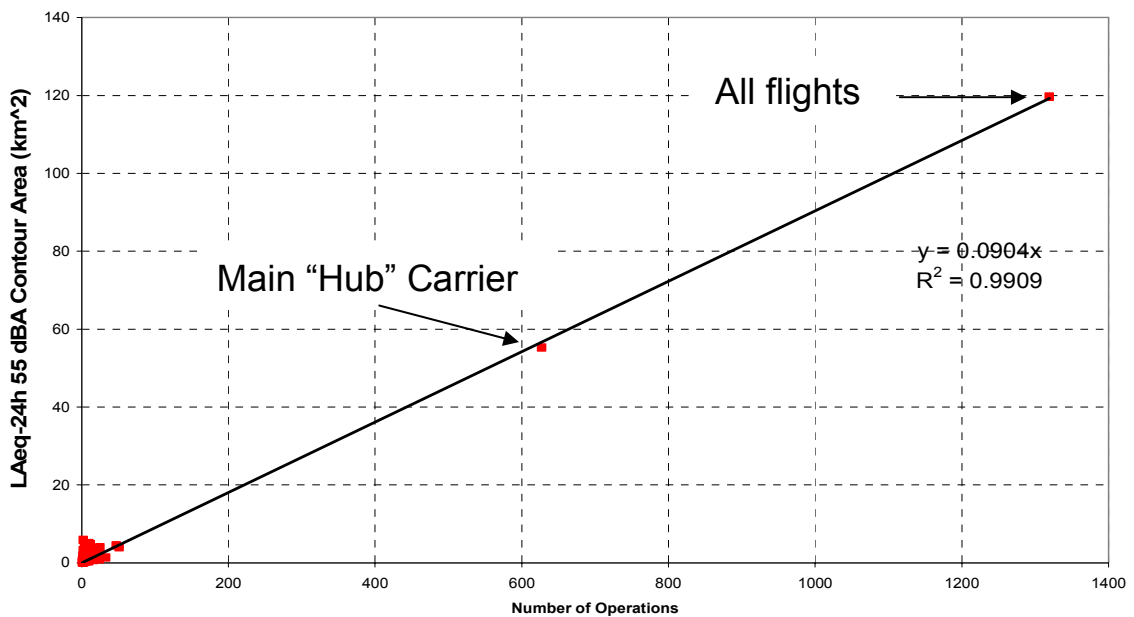


Figure 3. Graph of 55dB(A) $L_{EQ-24hr}$ contour for each airline's total movements in 24 hours against the number of movements for the given airline

It can be seen that a “biased” regression line (the total of the data is itself counted as a data point, though this has very little effect on the regression values) passes just above the point for the airport’s main carrier, which is responsible for almost half of the number of movements. This is a coherent result. All other carriers’ data is bunched up in the lower left segment. This segment is expanded in Figure 4. Here the regression line can be interpreted as showing the “right” noise contour size for the given number of movements. Some airlines produce contours smaller than their “right” size, other produce contours larger than theirs.

Imagine a system where each airline is allocated one noise permit per flight. Use of these permits can be determined by reading the number of movements needed to produce the “right” noise-contour of the same size as that produced by a given airline. It is clear that “Air Rightnoise” has used all of the permits allocated to it. “QuietAir.com”, by contrast, has only used 44 permits for its 51 movements. It has, therefore, 7 permits in hand to sell to an airline that requires them. “Heavy Metal Airlines” is in that situation: it’s two movements have produced as much noise as 65 “right” aircraft. It must, therefore, buy 63

additional permits from airlines such as “QuietAir.com” that have them to spare. Similarly, if Air Rightnoise wanted to increase its capacity it too would have to buy permits from QuietAir.com or others. However, QuietAir.com might not wish to sell its permits. It could use them to cover the noise generated by an increase in capacity of its own, of up to 8 flights ($7 \times 51 / 44 = 8.1$). This would, of course, increase the overall market value of permits available from other airlines.

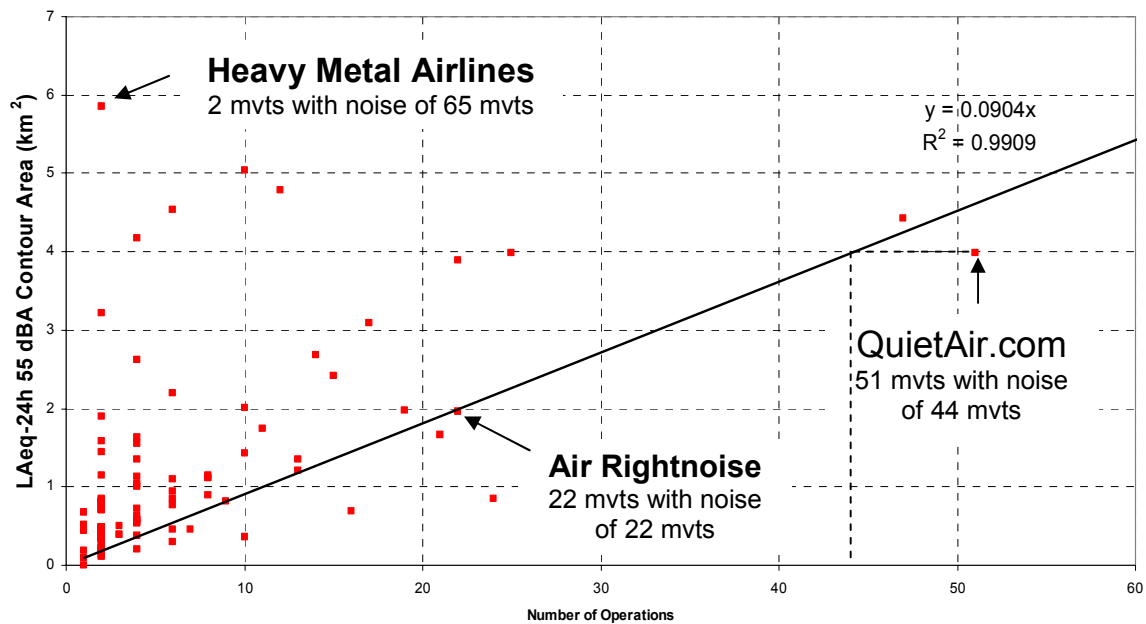


Figure 4. Distribution of airline noise contours against numbers of movements (smaller carriers)

Two important factors should be noted here. Firstly, the regression line does not equally bisect the data (it is a least-square fit, not a zero-average); more permits are required to be bought than there are for sale – even taking the main carrier’s into account. It is, therefore, a seller’s market and prices are likely to be high. Secondly, if “Heavy Metal Airlines” continues to fly the same aircraft into this airport, it is going to end up spending a large amount of money on noise permits, especially given their high price. There is, therefore, a major incentive to reduce contour size by flying quieter aircraft into this airport. In fact, since there are not enough noise permits to go around, there will be an obligation to do so.

As an example of how much money could be changing hands in these transactions, it is simply necessary to look at the UK's recent additional £5 "environmental surcharge" on (economy) passenger tickets, £2.50 per movement per passenger. If this were scrapped and noise permits replaced it, an average aircraft of 120 passengers means that a noise permit would have a value of £300. If QuietAir.com were to sell 7 permits per day, each day, it would make nearly £750 thousand per year from just that airport. (They would currently be paying the British Exchequer over £11 million per year for this "environmental charge" if this were a UK airport!) If Heavy Metal Airlines had just four movements per week it would have to pay nearly £4 million – just from this airport – to cover its permit purchases. These figures clearly show the incentive to invest in quieter aircraft.

Converting the theory into a workable system - MIME

The preceding example is, as has been stated, a least-square fit, and it is just as possible that the regression line could provide more permits for sale than required to be purchased, thus creating a buyer's market in which case the price of permit would fall and a large part of the incentive aspect would be lost. A true-life case, however, is unlikely to use a regression line but would rather have the line drawn by the regulator to fit the noise requirements of the airport thus ensuring that permit prices maintain an incentive level.

More importantly, we have so far looked at an example based on the size of 55dB(A) L_{EQ-24h} contours. This is a fairly large contour – in total 120km² at this airport. It is not obvious that controlling this contour would solve the problems with local residents that were mentioned in the introduction though, as has been seen, it provides a great incentive to airlines to remove the noisiest, and most annoying aircraft from their fleets. Above all, the size of the contour is not proportional to the number of people affected. Perhaps the population densities around the airport should be taken into account. Certainly a weighting should be applied for the different times of the day – this would allow a much finer weighting than simply looking at L_{DEN} and L_{Night} as is done at present. But we have looked at a permit based on a single flight. Is this the best granularity? At £300-a-permit it might be. But this might not allow for important noise-reduction measures such as noise-abatement procedures to be taken into account. The MIME project will examine

how noise permits will be defined and their use measured in order for them to become a usable tool.

Tradable permits should not, however, be seen as a panacea. There may be disadvantageous aspects, as well. For example, depending on permit price, some operators might choose to purchase, or hold on to, permits to discourage competition by blocking possibilities for increased capacity, perhaps cutting costs elsewhere in their operations. Such issues require careful analysis, and are part of the MIME project work plan.

The economic aspect of tradable permits has been looked at in the preceding chapter and touched upon in the above paragraph. It is, of course, extremely important that a noise permit system be defined in such a way that a market can exist, with permits being traded at an affordable price but at one that provides an incentive to reduce noise impact. These economic aspects are a major part of the work to be undertaken in the MIME project.

There are many airports that do not need such a system – either because they do not, yet, have a noise problem or because other methods might be easier and cheaper to implement at that airport. MIME will provide guidance for airports to enable them to understand the implications of such a system and to decide whether or not it is the right one to apply to their situation.

Whether it is good for a given airport or not, it is quite clear that a noise permit system cannot be defined to cover an area greater than an airport and its neighbourhood – trading noise between two airports in the same city, for example, is not going to keep residents happy! But perhaps even runways should be considered separately – another topic for investigation.

For such a system to work, it is important that it be applied uniformly at those airports it is applied at so that airlines do not have to work with competing systems. A key issue in this research, therefore, is the nature of the appropriate regulatory framework. Briefly stated, key requirements for the regulators of a system of marketable permits include:

- Sufficient information to determine the appropriate time period associated with a permit;
- Sufficient information on marginal costs and benefits of pollution control to set the level of control and the number of permits;
- A means of initially allocating permits fairly;
- A means of monitoring compliance with and use of the permits;
- A legal framework within which property rights associated with the permits are defined and protected.

A critical research issue is how to interpret these requirements in the complex and dynamic economic world of air transport.

Finally, there are many aspect of flight operations around an airport that are not in the hands of the airline operators. They and their pilots are not complete masters of the routes they fly by any means nor of the procedures available to them at a specific airport. The impact of Air Traffic Control of noise permit use has to be analysed, and MIME will study all aspects of this in coming to its conclusions.

Conclusions

The major innovation from the MIME project is a new economic paradigm for noise management in the air-transport industry. The project addresses the new regulatory framework required to implement this approach, and it addresses both the initial conditions and sustaining parameters for this new paradigm. If successful, this new paradigm could assist in avoiding major environmental problems associated with growth in the air-transport industry, and assist in maintaining viability and vitality in this key sector of the European economy.

The MIME project also is innovative in its approach to finding multi-dimensional solutions to this complex problem. The project will develop tools that will enable the airport owner to understand the implications of include noise trading in their selection of methods for reducing annoyance in the neighbourhoods around them. The project will

also propose methods and procedures that allow for the introduction of a “polluter pays” principle without the crude cudgels of taxation, charging and fining.

New ways of linking the disparate factors influencing behaviours of the air-transport players are also addressed. Airport fees can be linked to total noise impact; a combination of noise emission levels and number of people affected. By providing an economic incentive, airlines can be persuaded to choose low noise solutions in order to save operational costs. Such solutions may include changing to low noise emission aircraft, using low noise take-off and landing procedures within the constraints of the ATM, etc. A monitoring system may be implemented to yield accurate information about the actual per-event noise impact.

Hence innovations from MIME will contribute to:

- Reducing the negative noise impact around airports including harmful health effects
- Improving the community response to airport operations
- Increasing the acceptance of air transport
- Maintaining jobs at European airports
- Improving the quality of life of European citizens.

The MIME project will address the problem of aircraft noise in an entirely innovative way. A system of tradable noise permits would allow airports to restrict, and even reduce, noise immission (the noise received on the ground) from aircraft without having to apply blanket operating restrictions. Airlines would be free to manage their operations in whichever way they decided best. This could involve investment in quieter fleet, implementation of quieter procedures or purchasing another airline's excess permits. Use of fewer permits than those held by the airline would give rise to the possibility for that airline to increase its operational throughput.

MIME will therefore allow airports to both improve the environmental impact with regard to noise and to increase the operational capacity of those airlines that successfully control their noise.

Although primarily a noise related project, MIME will also look to provide an understanding of the interdependency between the noise permits and the aircraft's emissions. It is important that emission modelling be captured within MIME to ensure that the resulting legislation does not contradict emission targets. By ensuring that the noise permit scheme is consistent with emission modelling and emission trading ensures buy-in by stakeholders.