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ECONOMIC IMPLICATIONS OF FUTURE NOISE RESTRICTIONS ON SUBSONIC JET AIRCRAFT

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Glossary of Terms

Non-noise certificated (NNC) aircraft. A subsonic jet aircraft which has not been certificated to meet the noise level requirements prescribed in ICAO Annex 16, Volume I, Chapter 2 or 3.

Chapter 2 aircraft. A subsonic jet aircraft which has been certificated to meet the noise level requirements prescribed in ICAO Annex 16, Volume I, Chapter 2, but does not meet the requirements of ICAO Annex 16, Volume I, Chapter 3 (Chapter 2 is equivalent to Stage 2 under United States regulations).

Chapter 3 aircraft. A subsonic jet aircraft which has been certificated to meet the noise level requirements prescribed in ICAO Annex 16, Volume I, Chapter 3 (Chapter 3 is equivalent to Stage 3 under United States regulations).

Non-compliant aircraft. A subsonic jet aircraft which does not meet the noise level requirements prescribed in ICAO Annex 16, Volume I, Chapter 3 (this includes all NNC and Chapter 2 aircraft).

Hushkitting, re-engining and retrofitting. Hushkitting means modifying aircraft engines with sound absorbing material, changing exhaust mix nozzles, and/or making other mechanical changes to reduce noise emissions. Re-engining means replacement of noisy versions of older engines with new quieter (often more fuel efficient) versions or with a new type of engine. Retrofitting means modification of the airframe and/or engine which could include either hushkitting or re-engining, or both.

Noise-restricted areas. Geographical areas covering States which are assumed for the purpose of this study will implement operating restrictions on aircraft which do not meet the noise level requirements of ICAO Annex 16, Volume I, Chapter 3:

— Australia, Japan, New Zealand
— the 22 Member States of the European Civil Aviation Conference (ECAC)
— United States.

Non-restricted areas. Geographical areas covering States which are assumed for the purpose of this study will not implement operating restrictions on aircraft which do not meet the noise level requirements of ICAO Annex 16, Volume I, Chapter 3. For analytical purposes the States concerned have been divided into eight groups on the basis of their proximity to noise-restricted areas, the traffic patterns of their air carriers in relation to noise-restricted areas, and the subregional divisions used in the ICAO regional air transport studies:

— Canada
— Mexico/Central America/Caribbean
— South America
— Eastern Europe (including USSR)
— Middle East
— Northern Africa
— Western/Central/Eastern/Southern Africa
— Asia/Pacific (less Australia, Japan and New Zealand).

The States included in each of the subregions concerned are listed in Appendix 2.

PKPs (Passenger-kilometres performed). A passenger-kilometre is performed when a passenger is carried one kilometre. Calculation of passenger-kilometres equals the sum of the products obtained by multiplying the number of revenue passengers carried on each flight stage by the stage distance. The resultant figure is equal to the number of kilometres travelled by all passengers.

ASKs (Available seat-kilometres). A seat-kilometre is available when a seat is flown one kilometre. Seat-kilometres available are equal to the sum of the products obtained by multiplying the number of passenger seats available for sale on each flight stage by the stage distance.

Net Accrued Cost. The cost to airlines of replacing non-compliant aircraft earlier than planned because of an operating ban, taking into account both the additional cost of capital over the period concerned and any savings in operating cost accruing from use of the replacement aircraft over the same period. Unless otherwise specified all monetary data in this study are expressed in terms of millions of 1988 United States dollars, and costs are discounted at a rate of 6 per cent per annum to the year of commencement of the operating ban concerned.

Chapter 1

Introduction

1. The application of the noise standards contained in Annex 16 to the Chicago Convention was discussed extensively during the 26th Session of the Assembly in 1986. The Assembly discussed this matter against the background of decisions by a number of States to introduce operating restrictions in their territories on aircraft that do not meet the certification requirements of Annex 16, Volume I, Part II, Chapter 2 ("Chapter 2"), as well as indications that these restrictions would be followed up with future measures aimed at curtailing the operations by aircraft which do not meet the more stringent certification requirements set out in Annex 16, Volume I, Part II, Chapter 3 ("Chapter 3").

2. The main concern of the Assembly was to achieve a balance between the desire to protect the environment around airports against unnecessary noise and the desire to avoid excessive costs associated with an accelerated replacement of noisy aircraft.

3. Bearing in mind that the effect of adopting restrictions in some States on the use of foreign aircraft which do not meet the requirements of Chapter 3 had not yet been studied on a world-wide basis, and that a resolution of noise problems must be based on the mutual recognition of the difficulties encountered by Contracting States and a balance among their different concerns, the Assembly adopted Resolution A26-11 in which it:

> "REQUESTS the Council to study as a matter of urgency the economic implications of limiting operations of subsonic jet aircraft which comply with Annex 16, Volume I, Chapter 2, but which do not meet with Annex 16, Volume I, Chapter 3, with a view to making recommendations to the next ordinary session of the Assembly; and
>
> URGES all Contracting States to abstain from adopting provisions to prohibit the use to or from their territories of subsonic aircraft of foreign registration which comply with Annex 16, Volume I, Chapter 2 but which do not meet the noise certification standards in Annex 16, Volume I, Chapter 3, pending further review of the recommendations of the Council at the next ordinary session of the Assembly in the light of which action will be taken."

4. The Council assigned the study to the Secretariat on the understanding that extensive consultations would be held with all interested parties. In carrying out the study the Secretariat accordingly consulted a Study Group appointed for that purpose and with a membership including experts nominated by governments from different regions as well as airport and airline interests. The Study Group held two meetings of which the first, in February 1988, was to review initial results and to discuss the general approach to the study while the second meeting, held in September 1988, was to review the final results of the study.

5. In the course of the study contributions were also obtained from the manufacturing industry and a survey of airlines was carried out with the assistance of IATA in order to assess the extent to which operating restrictions on certain aircraft would affect the utilization of these aircraft.

6. While the assumptions underlying the study were agreed by consensus amongst the Study Group of Experts, it has to be recognized that a change in any of these assumptions would change the results of this study. Nevertheless, these results may be considered as giving a reasonable, broad measure of the impact which hypothetical future noise restrictions by certain groups of States would have if introduced at different times.

7. The Air Transport Committee reviewed the study in December 1988 and, following some revision, in January/February 1989. The study is published by decision of the Council in February 1989 and will serve as a reference for consideration of the subject of possible noise restrictions on subsonic jet aircraft by the 27th Session of the Assembly in September 1989.

Chapter 2

Scope of Study

1. The over-all impact on the air transport industry of future operating restrictions on noisy aircraft would greatly depend on the number of countries and airports introducing the restrictions. For the purpose of this study the assumption was that a general operating restriction on aircraft which do not meet the certification standards of Annex 16, Chapter 3 (non-compliant aircraft) will be implemented by the Member States of the European Civil Aviation Conference (ECAC), by the United States, and by Australia, Japan and New Zealand (assumed noise-restricted areas). This assumption concerning geographical coverage is intended to be a realistic reflection of the prospects, but it is hypothetical and in no way a prejudgment of the actions which these and other States may eventually take. The assumption was arrived at on the basis of actions which had been taken by States with respect to operations of aircraft which do not meet the Chapter 2 certification standards and indications by a number of States that further restrictions are being considered.

2. Although in practice all States would probably not introduce an operating restriction at exactly the same time, it is an underlying assumption that all the States mentioned above introduce the same kind of operating restriction and at approximately the same time. Jet aircraft which do not meet the certification Standards of Annex 16, Chapter 3 are predominantly older aircraft which are no longer in production. Because of the normal attrition due to age the impact of future operating restrictions on such aircraft depends greatly on the timing of the restrictions. Because of this sensitivity, the present study includes analyses of the impact for five scenarios, three being a complete operating ban from the years 1995, 2000, 2005 respectively, one being an operating ban to be implemented gradually from 1995 onwards, and the final one being a similar gradual ban commencing in the year 2000. Under each scenario an analysis has been carried out for an operating ban on non-compliant narrow-body jet aircraft and a separate analysis for a ban on wide-body jet aircraft, since the majority of the latter fully comply with the certification requirements of Chapter 3 and the remainder only marginally fail to meet the requirements of Chapter 3.

3. The impact of a general operating ban in a country will affect operators from that country and foreign operators into that country in fundamentally different ways. For operators based in the country all non-compliant aircraft will need to be replaced early whereas for foreign operators based in a country which does not itself pose a ban only aircraft which operate to the noise-restricted areas will be affected and there will usually be a possibility of assigning at least some of the other aircraft to routes where they remain acceptable. Bearing this in mind and also that the ECAC States and the United States have already introduced extensive studies of the impact of future operating restrictions on operators based in their own territories, the present study concentrates on the impact on operators based in other countries but operating into those countries where the restrictions are assumed to be implemented. The impact on operators in those countries where the future restrictions are introduced is addressed primarily by way of summary and discussion of other studies which have already been carried out.

4. The world-wide aircraft inventory developed for this study, as well as all the analyses of the impact of operating bans on carriers from the noise-restricted areas, relate to the subsonic commercial jet fleet of all operators and types of operation, including all-cargo and non-scheduled operations. However, for the non-restricted areas, where the impact of an operating ban elsewhere is dependent on the ability to redeploy aircraft,

the nature of all-cargo and non-scheduled operations has meant that it has not been possible to quantify the impact on such operations and, while the data base covers all operations, the analyses cover scheduled passenger and combination aircraft operations only. At the same time the all-cargo and non-scheduled operations concerned are known to be relatively insignificant compared with the scheduled passenger and combination aircraft services and/or to be predominantly to/from non-restricted areas.

5. Because of the number of States and operators involved it was not possible in this global study to evaluate the impact of future operating restrictions on individual States or operators. On the other hand, a study of the over-all impact on a global basis or for major regions would not be particularly relevant to individual States. As a compromise the States which are assumed not to introduce restrictions themselves were divided into eight groups. The individual States within each of these groups have fairly similar geographical locations and traffic patterns in relation to those States which are assumed to introduce a ban.

6. It is technically feasible and will probably also be economically worthwhile to retrofit some aircraft which do not meet the certification requirements of Annex 16, Chapter 3 so as to become compliant with these requirements. It has not been possible to make any assumptions about the extent of such measures in the present study. However, this possibility and the way such retrofit programmes could affect the conclusions of the study are discussed in Chapter 7.

7. For the analysis of environmental impact of noise restrictions, all the available material that could be taken into account dealt with the magnitude of the land areas or populations around airports that would be subjected to a certain noise exposure with and without operating restrictions on noisy aircraft. No material of general applicability provided monetary measures of the benefits which airport neighbourhoods would derive from such restrictions. Thus, while the impact of restrictions on the environment may be quantified in physical terms, it has not been possible to relate this impact directly to the financial repercussions encountered by aircraft operators.

8. Because of the extensive data base available regarding the fleets of civil jet aircraft and their operations, the emphasis has been placed in this study on estimating the number of aircraft that would need to be replaced before the end of their economic lives as a consequence of operating bans. The operating cost and revenue implications of early replacement of aircraft are subject to greater uncertainty, but they can nevertheless provide a broad indication of the financial impact of operating bans in relation to the carriers' scale of operations and have therefore also been evaluated. In addition, the possibilities of finding alternative uses and secondary markets for the non-compliant aircraft are discussed. It has not proved practical to convert the quantified financial implications for the airlines into the consequent implications for their shareholders and users or into the more general economic implications for the air transport and tourism industries.

Chapter 3

Main Findings

1. At the end of 1987 there were an estimated 5 361 non-compliant aircraft of more than 9 tonnes take-off weight or of 40-seat capacity registered world-wide. Within the noise-restricted areas comprising the 22 ECAC Member States, United States, Australia, Japan and New Zealand there were 3 609 non-compliant aircraft. In all other States there were 1 752 non-compliant aircraft, excluding the USSR domestic fleet. (See Chapter 5.)

2. If no operating ban is introduced in the meantime, normal attrition of the non-compliant aireraft fleets within and outside noise-restricted areas will result in the number of such aircraft declining by one third between 1987 and 1995, and by another third between 1995 and 2005. At the same time, total traffic by aircraft operators within and outside the noise-restricted areas is expected to continue its historical growth, reaching a level in the year 2005 which is almost three times as high as the total traffic of 2 300 billion ASKs in 1987. As a result of these dual trends of the declining fleet of non-compliant aircraft and the increase in traffic, the share of total traffic (excluding USSR domestic traffic) carried by non-compliant aircraft will decrease from just over 40 per cent in 1987 to 18 per cent in 1995, 10 per cent in 2000 and 5 per cent in 2005.

3. In the noise-restricted areas, the number of aircraft that would need to be retrofitted or whose replacement would be brought forward as a result of an operating ban in 1995 amount to about 2 400 and would account for about 16 per cent of all traffic of the countries concerned. Similarly, a ban in the year 2000 would imply early replacement of 1 700 aircraft accounting for 9 per cent of traffic and a ban in the year 2005 would imply early replacement of just over 1 000 aircraft accounting for 4 per cent of the traffic. (See Chapter 6.)

4. Outside the noise-restricted areas, the relative impact of the assumed operating bans would be smaller. Whereas virtually all flights by non-compliant aircraft registered within the noise-restricted areas are to, from or within those areas, less than half of the traffic performed by non-compliant aircraft registered elsewhere is to or from the noise-restricted areas. A survey of airlines registered outside the noise-restricted areas but having traffic into those areas with non-compliant aircraft confirms that such airlines would generally need to replace some aircraft if an operating ban were imposed. The number of non-compliant aircraft that would need to be replaced, however, would usually be less than the number engaged in traffic to the noise-restricted areas because of the possibilities available for re-assignment of non-compliant aircraft to routes which are not affected by the ban. The proportion of the non-compliant fleet that an airline would need to replace depends very much on its geographical location and its traffic pattern.

5. Based on the survey of airlines, estimates have been made of the number of narrow-body and wide-body aircraft that would need to be replaced early or retrofitted if a ban were imposed in 1995, 2000 or 2005. These estimates were made for all States outside the noise-restricted areas, divided into eight geographical groupings. While the proportions of the non-compliant aircraft that would have to be replaced earlier vary greatly among the groupings some general trends can be found. (See Chapter 8.)

6. A large proportion of the non-compliant narrow-body aircraft based outside the noise-restricted areas are used in short- to medium-haul traffic in the non-restricted areas. Furthermore, the possibility of future re-

assignment of such aircraft away from traffic into the noise-restricted areas is comparatively good. Hence the proportion of the non-compliant narrow-body fleet that would need to be prematurely disposed of tends to be low. Of the total fleet of non-compliant narrow-body aircraft registered outside the noise-restricted areas about one-fifth or less would need to be replaced. The estimated numbers of aircraft to be replaced in case of a ban are 219 in 1995, 142 in 2000 and 79 in 2005.

7. The non-compliant wide-body aircraft based outside the noise-restricted areas are much fewer but are predominantly used in long-haul traffic so the possibilities of using these aircraft in traffic outside the noise-restricted areas are therefore more limited than for narrow-body aircraft. It is estimated that around 50 per cent of aircraft would need to be replaced early if a ban were imposed, the estimated numbers being 45 in 1995, 34 in 2000 and 18 in 2005.

8. In principle, the effect of an operating ban is to accelerate an ongoing fleet modernization process, somewhat reducing the value of the assets of the operators concerned and requiring them to make capital commitments earlier than justified from purely commercial considerations. With respect to aircraft outside the noise-restricted areas it has been estimated that if a complete ban were to be imposed in 1995 the capital commitments that would need to be brought forward to that date amount to about $9 500 million (narrow-body aircraft $6 000 million; wide-body aircraft $3 500 million). Correspondingly, a complete ban in the year 2005 would necessitate an advanced capital commitment of about $3 500 million (narrow-body aircraft $2 000 million, wide-body aircraft $1 500 million). It must be emphasized that these figures do not represent additional investment in new aircraft, but rather investment which would be expected to be made at some stage in the future and which would need to be brought forward. (See Chapter 7.)

9. The costs to the airlines of an operating ban have been assessed in this study in terms of the additional capital costs over the period concerned associated with bringing forward the estimated investment requirements referred to above, less savings associated with disposal of existing aircraft at a date earlier than planned and savings in operating costs accruing from use of replacement aircraft over the period concerned. For a complete ban imposed in the noise-restricted areas in 1995 this "net accrued cost" to the airlines from the non-restricted areas would be about $2 250 million (narrow-body aircraft $725 million; wide-body aircraft, for which there was no clear-cut indication of reduced operating costs from replacement aircraft, $1 525 million). Correspondingly, a complete ban in the year 2005 would incur a net accrued cost of $410 million (narrow-body aircraft $130 million; wide-body aircraft $280 million).

10. The implications of a future operating ban have been evaluated on the assumption that the ban is introduced at one point in time. Indications are, however, that States which may need to introduce such a ban would do so in a phased manner, permitting their operators to phase out their fleets of non-compliant aircraft gradually. In broad terms the estimated effects of a complete ban in the year 2000 on fleets and traffic are indicative of the effects of a phased ban implemented around that time, for example, between 1995 and 2005. Similarly the estimated effects on fleets and traffic of a complete ban in 2005 would broadly reflect the effects of a ban which is phased in during the period 2000 to 2010. An advantage of a phased ban is that it reduces the abrupt surges in requirements of capital by the airlines and in requirements for the capacity of aircraft production lines that would result if a ban were fully implemented at one point in time. (See Chapters 6 and 7.)

11. Whereas non-compliant narrow-body aircraft tend to have noise levels which exceed the Chapter 3 standards by several decibels, non-compliant wide-body aircraft are all early models of Boeing 747 with noise levels which exceed the Chapter 3 standards by a much smaller margin. A special case study in the United States for an airport with a high volume of B747 traffic has shown that it would make very little difference in the noise contours whether or not non-compliant B747s were replaced by compliant B747s. (See Chapter 4.)

12. Available estimates made within the United States and ECAC indicate that at airports within the noise-restricted areas aircraft movements by aircraft registered outside the areas rarely amount to more than a few per cent of total movements. The future percentage of movements by "foreign" non-compliant aircraft will be even smaller, and the impact of these movements on the over-all noise environment may not be significant at the vast majority of airports, although even a relatively few movements by noisy aircraft can contribute to public perception of the noise climate.

Summary

13. The primary results of the ICAO analyses, namely the quantified estimates of the impact of hypothetical future noise restrictions on airline operations, are presented below in summarized form for the three scenarios of complete operating bans on non-compliant aircraft in the years 1995, 2000 and 2005 respectively. As indicated above and detailed in Chapters 6 through 8, the impact of the phased ban scenario commencing in 1995 would be broadly similar to that for the complete ban scenario for 2000 and similarly the impact of the phased ban scenario commencing in 2000 would be broadly similar to that for the complete ban scenario for 2005.

Number of Chapter 2 aircraft remaining in absence of an operating ban

	1995	2000	2005
Noise-restricted areas			
Total	2 400	1 739	1 085
Narrow-body	2 264	1 653	1 033
Wide-body	136	86	52
Non-restricted areas			
Total	1 129	886	572
Narrow-body	1 048	825	534
Wide-body	81	61	38

Number of aircraft to be replaced early or retrofitted due to ban in year concerned

	1995	2000	2005
Noise-restricted areas			
Total	2 400	1 739	1 085
Narrow-body	2 264	1 653	1 033
Wide-body	136	86	52
Non-restricted areas			
Total	264	176	97
Narrow-body	219	142	79
Wide-body	45	34	18

Net accrued cost to carriers assuming early replacement of aircraft* ($ million)

	1995	2000	2005
Noise-restricted areas			
Australia/Japan/ New Zealand**			
Total	1 400	700	330
Narrow-body	500	300	120
Wide-body	900	400	210
ECAC States***	500	–	–
United States***	2 687-5 657	1 563-3 805	482-3 053
Non-restricted areas			
Total	2 250	1 050	410
Narrow-body	725	335	130
Wide-body	1 525	715	280

* A cost discounting procedure has been applied, at a discount rate of 7.5 per cent with discounting to 1986 in the case of the figure for ECAC States, and at an annual discount rate of 6.0 per cent with discounting to the year of the operating ban in all other cases.

** Estimates, based on ICAO methodology used for noise-restricted areas.

*** Costs were estimated separately within the State and organization concerned and are not directly comparable with cost data for other areas derived using the ICAO methodology (see Chapter 7, paragraphs 12 through 14). They are included here purely for information to provide as complete a picture as possible.

Proportional impact on total capacity of ban in year concerned

	1995	2000	2005
Carriers from noise-restricted areas			
Per cent of ASKs affected	16	9	4
Per cent of jet fleet affected	41	25	15
Carriers from non-restricted areas			
Per cent of ASKs affected	10	6	2
Per cent of jet fleet affected	11	6	3

Chapter 4

Environmental Impact

1. If restrictions were introduced on operations of aircraft which do not meet Chapter 3 certification standards, noise in the vicinity of airports would be reduced. The main environmental impact of reduced noise would be that fewer people would be disturbed and for those who would still be affected the nuisance would be reduced. Although these benefits would arise primarily in those countries which decide to impose restrictions, there could also be some lesser benefits in other countries arising from the fact that flights to/from countries which impose restrictions could no longer be performed with Chapter 2 aircraft.

2. Aircraft noise consists of a series of discrete events corresponding to aircraft movements (take-offs, landings). Consequently, environmental studies generally use cumulative measures of exposure to aircraft noise which take into account the number of aircraft movements, their individual noise levels and even their timing (e.g. day or night). Although there are several different cumulative measures in use, they all enable "noise contours" to be plotted around airports so as to define the areas exposed to a certain level of aircraft noise.

3. With or without restrictions, some environmental improvement can be expected in the forseeable future. Noise levels have been declining at many airports in recent years as the proportion of total movements which are performed by Chapter 3 aircraft has increased and, in the absence of restrictions, this trend may be expected to continue until all Chapter 2 aircraft eventually disappear. Therefore any assessment of the impact of future aircraft operating restrictions needs to compare the situation anticipated when restrictions are in force against that which would have occurred in the absence of such restrictions.

4. Various studies have been conducted on this basis in the United States and Europe. The most commonly used approach in the available studies has been to estimate changes in the noise contours around airports and, when possible, the number of people resident within these contours, with results as indicated below. There appears to be no information available, however, which would enable the environmental benefits of restrictions to be expressed in monetary terms so as to enable comparisons to be made with the costs to aircraft operators of introducing noise restrictions.

Studies in the United States

5. In 1985, there were 3.2 million people in the United States living on land exposed to levels of aircraft noise which, according to the United States authorities, create a significant annoyance for most residents. In order to assess possible future changes in the noise environment, the United States authorities have analyzed data for 65 airports which accounted for 2.6 million of the 3.2 million people and have estimated that, without a ban on Chapter 2 aircraft, the total noise-affected population in the year 2000 would be 10 per cent less than in 1985, whereas with a ban it would be 57 per cent less than in 1985. Therefore a ban on Chapter 2 aircraft would reduce the total noise-affected population in the year 2000 by about 50 per cent.

Studies in Europe

6. Various studies have been undertaken by some member States of the European Civil Aviation Conference (ECAC) to estimate the environmental impact of the proposals for a phased ban on the operations of Chapter 2 aircraft commencing in 1995 which are under consideration by ECAC. For approximately equivalent noise levels to those examined at United States airports (see 5 above), the results of these studies point to a reduction in the noise-affected areas around airports of the order of 25 per cent in the year 2000 if the restrictions under consideration were implemented. This percentage reduction in terms of land area is distinctly lower than the estimated reduction of about 50 per cent in terms of population at United States airports. While it is difficult to make comparisons between the results of different studies and it could be misleading to compare changes in land area with changes in population, it may be presumed that one of the principal reasons for the lower European percentage in the year 2000 is that the ban under consideration by ECAC would not affect operations by Chapter 2 aircraft of less than a certain age in the year 2000, whereas the studies in the United States are based on a ban on all Chapter 2 aircraft operations.

Difference in environmental impact if all Boeing 747s continued to operate

7. In view of the possibility that future operating restrictions might not be applied to those Boeing 747 aircraft which are not certificated to Chapter 3 standards, a study was undertaken by the United States authorities of the extent to which the environmental impact at Los Angeles International Airport would change if these aircraft were exempted. The study showed that if all movements by Chapter 2 Boeing 747s were replaced by Chapter 3 Boeing 747s, there would be only a marginal difference in the noise contours at that airport. As Los Angeles International is one of the busiest airports in the world in terms of Boeing 747 traffic, this conclusion is likely to hold elsewhere as well.

Environmental impact of exempting foreign operators

8. Another potential issue concerns the extent to which the environmental benefits would be affected if restrictions on the operations of Chapter 2 aircraft did not apply to foreign operators (or to operators from States which would not themselves apply restrictions).

9. An analysis provided to the Secretariat by the United States authorities gives some indications of the likely effects of not applying such restrictions to foreign operators at the 12 United States airports with the largest noise-affected populations. Although this analysis was based on scheduled traffic only, it indicates that if such restrictions were applied to United States operators but not to foreign operators the environmental benefits at most of these airports would not be significantly different than if such restrictions were applied to all operators (based on one of the cumulative measures of noise exposure referred to in 2 above, the areas contained within a certain noise contour would be larger by 0 to 5 per cent at 9 airports, 10 to 12 per cent at 2 airports, and 57 per cent at one airport). This can be explained by the fact that aircraft movements by foreign operators represent only a small proportion of the total scheduled aircraft movements at these airports (0 to 7 per cent at 10 airports; 19 per cent at each of the remaining two airports). The situation in Western Europe is likely to be broadly similar, since ECAC estimates that the proportion of movements by non-ECAC airlines at ECAC airports is relatively small (less than 5 per cent) in most cases, although this proportion is much higher at some airports.

10. These broad indications suggest that foreign aircraft contribute only a small proportion of the noise, and hence the disturbance, at many airports. However, experience within ECAC with the phasing out of non-noise certificated aircraft has demonstrated that as the noise climate improves, the few remaining relatively noisy movements stand out, contributing disproportionately to the perceived noise climate.

11. If foreign operators were exempted, those airlines which would be forced to re-equip with new technology aircraft could be at a disadvantage compared with foreign operators who would be able to continue to operate whatever aircraft types they consider appropriate for the markets concerned.

Other benefits

12. Apart from the primary benefit of reducing community annoyance in the vicinity of airports, operating restrictions on Chapter 2 aircraft may open the possibility of deriving various secondary benefits at many airports. For example, there may be less likelihood of night-time curfews or other noise abatement restrictions being imposed in the future, possibilities for alternative uses of land could be created in the vicinity of airports, and there could be better opportunities for building new airports and expanding existing ones.

Chapter 5

Fleet and Traffic Without New Noise Restrictions

1. In order to be able to establish the noise classification of each aircraft in the world commercial subsonic jet aircraft fleet, a computerized data bank was compiled, recording under the registration number of each aircraft each of the relevant parameters from which noise classification is determined. This data bank includes all civil subsonic jet aircraft on registry greater than 9 tonnes (20 000 lbs) maximum take-off weight or of 40-seat capacity.

2. At the end of 1987 the world subsonic jet civil aircraft fleet consisted of 10 440 aircraft (excluding a very few small jet aircraft). Of these 10 440 aircraft, 593 were operated by government agencies and private bodies, and 1 871 were Soviet-built aircraft used solely in USSR domestic operations, and hence there were 7 976 aircraft in commercial service which are potentially subject to new noise legislation and about which detailed information is available on operations and age distribution.

3. These 7 976 aircraft concerned have been classified for the purposes of this study according to ICAO Annex 16. Of the aircraft, 439 (5 per cent) are non-noise certificated (NNC), 4 922 (62 per cent) have been classified as Chapter 2, and 2 615 (33 per cent) have been classified as Chapter 3 as depicted in Figure 5-1. Table A1-1 in Appendix 1 depicts the noise classification of this fleet by type of aircraft.

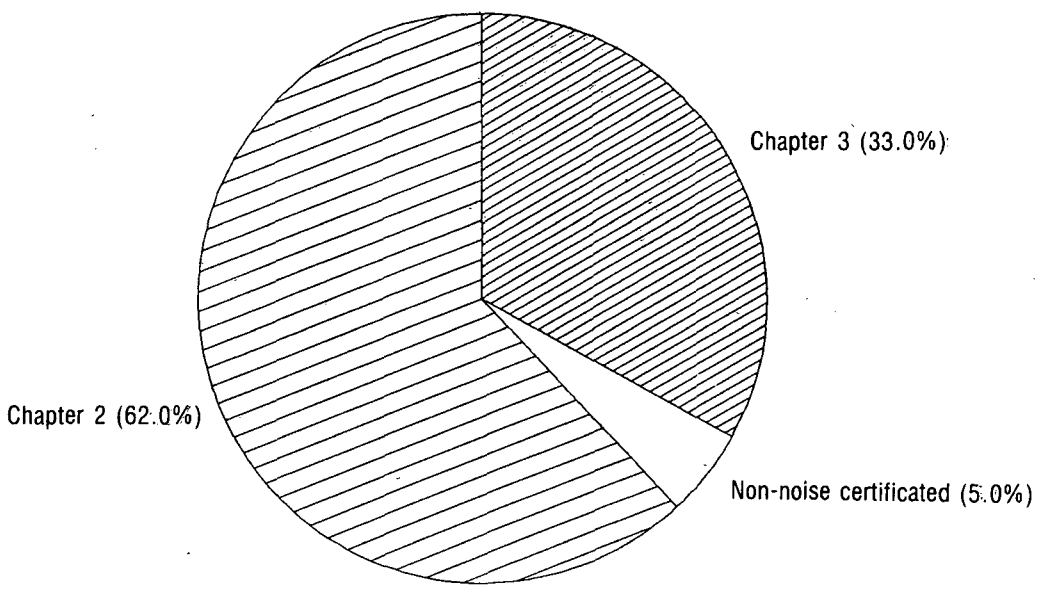


Figure 5-1. Noise classification of world jet fleet, 31 December 1987

4. The figures for Chapter 2 include 286 Boeing 747 aircraft, primarily earlier models, which exceed the noise certification requirements of Chapter 3 by a very small margin as well as all the 425 Soviet-built aircraft in international service. The figures for Chapter 3 include 360 later model Boeing 747 aircraft which do qualify as well as the 359 McDonnell Douglas DC-10 aircraft in commercial service, since all the latter are expected to be fully compliant with Chapter 3 in the very near future.

5. While the proportion of non-compliant aircraft (NNC plus Chapter 2) represents 67 per cent of the total fleet on a world-wide basis, on a regional basis it ranges from 50 per cent for the Asia/Pacific fleet to above 80 per cent for the fleets of Africa, Eastern Europe (excluding the USSR domestic fleet) and Latin America/Caribbean as illustrated in Figure 5-2.

6. The age distribution of the non-compliant fleet (NNC and Chapter 2) is illustrated in Figure 5-3. Virtually all the non-noise certificated fleet and over half the Chapter 2 fleet were built before 1975. With the exception of Soviet-built aircraft, production of each of these non-compliant categories of aircraft has now ceased and the number in service in the future will therefore essentially depend on the rate at which the present fleet is retired.

7. A quantified analysis of historic retirement rates and current economic and technological trends affecting retirement has led to the assumption for the purpose of this study that, in the absence of pertinent noise restrictions, once aircraft reach 20 years in age, 10 per cent of the remaining aircraft on average can be expected to be retired in each subsequent year. Thus the assumed size of the fleet falls proportionately each year after 20 years, and the average aircraft life on this basis is approximately 29 years. Figure 5-4 illustrates this assumed retirement pattern in relation to the historic retirement patterns of several different aircraft types.

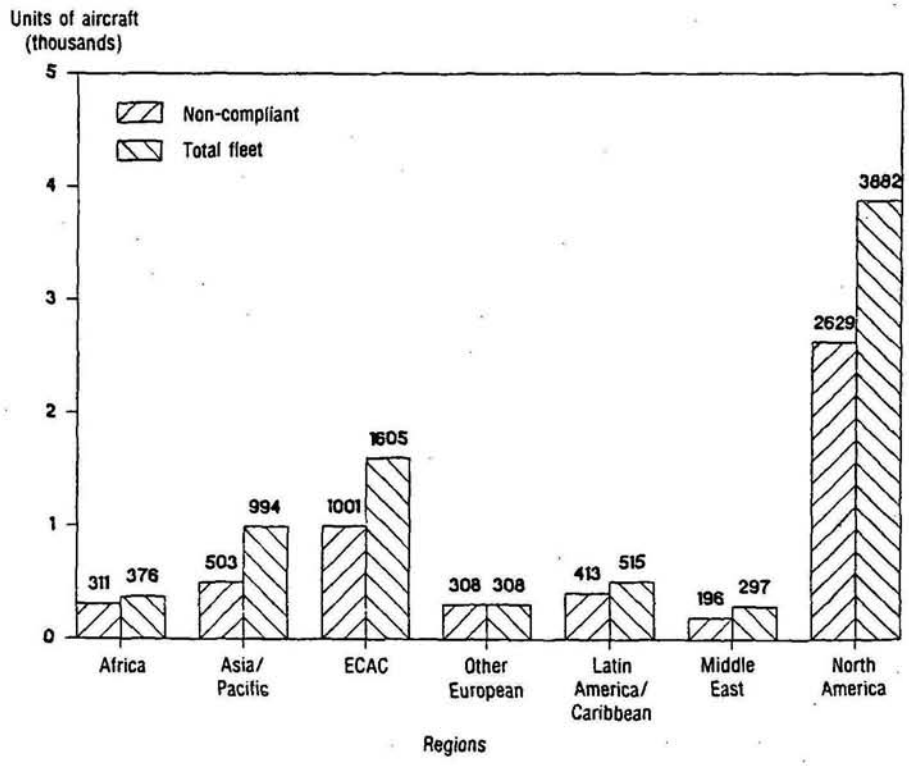


Figure 5-2. Geographical distribution of world jet fleet, 31 December 1987

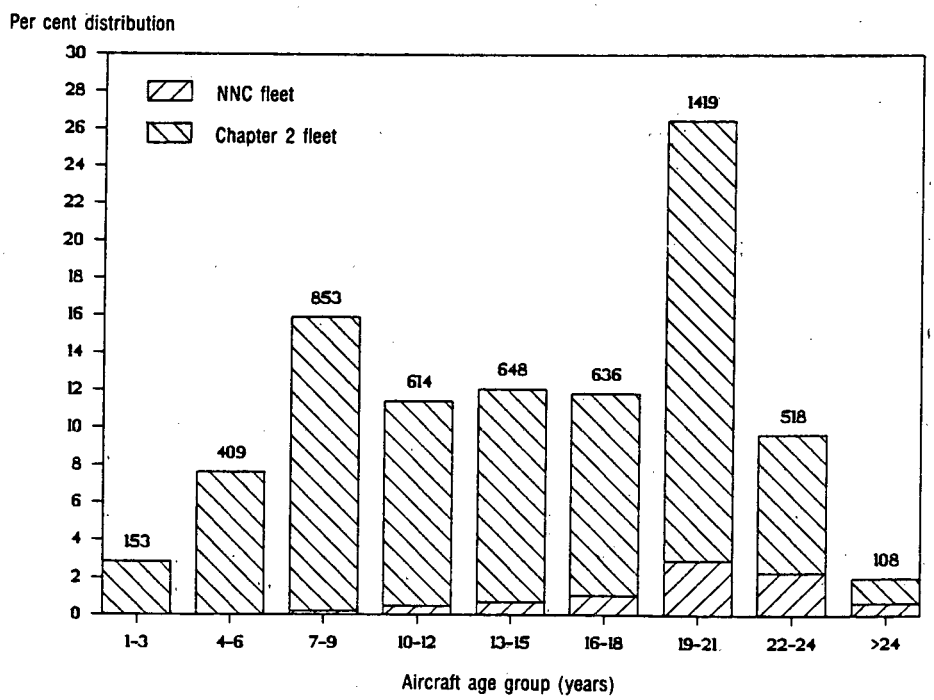


Figure 5-3. Age distribution of the non-compliant fleet, 31 December 1987

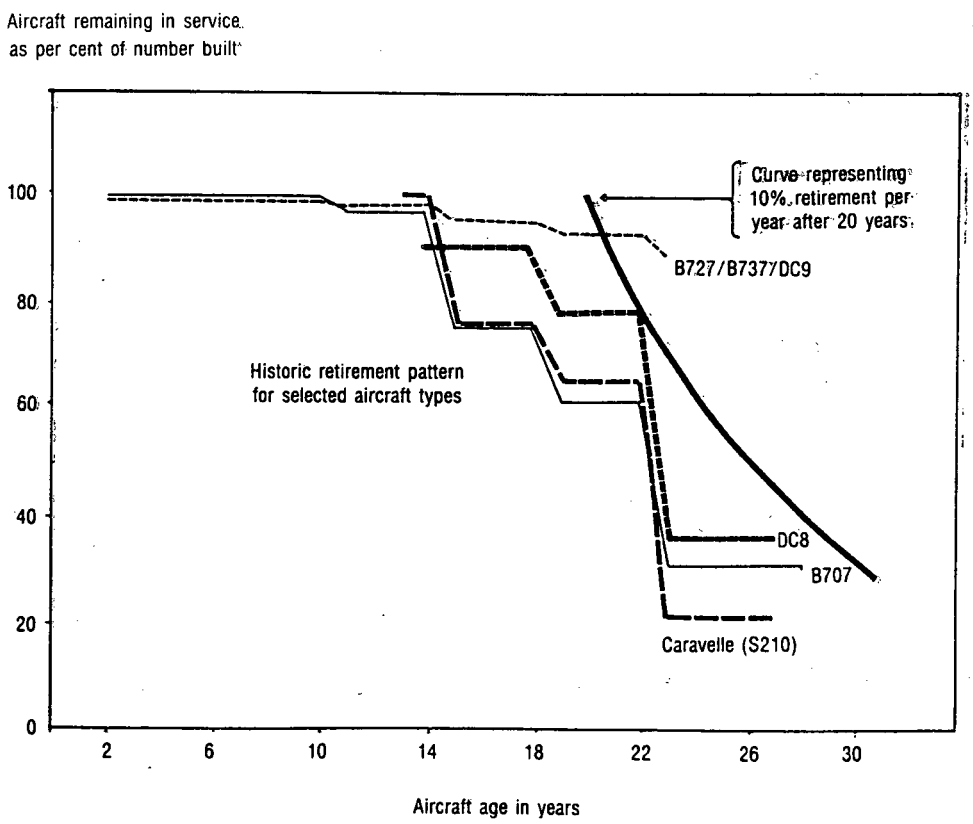


Figure 5-4. Retirement patterns of aircraft

8. Using this approach, the number of non-noise certificated and Chapter 2 aircraft that would be left in service in 1995, 2000 and 2005 have been calculated and are illustrated in Figure 5-5. The number of non-noise certificated aircraft would fall from 439 in 1987 to 176 in 1995 and to virtually zero in 2000. These aircraft would thus represent less than 2 per cent of the projected total jet fleet in commercial service as early as 1995, and for the practical purposes of this study it has been assumed that the entire non-noise certificated fleet will be withdrawn by that date. The number of Chapter 2 aircraft still remaining in service is estimated to be 3 529, 2 625 and 1 657 for 1995, 2000 and 2005 respectively. Any Chapter 2 aircraft that were on order at the end of 1987 are included in these projections, but it is assumed that no additional production of such aircraft will take place (see Appendix 1 for methodology).

9. Of the 5 361 non-compliant aircraft in 1987, 3 609 or almost 70 per cent are registered in the areas for which future noise restrictions have been assumed (ECAC area, United States, Australia, Japan, New Zealand), representing 64 per cent of the total fleet in these areas. Conversely, 1 752 or 30 per cent are registered in the non-restricted areas, representing 75 per cent of the total fleet in these areas. The breakdown of the total Chapter 2 fleet into the noise-restricted and non-restricted areas is illustrated in Figure 5-6. The attrition of the non-compliant aircraft fleet through to the year 2005 is expected to show a similar pattern for both the noise-restricted and the non-restricted areas, although the Chapter 2 aircraft in the noise-restricted areas tend to be older on average than those in the non-restricted areas and hence show greater attrition.

10. In order to adequately evaluate the economic impact of introducing noise restrictions for future time periods, it is essential to estimate the trend in traffic (PKP — passenger-kilometres performed) and capacity (ASK — available seat-kilometres) for future time periods when restrictions might be applied. The traffic forecasts used

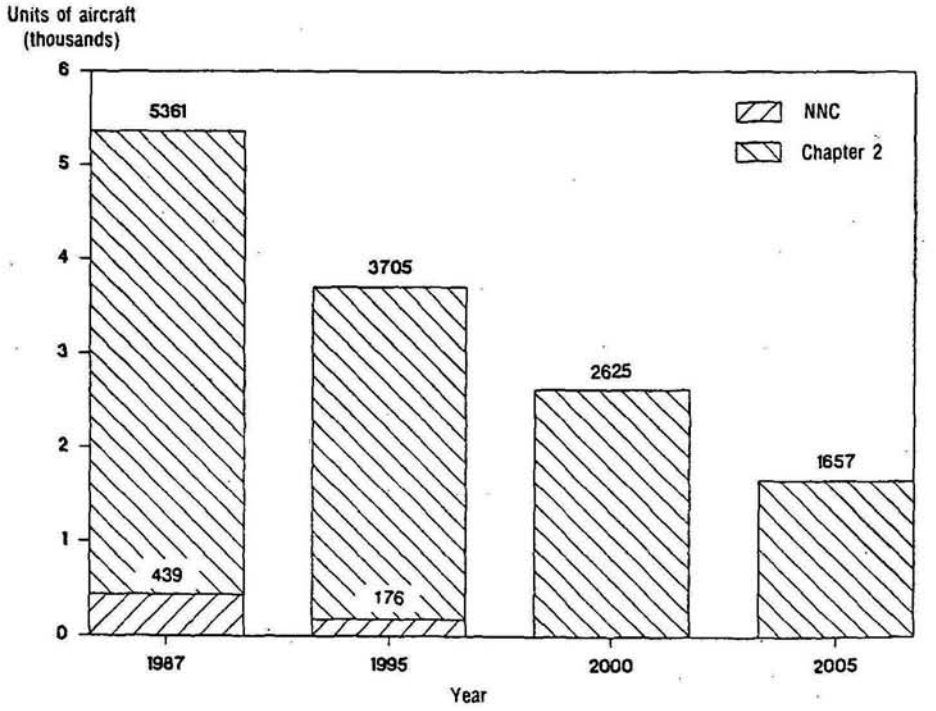


Figure 5-5. Global non-compliant fleet projections

in this analysis generally are based on forecasts presented in ICAO Circular 200 — *The Economic Situation of Air Transport — Review and Outlook, 1986,* adopting the assumptions indicated in that circular regarding economic trends, fuel prices, etc. World-wide PKPs are estimated to grow over the next 20 years at an average annual rate of 6.5 per cent. This world average conceals regional differences, which range from a low of 5 per cent in Europe to a high of 9 per cent in the Asia/Pacific Region. Load factors are expected to trend somewhat higher for the period 1995-2000, from 63 per cent in 1985 to 68 per cent in 1995. Based on the PKP forecast and load factor assumptions, the ASK requirement is estimated to grow at an average annual rate of 6 per cent, ranging from a low of approximately 4.5 per cent in Europe to a high of 9 per cent in the Asia/Pacific Region.

11. The resulting ASK forecasts for 1995, 2000 and 2005 are depicted in Figure 5-7, broken out between the contribution from non-compliant and Chapter 3 aircraft. In 1987, excluding all-cargo aircraft but including representative data for cargo carried on combination aircraft, approximately 43 per cent of total world traffic (international plus domestic excluding USSR, scheduled plus non-scheduled) was generated by the non-compliant fleet. For the years 1995, 2000 and 2005, the ASKs produced by the non-compliant fleet are 705, 509 and 318 thousand million, respectively. These amounts represent 18, 10 and 5 per cent of the total ASKs forecast for each of those years.

12. The total jet fleet requirements to meet such ASK growth are estimated to be 8 400, 9 800, and 10 500 aircraft for 1995, 2000 and 2005 respectively. In terms of percentages of the total jet fleet in each of these years the projected number of Chapter 2 aircraft remaining in service is estimated to be approximately 42, 27 and 16 per cent respectively, as illustrated in Figure 5-8. The relative impact of any new noise restrictions is greater in terms of affected fleet than in terms of affected traffic because of the predominance of narrow-body aircraft in the non-compliant fleet.

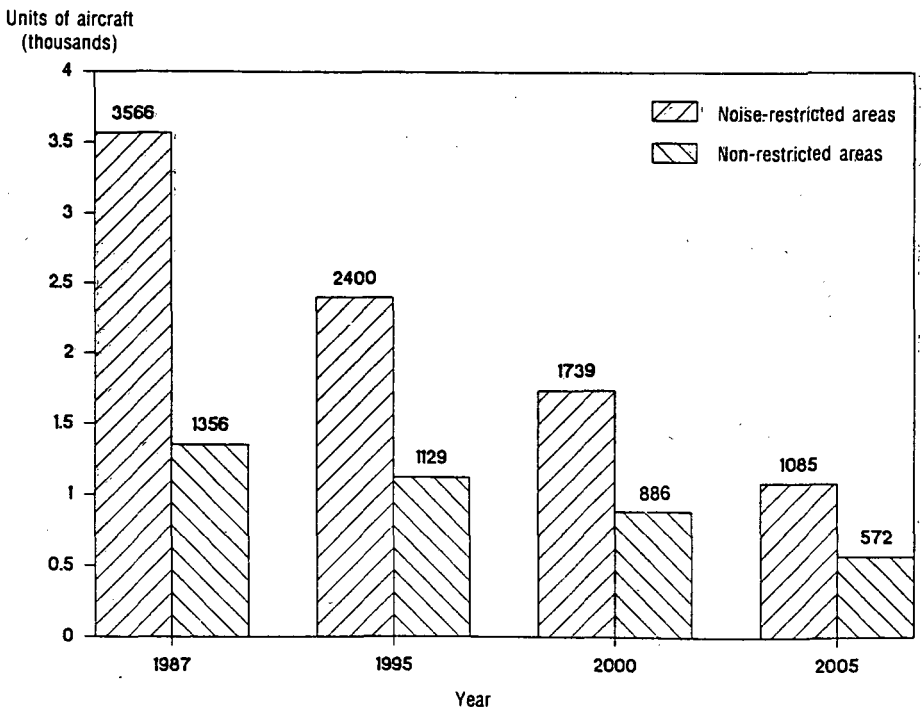


Figure 5-6. Chapter 2 fleet, noise-restricted and non-restricted areas

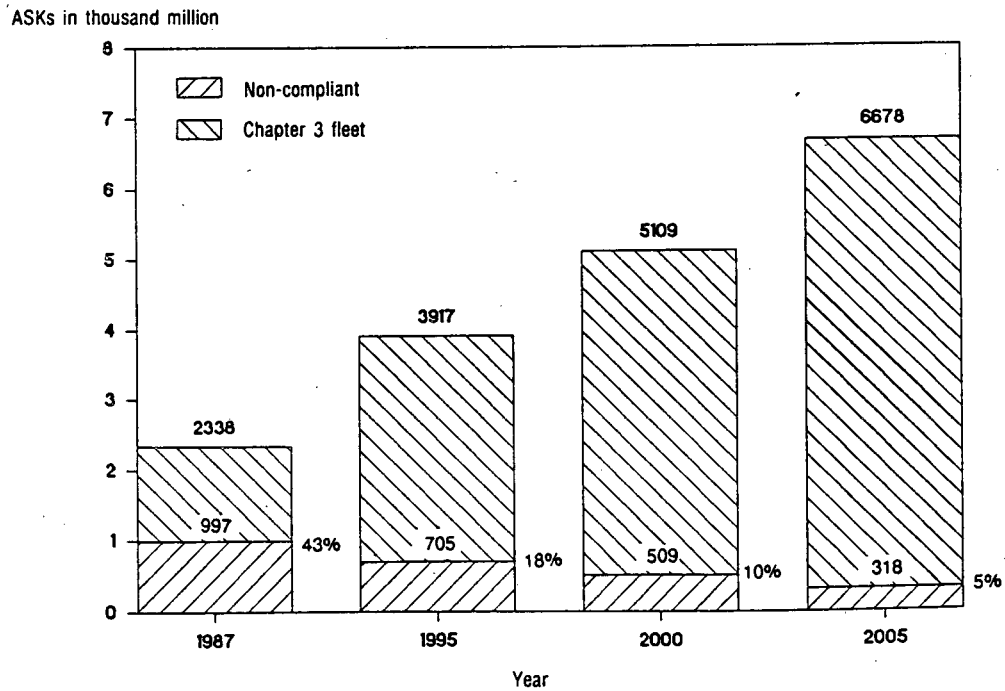
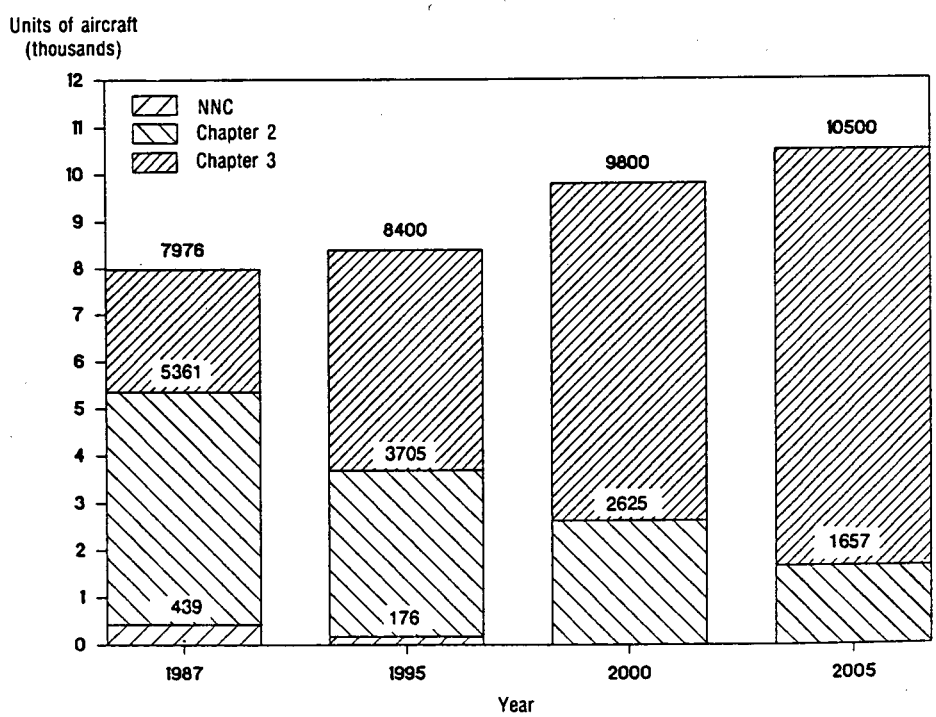


Figure 5-7. World available seat-kilometres forecast (scheduled and non-scheduled, international and domestic)



* 1987 figures include 425 aircraft built in the USSR, whereas the projections do not include USSR-built aircraft.

Figure 5-8. Global fleet projections*

13. The number of Chapter 2 aircraft remaining in service in each of the years 1995, 2000 and 2005 is presented below, broken down between the noise-restricted and non-restricted areas and including the anticipated relative contribution to the total fleet (estimated on the basis of the anticipated traffic growth of 6.5 per cent per annum world-wide in terms of passenger-kilometres, comprising 5 per cent for the noise-restricted areas and 8 per cent for the non-restricted areas). For comparative purposes, the 1987 fleet for each of the non-noise certificated and Chapter 2 categories of aircraft are also included.

	Non-noise certificated fleet	Chapter 2 fleet			
	1987	1987	1995	2000	2005
Aircraft registered in noise-restricted areas					
Narrow-body aircraft	43	3 360	2 264	1 653	1 033
Wide-body aircraft	–	206	136	86	52
Total narrow-body plus wide-body	43	3 566	2 400	1 739	1 085
Percentage of total fleet	1	63	41	25	15
Aircraft registered in non-restricted areas					
Narrow-body aircraft	396	1 263	1 048	825	534
Wide-body aircraft	–	93	81	61	38
Total narrow-body plus wide-body	396	1 356	1 129	886	572
Percentage of total fleet	17	58	45	30	18

14. The above figures include all-cargo aircraft. As indicated in Chapter 2, in the case of non-restricted areas these aircraft have had to be excluded from the analyses in Chapters 6 through 8 because of the nature of the operations concerned. The significance of this can be judged from the fact that in 1987 there were 54 all-cargo aircraft registered in the noise-restricted areas (47 narrow-body and 7 wide-body) and these are expected to be reduced through attrition to 32 by 1995, 26 by 2000 and 22 by 2005. Thus these aircraft represented only 4 per cent of the Chapter 2 fleet in non-restricted areas in 1987, a proportion which would not be exceeded through to 2005. It should be noted that 16 of the aircraft remaining through the period concerned are Soviet-built aircraft, 14 of which are in the fleet of carriers from Eastern Europe (including USSR).

Chapter 6

Numbers of Aircraft Affected by Hypothetical Future Noise Restrictions

1. In the case of aircraft registered in States where future noise restrictions are assumed to be applied, the number of aircraft which would have to be replaced early or retrofitted as a result of the restrictions equates, in the case of a complete ban, to the total non-compliant fleet remaining after attrition as developed in Chapter 5.

2. In the case of aircraft registered in States where no further noise restrictions are assumed, the number of aircraft affected by noise restrictions in other States will be significantly lower than the total number in the non-compliant fleet. In December 1987, the airlines from the non-restricted areas operated 1 356 Chapter 2 aircraft, but many of these aircraft did not operate to or from the noise-restricted areas, while for others only a small part of their operations were to or from the noise-restricted areas.

3. In order to quantify the number of aircraft that would be affected, a survey was conducted, in co-operation with IATA, of airlines in the non-restricted areas that are currently flying non-compliant aircraft into the assumed noise-restricted areas. Each airline was asked to give an assessment of the number of aircraft that would be affected if a ban on aircraft that do not meet the certification requirements of Annex 16, Chapter 3 were to be introduced immediately by a group of States comprising ECAC Member States, United States, Australia, Japan and New Zealand. In particular, an assessment was requested of the numbers of aircraft that could be deployed to other routes and the number of aircraft that would need to be removed from the fleet. As expected, the replies varied according to the geographic location of the airlines and amongst the airlines within a regional grouping. However, a substantial number of replies were received from all the geographic areas concerned, and the results could therefore be applied with an acceptable degree of accuracy in respect of each of the eight different regional groupings used in the study.

4. The survey results showed that the majority of the 1 356 Chapter 2 aircraft registered in the non-restricted areas in December 1987 would not have been substantially affected by an immediate operating ban in the noise-restricted areas. The results further indicated that the airlines would be able to redeploy a significant number of the affected aircraft to other routes, with the result that the number of aircraft that would need to be withdrawn from service early (and replaced or retrofitted) would be reduced to an estimated 358, or 26 per cent of the total Chapter 2 fleet of the airlines concerned.

5. Having established the number of aircraft registered in the non-restricted areas which would need to be withdrawn early under an immediate operating ban (both in total as indicated above and by regional grouping), the number of aircraft which would need to be withdrawn from service early under operating bans in 1995, 2000 and 2005 can readily be ascertained by applying the attrition assumptions presented in Chapter 5, resulting in estimates of 341, 253 and 128 aircraft, respectively. These estimates are higher than should be the case in practice because, with future growth of traffic in the non-restricted areas, the ability to redeploy aircraft away from routes to/from the noise-restricted areas should increase. Taking into account the varying growth rates in the different areas and the practical difficulties of redeploying aircraft amongst routes with different structures, it is estimated

that a further 77, 77 and 31 aircraft could be redeployed by 1995, 2000 and 2005 respectively, resulting in 264, 176 and 97 aircraft which would need to be withdrawn by 1995, 2000 and 2005 respectively, as illustrated in Figure 6-1. The breakdown of the affected fleet between narrow-body and wide-body aircraft and its contribution to the total fleet are presented below.

Year of ban on Chapter 2 operations
(number of aircraft to be replaced early or retrofitted)

	1995	2000	2005
Aircraft registered in non-restricted areas			
Narrow-body aircraft	219	142	79
Wide-body aircraft	45	34	18
Total narrow-body plus wide-body	264	176	97
Percentage of total fleet	11	6	3

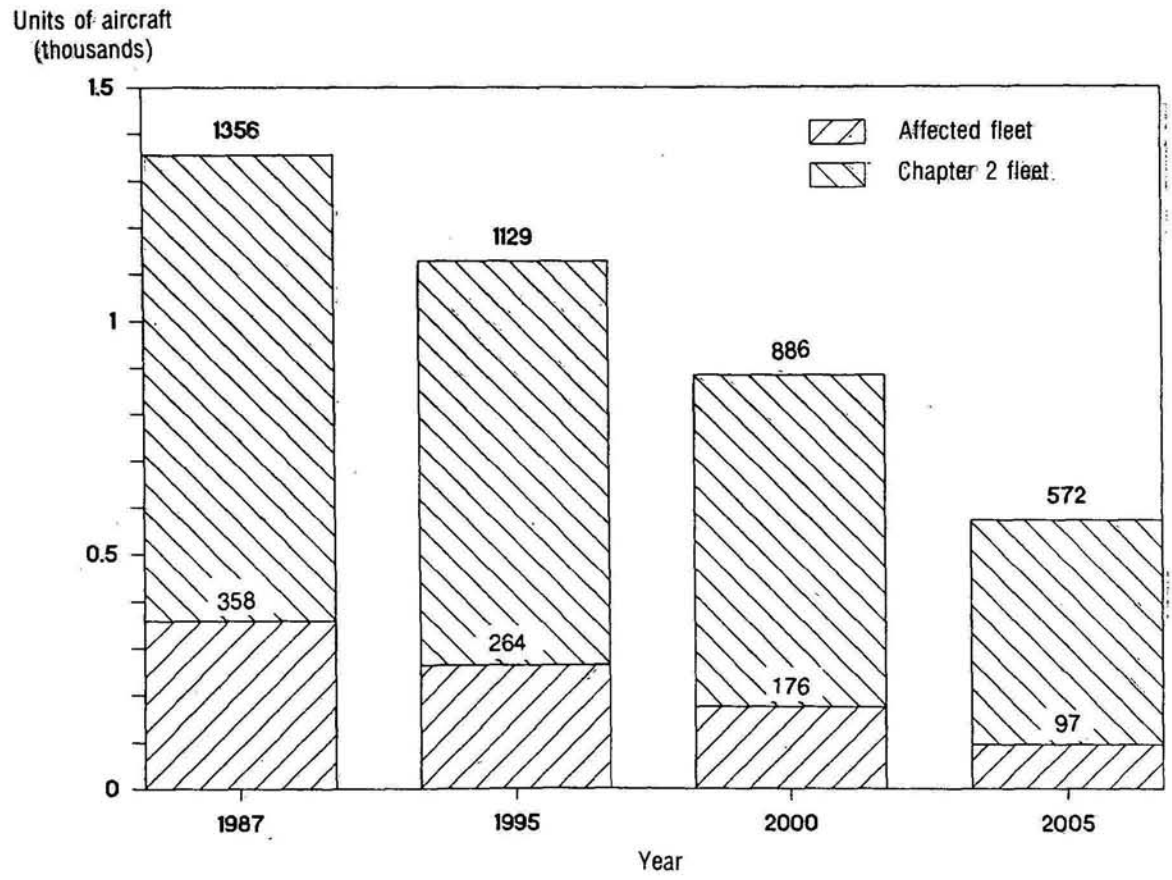


Figure 6-1. Chapter 2 and affected fleet, non-restricted areas

6. Within the context of the number of aircraft to be withdrawn from service early, the related number of wide-body jets assumes particular significance, because these aircraft are all Boeing 747 aircraft which fall fairly close to the noise limits prescribed by Chapter 3. In the case of the noise-restricted areas, as shown in Chapter 5 the numbers of these aircraft affected were 136, 86 and 55 for a ban in 1995, 2000 and 2005 respectively, and hence the total number of wide-body aircraft affected world-wide would be 181, 120 and 70 respectively, for a ban in these years.

7. Another important factor when considering the number of aircraft to be replaced early or retrofitted is the geographic location of registration of the aircraft concerned, and this is addressed in the table below (for both narrow-body and wide-body aircraft). Further details of the impact on each of the eight non-restricted area groupings are contained in Chapter 8.

Year of ban on Chapter 2 operations
(number of aircraft to be replaced early or retrofitted)

	1995	2000	2005
Aircraft registered in noise-restricted areas			
ECAC States	689	498	315
United States	1 586	1 144	708
Australia/Japan/New Zealand	125	97	62
Aircraft registered in non-restricted areas			
Canada	28	14	6
Mexico/Central America/Caribbean	60	35	16
South America	20	1	–
Eastern Europe (including USSR)	58	48	35
Middle East	25	18	10
Northern Africa	42	35	13
Western/Central/Eastern/Southern Africa	4	3	3
Asia/Pacific (less Australia, Japan and New Zealand)	27	22	14

8. All the above information relates solely to a complete ban on Chapter 2 operations in each of the specified years. Indications are, however, that States which may need to introduce a ban will do so in a phased manner, permitting operators to withdraw fleets of non-compliant aircraft gradually. Thus two other scenarios have been used in this study, relating to a phased operating ban commencing in 1995 and 2000 respectively. The assumption for each of these two scenarios is that 25 per cent of the affected aircraft would be removed from service in the first year of the operating ban. Thereafter, another 25 per cent of the originally affected aircraft would be removed during the next five years. The remainder of the affected fleet would be withdrawn linearly over the following ten years.

9. The over-all effect of the two assumed phased ban scenarios is presented below, both for the noise-restricted areas and for the non-restricted areas, along with summarized comparable implications for the three complete ban scenarios. In broad terms, the impact of a complete ban in the year 2000 may be considered as similar to that of a phased ban implemented from the year 1995, bearing in mind that the first aircraft to be withdrawn under the phased ban would be forced to do so at a relatively early date.

Number of aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Aircraft registered in noise-restricted areas				
Complete ban from				
1995	2 400	–	–	–
2000	–	1 739	–	–
2005	–	–	1 085	–
Phased ban commencing in				
1995	604	1 183	1 726	2 021
2000	–	422	832	1 026
Aircraft registered in non-restricted areas				
Complete ban from				
1995	264	–	–	–
2000	–	176	–	–
2005	–	–	97	–
Phased ban commencing in				
1995	72	128	171	184
2000	–	46	87	98

Chapter 7

Economic Impact on Carriers of Hypothetical Future Noise Restrictions

1. Having established the number of aircraft which would have to be withdrawn from service early as a consequence of an operating ban, the next step is to assess the economic impact of such withdrawal on the carriers concerned. In the case of carriers in ECAC Member States and the United States a number of relevant studies have already been undertaken by governments and carriers. No attempt has been made to supersede the results, but those of the governments concerned are summarized below. In the case of the non-restricted areas, however, a specific methodology has been developed and an analysis carried out, and this approach has also been applied in a general manner to carriers in Australia, Japan and New Zealand in order to provide as complete a picture as possible.

2. Early replacement of Chapter 2 aircraft before the end of their normal service life accelerates the capital expenditure associated with retirement but can also generate savings in operating costs from the use of new aircraft. The economic cost of early replacement, the "net accrued cost" of early replacement, is determined by compiling capital and operating cash flows associated with the retirement of aircraft before the end of their normal service life. The economic cost resulting from the imposition of an operating ban on Chapter 2 aircraft is therefore not the gross purchase cost of a replacement aircraft but rather the net cost of ending the remaining useful life of an aircraft earlier than otherwise planned (see Appendix 1).

3. In all analyses (ECAC, United States and ICAO) the quantified cost assessments presented below are based on the assumption that the affected aircraft are sold (for scrap or for use by other carriers in non-restricted areas) and hence may be a little on the high side in that they do not cover the benefits which may accrue to the purchasers of the affected aircraft or the possibilities of retrofitting non-compliant aircraft; these concepts are discussed later. No evaluation has been made of possible additional benefits arising from increased revenues achieved from operating new aircraft types because of the widely differing views as to whether any such revenues are quantifiable or in fact realizable.

Costs and savings in replacing non-compliant aircraft early

4. The costs to a carrier of withdrawing aircraft from service because of an operating ban may be assessed in terms of the following main elements:

a) additional expenditure associated with the need to invest (through purchase or lease) in replacement aircraft at a date earlier than otherwise planned; less

b) savings associated with disposal of existing aircraft at a date earlier than otherwise planned (taking into account the loss in market value of these aircraft arising from noise restrictions); less

c) savings in operating costs accruing from use of the replacement aircraft over the period concerned.

5. With regard to a), because differing aircraft capacities prevent consideration of equivalence in aircraft-for-aircraft terms, the economic analysis carried out by ICAO for the non-restricted areas was based on seat-for-seat replacement. For this purpose three sets of replacement seat costs were developed according to the characteristics of the aircraft concerned:

i) a mix of B737-400, MD-82 and A320 aircraft (Chapter 3) to replace B727, B737-100, B737-200 and DC-9 aircraft (Chapter 2), at a cost of $190 000 per seat in 1988 dollars;

ii) a mix of B757 and B767 aircraft (Chapter 3) to replace (retrofitted) B707 and DC-8 aircraft, at a cost of $200 000 per seat; and

iii) a mix of Chapter 3 B747 aircraft to replace Chapter 2 B747 aircraft, at a cost of $255 000 per seat.

6. With regard to b), the most significant factor is the resale value of aircraft in relation to their age. Resale values were estimated on the basis of present and forecast prices in the trade press, further discounting by about half to reflect a best estimate of the impact of an announcement of an operating ban on Chapter 2 aircraft. The resulting estimated resale values vary, depending on age, from $3 million to $1 million for short-haul narrow-body aircraft such as the B727, B737 and DC9, and from $15 to $7.5 million for the B747. For B707 and DC-8 aircraft, resale values are $0.5 million independent of age.

7. With regard to c), newer aircraft generally produce savings in operating costs compared with the aircraft they replace, notably in respect of fuel and maintenance. For narrow-body aircraft, operating costs per seat have been derived for each of the "baskets" of replacement and replaced aircraft referred to above, based on reported actual costs from a variety of sources world-wide and taking into account regional differences in operating costs for each aircraft type. Significant savings in operating costs were shown for each of the "baskets" of replacement narrow-body aircraft (varying according to geographic area). In the case of wide-body aircraft, examination of the operating costs structure does not, however, lead to any clear-cut indication of classifiable savings that can be assigned to the new replacement aircraft and that would significantly differentiate them from the aircraft they replace. There would, of course, be some savings of maintenance costs in replacing an older aircraft with a new aircraft. For the purpose of this study, it has been considered prudent to present only the capital cost element of the change in the case of wide-body aircraft without taking into account any savings in operating costs.

8. The results of the formulation a) additional expenditure associated with obtaining new aircraft, less b) savings associated with disposal of existing aircraft, less c) savings in operating costs from use of new aircraft, depend on the number of aircraft affected as determined in Chapter 6 and the number of years concerned between forced replacement and planned replacement. They have been calculated for the non-restricted areas, on the basis of a discount rate of 6 per cent per annum (discounted to the year of the ban concerned) and in terms of 1988 United States dollars, indicating a net accrued cost for airlines in these areas (for both narrow-body and wide-body aircraft) of $2 250 million for a complete ban on Chapter 2 operations in the noise-restricted areas in 1995 ($725 million for narrow-body aircraft, $1 525 million for wide-body aircraft), $1 050 million for a complete ban in 2000 ($335 million for narrow-body aircraft and $715 million for wide-body aircraft), and $410 million for a complete ban in 2005 ($130 million for narrow-body aircraft and $280 million for wide-body aircraft) as illustrated in Figure 7-1.

9. Considering the impact in terms of investment requirements rather than the net accrued costs related to these requirements (and excluding any savings in operating costs), if a complete ban were to be imposed in 1995, the total investment requirements by airlines outside the noise-restricted areas that would need to be brought forward to that date amount to about $9 500 million (narrow-body aircraft $6 000 million, wide-body aircraft $3 500 million). The comparable figures for complete bans in 2000 and 2005 would be about $6 500 million (narrow-body aircraft $3 500 million, wide-body aircraft $3 000 million) and about $3 500 million (narrow-body aircraft $2 000 million, wide-body aircraft $1 500 million), respectively. It must be emphasized, however, that these figures do not represent additional investment in new aircraft, but rather investment which would be expected to be made at some stage in the future and which would need to be brought forward.

10. The results were also calculated for the other two scenarios used in the study, namely phased operating bans commencing in the years 1995 and 2000, respectively. The net accrued costs for airlines for the phased ban scenario commencing in 1995 are estimated to be $735 million ($239 million for narrow-body aircraft and $496 million for wide-body aircraft) and for the phased ban scenario commencing in 2000 are estimated to be $320 million ($100 million for narrow-body aircraft and $220 million for wide-body aircraft) as illustrated in Figure 7-2.

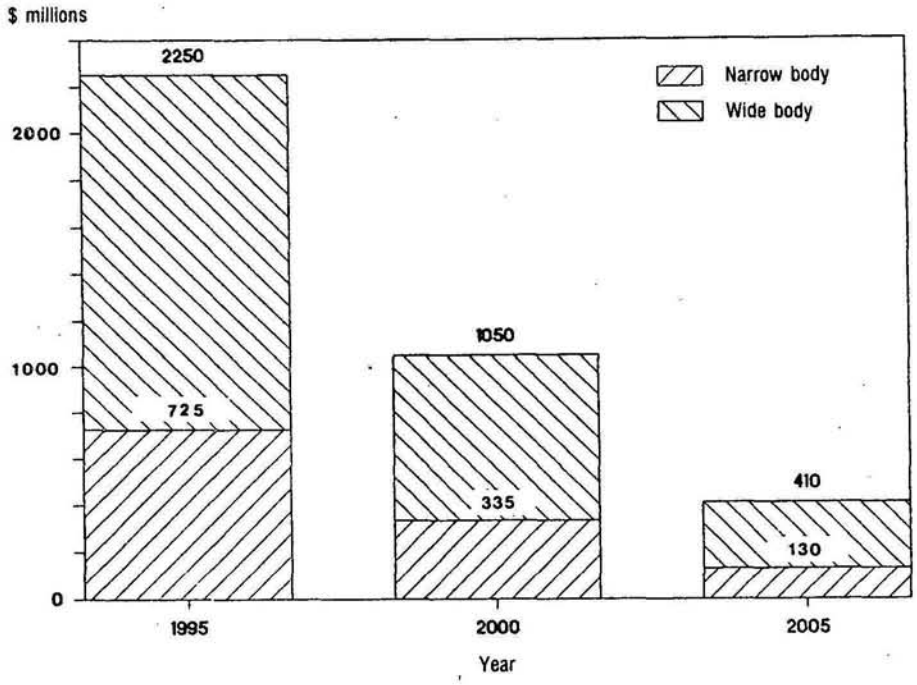


Figure 7-1. Net accrued costs, complete ban

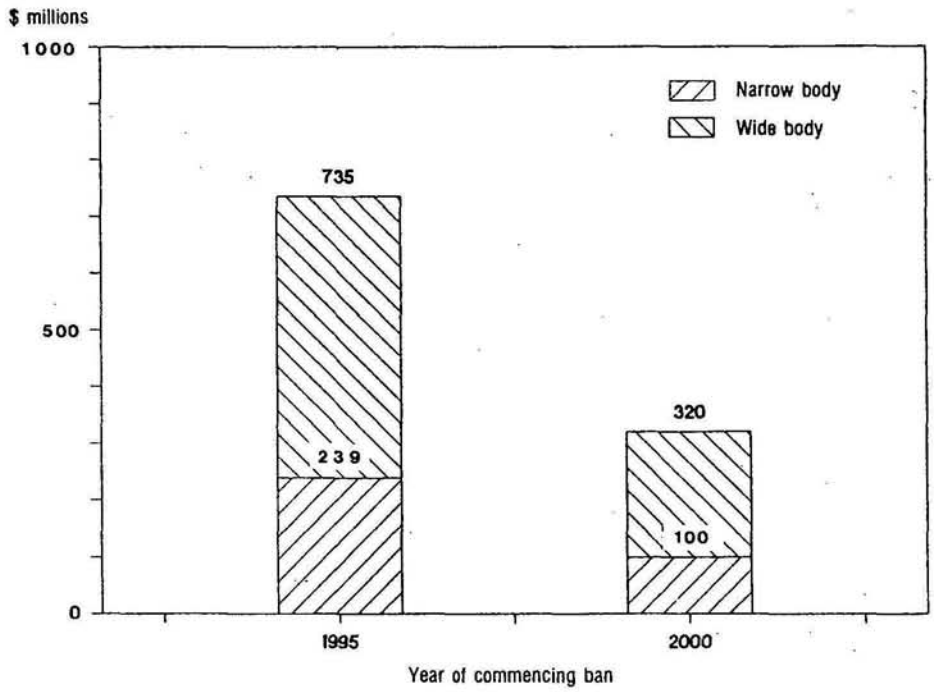


Figure 7-2. Net accrued costs, phased ban

11. The ICAO methodology and analysis were designed to focus on the non-restricted areas, with the results as just described. The findings, however, have also been generalized to evaluate the impact on carriers in Australia, Japan and New Zealand, which have been assumed as noise-restricted areas but for which no other studies were available. For airlines of these countries, whose entire operations with Chapter 2 aircraft would be affected, the net accrued costs, again using a discount rate of 6 per cent per annum and expressed in terms of 1988 United States dollars as in 8 above, would be, for a complete ban, in the order of $1 400 million in 1995 ($500 million for narrow-body aircraft and $900 million for wide-body aircraft), $700 million in 2000 ($300 million for narrow-body aircraft and $400 million for wide-body aircraft), and $330 million in 2005 ($120 million for narrow-body aircraft and $210 million for wide-body aircraft). Again, phased bans starting in 1995 and 2000 respectively, would have a similar impact to complete bans in 2000 and 2005 respectively.

12. Turning to the ECAC area, for which restrictions have also been assumed, a number of studies of the impact on carriers of the region have been carried out, both on the basis of non-addition of Chapter 2 aircraft to national registers and on the basis of non-operation of Chapter 2 aircraft at ECAC airports. ECAC's own study of the impact of a non-operation rule was based on the assumptions that such a rule would come into effect from 1995 and that Chapter 2 aircraft less than 25 years old would generally be exempt. The ECAC study also used two alternative assumptions regarding the life of Chapter 2 aircraft, one based on an economic assessment that they would be used for 24 to 30 years (depending upon aircraft type), the other that they would all have a life of 30 years. Under these two alternative assumptions, the number of aircraft which would be retired early was estimated at 814 or 910 respectively (the latter figure including 43 B747 aircraft). Translating these numbers of aircraft into the net accrued costs for the airlines concerned, ECAC derived figures of $187 million and $513-$987 million in 1986 dollars discounted to 1986 at a rate of 7.5 per cent per annum, the range in the latter case depending on whether fuel and maintenance costs were estimated on the basis of data reported to the United States government or information provided by the Association of European Airlines. Generalizing from these figures, the study concluded that the net accrued costs of ECAC's proposed non-operation rule were likely to be of the order of $500 million, but could well be less because certain factors that would tend to lower costs had not been taken into account.

13. Finally, there have also been a number of studies in relation to the United States, for which restrictions have also been assumed. In particular, the Federal Aviation Administration (FAA) has carried out numerous analyses, the most recent, released in September 1988, concerning the impact on carriers in the United States of an operating ban on Chapter 2 aircraft, excluding B747 aircraft, which were assumed to be exempt. Results were prepared for complete operating bans from 1995, 2000, 2005 and 2010 respectively (the first three being the same as for the three ICAO complete ban scenarios) and on the assumption of a useful aircraft life of 25, 30 and 35 years respectively (25 years being considered the "most likely"). The number of aircraft affected under these scenarios and assumptions, and their translation into the net accrued costs for the airlines concerned are presented below, in millions of 1988 United States dollars, at a discount rate of 6 per cent per annum discounted to the year of the ban concerned:

Year of ban on Chapter 2 operations

	1995	2000	2005	2010
Number of aircraft affected assuming				
25 year life	1 122	866	377	33
30 year life	2 069	1 122	866	203
35 year life	2 143	1 805	1 122	763
Net accrued costs (million $) assuming				
25 year life	2 687	1 563	482	17
30 year life	4 503	2 725	1 795	283
35 year life	5 657	3 805	3 053	1 797

14. The general approach to the cost evaluation by ICAO, ECAC and the FAA has been similar. Because of the different nature of the exercises concerned, however, different assumptions have been made regarding the economic costs involved as well as regarding useful aircraft life. For example, the ICAO and FAA studies estimate resale values for banned aircraft while ECAC uses scrap values, the ICAO and the FAA studies use a discount rate of 6 per cent and discount back to the year of the ban while ECAC uses 7.5 per cent and discounts back to 1986, and estimated savings in operating costs vary amongst all three studies. Nevertheless, the estimates of the number of aircraft affected are consistent with each other and, while the associated economic evaluations carry a fairly wide degree of uncertainty in reflection of the uncertainties attached to the assumptions, their results are also broadly consistent with each other and indicate similar orders of magnitude of the economic impact concerned.

Feasibility and costs of retrofitting

15. A factor that will affect whether airlines will place their Chapter 2 aircraft on the open market is the extent to which it is economically and technically feasible to "retrofit" existing aircraft, that is fit them with the newer high bypass ratio engines or with "hushkits" so that they will meet Chapter 3 standards. In certain cases it may also be feasible to comply with Chapter 3 standards by taking an acceptable operational penalty.

16. The technical feasibility of modifying many of the present fleet of Chapter 2 aircraft has been investigated and a review of current literature suggests that, by the early 1990s, there will be available commercially a variety of modifications that would enable many present day Chapter 2 aircraft to comply with Chapter 3 requirements. The cost of such a modification would range between about $3 million and $10 million per aircraft in 1988 prices, depending on the aircraft concerned. Some modifications under investigation for certain types of aircraft include major design changes.

Resale market for non-compliant aircraft

17. As indicated earlier, application of Chapter 3 certification requirements to the operations of world fleets could debar from operation in noise-restricted areas substantial numbers of aircraft that do not at present meet those requirements. There is an active world-wide market in used aircraft of all kinds which will be responsive to the effect of any such measures on either the supply or the demand. Aircraft with wider user bases particularly in the non-restricted areas will enjoy a greater market liquidity. It is easier for an airline to add an incremental unit rather than to introduce a new type of equipment.

18. The present day buoyancy of the prices of second-hand aircraft is itself an indication of a steady and unsatisfied demand in this market. For example, the Boeing Company has reported that of its B737 aircraft that have changed hands, 85 per cent had resale prices higher than the original sales price (in current terms). The significance of this demand may be considered in two parts: aircraft which comply or can be modified to comply with Chapter 3 requirements, and those which do not and cannot.

19. In the first of these categories, the aircraft manufacturers will seek to meet with sales of new aircraft as much of the demand as they find profitable, as they have only Chapter 3 compliant aircraft to sell. The used Chapter 3 aircraft market will continue in its role as marginal supplier, but in a market where demand for this product has been enlarged by the enforced regulatory change to Chapter 3 requirements, compliant aircraft are likely to be scarce and the pressure of increased demand is likely to keep prices high.

20. In the second category, those aircraft that do not and cannot be modified to comply to Chapter 3 requirements, demand can only come from the non-restricted areas. A broad outline of the likely pattern of supply

and demand for Chapter 2 aircraft in the event of an operating ban in ECAC countries, United States, Australia, Japan and New Zealand, coming into effect in 1995 can be illustrated as follows:

Supply:	Number of narrow-body Chapter 2 aircraft requiring to be withdrawn from service in 1995	=	2 500
Demand:	Number of additional aircraft estimated to be required to meet traffic growth and normal replacement in the non-restricted areas	=	700

Both of these figures call for qualification: the supply side takes no account of the technical or economic possibilities of modification; only part of the demand shown will be for Chapter 2 aircraft, since some at least of the replacements for retirements will be new aircraft (and therefore Chapter 3 compliant) chosen for reasons other than their noise performance. And to the extent that the regulations, when imposed, may allow for a gradual phasing out of non-compliant aircraft, so will the effects on buyers and sellers be diluted, consequent on a progressive reduction on the supply side and increase in the demand side. However, the imbalance which will create something of a buyers' market is unlikely to be wholly overcome.

Interaction of retrofitting and resale

21. The effect of future operating bans in curtailing the otherwise useful economic life of certain aircraft will, as was the case with non-noise certificated aircraft, provide a powerful incentive to develop modifications that will rescue some of that threatened asset. Retrofitting could be applied to those aircraft. The decision whether to retrofit or sell will be taken by each airline in the light of its own corporate plan and capital structure, governed by the following principal considerations:

a) the remaining "useful life" of the aircraft, noise considerations apart;

b) the resale price at that time;

c) the cost of replacing capacity with new or second-hand aircraft that will meet Chapter 3 requirements at an earlier time than would otherwise have been necessary;

d) in certain cases, the attitudes of particular airport authorities towards retrofitted aircraft (which may only marginally comply with Chapter 3 standards).

While these considerations have been taken into account in general terms in this study, it remains difficult to predict how modification decisions will be affected, and in turn how the second-hand market will react.

22. While normal retirement patterns, phased withdrawal programmes, development of compliant derivatives and new types, and retrofit may ease the transition to a new Chapter 3 regime in those areas where environmental considerations make it necessary, some reduction in market prices of used aircraft is certain. The reduction of market prices for the aircraft will, however, to a limited extent be offset by an increased demand in non-restricted areas, where these aircraft may be suitable for domestic and regional services. On balance, however, operators in non-restricted areas, even where their networks include points in noise-restricted areas, may enjoy a bonus when purchasing these aircraft to meet their expanding regional and domestic needs. At the same time, this could adversely affect noise levels in the areas concerned.

Chapter 8

Impact by Geographical Area on Carriers from Areas where Further Noise Restrictions are not Anticipated

1. This chapter provides information on the international scheduled airlines registered in geographical areas where further noise restrictions are not anticipated and on the impact on the traffic, fleet and finances of noise restrictions imposed on the operations of these airlines to other areas.

2. The information concerned is provided for each of the eight geographical groupings of States and airlines in the non-restricted areas which have been used in the study:

— Canada
— Mexico/Central America/Caribbean
— South America
— Eastern Europe (including USSR)
— Middle East
— Northern Africa
— Western/Central/Eastern/Southern Africa
— Asia/Pacific (less Australia/Japan/New Zealand).

The States included in each of the subregions concerned are listed in Appendix 2.

3. For airlines in each of the above subregions and over-all, the impact of operating restrictions is assessed in terms of a) the number of Chapter 2 aircraft to be replaced early or retrofitted and b) the associated net accrued costs of early replacement for each of the five scenarios used in this study, namely a complete operating ban from 1995, 2000 and 2005 and a phased operating ban commencing in 1995 and 2000 respectively.

4. The data presented relate only to scheduled airlines because the nature of non-scheduled operations is generally such that the routes flown can vary from day-to-day or week-to-week, and very little information is therefore available on the proportion of operations affected or the ability to redeploy aircraft away from noise-restricted areas. Non-scheduled operations, however, are known in the case of each subregion to be relatively insignificant compared with scheduled services (less than 2 per cent of the total traffic) or, in the specific case of Canada, to be predominantly to/from non-restricted areas.

Canada

5. As of 31 December 1987, air transport services were provided by six scheduled international airlines registered in Canada, all operating to destinations in noise-restricted areas, five with aircraft that do not meet the requirements of ICAO Annex 16, Chapter 3.

6. Out of a total of 235 aircraft in Canada, 60 (26 per cent) met the requirements of ICAO Annex 16, Chapter 3, 165 (70 per cent) met the requirements of Chapter 2, and the remaining 10 (4 per cent) were non-noise certificated aircraft which have been assumed to be withdrawn from service by 1995. The expected attrition of the 165 Chapter 2 aircraft is as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the subregion.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	74	117	142	180
Remaining Chapter 2 aircraft				
Narrow-body	156	120	95	58
Wide-body	9	8	5	2
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	21	13	7	2

7. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	20	9	4	–
Wide-body	8	5	2	–
Phased ban (1995)				
Narrow-body	7	10	12	–
Wide-body	2	4	5	–
Phased ban (2000)				
Narrow-body	–	3	5	–
Wide-body	–	1	2	–

8. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	27	12	3	–
Wide-body	188	103	20	–
Phased ban (1995)				
Narrow-body	15	–	–	–
Wide-body	89	–	–	–
Phased ban (2000)				
Narrow-body	–	3	–	–
Wide-body	–	31	–	–

Mexico/Central America/Caribbean

9. As of 31 December 1987, air transport services were provided by 20 scheduled international airlines registered in this subregion, of which 17 operated to destinations in noise-restricted areas, 14 with aircraft that do not meet the requirements of ICAO Annex 16, Chapter 3.

10. Out of a total of 182 aircraft in this subregion, 34 (19 per cent) met the requirements of ICAO Annex 16, Chapter 3, 126 (69 per cent) met the requirements of Chapter 2, and the remaining 22 (12 per cent) were non-noise certificated aircraft which have been assumed to be withdrawn from service by 1995. The expected attrition of the 126 Chapter 2 aircraft is as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the subregion.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	45	77	100	134
Remaining Chapter 2 aircraft				
Narrow-body	125	106	82	50
Wide-body	1	1	–	–
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	37	20	12	5

11. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	60	35	16	–
Wide-body	–	–	–	–
Phased ban (1995)				
Narrow-body	16	29	38	–
Wide-body	–	–	–	–
Phased ban (2000)				
Narrow-body	–	9	16	17
Wide-body	–	–	–	–

12. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	243	85	37	–
Wide-body	–	–	–	–
Phased ban (1995)				
Narrow-body	62	–	–	–
Wide-body	–	–	–	–
Phased ban (2000)				
Narrow-body	–	25	–	–
Wide-body	–	–	–	–

South America

13. As of 31 December 1987, air transport services were provided by 20 scheduled international airlines registered in this subregion of which 12 operated to destinations in noise-restricted areas, 11 with aircraft that do not meet the requirements of ICAO Annex 16, Chapter 3.

14. Out of a total of 333 aircraft in this subregion, only 68 (20 per cent) met the requirements of ICAO Annex 16, Chapter 3, 185 (56 per cent) met the requirements of Chapter 2, and the remaining 80 (24 per cent) were non-noise certificated aircraft which have been assumed to be withdrawn from service by 1995. The expected attrition of the 185 Chapter 2 aircraft as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the subregion.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	75	129	168	225
Remaining Chapter 2 aircraft				
Narrow-body	182	118	82	49
Wide-body	3	2	2	1
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	9	4	1	1

15. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	19	–	–	–
Wide-body	1	1	–	–
Phased ban (1995)				
Narrow-body	6	–	–	–
Wide-body	–	–	–	–
Phased ban (2000)				
Narrow-body	–	–	–	–
Wide-body	–	–	–	–

16. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	34	–	–	–
Wide-body	47	33	–	–
Phased ban (1995)				
Narrow-body	8	–	–	–
Wide-body	–	–	–	–
Phased ban (2000)				
Narrow-body	–	–	–	–
Wide-body	–	–	–	–

Eastern Europe (including USSR)

17. As of 31 December 1987, air transport services were provided by seven scheduled international airlines registered in this subregion, and each of the airlines concerned operated to destinations in noise-restricted areas. The entire fleet of this subregion does not meet the requirements of ICAO Annex 16, Chapter 3.

18. All 308 aircraft in this subregion met the requirements of ICAO Annex 16, Chapter 2. The expected attrition of the 308 Chapter 2 aircraft is as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the subregion.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	38	59	73	92
Remaining Chapter 2 aircraft				
Narrow-body	294	261	207	138
Wide-body	14	14	14	11
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	41	27	20	12

19. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	55	45	32	-
Wide-body	3	3	3	-
Phased ban (1995)				
Narrow-body	15	30	45	-
Wide-body	1	2	3	-
Phased ban (2000)				
Narrow-body	-	12	24	28
Wide-body	-	1	2	3

20. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	65	35	25	–
Wide-body	150	118	76	–
Phased ban (1995)				
Narrow-body	22	–	–	–
Wide-body	74	–	–	–
Phased ban (2000)				
Narrow-body	–	17	–	–
Wide-body	–	62	–	–

Middle East

21. As of 31 December 1987, air transport services were provided by 12 scheduled international airlines registered in this subregion of which 10 operated to destinations in noise-restricted areas, seven with aircraft that do not meet the requirements of ICAO Annex 16, Chapter 3.

22. Out of a total of 298 aircraft in this subregion, 102 (34 per cent) met the requirements of ICAO Annex 16, Chapter 3, 154 (52 per cent) met the requirements of Chapter 2, and the remaining 42 (14 per cent) are non-noise certificated aircraft which have been assumed to be withdrawn from service by 1995. The expected attrition of the 154 Chapter 2 aircraft is as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the subregion.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	76	151	212	291
Remaining Chapter 2 aircraft				
Narrow-body	121	109	89	57
Wide-body	33	27	18	11
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	22	10	5	2

23. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	15	12	8	–
Wide-body	10	6	2	–
Phased ban (1995)				
Narrow-body	5	9	11	–
Wide-body	2	3	4	–
Phased ban (2000)				
Narrow-body	–	4	8	9
Wide-body	–	1	2	–

24. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	97	64	26	–
Wide-body	275	62	24	–
Phased ban (1995)				
Narrow-body	45	–	–	–
Wide-body	101	–	–	–
Phased ban (2000)				
Narrow-body	–	24	–	–
Wide-body	–	39	–	–

Northern Africa

25. As of 31 December 1987, air transport services were provided by eight scheduled international airlines registered in this subregion of which six operated to destinations in noise-restricted areas, five with aircraft that do not meet the requirements of ICAO Annex 16, Chapter 3.

26. Out of a total of 146 aircraft in this subregion, only 17 (12 per cent) met the requirements of ICAO Annex 16, Chapter 3, 99 (68 per cent) met the requirements of Chapter 2, and the remaining 30 (20 per cent) were non-noise certificated aircraft which have been assumed to be withdrawn from service by 1995. The expected attrition of the 99 Chapter 2 aircraft is as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the subregion.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	27	47	61	82
Remaining Chapter 2 aircraft				
Narrow-body	97	86	65	42
Wide-body	2	2	1	1
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	27	16	11	3

27. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted (before year specificed, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	42	35	13	–
Wide-body	–	–	–	–
Phased ban (1995)				
Narrow-body	11	22	30	34
Wide-body	–	–	–	–
Phased ban (2000)				
Narrow-body	–	9	17	20
Wide-body	–	–	–	–

28. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	219	119	29	–
Wide-body	–	–	–	–
Phased ban (1995)				
Narrow-body	72	–	–	–
Wide-body	–	–	–	–
Phased ban (2000)				
Narrow-body	–	26	–	–
Wide-body	–	–	–	–

Western/Central/Eastern/Southern Africa

29. As of 31 December 1987, air transport services were provided by 28 scheduled international airlines registered in this subregion of which 23 operated to destinations in noise-restricted areas, eight with aircraft that do not meet the requirements of ICAO Annex 16, Chapter 3.

30. Out of a total of 224 aircraft in this subregion, 48 (21 per cent) met the requirements of ICAO Annex 16, Chapter 3, 94 (42 per cent) met the requirements of Chapter 2, and the remaining 82 (37 per cent) were non-noise certificated aircraft which have been assumed to be withdrawn from service by 1995. The expected attrition of the 94 Chapter 2 aircraft is as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the subregion.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	37	63	82	110
Remaining Chapter 2 aircraft				
Narrow-body	93	75	61	37
Wide-body	1	1	1	–
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	8	7	5	3

31. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	3	2	2	–
Wide-body	1	1	1	–
Phased ban (1995)				
Narrow-body	1	2	–	–
Wide-body	–	–	–	–
Phased ban (2000)				
Narrow-body	–	–	–	–
Wide-body	–	–	–	–

32. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	13	8	4	–
Wide-body	44	30	10	–
Phased ban (1995)				
Narrow-body	6	–	–	–
Wide-body	–	–	–	–
Phased ban (2000)				
Narrow-body	–	–	–	–
Wide-body	–	–	–	–

Asia/Pacific (less Australia/Japan/New Zealand)

33. As of 31 December 1987, air transport services were provided by 28 scheduled international airlines registered in this subregion of which 18 operated to destinations in noise-restricted areas, 13 with aircraft that do not meet the requirements of ICAO Annex 16, Chapter 3.

34. Out of a total of 629 aircraft in this subregion, 274 (44 per cent) met the requirements of ICAO Annex 16, Chapter 3, 225 (38 per cent) met the requirements of Chapter 2, and the remaining 130 (18 per cent) were non-noise certificated aircraft which have been assumed to be withdrawn from service by 1995. The expected attrition of the 225 Chapter 2 aircraft is as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the subregion.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	190	394	592	870
Remaining Chapter 2 aircraft				
Narrow-body	195	173	144	103
Wide-body	30	26	20	12
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	15	7	4	2

35. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	5	4	4	-
Wide-body	22	18	10	-
Phased ban (1995)				
Narrow-body	1	2	3	-
Wide-body	5	10	15	-
Phased ban (2000)				
Narrow-body	-	1	2	-
Wide-body	-	4	8	9

36. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	27	12	7	–
Wide-body	817	387	154	–
Phased ban (1995)				
Narrow-body	9	–	–	–
Wide-body	232	–	–	–
Phased ban (2000)				
Narrow-body	–	5	–	–
Wide-body	–	88	–	–

Summary for all non-restricted areas

37. As of 31 December 1987, air transport services were provided by 129 scheduled international airlines registered in the non-restricted areas, of which 97 operated to destinations in noise-restricted areas, 62 with aircraft that do not meet the requirements of ICAO Annex 16, Chapter 3.

38. Out of a total of 2 355 aircraft in the non-restricted areas, 603 (26 per cent) met the requirements of ICAO Annex 16, Chapter 3, 1 356 (57 per cent) met the requirements of Chapter 2, and the remaining 396 (17 per cent) were non-noise certificated aircraft which have been assumed to be withdrawn from service by 1995. The expected attrition of the 1 356 Chapter 2 aircraft is as follows, along with the proportion of traffic that would be affected by a complete operating ban on aircraft registered in the non-restricted areas.

Contribution of Chapter 2 fleet

	1987	1995	2000	2005
ASKs produced by total fleet (thousand million)	562	1 036	1 431	1 984
Remaining Chapter 2 aircraft				
Narrow-body	1 263	1 048	825	534
Wide-body	93	81	61	38
ASKs by Chapter 2 aircraft to and from noise-restricted areas as a proportion of total ASKs (per cent)	19	10	6	2

39. For each of the operating ban scenarios the number of aircraft that would be affected is illustrated below.

Number of Chapter 2 aircraft to be replaced early or retrofitted
(before year specified, cumulative for phased ban)

	1995	2000	2005	2010
Complete ban				
Narrow-body	219	142	79	-
Wide-body	45	34	18	-
Phased ban (1995)				
Narrow-body	62	110	145	-
Wide-body	10	18	24	-
Phased ban (2000)				
Narrow-body	-	38	72	91
Wide-body	-	7	14	16

40. The net accrued cost to the airlines resulting from the respective operating bans is as follows.

Net accrued cost of early replacement of Chapter 2 aircraft
($ million)

	1995	2000	2005	2010
Complete ban				
Narrow-body	725	334	130	–
Wide-body	1 522	733	283	–
Phased ban (1995)				
Narrow-body	239	–	–	–
Wide-body	496	–	–	–
Phased ban (2000)				
Narrow-body	–	100	–	–
Wide-body	–	220	–	–

41. The proportion of traffic affected by a complete operating ban on aircraft registered in the non-restricted areas would thus be 10 per cent if the ban were imposed in 1995, 6 per cent if it were imposed in 2000 and 2 per cent if it were imposed in 2005. However, the proportion varies significantly from subregion to subregion in the non-restricted areas, to a great extent depending on the geographic location in relation to a noise-restricted area.

42. Thus a relatively high proportion of traffic would be affected in the case of Northern Africa (16 per cent for 1995, 14 per cent for 2000 and 3 per cent for 2005) because of the proximity to Europe, and in the case of Mexico/Central America/Caribbean (20 per cent for 1995, 12 per cent for 2000 and 5 per cent for 2005) because of the proximity to the United States. Conversely a relatively low proportion of traffic would be affected in the case of South America which is located at a substantial distance from the noise-restricted areas. In the case of Eastern Europe (including USSR), while the proportion of total operations into the noise-restricted areas is not particularly high, the vast majority of these operations are presently carried out with non-compliant aircraft, and hence the impact of a ban on total traffic (excluding USSR domestic traffic) would be relatively high (27 per cent of total traffic for 1995, 20 per cent for 2000 and 12 per cent for 2005).

43. The proportion of aircraft that would need to be replaced earlier or retrofitted because of operating bans in noise-restricted areas is different from the proportion of the traffic affected, primarily because of the predominance of the narrow-body aircraft in the non-compliant fleet, and also because some of these aircraft may be redeployed to routes in non-restricted areas. However, the proportion of aircraft affected remains primarily dependent on the proximity of the non-restricted area concerned to noise-restricted areas.

44. Thus the number of aircraft that would be required to be replaced or retrofitted in relation to the total non-compliant fleet is highest in the case of Northern Africa (48 per cent in 1995, 53 per cent in 2000 and 30 per cent in 2005), and in the case of Mexico/Central America/Caribbean (56 per cent in 1995, 43 per cent in 2000, and 32 per cent in 2005). In the case of Eastern Europe (including USSR) the proportion of aircraft that would be affected is estimated to be 21 per cent in 1995, 22 per cent in 2000 and 23 per cent in 2005.

45. The net accrued costs likewise vary from subregion to subregion. In the case of narrow-body aircraft, the subgroup of Northern Africa would incur net accrued costs of $219 million in the case of a complete operations ban in 1995, $119 million for 2000 and $29 million for 2005, and Mexico/Central America/Caribbean would incur $243 million for 1995, $85 million for 2000 and $37 million for 2005.

46. In the case of wide-body aircraft, the net accrued costs would be highest in the subgroup Asia/Pacific less Australia, Japan and New Zealand ($817 million for 1995, $387 million for 2000 and $154 million for 2005). This is primarily due to the high proportion of wide-body aircraft that would need to be replaced prematurely in this particular subregion.

Appendix 1

Detailed Methodology and Assumptions

Noise classification of the jet aircraft fleet

1. Table A1-1 depicts the noise classification of the world commercial jet fleet of 7 976 aircraft as of 31 December 1987. The aircraft that do not meet Chapter 3 certification standards (described hereafter as non-compliant) comprise 439 non-noise certificated aircraft and 4 922 Chapter 2 aircraft which together account for 67 per cent of the aircraft fleet. The number of aircraft that meet the requirements of ICAO Annex 16, Chapter 3 is 2 615 or 33 per cent of the fleet. Approximately 50 of the DC-10 aircraft classified as Chapter 3 aircraft in the fleet projections in Tables A1-2 and A1-3 are not currently certificated to meet those requirements, but are expected to be so in the very near future and therefore are included with the other DC-10 aircraft.

Methodology for aircraft retirement

2. Retirement rate of aircraft becomes one of the key parameters in estimating the size of the affected fleet for future time periods. Historical trends on retirement rates of jet aircraft seem rather limited.

3. In the development of fleet projections, the criteria used by major aircraft manufacturers to retire in-service aircraft seem to vary from manufacturer to manufacturer. In general, manufacturers use a service life span of 25 years for the older technology aircraft such as the B707, DC-8, B727, DC-9, etc., and 28-30 years for new technology aircraft such as the A300, MD-80, B757/767 and other wide-body aircraft.

4. Whereas adequate and reliable historical data on retirement rates for different aircraft types are not available, data are available on the number of aircraft by type which were produced and delivered in a given year and the number of those aircraft which are still in service. From this data, the percentage of aircraft still in service compared to the total built was compiled for selected age groups. These selected age groups are 0-10, 11-14, 15-18, 19-22 and greater than 22.

5. Figure 5-4 in Chapter 5 illustrates the retirement patterns of several such aircraft types from their respective year of entry into service. It should be recognized, however, that the historic retirement patterns of the non-noise certificated aircraft such as B707, DC-8 and Caravelle could have been influenced by operating restrictions imposed on such aircraft by certain States.

6. In general, some retirement seems to occur during the first ten years of service; then the proportion retiring increases gradually as aircraft get older. The number of aircraft remaining in service after 15-20 years tends to form a significantly declining proportion.

7. Based on these historical trends, it seemed appropriate to adopt the following criterion for retirement of aircraft: Retire 10 per cent of remaining aircraft fleet per year after an aircraft reaches 20 years. This approach as illustrated in Figure 5-4 provides a better basis for aircraft retirement based on a probability distribution of the aircraft service life, rather than retiring every aircraft that reaches a certain fixed age. The average service life of

the aircraft reaches approximately 29 years based on this method of retirement. This methodology would tend to retire a higher proportion of aircraft before reaching the average age. In addition, the number of aircraft retired in a given year would be influenced by the variations in the historic annual delivery rates of aircraft. Applying this retirement methodology, the number of Chapter 2 aircraft that would be removed from service due to normal attrition is estimated to be 1 393, 905 and 967 for the years 1995, 2000 and 2005 respectively.

Methodology for cost analysis

8. The economic measures of costs resulting from an imposition of an operating ban on non-compliant aircraft is not the gross investment (purchase price) of a replacement aircraft but rather the net accrued cost of ending the remaining useful life of the aircraft concerned earlier than planned.

Table A1-1. Noise classification of the world commercial aircraft fleet, 31 December 1987, used for further analysis

Aircraft	None	Chapter 2	Chapter 3	Total
Airbus A300	-	-	275	275
Airbus A310	-	-	114	114
Aerospatiale SE210 Caravelle	24	46	-	70
British Aerospace BAC 1-11	13	156	-	169
British Aerospace 146	-	-	75	75
Convair 880 and 990	12	-	-	12
Boeing 707	155	142	-	297
Boeing 720	33	-	-	33
Boeing 727	29	1 656	-	1 685
Boeing 737	39	1 024	319	1 382
Boeing 747	-	286	360	646
Boeing 757	-	-	151	151
Boeing 767	-	-	191	191
Dassault 100 Mercure	-	11	-	11
Fokker VFW F28	-	203	-	203
Fokker F-100	-	-	8	8
Hawker Siddeley HS-121 Trident	33	-	-	33
Lockheed L1011	-	-	232	232
McDonnell Douglas DC-10	-	-	359	359
McDonnell Douglas DC-8	70	134	96	300
McDonnell Douglas DC-9	31	839	-	870
McDonnell Douglas MD-80	-	-	435	435
IL-86	-	14	-	15
IL-62	-	86	-	86
TU-134	-	80	-	80
TU-154	-	117	-	117
YAK-40/42	-	128	-	127
Total	439	4 922	2 615	7 976

9. Early replacement of Chapter 2 aircraft before the end of their service life accelerates both the capital expenditures and the operating cost savings associated with retirement. The economic cost of early replacement, i.e. the net capital cost of early replacement, is determined by comparing capital and operating cash flows associated with the retirement of the aircraft before the end of their service life.

10. The critical factor in determining economic impact is the remaining economic life of aircraft affected by the imposition of Chapter 3 requirements on operations. It has a direct bearing on the values assigned to each of the elements that together make up the over-all economic impact. It can be defined as the discounted value of early purchase consisting of (1) the opportunity cost of capital tied up in purchase of a new asset, less (2) the discounted value of changes in operating and maintenance costs which may accrue by substituting Chapter 3 newer aircraft for older Chapter 2 aircraft.

11. For example, in the absence of a ban, if an operator is forced to retire an aircraft one year earlier than planned, the cost to this particular operator is the net purchase cost (cost of new Chapter 3 aircraft minus any residual value for the Chapter 2 aircraft) in the year of regulation (for example, 2000) minus the present value of the aircraft purchase cost in the year of normal replacement (for example, 2001).

Table A1-2. Projections of the world commercial jet aircraft fleet*

	1987	1995	2000	2005
Total aircraft fleet	7 976	8 400	9 800	10 500
Narrow-body aircraft				
B727	1 656	1 158	823	490
B737	1 024	875	737	491
DC-9	839	494	318	188
F28	203	178	145	98
BAC 1-11	156	80	52	31
B707/DC-8	276	117	71	41
IL-62	86	81	70	46
TU-134	80	79	64	35
TU-154	117	114	101	75
Other	185	136	97	72
Sub-total	4 622	3 312	2 478	1 567
Wide-body aircraft				
B747	286	203	133	79
IL-86	14	14	14	11
Sub-total	300	217	147	90
Total Chapter 2 aircraft	4 922	3 529	2 625	1 657
Per cent contribution of Chapter 2 aircraft	62	42	27	16

* Including all-freight aircraft, excluding the domestic fleet of Aeroflot.

12. Assuming a purchase cost of $32 million per aircraft including provisions for training, tooling, spare parts, etc., the capital expenditure to this particular operator is given by:

Capital expenditure = ($32 m − $32 m * 1/1.06) = $1.81 m.

Since no provision for inflation has been made, 6 per cent per annum has been used to reflect the real cost of money over the study period.

13. To determine total industry capital expenditures, the basic formula is simply expanded to account for the total Chapter 2 fleet expected to be adversely affected by a proposed rule.

14. The general formula can be expressed as follows:

Capital expenditure = (P * # of seats) — (P * # of seats * $1/(1 + r)^n$)

Where:

P = net seat cost of Chapter 3 replacement in year of proposed regulation (purchase price − residual value);

# of seats = number of seats prematurely retired as determined from fleet forecast;

r = discount rate; and

n = remaining useful life affected.

15. *Factors determining "capital expenditure" requirements.* The above model is dependent upon numerous assumptions which can influence the capital expenditure calculation significantly. The assumptions used for aircraft life, interest rates, salvage values, alternative uses for the aircraft, availability of hushkits, and types of replacement aircraft will determine over-all costs, which must be weighed against the environmental benefits derived from an operating ban.

16. The model assumes that all Chapter 2 replacements will consist of new Chapter 3 aircraft. The availability of hushkits and engine retrofits will lower the costs associated with Chapter 3 compliance. It is not possible to determine the impact it may have on over-all costs at present.

17. *Replacement aircraft.* Also critical to the analysis is the determination of the type of aircraft that will serve as the most likely replacement for the non-compliant aircraft. To avoid replacing existing Chapter 2 aircraft with smaller or larger aircraft on a tail-for-tail basis, a seat-for-seat replacement was employed. Total Chapter 2 available seats were determined from the size of the affected aircraft fleet then replaced by an equivalent amount of Chapter 3 seating capacity.

18. Replacement seat costs were determined by calculating the weighted seat cost of a representative mix of existing Chapter 3 aircraft. Replacements were chosen based upon similar flight profiles, seating capacities, range, etc. Average selling prices were determined by tracking sales of these aircraft during 1988 using published information. Replacement seat costs ranged from $190 000 to $255 000 depending on the model type replaced. All selling prices and subsequent costs are expressed in constant 1988 dollars.

19. *Operating cost savings.* Replacement of a Chapter 2 aircraft with a Chapter 3 aircraft is likely to provide savings in operating costs to the operator. These savings arise primarily in two areas. Firstly, the major

Table A1-3. Projections of world commercial traffic*

	1987	1995	2000	2005
		(ASK millions)		
Total traffic (scheduled and non-scheduled)				
Narrow-body	1 122 400	1 880 300	2 452 300	3 191 100
Wide-body	1 215 900	2 037 000	2 656 700	3 487 000
Traffic generated by Chapter 2 aircraft				
Narrow-body aircraft				
B707/DC-8	37 210	15 450	9 450	5 620
B727	342 050	238 020	169 080	100 660
B737	157 880	134 070	112 470	76 560
DC-9	126 050	73 740	47 530	28 030
F28	10 670	9 260	7 440	4 970
BAC 1-11	6 940	3 530	1 950	1 160
IL-62	21 360	20 160	17 190	11 600
TU-134	5 490	5 400	4 400	2 450
TU-154	16 790	16 290	14 560	11 080
Other	15 530	5 390	3 230	1 990
ASK produced Sub-total	740 010	521 310	387 300	244 120
Wide-body aircraft				
IL-86	6 000	6 000	6 000	5 200
B747	251 080	177 390	115 440	69 030
ASK produced Sub-total	257 080	183 390	121 440	74 230
Total from affected fleet	997 090	704 700	508 740	318 350
Total	2 338 300	3 917 300	5 109 000	6 678 100
Per cent contribution of Chapter 2 aircraft				
Narrow-body	66	28	16	8
Wide-body	21	9	5	2
Total	43	18	10	5

* Excluding traffic for all-freight aircraft and USSR domestic services.

performance advances made by high bypass and super high bypass ratio engines employed on Chapter 3 aircraft have led to significant fuel efficiencies. Secondly, a new aircraft by virtue of its lower accumulated utilization will have lower maintenance costs than an aircraft which has been in service for many years or is reaching the end of its service life. The earlier replacement of Chapter 2 aircraft will enable the benefits of lower operating costs to be realized at an earlier date than planned. Thus, if a proposed regulation results in a Chapter 2 aircraft being replaced in the year 2000 (year of ban) one year prior its useful service life, the cost savings can be estimated by $(C_3 - C_2)/1+r$, where:

C_3 = the operating cost of new Chapter 3 aircraft;

C_2 = operating cost of Chapter 2 aircraft in that year;

r = the discount rate.

20. Operating cost savings resulting from replacing each affected Chapter 2 aircraft earlier than planned with a Chapter 3 aircraft has been carried out for all affected Chapter 2 aircraft.

21. The formula can then be generalized in the following manner:

$$\text{Operating Cost Savings} = C_{3_1} - C_{2_1}/(1 + r) + C_{3_2} - C_{2_2}/(1 + r)^2 + \ldots\ldots\ldots\ldots + C_{3_n} - C_{2_n}/(1 + r)^n$$

Where:

n = number of years the aircraft retirement has been advanced.

22. The net accrued cost to an operator is the difference between the capital expenditure and the operating cost savings brought forward to the year of ban using the established discount rates.

Thus net accrued costs = (capital expenditure − operating cost savings) brought forward to the year of the operating ban concerned.

23. The above analysis was applied to all narrow-body aircraft. The costs of application of Chapter 3 certification requirements to operators of wide-body aircraft may be viewed more simply, even though the question of replacement may be more complex. The principal element in replacement costs is the capital expenditure, and this is treated in the same way as with the narrow-body aircraft. Examination of the operating costs structure does not, however, lead to any clear-cut indication of classifiable savings that can be assigned to the new replacement aircraft and that would significantly differentiate them from the aircraft they replace. There would, of course, be some savings of maintenance costs in replacing an older aircraft with a new aircraft. For the purpose of this study, it has been considered prudent to present only the capital cost element of the change in the case of wide-body aircraft, without taking into account the uncertain economics of operating costs.

Appendix 2

States and Territories in the Non-restricted Areas

North America
Canada

Mexico/Central America/ Caribbean
Antigua and Barbuda
Bahamas
Barbados
Costa Rica
Cuba
Dominican Republic
El Salvador
Grenada
Guatemala
Haiti
Honduras
Jamaica
Mexico
Nicaragua
Panama
Saint Lucia
Trinidad and Tobago

South America
Argentina
Bolivia
Brazil
Chile
Colombia
Ecuador
Guyana
Paraguay
Peru
Suriname
Uruguay
Venezuela

Territory
French Guiana

Eastern Europe (including USSR)
Bulgaria
Czechoslovakia
German Democratic Republic*
Hungary
Poland
Romania
Union of Soviet Socialist Republics

Middle East
Bahrain
Democratic Yemen
Iran, Islamic Republic of
Iraq
Israel
Jordan
Kuwait
Lebanon
Oman
Saudi Arabia
Syrian Arab Republic
United Arab Emirates
Yemen

Northern Africa
Algeria
Egypt
Libyan Arab Jamahiriya
Morocco
Sudan
Tunisia

Western/Central/Eastern/ Southern Africa
Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Cape Verde
Central African Republic
Chad
Congo
Côte d'Ivoire
Djibouti
Equatorial Guinea
Ethiopia
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Madagascar
Mali
Mauritania
Mauritius
Mozambique
Niger
Nigeria
Rwanda
Sao Tome and Principe
Senegal
Seychelles
Sierra Leone
Somalia
South Africa
Swaziland
Togo
Uganda
United Republic of Tanzania
Zaire
Zambia
Zimbabwe

* Non-Contracting State

Asia/Pacific (less Australia/Japan/ New Zealand)

Afghanistan
Bangladesh
Bhutan
Brunei Darussalam
Burma
China
Democratic Kampuchea
Democratic People's Republic of Korea
Fiji
India
Indonesia
Kiribati
Lao People's Democratic Republic
Malaysia
Maldives
Mongolia*
Nauru
Nepal
Pakistan
Papua New Guinea
Philippines
Republic of Korea
Samoa*
Singapore
Solomon Islands
Sri Lanka
Thailand
Tonga
Tuvalu*
Vanuatu
Viet Nam

Territories

Hong Kong
Macao

* Non-Contracting State

— END —

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The following summary gives the status and also describes in general terms the contents of the various series of publications in the air transport field issued by the International Civil Aviation Organization:

International Standards and Recommended Practices on Facilitation *(designated as Annex 9 to the Convention)* which are adopted by the Council in accordance with Articles 37, 54 and 90 of the Convention on International Civil Aviation. The uniform observance of the specifications contained in the International Standards on Facilitation is recognized as practicable and as necessary to facilitate and improve some aspect of international air navigation, while the observance of any specification contained in the Recommended Practices is recognized as generally practicable and as highly desirable to facilitate and improve some aspect of international air navigation. Any differences between the national regulations and practices of a State and those established by an International Standard must be notified to the Council in accordance with Article 38 of the Convention. The Council has also invited Contracting States to notify differences from the provisions of the Recommended Practices;

Council Statements on policy relating to air transport questions, such as the economics of airports and en-route air navigation facilities, taxation and aims in the field of facilitation;

Digests of Statistics which are issued on a regular basis, presenting the statistical information received from Contracting States on their civil aviation activities;

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Manuals providing information or guidance to Contracting States on such questions as airport and air navigation facility tariffs, air traffic forecasting techniques and air transport statistics.

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