Economic measures for the reduction of the environmental impact of air transport: noise-related landing charges (FKZ 201 96 107)

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16. Abstract Because of existing growth rates for air traffic and capacity extensions at many international airports, efforts to find effective instruments for the reduction of noise problems increase. Economic instruments gain increasingly in importance. This study examines, with an LTO-charging model differentiated according to aircraft-noise emissions and incentives for air transport companies for the use of less-noisy aircraft. The results of the study are based on a comprehensive status-quo analysis of European LTO-charging models; they demonstrate the need for harmonized development of this kind of instrument as an incentive, in order to be able to obtain transparency and comprehensibility. The study draws attention to a set of guidelines that must be considered in future.		
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Abbreviations

Abbreviation	Explanation
ACC	Air Cargo Carrier
ACI	Airports Council International
ADV	Germans Airports Association
AEA	Association of European Airlines
APNL	Approach Noise Level
ATC	Air Traffic Control
AzB	Instructions on the calculation of noise protection zones
AZNF	Airport Zurich Noise Fund
BADV	Groundhandling Ordinance
BARIG	Board of Airline Representatives in Germany
BGB	Federal Civil Code
BGH	Federal Court of Justice
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMVBW	Federal Ministry for Transport, Building and Housing
C	Unit Noise Charge
C_a	Unit noise charge on arrival
CAA	Civil Aviation Administration
C_d	Unit noise charge on departure
CHF	Swiss Franc
dB	Decibel
DES	data entry system for AzB
DFS	DFS (Deutsche Flugsicherung GmbH) German Air Traffic Control
DIW	German Institute for Economic Research
DWD	German National Meteorological Service
ECAC	European Civil Aviation Conference
EMPA	Swiss Federal Laboratories for Materials Testing and Research
EPNdB	Effective Perceived Noise in dB
EPNL	Effective Perceived Noise Level

Abbreviation	Explanation
EU	European Union
FAA	Federal Aviation Administration, USA
FLULA	Aircraft-noise computation program by EMPA
FRA	Frankfurt
FSAAKV	Ordinance on the levying of charges for the use of ATC services and facilities on arrival and departure
FS-AuftragV	Ordinance on the assignment of ATC business company
FSC	Full Service Carrier
FSStrKV	Ordinance on the levying of charges for the use of en-route air navigation services and facilities
GG	Basic Law (German Federal Constitution)
GWB	Act against Restraints on Competition
HLUG	Hessian national office for environment and geology
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IER	Institute of Energy Economics and the Rational Use of Energy, University of Stuttgart
INM	Integrated Noise Model
L_a	Certificated noise level at approach
L_{Amax}	Maximum value of the measured sound level
L_{AS}	measured sound pressure level
L_{AX}	Single event sound level (with q=3 and t_{ref}=1 s)
L_{AZ}	Single event sound level (with q=4 and t_{ref}=10 s)
L_d	Certificated noise level at departure (mean value of flyover and lateral measurement point)
L_{DEN}	Day-evening-night level (A-weighted long-term average sound level as defined in ISO 1996-2)
L_{eq}	A-weighted long-term average sound level
LBA	Federal Office of Civil Aviation
LCC	Low Cost Carrier
LHR	London-Heathrow
LK	Category of noise

Abbreviation	Explanation
L_s	Certificated noise level at departure (lateral measurement)
LTO-Zyklus	Landing and Take-Off cycle (defined by ICAO)
$L_ü$	Certificated noise level at departure (flyover)
LuftKostV	Ordinance on the costs of air traffic management
LuftVG	Air Traffic Act of 1.8.1922
LuftVZO	Air Traffic Licensing Regulations of 19.6.1964
LVL	Noise regulations for aircraft
MD	Mc Donnell Douglas
MTOM	Maximum-Take-Off-Mass
NAT	Number above threshold
NNI	Noise and Number Index
PAX	Passenger
Pkm	Passenger Kilometre
RNAV	Area Navigation
LTO-charge	Landing and take-off charge
SEK	Swedish Crowns (Krona)
T_a	Noise threshold at arrival (COM (2002) 683 final)
TANC	Transport Aircraft Noise Classification Group
T_d	Noise threshold at departure (COM (2002) 683 final)
TNC	Terminal Navigation Charge
TSU	TÜV Rheinland Group safety and environment protection
UBA	Umweltbundesamt - Federal Environmental Agency
WI	Wuppertal Institute for Climate, Environment, Energy
WMO	World Meteorological Organization
ZLW	German Journal of Air and Space Law

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1 Summary

International air transport involves considerable adverse effects on the environment at both a national and an international level, which, particularly against the background of high rates of growth in the volume of air transport in recent years, has become the focus of increased public interest. While at a global level discussion centres on the significance of air transport for the climate, at a local level the focus is on problems of noise, which is now one the most important environmental problems in the Federal Republic of Germany.

Particularly against this background of growing traffic volume, but also with regard to the discussed expansion of capacity at German commercial airports (*inter alia* Frankfurt and Berlin), increasing efforts are being directed at problems of noise mitigation, and economic instruments are becoming even more important. One promising option is the creation of economic incentives for the use of environmentally sound technologies – with less noise and lower emissions – by airlines. One such instrument is the differentiation of airport charges according to aircraft noise emissions and flight movements.

It is this point that provides the focus of the R & D project, "*Economic measures for the reduction of the environmental impact of air transport: noise-related landing charges"* from the Ministry of the Environment's environmental research plan, which was awarded by the Federal Environmental Agency in December 2001 to the Öko-Institut for Applied Ecology and the German Institute for Economic Research (DIW).

The main objective of this project is the "*development of an effective system of noise-related landing charges",* since – so the thesis of the commissioning agency – "*a noise-related landing charge is currently levied at German commercial airports, which offers aircraft operators, however, no perceptible incentive for the use of less-noisy aircraft."*"[1]

Legal and political framework

In order to pursue this objective, the legal framework was investigated that is important for the structure of noise charges within the framework of a German or European airport charging system. The project focused on **noise-related landing and take-off (LTO) charging systems.** In addition, legislation and proposed legislation at an international, European and national level were also examined. As a result of the analysis, a number of key criteria have been identified that have to be considered in the design of a LTO charging system, and these include, besides system transparency, freedom from discrimination, the principle of cost-recovery and revenue neutrality.

[1] Text in italics derives from the invitation to tender, on which this study is based.

Status Quo Analysis

On this basis, within the framework of status quo analysis, noise-related LTO charging systems in use at European and German airports at the end of the year 2002 were extensively and systematically investigated with regard to

- their structure (basis for assessment, rates and spread of charges, time-related differentiation of charges etc.) and
- their economic incentives for the introduction of less-noisy aircraft.

As far as Germany is concerned, all 17 international airports were analysed together with the regional airports at Dortmund and Hahn. Outside Germany, status quo analysis concentrated on 10 major European airports with noise-related LTO charges. Status quo analysis was supplemented by assessment of the economic significance of noise-related LTO charges for airline companies and airport operators.

The comparison of LTO charging systems showed that the structure of noise-related LTO charges at Frankfurt, Hamburg and Zurich airports, as well as – to a certain extent – at Munich and Stuttgart, have purpose-related elements:

- transparency of charging systems through clear differentiation of MTOM-related charges and separately-shown noise components;
- orientation towards the polluter-pays principle through the separate treatment of take-off and landing, higher pricing at night as well as greater differentiation of noise categories (compared to noise certification values of the International Civil Aviation Organization, ICAO; and
- consideration of the local noise-nuisance situation through, among other measures, the laying down of local noise-categories based on measurements at individual airports.

For the status quo it was basically established that the financial incentive is insufficient to bring about intended reactions on the part of airlines (operation of less-noisy aircraft, shift in the timing or place of flight movements). That the present systems of noise-related LTO charges are hardly likely to produce a control effect is also confirmed by analysis of the cost structures of airlines. Airline reactions could only be expected when the noise component of LTO charges clearly exceeds the usual status quo limits. That a noticeable increase in noise charges would be followed by the purchase and operation of less-noisy aircraft, or a shift in the timing or place of flight movements, is not foreseeable.

Detailed assessment of existing LTO charging systems

Within the scope of the study, and on the basis of status quo analysis, the attempt was made to investigate the effectiveness of noise-related LTO charging systems at three selected airports (Frankfurt, Cologne/Bonn and Zurich) with respect to the reduction of local noise nuisance by means of operational changes. The analyses showed that an assessment of the effectiveness of noise-related airport charges on the basis of publicly-available traffic statistics or noise measurements/computations is not possible.

One of the reasons for this is the overlapping of the effect of landing charges and the effect of other factors and noise mitigation measures (for example, night-flight restrictions). Irrespective of the assessment of the effectiveness of the instrument, important conclusions could be drawn from the detailed analysis for the design of efficient noise-related LTO charging systems (see below).

Scenario analysis

Based on the sound results of status quo analysis and detailed operational and noise-side assessments at selected airports, the focus of work on the design phase was directed at examination of the circumstances under which the effectiveness of this economic instrument with respect to noise reduction could be increased by way of the accelerated operation of less-noisy aircraft. For this purpose, two scenarios were developed, whose implementation was analysed exemplarily at a **reference airport (Frankfurt)** with respect to changes to the existing system and their possibly modified incentive structure. One scenario was orientated towards the **proposed EU Directive COM (2002) 683 final**, while the other scenario was based on the marginal **external costs of noise**. The strengths and weakness of the scenarios in the contentious area between effectiveness and realizability were evaluated. Whereas the scenario based on the proposed EU Directive tended to be counter-productive as far as an improved incentive effect is concerned, in the consideration of external costs it is legal implementation and practicability that must be called into question, an improved incentive effect not having been proven.

Guidelines for the future design of noise-related LTO charging systems

Through the analysis of the national and international legal framework of charging systems, the description of noise-related charges at German and international airports and the assessment of the effect of noise-related LTO charges, a number of critical factors were identified that could in future enable effective (further) development of noise-related LTO charging systems for the purpose of noise mitigation:

An important guiding principle is that, in future, noise-related LTO charging systems should focus more strongly than in the past on the objective of noise mitigation. For this purpose, the following principles should be promoted:

1. Strengthening the **incentive effect** of LTO charges for the operation of less-noisy aircraft and the switching of flight movements to times of the day that are less sensitive to noise.
2. Strengthening the **financing function** of noise-related LTO charges as an instrument of active and passive noise mitigation at particular airports.
3. Strengthening the **communicative function** of LTO charges as an instrument of noise mitigation; improvement in communication with those affected by noise, also to encourage acceptance of developments in flight operations (*licence to operate*).

To ensure adherence to these principles, harmonization of systems and bases for assessment appears to be necessary for fair competition between airports, if possible at the EU level. Further development of charges for the purpose of noise mitigation, in particular at highly-frequented hubs, should not open the door to undesirable reactions on the part of airlines to the cost of noise mitigation, such as switching flight movements to secondary or tertiary airports.

An essential basis for the further development of LTO charging systems is the improvement and **harmonization of bases for assessment**. The calculation of noise-related LTO charges should be carried out, in the opinion of the project team, on a largely harmonized basis, namely on the basis of the actual noise emissions of the respective aircraft. For the purpose of calculating LTO charges on the basis of actually emitted noise and the resulting nuisance effect, the project team favours, in the long term, maximum noise level (L_{Amax}) measured locally at airports, which, however, would place great demands on noise measurement that are not yet met at all European airports. In the short term, ICAO certification levels represent an adequate and, above all, practicable basis for assessment. Harmonization of the basis for assessment therefore requires a transitional period. Allocation of aircraft types to noise categories, as carried out at many German and European airports, should be abandoned. In the view of the project team, much is to be said for calculation of noise-related LTO charges by way of a **constant function**, dependent **solely on measured noise values** (and in the short term also on certification values. see above).

Analytical investigations – particularly those for the scenario concerning the marginal external costs of noise – have shown that a noise-related LTO charging system can and should distinguish between

- the type of flight movement (landing and take-off) and
- the timing of the flight movement (day, evening, night).

This way, with particular regard to the communicative function of the charging system, the varied nuisance effect of landing and take-off is emphasized. In combination with **differentiation of charges by time of day**, an incentive for changes in the timing of flight movements could arise.

The **spread of charges** is, in the opinion of the project team, one of the main success factors for an effective noise-related LTO charging system. Restricting spread to a ration of 1 to 40 (in accordance with the proposed EU Directive COM (2002) 683 is counter-productive as far as the incentive effect is concerned. The project team makes a clear recommendation for a progressive **design**; that is, a design with an exponential increase in noise charges for loud aircraft. The aircraft mix can vary greatly between airports. For this reason, charging systems have to be structured to suit the objectives of a particular airport. It should also be possible in the future to vary the level and spread of charges between airports. Apart from a progressive design, the project consortium also proposes the **dynamization and tightening up of noise-related charging systems**, in order to emphasize the long-term objective of noise mitigation, to ensure planning security for airline companies and to increase the incentive for the purchase and operation of less-noisy aircraft.

The determination of rates and spread of charges should also take into account the nuisance effect of noise on those living in the vicinity of airports. Consideration of the nuisance effect of aircraft noise can be established and considered for a given airport on the basis of the size of the resident population within certain isophones. In the view of the project consortium, local concernment at noise could be considered in charging systems when a certain number of people live within defined isophones. Such modulation of LTO charging systems still needs to be elaborated, however.

Even if, in future, further differentiation criteria can be better incorporated into a transparent and harmonized noise-related LTO charging system than at present, on the basis of current knowledge it is not possible to foresee whether an appreciable incentive can be produced for the operation of less-noisy aircraft or for a shift in the timing of flight movements. Basically, there is a lack of transparency with regard to the general effectiveness and precise effects of different charging systems as well as to their specific design at individual airports.

To deal with this problem, the project team recommends that, in future, a harmonized system of noise-related LTO charges should be linked to a **monitoring and reporting obligation**. The project team sees in this proposal an effective means to make the discussion of assumed effect mechanisms and precise effects of noise-related LTO charges more transparent. In other words: should it not be possible to introduce such a monitoring and reporting system, and beyond that, to describe the precise effects of this economic instrument, its potential for initiating a control effect must be subject to even more doubt.

Against the background of uncertain assessment of the current and future incentive effect of noise-related LTO charges, with particular regard to the operation of less-noisy aircraft, the project teams recommends further measures to strengthen the **financing function** – and also the communicative function – of this instrument. An important element could be the **use of revenue** from noise-related LTO charges at individual airports for **noise mitigation**. Revenue from charges should be used as far as possible for measures in the area of active and passive noise mitigation (for instance, development and expansion of noise monitoring, regional noise alleviation planning, constructional noise mitigation).

2 Introduction

2.1 Background

International air transport involves considerable adverse effects on the environment at both a national and an international level, which, against the background of high rates of growth in the volume of air transport in recent years, has become the focus of increased public interest.

While, at a global level, discussion centres on the significance of air transport for the climate, at a local level the focus is on problems of noise, which is now one the most important environmental problems in the Federal Republic of Germany. Generally speaking, traffic is the main source of noise, and particularly in the vicinity of airports, aircraft noise. Against this particular background of the growing volume of traffic, but also with regard to the discussed expansion of capacity at German commercial airports (*inter alia* Frankfurt and Berlin), increasing efforts are being directed at problems of noise mitigation. Approaches at both a national and an international level are varied, but on the basis of results achieved so far, they cannot be regard as adequate.

The debate in Germany in recent years has centred on the amendment of the Aircraft Noise Act (*Gesetz zum Schutz gegen Fluglärm*). In recent legislative periods, however, consensus could not be achieved on the fundamental amendment of the 1971 Act, the debate on the financing of necessary passive noise mitigation being responsible for the impasse.

Parallel to the legal debates, measures are being discussed that support both active and passive noise mitigation and can also contribute to a reduction in problems of noise in the vicinity of airports. In the discussion that is being conducted at a EU level it is above all economic instruments that play a significant role. The European Commission's Communication on Air Transport and the Environment (COM(1999) 640 final), proposed, among other measures, the introduction of economic incentives to encourage airline companies to make use of technologies that lessen adverse effects on the environment. This approach was approved by the Council. One possibility being discussed is the differentiation, or modulation, of airport charges in accordance with the environmental impact of aircraft.

It is this point that provides the focus for the R & D project, "*Economic measures for the reduction of the environmental impact of air transport: noise-related landing charges"* from the Ministry of the Environment's environmental research plan, which was awarded by the Federal Environmental Agency in December 2001 to the Öko-Institut for Applied Ecology and the German Institute for Economic Research (DIW).

Objectives of the project

The main objective of the project, "*Economic measures for the reduction of the environmental impact of air transport: noise-related landing charges"* is the "*development of an effective system of noise-related landing charges",* because, so the thesis of the commissioning agency, "*a noise-related landing charge is currently levied at German commercial airports that, however, offers aircraft operators no perceptible incentive for the use of less-noisy aircraft."*"

For this purpose the following operating steps were put out to tender:

- "*Selection and brief description of the most important international systems of noise-related landing charges.*
- *Assessment of the effectiveness of the selected charging systems with regard to the operation of low-noise aircraft.*
- *Elaboration of a practicable system of landing charges, taking account of the noise emissions of aircraft operated at German airports at present and in the near future.*
- *Description of the legal prerequisites for the introduction of such a system of landing charges at German airports.*
- *Model application of the planned noise-related charging system at a German airport with a high volume of traffic, in agreement with the commissioning Agency.*
- *Assessment, on the basis of a case study, of the effects of the charges model with particular regard to aircraft noise nuisance in the vicinity of airports, the scale of operation of low-noise aircraft as well as costs for aircraft owners and airline companies, airport operators, passengers and cargo customers."*[2]

2.2 Structure and procedure

The structure of this report is based as far as possible on the specifications of the Federal Environmental Agency (UBA). The report begins with a description of the applicable political and legal framework of noise-related landing and take-off (LTO) charging systems as well as of possible future changes (see **Chapter 3**). For this purpose, national, European and international legislation are examined, and on this basis, within the framework of status quo analysis, noise-related LTO charging systems in use at European and German airports at the end of the year 2002 are extensively and systematically investigated with regard to

- their structure (basis for assessment, rates and spread of charges, time-related differentiation of charges etc.) and
- their economic incentives for the use of less-noisy aircraft.

Presentation of the analysis is to be found in **Chapter 4**, which also contains an assessment of the financial significance of charges from important participants in the aviation market. An in-depth assessment of the effectiveness of the charging systems at selected airports (Frankfurt, Cologne/Bonn and Zurich) is carried out in **Chapter 5**

2 Text in italics is from the invitation to tender, on which this report is based.

and covers the economic, operational and noise-side effects of existing charging systems.

Based on the example of the reference airport at Frankfurt, model application of possible alternative charging system is conducted in the form of scenarios (**Chapter 6**). For this purpose, the amended EU Directive (COM(2002 683) on the establishment of a Community framework for noise charges for civil subsonic aircraft is drawn upon in Scenario I, and the marginal external costs of noise are considered in Scenario II. This analysis comprises, in each case, the development, effect analysis and assessment of the scenarios, and is focused on strengthening the incentive for the operation of low-noise aircraft.

Finally, on the basis of the preceding analyses, conclusions are drawn in the form of guidelines for the development and design of a future system of noise-related LTO charges. For this purpose, **Chapter 7** contains proposals for recommendations, which, in the view of the project team, should be considered in the future design of charging systems.

2.3 Definitions

Both in legal provisions and in bibliographical references to LTO charging systems, the terms "landing fees/charges" and "airport charges" are neither precisely distinguished nor used synonymously. In the following section, these terms, and other associated terms, are defined for uniform application in this report. In addition, legally-acceptable forms of noise charges are treated.

2.3.1 "Airport charges" and operational charges

"Airport charges" can be subject to a broad or a narrow definition.

According to a **broad definition,** "airport charges" cover all financial payments connected with the use of airports. Besides charges for facilities and services that are exclusively provided by airport operators, these would also include services provided by third parties, such as meteorological services from the German Weather Service.

According to a **narrow definition,** "airport charges" are understood to mean financial payments for services and facilities that can typically only be provided by airports and that are collected by airport operators. According to the narrow definition, "airport charges" comprise only such payments as are levied for the use of facilities that, on account of complexity or from the point of point of view of costs or the environment, have up to now only been provided by airports themselves.[3]

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[3] Schwenk, Handbuch des Luftverkehrsrechts, 2. Auflage 1996, p. 151 ff.; Giesberts, Ludger/ Geisler, Markus, „Flughafengebühren“ – Neue Entwicklungen bei Entgelten für die Benutzung von Flughäfen, ZLW 1/1998, p. 35, 36.

Airport charges are defined in **Article 2, No. 4 of the proposed EU Directive on airport charges**[4] as

> *"the sums collected at an airport for the benefit of the management body and paid by the airport's users ensuring the remuneration of facilities and services, which, by their nature, can only be provided by the airport and which are related to handling passengers, freight and mail, landing, parking of aircraft and, where appropriate, the security of passengers as well as the environmental effects of handling passengers, freight and mail, excluding any amounts paid for air navigation or meteorological services."*

Since the different approaches do not clearly distinguish between "fee" and "charge", a definition of "airport charges" is made within the context of German law.

The terminological allocation of payments required by an airport operator in connection with landing and take-off depends on the respective legal grounds. The term "fee" is used in administrative law for such payments required in return for a particular official act or other administrative activity, or for the utilization of public facilities and installations.[5] In Germany, airports do not have the legal status of public facilities; they are rather private enterprises that levy charges on their users in accordance with civil law.[6]

All payments demanded for services provided by airport operators on the basis of contracts under civil law are therefore to be described as charges. These charges, which are generally described in this study as air traffic charges, can be split into airport and infrastructure charges. In the case of airport charges, a distinction can be made between fixed and variable charges. Variable airport charges include passenger charges, which are levied per passenger. Charges described in the air transport sector as fixed airport charges cover landing and take-off (LTO) charges, as well as parking charges. Infrastructure charges include ground services such as passenger and baggage handling, apron services and catering.[7] An overall view of the system of German air traffic charges is provided in Figure 1.

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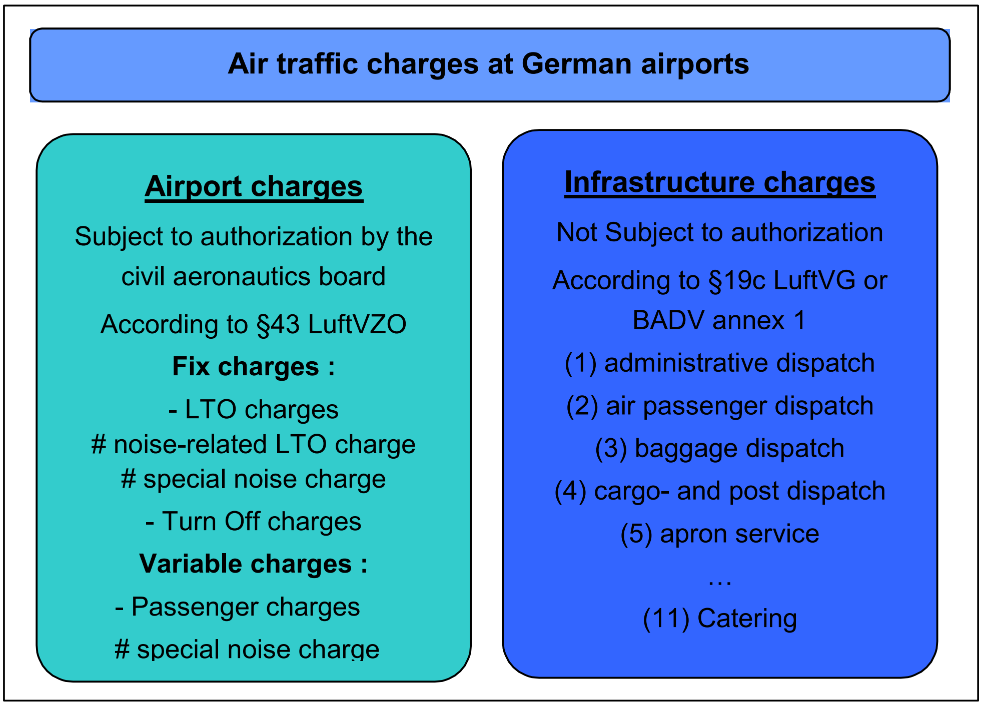
4 Amended proposal COM (1998) 509 final for a Directive on airport charges, Official Journal C 319/4 of 16.10.1998, which modified the original proposal COM (1997) 154 final, Official Journal C 257 of 22.08.1997, p.2.

5 Grupp, in Achterberg/Püttner, Besonderes Verwaltungsrecht, Kapitel 6, Haushalts- und Abgabenrecht, Rz. 161.

6 BGH, DVBl 1974, S.558; BGH, ZLW 1974, p. 140; Hoffmann/Grabherr, § 6 Rz. 166; different view Ossenbühl, DVBl 1974, S. 541.

7 Regarding the wider scope of ground services cf. § 19 c *Luftverkehrsgesetz* [Air traffic Act] as well as Appendix 1 to § 2 No. 4 of the *Bodenabfertigungsdienstverordnung (BADV)* [Groundhandling Ordinance] of 10 December 1997, BGBl. I, p.2885, last amended by Article 28 of the Act of 15 December 2001 BGBl. I, p.3762. The BADV implements in German law EU Directive 96/67/EC of 15. October 1996 on access to the groundhandling market at Community airports, Official Journal L 272 of 25.10.1996, p.36 in.

Figure 1 Air traffic charges at German airports



Apart from charges levied under civil law, airport users (airline companies) also have to pay fees for official duties in connection with landing and take-off. For instance, Deutsche Flugsicherung GmbH (DFS), a private company charged with performing the official duties of air traffic control,[8] imposes charges for the control of take-off and landing (see Section 3.3).

2.3.2 Noise charges

The object of the study is the examination of "noise-related landing charges" as an economic measure for the reduction of the environmental impact of air transport. German airports, such as Frankfurt, already levy noise charges as a part of airport charges. At Frankfurt Airport, however, a noise charge is levied as part of the passenger charge, and on the other hand LTO charges contain an MTOM-related charge. The features and objectives of individual noise charges, as well as the legal basis on which they are levied, are described below.

According to the Communication of the EU Commission on the sustainable development of air transport, noise-related charges are levied at different European airports in connection with landing and take-off, in order to provide an incentive for the

8 The official authorization of the DFS is in accordance with § 31 b, paragraph 1, § 31 d paragraph 1 sentence 1 *LuftVG* [Air Traffic Act] in connection with the *Verordnung zur Beauftragung eines Flugsicherungsunternehmens (FS-AuftragV)* [ATC Authorization Ordinance] of 11.11.1992, BGBl. I, p. 1928.

operation of low-noise aircraft and to finance noise-mitigation measures.[9] The EU Directive on the calculation of noise charges[10] defines "noise charge" in Article 2 (1a) as

> *"a specific noise levy by the airport, related to the certificated noise characteristics of the aircraft, which is designed to recover the costs of alleviation or prevention of noise problems and to encourage the use of less noisy aircraft."*

According to this definition, "noise charge" covers not only the noise element of LTO charges, but also specific noise charges, for noise mitigation programmes for example. In the annex to the Directive, under "modulation of noise charges" a distinction is made between "specific noise charges", which can be levied for the purpose of financing noise mitigation programmes, and "other noise charges". Referring to the principle of cost-relatedness, the draft directive lays down "that charges should be based as closely as possible on underlying costs". Because of cost relatedness, the directive concludes that "there should be specific noise charges for financing noise mitigation programmes, and other noise charges should be compensated by negative noise charges (rebates) in order to be revenue neutral."

As a result of the differentiation in the proposed directive, the term "noise charges" is applied in this report as a generic term for "specific noise charges" and "noise-related LTO charges":

- "Specific noise charges" are cost-related and are levied in respect of measures for the alleviation or prevention of noise problems, in particular for noise mitigation programmes.
- "Noise-related LTO charges are levied in connection with landing and take-off. They provide airport operators with the opportunity to encourage the use of less-noisy aircraft at their airports, and, as a rule, they are unrelated to cost. There can be components of noise-related LTO charges, however, that not only have a control effect, but are also related to costs. For instance, an MTOM-related component of LTO charges is also related to the costs of runway deterioration.

Noise charges can be imposed in a number of ways. At present, noise charges are imposed in Germany on a private legal basis within the scope of airport charges. It ought to be examined, whether they could be imposed in the form of taxes, special levies and fees.

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9 Cf. Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions – Air Transport and the Environment: Towards meeting the Challenges of Sustainable Development, COM (1999) 649 final.

10 Amended Proposal COM (2002) 683 final for a Directive on the establishment of a Community framework for noise classification of civil subsonic aircraft for the purposes of calculating noise charges.

In the view of the European Commission, noise charges can take the form of an "extra landing charge" or a "specific noise charge or tax".[11] In the language of international conventions and organizations a distinction is made between "taxes" and "charges". Levies, which primarily serve the achievement of state revenue, are described as "taxes"; levies in return for a service are described as "charges". According to the ICAO, charges in air transport are levied in particular to cover the costs of providing facilities and services. "Taxes“ are neither used wholly for air transport, nor are they cost-related.[12] According to § 3 (1) of the Ordinance on charges *(Abgabenordnung)*, taxes are "one-off or continuing payments, which are not in return for a particular service, and which are generally and uniformly imposed by a public body for the achievement of revenue, by which the circumstance applies to which the Act attaches liability." Taxes are typically levied for the purpose of achieving revenue, and not as reciprocation on the part of the authorities in favour of those liable to pay.[13] Besides this financing function, taxes also acquire a control function.[14]

2.3.3 Form of noise charges

As far as the form is concerned in which noise-related LTO charges and specific noise charges can be levied in Germany, the following possibilities arise:

- Specific noise charges for noise-mitigation programmes, for example, cannot be levied under German law in the form of taxes, since they are not intended for the purpose of raising government revenue, but rather for the financing of a particular measure. Designation as taxes would also be in contradiction of international use of the term "charges".[15]
- It remains to be considered, whether the imposition of specific noise charges in the form of a special levy or an airport charge is possible, instead of the existing practice of inclusion in airport charges.[16] Up to now, there has been no provision under public law according to which airports are entitled to impose specific noise charges on airlines or their passengers. According to § 9 of the Aircraft Noise

[11] Cf. The English version of the Communication of the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions – Air Transport and the Environment: Towards Meeting the Challenges of Sustainable Development, COM (1999) 649 final, p. 20.

[12] A33-7: Consolidated statement of continuing ICAO policies and practices related to environmental protection, Appendix I, at: http://www.icao.int/cgi/goto_atb.pl?icao/en/env/overview.htm;env.

[13] BVerfGE 36, 66, 70.

[14] BVerfGE 55, 274,299.

[15] Cf.: ICAO Policy on Airport Charges, Section 3.1.1.

[16] According to the systematics of traffic charges, not only noise-related LTO charges, but also specific charges are levied in Germany within the scope of airport charges; that is, on a contractual basis under civil law; cf. Section 2.3.1.

Act[17], owners of land in Protection Zone 1 on which – after a noise protection zone has been established – residential property is built or may be built, can demand compensation from the respective airport owner, in accordance with § 12 of the Aircraft Noise Act, in respect of expenditure on structural noise mitigation measures. The Aircraft Noise Act provides for no legal authorization under public law, according to which the costs of noise prevention or alleviation could be recovered in the form of charges or special levies on airlines or their passengers.[18]

- Noise-related LTO charges are not cost-related but, for the most part, have a control effect, which is why imposition in the form of a tax could be considered. According to European and international objectives for noise-related LTO charges, these do not serve the purpose of raising revenue, but should be realized with a neutral effect on costs through a system of surcharges and rebates on existing airport charges.[19] Imposition in the form of a charge is not possible, since noise-related LTO charges are levied neither as reciprocation nor for the utilization of a public facility.[20]

With the agreement of the commissioning Agency, a detailed examination of the legal realizability of specific noise charges in the form of a fee or special levy, as well as of noise-related LTO charges in the form of a special levy, has not been carried out in the further course of the study.

2.3.4 Description and explanation of other levies

In connection with air transport, apart from the levies already discussed in detail, further items crop up that, in the view of airlines in Germany, give rise to costs. These concern, in particular, infrastructure charges, which are generally not subject to authorization and are levied for ground-handling services at airports. Further aspects of these charges are regulated in the Ordinance on ground-handling services *(Bodenabfertigungsdienst-Verordnung (BADV))*, which regulates, above all, access to the market for ground-handling services at airports in Germany. The ground-handling services covered by this ordinance are listed in Appendix 1 of the ordinance, which implements EU Directive 96/67/EC on "access to the market for ground-handling services at Community airports" of 15 October 1996 in German law.

The Ordinance on the costs of air traffic management (*Kostenverordnung der Luftfahrtverwaltung - LuftKostV)* lays down that authorized representatives of the Civil Aeronautics Board and the Ministry of Transport may collect costs (charges and

17 *Gesetz zum Schutz gegen Fluglärm (FluglärmG) [*Aircraft Noise Act], in the version published on 30 March 1971, BGBl I, p. 282, last amended by Article 46 of the *Siebenten Zuständigkeitsanpassungs-verordnung* of 29 October 2001, BGBl. I, p 2785.

18 Cf. The position of the Federal Environment Ministry on the amendment of the Aircraft Noise Act at: http://www.bmu.de/fset1024.php

19 Cf. under: ICAO Policy on Airport Charges (Section 3.1.1).

20 See Section 3.2.1.

expenses) in accordance with §§ 31b (air traffic control) and 31c (use of airspace by balloons, light planes and model airoplane) of the Air Traffic Act in respect of official duties in the sphere of air traffic management.

Levies for ATC services, which are officially performed in Germany by the Deutsche Flugsicherung DFS GmbH, are legally regulated by means of cost ordinances and are imposed in the form of charges. A distinction is made between en-route and LTO charges. The Ordinance on the levying of charges for the use of en-route air navigation services and facilities (*FS-Strecken-Kostenverordnung - FSStrKV)* of 14 April 1984 regulates and determines en-route charges in inner-German and cross-border traffic. The Ordinance on the levying of charges for the use of ATC services and facilities on arrival and departure *(FS-An- und Abflug-Kostenverordnung - FSAAKV*) of 28 September 1989 contains regulations on LTO charges.

The so-called aviation security charge, which is levied by the Ministry of Transport, was introduced in 1990 for the offical security control of air passengers and is levied on the basis of the Ordinance on the costs of air traffic management and the Air Traffic Act. The rate of charge is calculated on the basis of passenger traffic and the size of airports, and ranges between 2.05 and 10.23 euros. Only those transfer passengers are affected who are controlled by the *Bundesgrenzschutz* [Federal Border Guard].

The aviation weather service, which is conducted according to regulations of the ICAO and the World Meteorlogical Organizastion (WMO), covers, among other things, continuous weather observations and related services in line with the specific demands of aviation. The conduct of meteorological services is encumbent on the German Weather Service (DWD, Offenbach) and aviation advice centres. Charges for services provided by the DWD are levied in accordance with the Ordinance on the levying of charges for the use of ATC services and facilities. Charges for further services are levied in accordance with the latest DWD price-list.

3 Legal framework of charging systems

In this chapter, legal criteria are described that are significant for the design of noise charges within the framework of a German regulation on airport charges. In addition, legislation and proposed legislation at an international, European and national level are also examined.

3.1 International law

3.1.1 ICAO standards and recommendations

Legal specifications for the design of a German regulation on noise charges are to be found in the Chicago Agreement, in "ICAO Policies on Charges for Airports and Air Navigation Services“ and in the "Airport Economics Manual“.

Binding effect of ICAO recommendations

Before dealing with ICAO guidelines on the design of noise-related LTO charges, it should first of all be explained to what extent such guidelines have a binding effect on the design of noise charges in Germany.

In the introduction to "ICAO Policies on Airport Charges“, the policies are described as "recommendations and conclusions of the Council“ and as "policies and guidance on charges“.[21] Within the framework of its mandatory functions under Article 54 (i) of the Chicago Convention the ICAO Council can:

> *"adopt, in accordance with the provisions of Chapter IV of this convention, international standards and recommended practices; for convenience designate them as Annexes to this Convention; and notify all contracting States on the steps taken;”*

The terms "standard“ and "recommended practices" are not defined in the Chicago Convention. The ICAO Assembly had, however, already carried out a detailed definition of these terms in 1947 in connection with "air navigation".[22] Following modification in 1949, the following definitions apply:

> *"Standards: Any specification, the uniform observance of which has been recognized as practicable and as necessary to facilitate and improve some aspects of international air navigation, which has been adopted by the Council pursuant to Article 54 (i) of the Convention, and in respect of which non-compliance must be notified by States to the Council in accordance with Article 38.*

[21] ICAO´s Policies, Doc 9082/6, p. 1.

[22] ICAO Assemby, Resolution A1-31, ICAO Doc. 4411 (A1-p/45) (1947); printed in: Burgenthal, T., Law Making in the International Civil Aviation Organization 60 (1969).

Recommended Practices: Any specification, the observance of which has been recognized as generally practicable and as highly desirable to facilitate and improve some aspects of international air navigation, which has been adopted by the Council pursuant to Article 54 (i) of the Convention, and to which Contracting States will endeavour to conform in accordance with the Convention."[23]

A standard, which has been properly adopted, is mostly regarded as binding, whereas recommended practices have no binding effect (Loibl 1998).

Chicago Convention

In drawing up a regulation on charges for German airports, Article 15 paragraphs 1 and 2 of the Chicago Convention[24] have to be considered, which contain the following provisions:

"Every airport in a contracting State, which is open to public use by its national aircraft shall likewise, subject to the provisions of Article 68, be open under uniform conditions to the aircraft of all other contracting States […].

Any charges that may be imposed or permitted to be imposed by a contracting State for the use of such airports and air navigation facilities by the aircraft of any other contracting State shall not be higher,

a) [...]

b) as to aircraft engaged in scheduled international air services, than those that would be paid by its national aircraft in similar scheduled international air services."

Under the terms of Article 15 of the Chicago Convention, the levying of airport charges is subject to a ban on discrimination. According to an arbitration award, this ban is to be interpreted in such a way that it protects against both formal and actual discrimination.[25] The levying of noise charges amounts to neither formal nor actual discrimination, since it is based on the objective criterion of "the noise emission of an aircraft". The objection that charges modulated according to actual noise emissions impose a greater burden on airlines with "loud" aircraft types than on airlines with "quiet" aircraft types is inappropriate. This disadvantage lies in the nature of the regulation, which applies to noise emissions and is not of a discriminatory nature. Discrimination between foreign and national airport users, in particular, is not evident.

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23 ICAO, Standards and Recommended Practices: Facilitation – Annex 9 to the Convention on International Civil Aviation, VI, (9th edition, 1990).

24 Convention on International Civil Aviation of 7.12.1944, ratified by Act of 7.04.1956, printed in: BGBl [Federal Law Gazette] 1956 II, p. 411.

25 Cf. The arbitration award in the dispute between the USA and the UK concerning airport charges at Heathrow, printed in:: Mendes de Leon, Air and Space Law 1997, p. 131, 133 f.

ICAO's Policies on Charges for Airports and Air Navigation Services

ICAO recommendations on the permissibility of airport charges are laid down in "ICAO Policies on Charges for Airports and Air Navigation Services“.[26] The **general principles** of these ICAO Policies are presented below, in so far as they are relevant for the design of noise charges:[27]

- Any charging system should, as far as possible, be simple and suitable for general application at international airports.
- Charges should be determined on the basis of sound accounting principles and may reflect, as required, other economic principles, provided that these are in conformity with Article 15 of the Convention on International Civil Aviation.
- Charges must be non-discriminatory both between foreign users and those having the nationality of the State in which the airport is located and engaged in similar international operations.
- Where any preferential charges, special rebates or other kinds of reduction in the charges normally payable in respect of airport facilities are extended to particular categories of users, governments should ensure, so far as practicable, that any resultant under-recovery of costs properly allocable to the users concerned is not shouldered onto other users.
- To avoid undue disruption to users, increases in charges should be introduced on a gradual basis; however, it is recognized that in some circumstances a departure from this approach may be necessary.

The ICAO recommends, in connection with the levying of noise-related charges, that the following **principles** be applied:[28]

- "Noise-related charges should be levied only at airports experiencing noise problems and should be designed to recover no more than the costs applied to their alleviation or prevention.
- Any noise-related charges should be associated with the landing charge, possibly by means of surcharges or rebates, and should take into account the noise certification provisions of ICAO Annex 16 to the Convention on International Civil Aviation – *Environmental Protection* in respect of aircraft noise levels.
- Noise-related charges should be non-discriminating between users and not be established at such levels as to be prohibitively high for the operation of certain aircraft.“

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26 Adopted by the Council on 22.06.1992 at the 14th Meeting of its 136th Session, modified on 8.12.2000 at the 18th Meeting of its 161st Session, Doc 9028/6, 6th Edition, 2001 (quoted in: ICAO Policies, DOC 9082/6).

27 ICAO's Policies, Doc 9082/6, p. 8.

28 Paragraph 30, ICAO's Policies, Doc 9082/6.

In Appendix I to ICAO Policies, Doc. 9082/6, under "Noise alleviation and prevention", the following services, measures and facilities are listed whose costs are to be taken into account in determining airport costs:

- Noise-monitoring systems, noise-suppressing equipment and noise barriers.
- Land or property acquired around airports.
- Soundproofing of buildings near airports and other noise alleviation measures arising from legal or governmental requirements.

Airport users should be consulted before changes in charging systems or levels of charges are introduced (principle of consultation). The aim should be that charges, wherever possible, be levied on the basis of agreement between users and providers. The purpose of consultation is to ensure that the provider supplies sufficient information to users concerning the proposed change and gives proper consideration to the views of users and the effect the charges will have on them (principle of transparency).[29]

It stands to reason that, according to ICAO recommendations, noise-related charges should only be levied at airports experiencing problems of aircraft noise. However, ICAO Policies contain no guidelines defining the existence of a noise problem at an airport. It is therefore left up to contracting states to decide whether an aircraft-noise problem exists at an airport and which criteria are to be applied in its assessment.

In Paragraph 30 – "Noise-related charges“ – the ICAO recommends that noise-related charges should be levied only for such measures as are intended to alleviate or prevent aircraft-noise problems. As far as the measures listed in Appendix I to ICAO Policies, Doc. 9082/6 are concerned, the ICAO assumes a connection between measures of noise alleviation and noise prevention. This list of measures cannot be conclusive, however, since the ICAO recommendation on the recovery of costs is to be treated as a principle. This principle is to be applied to "any items of expenditure“ to be recovered from airport users.[30] Measures other than those listed in Appendix I can therefore satisfy this principle if they serve the alleviation or prevention of noise problems.

The calculation of noise-related charges should be based, according to ICAO recommendations, on noise certification and aircraft noise levels according to Annex 16 of the Chicago Convention. The question arises, whether contracting States can also select another basis for the calculation of noise-related charges; for example, the noise level of an aircraft measured at an airport. The wording of the regulation refers to a "recommendation". That the guidelines have the character of a recommendation is supported by deviation from ICAO recommendations in practice. For instance, noise levies at Amsterdam and Zurich airports are not based on ICAO noise classification (Fichert 1999).

29 Paragraph 31 ICAO Policies, Doc 9082/6.

30 ICAO's Policies, Doc 9082/6 p. 12, paragraph 30, sentence 3.

Airport Economics Manual

Further ICAO recommendations concerning noise-related charges are to be found in the “Airport Economics Manual”[31]. In Paragraph 4.54 of the Manual, the cost basis for noise-related charges is described as the costs of noise monitoring and noise abatement measures.

In connection with "charges on air traffic and their collection“, Paragraph 17 (i) contains the recommendation that "noise-related charges“ should only be collected for noise alleviation and prevention and should not give rise to additional earnings for airports.

With regard to the design of a noise-related charging system, Paragraph 17 (ii) recommends:

> *"No specific noise-related charging or rebating method is recommended, but the effective perceived noise level (EPNL) of the aircraft concerned could be used as a charging or rebating parameter. The sophistication or complexity in the design of the scale would vary according to local circumstances and requirements. The scale could be linear or in steps. For ease of application it could be supplemented with a list indicating the charge or rebate that would apply to the different aircraft types known to be operating into the airport which could be subject to the noise-related charges or rebates.”*

The recommendations contained in the "Airport Economics Manual“ reflect, in the main, the guidelines of the ICAO´s Policies, DOC 9082/6: Noise-related charges should cover the costs of measures of noise alleviation and prevention. The Manual makes clear that the ICAO allows considerable latitude in the design of charging systems.

3.1.2 Summary of ICAO guidelines

ICAO guidelines on the design of (noise-related) airport charges can be summarized as follows:

1. Noise-related charges should only be levied at airports where aircraft noise problems occur. Whether an aircraft noise problem exists at an airport can be determined by a contracting state.
2. The design of noise charges may not discriminate between foreign and national airport users; that is, the levying of noise charges at differing levels must be based on objective criteria (**ban on discrimination**). Noise-related charges should not be established at such levels as to be prohibitively high for the operation of certain aircraft.
3. Noise-related charges should be levied only for such measures as are intended to alleviate or prevent aircraft-noise problems (**principle of cost-recovery**). In the case of the following services, measures and facilities, it is to be assumed that they are intended to alleviate or prevent aircraft noise problems, and that

[31] Airport Economics Manual, Doc 9562, First Edition, ICAO 1991.

their costs may therefore be taken into account in the calculation of noise-related charges (Appendix I to ICAO's Policies, Doc. 9082/6):

- Noise-monitoring systems, noise-suppressing equipment and noise barriers.
- Land or property acquired around airports.
- Soundproofing of buildings near airports and other noise alleviation measures arising from legal or governmental requirements.

In addition, other measures can be covered by noise charges if they serve the alleviation or prevention of noise problems.

4. The calculation of noise-related charges should be based, according to ICAO recommendations, on noise certification and aircraft noise levels according to Annex 16 of the Chicago Convention.
5. Noise-related charges should be determined on the basis of sound accounting principles and be associated with the landing charge, possibly by way of surcharges or rebates.
6. To avoid undue disruption to users, increases in charges should be introduced on a gradual basis; however, it is recognized that in some circumstances a departure from this approach may be necessary.
7. Airport users should be consulted before changes in charging systems or levels of charges are introduced (**principle of consultation**). The aim should be that charges, wherever possible, be levied on the basis of agreement between users and providers. The purpose of consultation is to ensure that the provider supplies sufficient information to users concerning the proposed change and gives proper consideration to the views of users and the effect the charges will have on them (**principle of transparency**)

3.1.3 Bilateral air transport agreements of the Federal Republic of Germany

Besides the Chicago Convention, international regulations on airport charges are to be found in the bilateral air transport agreements of the Federal Republic of Germany, in which rights necessary for the conduct of scheduled air services with the respective contracting partner are regulated. The Federal Republic of Germany has concluded 135 bilateral air traffic agreements with other countries,[32] of which a number have not yet come into force. Bilateral agreements with Member States of the European Union have been largely superseded by European air transport regulations.[33] By contrast, air transport agreements with non-members of the EU retain their legal significance. Bilateral German air transport agreements are based, in part, on a specimen

[32] Cf. http://www.luftrecht-online.de/regelwerke/lva.htm (as at 1.08.2002).

[33] For example, Council Regulation (EEC) No. 2408/92 of 23.07.1992 on access for Community air carriers to intra-Community air routes.

agreement[34] that contains, in Article 5 on the subject of "charges", the following regulation proposal:

"Equal treatment in the case of charges

i. Charges that are levied in the territory of a contracting party for the use of airports and other air navigation facilities by the aircraft of each designated airline of the other contracting party may not be higher than the charges that are imposed on the aircraft of a national airline in similar scheduled international air services

(2) Charges for the use of airports or other air navigation services and facilities or similar levies or charges in connection with the operation of airline services are to be determined on a cost-related basis; corresponding evidence can be required. At airports with only one supplier of such services the same applies for charges for handling passengers, baggage and cargo as well as for the handling of aircraft."

The "regulation of charges" in Article 5 (1) of the specimen air transport agreement contains the principle of non-discrimination. It should also be noted that, according to Article 5 (2) of the specimen air transport agreement, airport charges have to be cost-related and transparent.

Article 7bis of the Air Transport Agreement between the Federal Republic of Germany and the United States of America contains, for example, the following regulation on user charges:

"(1) User charges that may be imposed by the competent charging authorities or bodies of each contracting party on the airlines of the other contracting party shall be just, reasonable, not unjustly discriminatory, and equitably apportioned among categories of users. In any event, any such user charges shall be assessed on the airlines of the other contracting party on terms not less favourable than the most favourable terms available to any other airline at the time the charges are assessed.

(2) User charges imposed on the airlines of the other contracting party may reflect, but shall not exceed, the full cost to the competent charging authorities or bodies of providing the appropriate airport, airport environmental, air navigation, and aviation security facilities and services at the airport or within the airport system. Such full cost may include a reasonable return on assets, after depreciation. Facilities and services for which charges are made shall be provided on an efficient and economic basis.

(3) [...]

(4) [...]"[35]

[34] Muster-Luftverkehrsabkommen der Bundesrepublik Deutschland, www.luftrecht-online.de .

Compared with ICAO guidelines, Article 7bis of the Air Transport Agreement contains no new criteria that would have to be considered in the design of a noise-related charging system in Germany.

Article 8 (2) of the Air Transport Agreement lays down the following regulations with respect to limitations on competition:

> *(2) Each contracting party shall allow each designated airline to determine the frequency and capacity of the international air transportation it offers, based upon commercial considerations in the marketplace. Consistent with this right, neither contracting party shall unilaterally limit the volume of traffic, frequency or regularity of service, or the aircraft type or types operated by the designated airlines of the other contracting party, except as may be required for customs, technical, operational, or environmental reasons under uniform conditions consistent with Article 15 of the Convention.*

Through the introduction of noise-related charges, whose aim is to influence the type of aircraft operated at an airport, indirect limitation on aircraft type is at least possible; and since noise charges are restrictions for environmental reasons, they are not contrary to the German-American Air Transport Agreement.

A detailed examination of all German bilateral air transport agreements with other states could not be carried out within the framework of this report. Were regulations on noise charges to be introduced at a EU level, however, corresponding EU law would have precedence over bilateral agreements between Member States and supersede conflicting regulations.[36] In such a case, Germany would have to terminate and re-negotiate the respective bilateral agreement.

3.1.4 Interim conclusion

German bilateral air transport agreements lay down non-discrimination, cost-relatedness and transparency of charges and thus contain no new specifications for the design of a noise charging system as compared to ICAO guidelines.[37] An examination of all 135 German bilateral air transport agreements could not be carried out within the framework of this report. Where regulations laid down in German air transport agreements with other states are at variance with the substance of a noise charging system, two cases have to be distinguished. While conflicting regulations in air transport agreements with other Member States would be superseded by a noise-

[35] Current version of the Agreement of 7. July 1955 (BGBl. [Federal Law Gazette] 1956 II p. 403), amended by Protocols of 25. April 25 1989, 23. May 1996 and 10. October 2000 between the Government of the Federal Republic of Germany and the Government of the United States of America on the amendment of the Air Transport Agreement of 7. July 1955.

[36] Cf. Article 307 (1) European Community Treaty

[37] Cf. Specimen air transport agreement for the Federal Republic of Germany in Section 3.3.

charge regulation at EU level, air transport agreements with states outside the EU would have to be amended.

3.2 European Community legislation

Secondary community legislation provides criteria for and restrictions on the design of a noise-related charging system in

- the amended Proposal (COM 2002/683) for a Directive on the establishment of a Community framework for noise charges for civil subsonic aircraft,
- Directive 2002/30/EC on noise-related operating restrictions,
- Regulation 2408/92/EEC on access for Community air carriers to intra-Community air routes.

3.2.1 Proposal COM (2002) 683 final for a Directive on noise charges

The amended proposal COM (2002) 683 final for a Directive on the establishment of a Community framework for noise classification of civil subsonic aircraft for the purposes of calculating noise charges (hereafter: proposed directive on noise charges)[38] could, in the opinion of the Commission, usefully complement the proposed airport charges directive or stand alone.[39] The proposed airport charges directive allows for the modulation of charges depending on environmental impact, but it does not contain guidelines on the criteria to be used for such modulation.[40]

The aim of the proposed directive on noise charges, according to Article 1, paragraph 1, is "to enhance the environmental effectiveness of noise charges levied at airport level". The directive seeks to achieve this by ensuring that common criteria based on the noise performance of aircraft are used when calculating noise charges. The directive applies to airports and airport systems that operate commercial flights between Members States and which are located in a Member State. However, the directive applies only to airports at which noise charges are applied (Article 1, paragraph 2 COM (2002) 683).[41] Though the proposed directive creates a harmonized framework for all airports with noise charges, it contains no guidelines defining the existence of a noise problem at an airport or when the instrument of noise charges

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38 The amended proposal COM (2002) 683 final of 29.11.2002 replaces proposal COM (2001) 74 final of 20.12.2001 for the establishment of a Community framework for noise classification of civil subsonic aircraft for the purposes of calculating noise charges.

39 Cf. The Commission's reasoning in 2001/308 (COD), p. 3 concerning proposal COM (2001) 74 final.

40 Recital 4 of proposed Directive COM (2002) 683.

41 Consequently, Member States are required under Article 4 of the proposed directive to ensure that the Community framework for the calculation of noise charges is applied as from 1. April 2004 in any significant revision of existing systems of noise charges or for newly introduced systems of noise charges, and as from 1. April 2006 to any system of noise charges.

should be used to tackle noise problems. The latter issue is intended to be settled by Directive 2002/30/EC on noise-related operating restrictions (see Section 3.2.2).

Basic principles of Proposal KOM (2002) 683 for a Community framework on the levying of noise charges in the EU are:

- non-discrimination of airport users,[42]
- transparency of noise-related charges,[43]
- revenue neutrality of noise-related airport charges,[44]
- cost-relatedness,
- proportionality between noise charges and noise nuisance and
- objective criteria for the assessment of the impact of aircraft noise. Certified noise levels as defined in Annex 16 – Volume 1 to the Convention on International Civil Aviation are considered to reflect adequately this impact.[45]

The legal provisions of the proposed Directive COM (2002) 683, which are significant for the regulation of noise-related charges in Germany, are as follows:

a) "Specific noise charge" and "other noise charges"

The proposed directive defines "noise charge" in Article 2 (a) as

> *"a specific noise levy by the airport, related to the certificated noise characteristics of the aircraft, which is designed to recover the costs of alleviation or prevention of noise problems and to encourage the use of less noisy aircraft ".*

The levying of a noise charge should accordingly serve two purposes:

- recovery of the costs of alleviation or prevention of noise problems and
- encouragement of the use of less noisy aircraft.

From the use of the term "noise charges for arrivals and departures" in Article 3 (1) COM (2002) 683 and the distinction between "specific noise charges"“ and "other noise charges“ under the heading "Modulation of noise charges" in the Annex to the directive, it follows that the directive distinguishes between two forms of noise charge:

- a **noise charge**, which is levied in connection with arrivals and departures (referred to in this report as "noise-related LTO charges",[46]
- and a **special noise charge**, which serves the "specific purpose of financing environmental mitigation measures at or around airports"[47] (referred to in this

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[42] Cf. Recital 6 of proposed Directive COM (2002) 683.

[43] Cf. Recitals 5, 6 and 9 of proposed Directive COM (2002) 683.

[44] Cf. Recital 6 of proposed Directive COM (2002) 683.

[45] Cf. Recitals 7 and 8 of proposed Directive COM (2002) 683.

[46] Described in the Annex to proposed Directive COM (2002) 683 as "other noise charges“.

[47] See Explanation memorandum", No. 2 of proposed Directive COM (2002) 683.

report as "specific noise charge". The financing of sound insulation programmes is expressly mentioned in the directive.

While noise-related arrival and departure charges are required to have a neutral effect on revenue, specific noise charges have to be related to costs but can be levied in addition to noise-related LTO charges.

b) Cost-relatedness

The directive takes account of the principle of cost-relatedness, namely, that charges be based as far as possible on underlying costs. While in the case of specific noise charges a direct relation is established between flight operations and underlying costs (for example, of a sound insulation programme) with the aim of noise alleviation and prevention, this is not inevitably so in the case of measures promoting the operation of low-noise aircraft. In the latter case, the focus is rather on the control function of noise charges. The directive therefore requires that specific noise charges be based on underlying costs. This applies in particular to the financing of noise mitigation programmes. Whether this also includes the costs of noise monitoring is not mentioned in the directive. Furthermore, the cost-related levying of specific noise charges is formulated as a recommendation; this means that exceptions can be made to the basic principle of cost-relatedness.[48]

c) Revenue neutrality

The collection of noise-related LTO charges "should be compensated by negative noise charges (rebates)". This revenue neutrality should be achieved separately at departure and arrival.[49] Accordingly, negative and positive LTO charges have to be determined for respective aircraft types in accordance with certified noise energy levels. The sum totals of all LTO charges in a given year for a particular airport must level out. The question of which benchmark is to be applied for the assessment of revenue neutrality is not dealt with in the directive. A possible benchmark could be the total of all LTO charges at the respective airport in the year preceding introduction of noise-related LTO charges.

The introduction of noise-related LTO charges therefore results in the situation that airlines that operate loud aircraft will pay proportionally more than others, but the sum of surcharges and rebates should not exceed the cost of providing the service. This means that airports should not in the end receive additional revenue through the levying of noise-related LTO charges, and that airlines as a whole should not be faced with higher costs.

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48 Cf. comments under "Modulation of noise charges" in the Annex to proposed Directive COM (2002) 683.

49 Cf. comments under "Modulation of noise charges" in the Annex to proposed Directive COM (2002) 683.

d) Proportionality between noise-related LTO charges and noise impact

According to Article 3 (1) of Directive COM (2002) 683, the noise charge for arrivals and departures has to be proportional to the relative noise impact of arrivals and departures on populations around airports. The relationship between this incremental noise nuisance and the aircraft noise level, according to the Commission, can be most adequately reflected by the noise energy level.[50] "Certified noise levels, as defined in Annex 16 – Volume 1 of the Convention on International Civil Aviation, Third Edition, July 1993", are considered to reflect adequately the noise impact for the population living in the vicinity of airports.[51]

e) Calculation of noise charges

Article 3 of Directive COM (2002) 683 lays down criteria for the calculation of noise charges at the airports of Member States, which are specified in a formula in the Annex to the proposed directive. Technical details with respect to the calculation of noise charges are dealt with in Section 6.2.1.

An important amendment in Proposal COM (2002) 683, compared to the preceding Draft COM (2001) 74, concerns the maximum noise charge for a given part of a 24-hour period, which now amounts to 40 times the minimum charge, as compared to the previous limit of 20 times the minimum charge (Article 3 (3). A lower ratio – for example, 10 times the minimum charge – may also be applied. Because this bandwidth is not mandatory, a ratio in excess of 40 times the minimum charge may be applied in exceptional cases.

The ratio of 40 relates only to a given part of a 24-hour period, which may be subdivided into a maximum of three periods: day, evening and night (Article 3 (4)). Different unit charges may be applied for different times of the day (Article 3 (1). Other sub-divisions in periods of time – such as "at weekends" or "afternoons" are no longer permitted.

3.2.2 Directive 2002/30/EC on noise-related operating restrictions

Directive 2002/30/EG[52] has the objective of establishing rules and procedures for the introduction of noise-related operating restrictions at the airports of Member States.[53] The same operating restrictions should be introduced at airports with comparable noise problems.[54] Operating restrictions should not only conform to internal market requirements (Article 1 (b)), they should also facilitate the achievement of specific

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50 Cf. Recital 8 of proposed Directive COM (2002) 683.

51 Cf. of proposed Directive COM (2002) 683.

52 Directive 2002/30/EC of the European Parliament and the Council of 26. March 2002 on rules and procedures for noise-related operating restrictions at Community airports, Official Journal L 85/40 of 28.03.2002.

53 Cf. The objective of the directive in Article 1(a) Directive 2002/30/EC.

54 Cf. Recital 7 of Directive 2002/30/EC

noise-abatement objectives at individual airports (Article 1 (d)). Noise charges can also be regarded as operating restrictions, which are defined in Article 2 ((e) of the Directive as "noise-related action that limits or reduces access for civil subsonic jet aeroplanes to an airport", including "operating restrictions aimed at the withdrawal from operations of marginally compliant aircraft at specific airports, as well as operating restrictions of a partial nature, affecting the operation of civil subsonic aeroplanes according to time period". That the levying of noise charges is a form of operating restriction in terms of the directive is confirmed by the exemplary description of possible operating restrictions in Annex II (no. 1.4) to the directive, where "noise charges" are also mentioned.

In order to achieve the objective of the directive – the reduction of aircraft noise problems at airports – Member States have adopted, according to Article 4 (1) of the directive, a "balanced approach". This "balanced approach" is a procedural concept for the mitigation of aircraft noise, which was agreed by the contracting States of the ICAO at the 33rd ICAO Assembly in Resolution 33/7[55]. The directive refers to Resolution 33/7[56] and defines the "balanced approach" in Article 2 (g) as "an approach under which Member States shall consider the available measures to address the noise problem at an airport in their territory, namely the foreseeable effect of a reduction of aircraft noise at source, land-use planning and management, noise-abatement operational procedures and operating restrictions."

Through Directive 2002/30/EC, the specific approach to the resolving of noise problems – "the levying of noise charges" – is embedded in the context of further possibilities for operating restrictions at airports. In resolving noise problems at airports, Members States should pursue a "balanced approach"; that is, the measures taken must be appropriate and necessary to resolve the problem. Noise charges are appropriate to resolving noise problems since, on the one hand, they offer airlines an incentive to operate aircraft with lower noise performance, and on the other hand, they can be used to finance noise-mitigation programmes. A measure is necessary when a similarly appropriate but less restrictive measure to resolve the noise problem is not available. According to Directive 2002/30/EC, measures or a combination of measures should not be "more restrictive than necessary in order to achieve the environmental objective established for a specific airport" (Article 4 (3)). The regulation of noise charges at German airports has accordingly to be examined with respect to its necessity.

Article 4 (4) of Directive 2002/30/EC lays down that "performance-based operating restrictions" are to be based on the noise performance of aircraft as determined by the certification procedure conducted in accordance with Volume 1 of Annex 16 to the Convention on International Civil Aviation, Third Edition (July 1993). Here it is not made

55 Cf. on "balanced approach": Assembly Resolution 33/7, in particular Annex B and C, at: www.icao.int/icao/en/env/a33-7.htm.

56 Cf. Recital 10 of Directive 2002/30/EG

clear to what extent recourse has to be made in noise classification and the calculation of noise charges to noise certification according to the ICAO. The Directive does not further define "performance-based operating restrictions".

3.2.3 Regulation on market access

In order to bring about the internal market in civil aviation, the European Union issued, in 1992, a regulation on access for Community air carriers to intra-Community air routes (regulation on market access)[57]. The regulation concerns, according to Article 1 (1), access to routes within the Community for scheduled and non-scheduled air services. The exercise of traffic rights, according to Article 8 (2), is subject to published Community, national, regional or local operational rules relating to the protection of the environment. At the request of a Member State, or on its own initiative, the Commission examines and decides within one month of receipt of a request, and after consulting a committee, whether the Member State may continue to apply the provisions on environmental protection (Article 8 (3). Since the regulation of noise charges by individual states in connection with problems of aircraft noise at airports serves the mitigation of environmental problems, this does not represent an unlawful restriction on the exercise of traffic rights.[58] In contrast to measures in accordance with Article 9 of the regulation on market access, measures covered by Article 8 can have an unlimited period of validity.

The regulation also allows Member States to impose conditions on, limit or refuse the exercise of traffic rights when serious congestion and/or environmental problems exist (Article 9 (1). According to Article 9 (2), action in accordance with Article 9 (1) should

- be non-discriminatory on grounds of nationality or identity of air carriers,
- have a limited period of validity, not exceeding three years,
- not unduly affect the objectives of this Regulation,
- not unduly distort competition between air carriers,
- not be more restrictive than necessary in order to relieve problems.

Because of the limitation on the period of validity of action to three years, a noise-charge regulation that refers to Article 9 (1) of the regulation on market access should be avoided.

[57] Regulation (EEC) 2408/92 of the Council of 23.07.1992 on access for Community air carriers to intra-Community air routes, Official Journal L 240 of 24.08.1992, p. 8.

[58] Cf. On environmental issues in general: Niejahr, in: Frohnmeyer/Mückenhausen, EG-Verkehrsrecht, München 2001, marginal note 232.

3.3 German legislation

The relationship between airport operators and airport users in Germany is regulated by civil law.[59] Regulations on airport use and airport charges are general terms of business. There are no legal norms in German legislation (in particular, the Air Traffic Act or the Air Traffic Licensing Regulations) laying down explicit criteria for the regulation of charges. This does not mean, however, that airports are completely free in the design of their charging systems. Restrictions arise in particular from legal practice, ICAO regulations and supervision on the part of the respective licensing and cartel authorities.

The legal relationship between an airport operator and the licensing authority with respect to regulations on airport use and airport charges is governed by public law. According to § 43 (1) of the Air Traffic Licensing Regulations (*LuftVZO*), an airport operator has to submit regulations governing charges for the arrival, departure and parking of aircraft as well as for the use of passenger facilities to the competent authority for approval. The determination of airport charges can also be settled in a public contract between the airport operator and the competent licensing authority.[60]

According to decisions of the Federal Administrative Court (*Bundesverwaltungsgericht – BVerwG*) the authorization of regulations on charges is legally binding only on the respective airport.[61] This means that the airport user cannot bring an action against authorization of the regulation on charges, since he is not empowered to do so. The airport user still has the possibility, however, to have the regulation on charges examined by the cartel office and civil courts.

The licensing authority examines the level of charges on the grounds of public interest in accordance with § 43 Air Traffic Licensing Regulations and § 6 (2) and (3) of the Air Traffic Act. In addition, compliance with the following criteria is also examined:

- Are transport policy aspects considered?
- Do landing charges as a whole recover costs?
- Can a reasonable return on capital employed be achieved?
- Are landing charges not unreasonably high.[62]

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59 Giemulla/Schmid, Luftverkehrsgesetz, § 6 LuftVG, marginal note 40.

60 Cf. The draft for a public contract concerning the determination and adjustment of regulated airport charges of 4.09.2002 between the State of Hesse and Fraport AG [operator of Frankfurt Airport].

61 BVerwGE, printed in ZLW 1978, p. 49 ff. and DÖV 1978, p. 619.

62 Unpublished minutes of 11.07.1980 of a special session of the Working Group on Administration and Law of the Committee on Air Transport of the German *Länder* on 4.07.1980 in Düsseldorf (V/A 5-16-00/02).

3.3.1 Requirements under civil law

The equitability of regulations on charges at German airports is subject to control by the civil courts in accordance with § 315 (3) BGB (Federal Civil Code). Legal practice has developed the following criteria for the control of equitability:

a) Non-discrimination

According to the principle of equality contained in Article 3 (1) GG (Basic Law - German Federal Constitution), the classification of airport charges must occur on the basis of objective criteria. In accordance with Article 3 (1) GG, matters that are fundamentally similar have to be treated equally and matters that are fundamentally dissimilar have to be treated differently, unless there is a material reason in the nature of the matter or other material reason for unequal treatment. Protection against noise and the enhanced need for protection at night were recognized in a decision of the District Court (*Landgericht*) in Berlin of 20.08.2000 as objectively justified reasons for the modulation of LTO charges.[63] The Federal Court of Justice has up to now judged the impact on individual users on the basis of classification according to aircraft mass to be an objective reason for the modulation of charges. Relating the charge to the maximum mass of departing aircraft is also deemed to be in accordance with the polluter-pays principle.[64] In connection with the use of mass at departure as a basis for the level of charges, the District Court in Berlin, in its decision of 20.08.2000, considered degressive charges for the use of LTO facilities to be objectively justified.

The principle of equality is, however, not already infringed when a "more just" or "more purposeful" charging system is conceivable, or when an alternative system of charges better corresponds with the imperative of equal treatment.[65] Within the framework of § 315 (3) BGB, which is an expression of the principle of equality under constitutional law, the airport operator therefore retains a further degree of latitude regarding the determination of conditions for a system of charges.[66] The airport operator can therefore shift costs, imputed interest and depreciation onto charges, and thus maximize profits in the determination of charges.[67]

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[63] District Court (*Landgericht*) Berlin, decision of 25.08.2000, ref. no.: 96 O 197/99, in which the new system of charges at Berlin-Tegel and Tempelhof airports was examined. The new system of charges will also be applied at Berlin-Schönefeld airport.

[64] Cf. BGH, judgement of 24.11.1977, ref. no.: III ZR 27/76, printed in WM 1978, p. 1097, 1099; LG Berlin, decision of 25.08.2000, ref. No.: 96 O 197/99.

[65] Cf. BGH, judgement of 24.11.1977, ref. no.: III ZR 27/76, printed in WM 1978, p. 1097, 1099; LG Berlin, decision of 25.08.2000, ref. no.: 96 O 197/99.

[66] Landgericht Berlin, decision of 25.08.2000, ref. no.: 96 O 197/99.

[67] Giesberts, Umfang und Grenzen der Nutzerbeteiligung beim Zustandekommen flughafenrechtlicher Entgeltordnungen, ZLW 3/2001, p. 319, 323.

b) Disproportionate increase in a component of charges

In its decision of 25.08.2000, the District Court in Berlin judged the disproportionate increase in passenger charges and the simultaneous clear reduction in one or more fixed components of charges within the framework of the structural reform of airport charges to be permissible. In the opinion of the Court, the structural reform of airport charges may not be focused on one position or component that, compared with the previous system of charges, is disproportionately increased. What is important is that the new system of charges be balanced and non-discriminatory as a whole.[68] A switch in the system of charges from fixed to variable charges is justified when the development of costs and the burden of costs are justly distributed.[69] Such a system of costs does not violate § 315 (3) BGB.

c) Consultation and transparency

In its decision of 25.08.2000, the District Court in Berlin examined for the first time not only the material control of the system of charges in accordance with § 315 (3) BGB, but also the materialization of the system. According to the court, the monopolistic position of the airport operator resulted in an obligation to involve airport users in the drawing up and modification of the charging system. In practice, airport operators already conduct consultations with airport users. But there had not previously been a legal obligation to consult. The court deduced this obligation from § 315 (3) BGB. Airport users should be enabled to submit views.[70] Where users are not involved in the introduction or modification of a system of charges, the regulation can be declared by a court to be invalid, even when the requirements of § 315 (3) BGB are otherwise fulfilled.[71] An obligation to take views into consideration or to mutually agree materialization of the charging system is, however, not demanded. At the same time,

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68 Landgericht Berlin, decision of 25.08.2000, ref. no.: 96 O 197/99.

69 Landgericht Berlin, decision of 25.08.2000, ref. no.: 96 O 197/99. Cf. Giesberts, Umfang und Grenzen der Nutzerbeteiligung beim Zustandekommen flughafenrechtlicher Entgeltordnungen, ZLW 3/2001, p. 319, 325.

70 Cf. in this connection, Article 7 of the Draft Directive on airport charges (Annex), which also requires a consultation procedure. Here, the views of airport users have also "to be taken into account" before a decision is taken by the supervisory authority. According to Article 7: "These views do not bind the authority responsible for taking a decision with regard to the airport charges." Whether airport operators have merely to take note of the views of airport users, or whether they have also to consider them (that is, whether they have to explain divergence from positions expressed in such views, is not clear from the formulation "take into account".

71 Giesberts, Umfang und Grenzen der Nutzerbeteiligung beim Zustandekommen flughafenrechtlicher Entgeltordnungen, ZLW 3/2001, p. 319, 323.

by informing users about the charging system, transparency of charging systems is brought about.[72]

3.3.2 Cartel-related requirements

Cartel-related requirements concerning the introduction of noise-related LTO charges in Germany can only be dealt with briefly in this report.

Since the deletion, in the 5th Amending Act, of § 99 (2) (exemption in respect of the contracts of airport operators) of the Act against Restraints on Competition (*GWB*)[73], agreements on the uniform design of charging systems are no longer permissible. According to § 19 (4) No. 1 GWB, discriminatory treatment of airport users in charging systems, which is not objectively justified, is deemed to be an abuse of the dominant market role of the airport operator.[74]

3.4 Legal criteria for noise charges and possibilities of implementation

3.4.1 Criteria

Analysis at the level of international, European and national – German – law yields the following fundamental requirements for the design of noise-related LTO charging systems in Germany:

- Noise charges should only be applied at airports where noise problems exist. There is, however, no legal specification concerning the definition of airport noise problems.
- The introduction of noise-related LTO charges has to be appropriate and necessary ("**balanced approach**"). That means that noise-related LTO charges

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72 Further information for airport users – services and facilities subject to charges as well as accounting data corresponding financial information – that is demanded in the consultative paper on "Airport charges" of the Federal Ministry of Transport is not laid down in the proposed Directive on airport charges. The District Court in Berlin, in its decision of 25.08.2000, ref. no.: 96 O 197/99, also denied the obligation to provide such detailed information (for instance, the economic basis of calculation does not have to be disclosed, the provision of the method of calculation being sufficient).

73 Gesetz gegen Wettbewerbsbeschränkungen (GWB) [Act against Restraints on Competition], as published in the revised version of 26. August 1998, which came into force on 1. January 1999, BGBl. I, p. 2546, last amended by Article 7 of the Gesetzes zur Umstellung von Gesetzen und Verordnungen im Zuständigkeitsbereich des Bundesministeriums für Wirtschaft und Technologie sowie des Bundesministeriums für Bildung und Forschung auf Euro (Neuntes Euro-Einführungsgesetz) [Act on the Conversion to Euro of Acts and Ordinances within the jurisdiction of the Federal Ministry of Economics and Labour and the Federal Ministry of Education and Research (Ninth Act on the Introduction of the Euro)] of 10. November 2001, which came into force on 1. January 2002, BGBl. I, p. 2995.

74 Giemulla, Schmid, Frankfurter Kommentar zum Luftverkehrsrecht, § 6 LuftVG, marginal note 40; District Court, Munich, decision of 16.07.1993, ref. no.: 21 O 22199/92.

must be appropriate for resolving the noise problem at the particular airport. They are necessary when no other instrument is available that, though similarly appropriate, has a less adverse effect on the airport users concerned.

- Noise charges must be **non-discriminatory**. This is the case when the levying of modulated noise charges for aircraft is based on objective criteria (for instance, the noise level of each arriving and departing aircraft. According to both ICAO recommendations and the proposed EU Directive COM (2002) 683, the relevant noise level is that determined in the noise certification of aircraft in accordance with Annex 16, Volume 1 of the Chicago Convention.
- Noise charges must be **transparent**. This requires, in particular, that noise-related LTO charges be separately shown as components of the total charge for an aircraft, and that both the calculation and the calculation method be understood by the airport user.
- Noise charges must be used to cover the costs of alleviation and prevention of noise problems (**Principle of cost-recovery**). The following services, measures and facilities may be considered:
    - Noise-monitoring systems, noise-suppressing equipment and noise barriers.
    - Land or property acquired around airports.
    - Soundproofing of buildings near airports and other noise alleviation measures arising from legal or governmental requirements.
- Noise-related LTO charges should in each case have a **neutral effect on revenue**.
- The maximum noise-related LTO charge for a given part of a 24-hour period is 40 times the minimum charge. Noise-related LTO charges may be subdivided within a 24-hour period into a maximum of three periods (for example, day, evening or night).
- Noise-related charges should be determined on the basis of sound accounting principles and be associated with the landing charge; for instance, by means of surcharges or rebates.
- Noise-related LTO charges should not be established at such levels as to be prohibitively high for the operation of certain aircraft.
- To avoid undue disruption to users, increases in charges should be introduced on a gradual basis. Under certain circumstances, a departure from this approach may be necessary.
- Airport users should be consulted before introduction of a charging system at an airport (**principle of consultation**).

3.4.2 Possibilities of implementation

Noise charges (noise-related LTO charges and specific noise charges) can be introduced in a number of ways:

- Informal agreement between the airport operator and the licensing authority within the framework of the authorization of airport charging systems in accordance with § 43 (1) of the Air Traffic Licensing Regulations.
- A public contract between the licensing authority and the airport operator in connection with the authorization of airport charging systems in accordance with § 43 (1) of the Air Traffic Licensing Regulations.[75]
- Determination of material demands on noise charges in § 43 of the Air Traffic Licensing Regulations on the basis of the list of authorisations in § 32 of the Air Traffic Act.
- Determination of demands on noise charges in the Air Traffic Act.

The determination of material demands on noise charges in § 32 of the Air Traffic Act and in § 43 of the Air Traffic Licensing Regulations offers the particular advantage, compared with informal or contractual solutions, of uniform legal practice and greater binding force for the participating parties. It should to be borne in mind, however, that a charging system, in which specific charges and LTO charges are separately collected, demonstrates greater transparency than one in which specific charges are incorporated into LTO charges (Fichert 1999).

[75] Cf. the draft for a public contract on the determination and adjustment of regulated airport charges of 4.09.2002 between the State of Hesse and Fraport AG.

4 Status quo analysis of noise-related LTO charging systems

The aim of status quo analysis is the systematic and comprehensive investigation of noise-related LTO charging systems in place at German and European airports at the end of 2002 with regard to

- their structure (basis for assessment, level and spread of charges, time-related modulation of charges etc.) and
- monetary incentives for the operation of low-noise aircraft.

Status quo analysis is supplemented by an assessment of the economic implications of noise-related LTO charges for airlines and airport operators. Status quo analysis is thus the basis for

- the choice of noise-related LTO charging systems for detailed effect analysis in Chapter 5 and
- the development of a LTO charging system that is optimized from a noise management viewpoint (see Chapter 7).

In Section 4.1, an analysis is made of noise-related LTO charging systems currently in force at German and European airports. In Section 4.1.1 the methodical concept of status quo analysis is explained. The presentation and analysis of noise-related LTO charging systems at German airports is the subject of Section 4.1.2, while in Section 4.1.3 noise-related LTO charging systems at European airports are examined. In Section 4.2 the economic implications of charging systems for airlines and airport operators are set out, while in Section 4.3 an interim conclusion is drawn from status quo analysis.

4.1 Noise-related charges at German and European airports

4.1.1 Methodical concept

At the present time, noise charges are paid by airlines to airport operators or state authorities[76] at around 100 airports worldwide, partly as a noise-related additional component of LTO charges, partly as specific noise charges.[77] The latter are generally levied for measures of noise alleviation or prevention, including, in particular, noise mitigation programmes (financing function). Noise-related LTO charges, on the other hand, have the aim of imposing such a burden on loud aircraft that a financial incentive is created for the operation of low-noise aircraft (control effect).

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[76] An overall view is to be found at www.boeing.com/commercial/noise/flash.html.

[77] Specific noise charges can be levied for each arrival and departure as well as per passenger. Mixed variants are also found in practice (for example, at Frankfurt Airport).

Status quo analysis focuses on *noise-related LTO charges* as an instrument of control. In terms of their control effect, specific noise charges are irrelevant in Germany. Within the framework of status quo analysis they are only dealt with in an excursus on the example of Frankfurt Airport. In other European countries – Amsterdam, for example – greater use is made of specific noise charges for noise-related control than in Germany; and as a consequence they are included in status quo analysis.

While at Frankfurt, Hamburg, Munich and Stuttgart airports, as well as at most foreign airports, the noise component of LTO charges is shown separately from MTOM-related basic charges, at other German airports a noise surcharge cannot be easily isolated. At these airports, LTO charges are directly dependent on the ICAO noise classification of the operated aircraft. The noise surcharge could only be identified if the fee for an aircraft of the lowest noise category with corresponding MTOM was deducted from the LTO fee of an aircraft (de Wit/Cohen 1999; Morerell/Lu 1999). This line of proceeding was not pursued within the framework of the analysis under consideration; instead, *total LTO charges including noise components* were looked at.

Considering LTO charges as a whole also has the advantage that by overlaying the noise surcharge with the MTOM-related basic component of the LTO fee it becomes clear whether there is any incentive for the operation of low-noise aircraft. Quieter alternative aircraft differ from aircraft to be replaced not only in noise emission, but also mostly in MTOM. The overlaying of both effects can thwart the noise-related preferential treatment of aircraft.

To determine these effects, apart from analysis of the design of charging systems, for each airport the **savings or additional costs** were investigated that would arise in the case of LTO charges and specific noise charges **through the use of a quieter or louder aircraft compared with a typical reference aircraft**.[78]

Depending on the type of air service, the following internationally-operated, but generally older aircraft types were selected as reference aircraft:

- Boeing 737-300 in national and continental scheduled passenger services,
- Boeing 747-200 in inter-continental scheduled passenger services,
- Boeing 737-800 in continental holiday/charter services,
- Boeing 727 (Hushkit) in continental cargo services,
- Boeing 747-200 F in intercontinental cargo services.

78 This comparison related exclusively to LTO charges. Through aircraft substitution, further cost components (for example, costs of maintenance, personnel and fuel) are also modified, and this should be considered in a detailed analysis of the impact of noise-related LTO charges. It should also be borne in mind that many factors (for example, total turnaround costs, traffic-related importance of an airport, an airline's fleet of aircraft) can influence whether, from a commercial viewpoint, airlines can be encouraged to act in the way intended by savings or additional costs (for instance, through the operation of less-noisy aircraft or the rescheduling of flight movements). As a result, the comparison of savings or additional costs merely provides orientation in respect of the incentive effect of noise-related LTO charges.

Depending on the type of air service, quieter, more modern aircraft (with the exception of holiday/charter services[79]) were generally compared with reference aircraft (see Table 1). All investigated aircraft fulfil Chapter 3 noise classification of Annex 16 to the Convention on International Civil Aviation.[80]

Table 1 Reference and alternative aircraft of status quo analysis

Air services	Reference aircraft	MTOM[1)]; seats/ cargo volume[2)]	Alternative aircraft	MTOM[1)]; seats/ cargo volume[2)]
Scheduled passage – national	B 737-300	62.8 t; 128 seats	- A 319: - A 320-200:	68.0 t; 124 seats 73.5 t; 150 seats
Scheduled passage – continental	B 737-300	62.8 t; 128 seats	- A 320-200: - A321:	73.5 t; 150 seats 89.0 t; 185 seats
Scheduled passage – inter-continental	B 747-200	377.8 t; 389 seats	- B 747-400: - MD 11:	394.6 t; 390 seats 286.0 t; 292 seats
Holiday/charter services – continental	B 737-800	78.2 t; 189 seats	- A 320-200: - B 757-300:	75.5 t; 179 seats 123.6 t; 280 seats
Cargo services – continental	B 727 –200 (Hushkit)	88.9 t; 23 t cargo	- B 737-300QC: - B757SF0:	62.8 t; 15 t cargo 99.7 t; 29 t cargo
Cargo services – inter-continental	B 747-200F	371.9 t; 100 t cargo	- B 747-400F: - MD 11:	396.9 t; 100 t cargo 286.0 t; 93 t cargo

[1)] Typical reference values of aircraft manufacturers; depending on the specific configuration of aircraft (e.g. engine type), MTOM can differ considerably from the values shown in the table. – [2)] Typical reference values of aircraft manufacturers and airlines; depending on the airline company, real values can differ from the values shown (e.g. on account of closer seating)

Source: Websites of aircraft manufacturer.

The alternative aircraft types considered and the parameters required for calculation (MTOM, number of seats or potential cargo capacity) are shown in Table 1. The parameters in the table are typical for aircraft operated in Europe. Depending on aircraft configuration, MTOM and the number of seats can differ from the figures shown, due, for example, to different engine specifications and seating arrangements.

Savings or additional costs arising from a change in the choice of aircraft were calculated for a turnaround on the basis of charging systems valid at the end of 2002.[81]

79 German tour operators make almost exclusive use of modern and less-noisy aircraft (Lufthansa 2002b; Hapag-Lloyd 2001; LTU 2000). For this reason – in contrast to other air services – older and thus louder reference aircraft (e.g. MD 87) were not selected.

80 Due to the ban on Chapter 2 Aircraft in the EU from 1.4.2002, corresponding aircraft were not considered in the calculation of charges.

81 The analysis was therefore based on charging systems in force at 31.12.2002 (DFS 2003). Later changes could not be considered due to the scheduling of work on this report.

For all airports it was assumed that all aircraft types listed in Table 1 can land and take-off – irrespective of the length of runways and resultant restrictions on the size of aircraft. The comparison of savings and additional costs for German airports arising from the substitution of aircraft in inter-continental transportation is therefore largely a theoretical matter[82] that, however, is intended to show the effects of LTO charging systems on heavy aircraft types.

Two case were distinguished in the analysis:

- *Case 1:* Landing and take-off occur at daytime (corresponding to the definition of daytime at the respective airports),
- *Case 2:* Landing and take-off occur at night (once again corresponding to the definition of night at the respective airports).

Case 2 was calculated for all airports irrespective of existing night-flight restrictions (cf. Öko-Institut 2003). The ascertained savings or additional costs for both cases were shown

- in absolute terms (in euros) and
- also in specific terms (in euros per passenger or per tonne of transported cargo).

Data in euros per passenger or per tonne of cargo allows for the fact that potential alternative aircraft have not only varied take-off mass, but also different seating arrangements and cargo capacity. Assumed average aircraft load, depending on type of service and the share of transfer passengers, is displayed in Table 2. These figures are based on information provided by Lufthansa (Lufthansa 2002a) and the Federal Statistical Office (StaBu 2002).

[82] Restrictions arise at certain airports for aircraft with a take-off mass (MTOM) above a maximum level, due to the length of runways (see for example, Mörz 2001). For calculations it was assumed, irrespective of such restrictions, that heavy aircraft (e.g. Boeing 747) can also land and take-off at these airports.

Table 2 Average aircraft load and share of transfer passengers, depending on air service

	Average load	Share of transfer passengers
Scheduled passenger services – national	65 %	10 %
Scheduled passenger services – continental	65 %	10 %
Scheduled passenger services – inter-continental	80 %	20 %
Holiday/Charter services – continental	80 %	0 %
Cargo services – continental	80 %	-
Cargo services – inter-continental	80 %	-

Source: Lufthansa 2002; StaBu 2002; Doganis et al 1998; own estimates.

For reference aircraft, supplementing the presentation of savings and additional costs,

- LTO charges and
- passenger charges[83] (passenger services only)

are shown in absolute terms. On the one hand, savings and additional costs can be set in relation to the level of total LTO charges for every airport; on the other hand, the difference in charges between day and night movements (Cases 1 and 2) can be identified for a particular aircraft type. Furthermore, the relation between LTO charges on the one side and passenger charges on the other can be shown.

It has to be emphasized at this point that *simple comparison of the level of individual charges at airports serves only a limited purpose*, since

- LTO charges represent only one of several charging system components, and airports spread their costs over individual charges according to their respective charging policy. For example, Frankfurt Airport has lower LTO charges but higher passenger charges than other German airports (cf. Doganis et al. 1998; de Wit/Cohn 1999; Stockman 2001);
- airlines base their commercial decisions not on the level of isolated charges, but on total turnaround costs (including the total of all charges) (TÜV/DIW/WI 2001; de Neufville/Odoni 2003); and
- depending on the airport, LTO charges include or exclude different services[84] (parking of aircraft, lighting of runways etc.) (Cf. for example ACI 2002).

It has further to be considered that due to different operating conditions at airports (for example, hub function, home airport of airlines, political conditions) comparisons of

[83] Again based on available seating, load level and share of transit passengers as displayed in Table 1 and Table 2.

[84] For example, airports in Paris levy a separate lighting charge, so this item is no longer included in take-off and landing charges (ACI 2002).

airports, carried out within the scope of status quo analysis, allow merely an initial orientating assessment of the effectiveness of noise-related charges; and this applies in particular to the comparison of LTO charging systems at German airports. For an in-depth investigation, the effects of charging systems on aircraft fleet mix and noise problem would have to be analysed at an airport over a prolonged period of time. Only in this way could it be conclusively determined whether noise-related LTO charging systems also achieve their intended effect of noise reduction (for example, through the use of quieter aircraft or through changes in the timing or place of flight movements).

The results of status quo analysis are presented below, differentiating national airports (Section 4.1.2) and foreign airports (Section 4.1.3). As far as Germany is concerned, *all 17 international airports,* together with the regional airports at Dortmund and Hahn, have been analysed. Outside Germany, status quo analysis concentrated on *major European airports with noise-related LTO charges*. In the case of these airports, specific noise charges – where applicable – differentiated according to aircraft type were also examined. At major international airports outside Europe, on the other hand, noise-related LTO charging systems are irrelevant.[85] Table 3 surveys the airports that were the subject of status quo analysis.

Table 3 Survey of airports with noise-related LTO charging systems that were the subject of status quo analysis

Airports in Germany	**European Airports**
International airports: ▪ Berlin Tegel, Tempelhof and Schönefeld ▪ Bremen ▪ Düsseldorf ▪ Dresden ▪ Frankfurt ▪ Leipzig/Halle ▪ Munich ▪ Hamburg ▪ Hanover ▪ Cologne/Bonn ▪ Münster/Osnabrück ▪ Nuremberg ▪ Stuttgart *Regional airports:* ▪ Dortmund ▪ Hahn	▪ Amsterdam ▪ Brussels ▪ London Gatwick ▪ London Heathrow ▪ London Stansted ▪ Mailand-Malpensa ▪ Paris Charles de Gaulle ▪ Paris Orly ▪ Stockholm Arlanda ▪ Zurich
Source: Boeing 2003; DFS 2003; Öko-Institut 2003; ICAO 2002; Morell/Lu 1999; de Wit/Cohn 1999; Doganis et al. 1998; own presentation.	

85 Cf. www.boeing.com/commercial/noise/flash.html or ICAO (2002). For example, none of the large American airports levy noise-related LTO charges.

4.1.2 Airports in Germany

4.1.2.1 Structure of investigated LTO charging systems

In the main, LTO charging systems in Germany are structured in two ways (see Table 4):

- Mass-related fee (in euros/t) x MTOM,
- Noise-related fee (in euros) + mass-related fee (in euros/t) x MTOM.

The object of assessment is

- *landing only* (take-off is settled with landing) at Berlin, Dresden, Düsseldorf, Erfurt, Leipzig/Halle, Munich, Münster/Osnabrück, Nuremberg, Stuttgart and Dortmund;
- *landing*, with the increased night fee being payable when *take-off occurs at night*, at Bremen, Hanover, Cologne/Bonn and Saarbrücken; and
- *landing and take-off* at Frankfurt, Hamburg and Hahn.

The polluter-pays principle is therefore applied most consistently at Frankfurt, Hamburg and Hahn.

All investigated airports in Germany vary the level of LTO charges depending on the noise certification of aircraft, and they therefore apply noise-related LTO charging systems. The systems differ, however, with regard to the classification of aircraft in noise categories and the transparent presentation of noise components.

As a rule, the classification of aircraft in noise categories is based on the so-called "bonus list" of the Federal Ministry of Transport and ICAO noise classification (Chapter 2 and 3, without noise certification) (see Table 4). Only Frankfurt, Hamburg, Munich and Stuttgart make use of their own noise categories. The allocation of aircraft to specific groups occurs on the basis of noise measurements at airports and therefore better reflects real noise nuisance at the respective airports.

Analyses also show, however, that of these four airports Hamburg has most consistently gone the way of differentiation of aircraft types in noise categories. It has to be stated, however, that with all four cities charges in low noise categories vary only insignificantly, which is why only a negligible incentive for the operation of low-noise aircraft can be assumed. Charging systems at these four airports also have the aim of levying heavy charges particularly on loud aircraft, and especially at night.

With regard to the transparency of LTO charging systems as well as the clear identification of noise components, Frankfurt, Hamburg and Stuttgart airports have distinct advantages. Whereas other airports vary the MTOM-related share of LTO charges according to noise categories and – as mentioned in Section 4.1.1 – do not separately show the noise-related share, Frankfurt, Hamburg and Stuttgart do distinguish a separate noise component, which is payable as a fixed amount depending on the noise category of the aircraft and daytime or night movement, and a purely mass-related share, which is levied per tonne MTOM and is not dependent on other variables.[86]

Apart from consideration of the noise emission of aircraft, most airports impose higher LTO charges at night – at least for loud aircraft – than during the day. Hamburg, for example, has greatly increased the cost of all flight movements between 23.00 and 06.00 hours with a 200% surcharge on the daytime fee, and consistently pursues the aim of making every night flight economically unattractive. This way, instead of a ban on night flights, noise-related LTO charging systems are applied to reduce noise nuisance at night. Apart from Hamburg Frankfurt, Berlin, Bremen, Cologne/Bonn, Munich and Hahn tend towards greater differentiation of LTO charges depending on the time of day (and not only for Chapter 2 aircraft that are nowadays irrelevant).

On the other hand, many airports have foregone greater differentiation of charges since, with few exceptions, no – or only "bonus list" – aircraft may land at night. The exceptions are Dresden and Leipzig/Halle airports, where not only Chapter 3 but also "bonus list" aircraft may land; both airports have refrained from differentiating daytime and night flights for Chapter 3 aircraft (Öko-Institut 2003).

In the following table, the main structural elements of and differences in noise-related LTO charging systems at investigated German airports are summarized once more.

86 In Hamburg the weight-related component of charges increases at night.

Table 4 Summary of the structure of noise-related LTO charging systems applied at German airports in 2002[1)]

Calculation formula and exemplary airports	LTO fee components according to			
	ICAO noise categories	New noise categories	Day/Night	MTOM[2)]
fee x MTOM				
▪ Erfurt; Münster/Osnabrück; Nuremberg; Dortmund	x			
▪ Bremen; Dresden; Hannover; Leipzig/Halle; Saarbrücken	x		x	
▪ Berlin; Hahn	x		x	x
[Fee + (declining value x (400 - MTOM))] x MTOM				
▪ Cologne, Bonn				
- Basic fee in €	x		x	
- **Declining value**	x		x	
Basic fee + fee rate x MTOM				
▪ Düsseldorf				
- basic fee in €	x			
- mass-related fee in €/t MTOM	x		x	
▪ Frankfurt				
- noise component in €		x	x	
- mass-related fee in €/t MTOM				
▪ Hamburg				
- noise surcharge in €		x	x	
- mass-related fee in €/t MTOM			x	
▪ Munich				
- noise-related basic fee in €		x		
- mass-related fee in €/t MTOM	x		x	
▪ Stuttgart				
- noise-related basic fee in €		x		
- mass-related fee in €/t MTOM				

[1)] For small, light aircraft other regulations apply. The presentation relates, as a rule, to jet planes with a MTOM of more than: 2.0 t (Munich, Düsseldorf, Hahn: 5.7 t; Berlin-Tegel and -Tempelhof: 6 t (with noise certification); Cologne-Bonn: 12 t; Frankfurt: 35 t). – [2)] All fee rates that have to be multiplied with MTOM are as such dependent on MTOM. The dependence specified here relates to the fact that the rate of fee is itself differentiated depending on MTOM.

4.1.2.2 Comparison of the incentive effects of noise-related LTO charging systems

The results of analysis of the incentive effects of German LTO charging systems are presented below; these are exemplary for German domestic passenger services, inter-continental passenger services and continental cargo services.

Figure 2 displays the level of LTO charges in absolute terms as well as passenger charges for a Boeing 737-300 in German domestic services. For landing and take-off during the day, a total of around 1,000 euros is payable in respect of both charges (see the upper part of Figure 2). Related to the total amount of charges, for the assumed aircraft load (see Chapter 4.1.1) the share of LTO charges is about 50 %. In Frankfurt this share is much lower, which is attributable to a different policy on charges. While most other airports make greater use of (fixed) mass- and movement-related LTO charges to finance their costs, Frankfurt airport makes greater use of (variable) passenger charges. The concept goes even further at Hahn airport, where aircraft up 90 t MTOM are subject to no fixed LTO charges whatsoever, but only to passenger charges. For airlines, in particular for low cost carriers, this system is especially attractive in terms of risk minimization, since passenger charges are only payable for passengers on board.

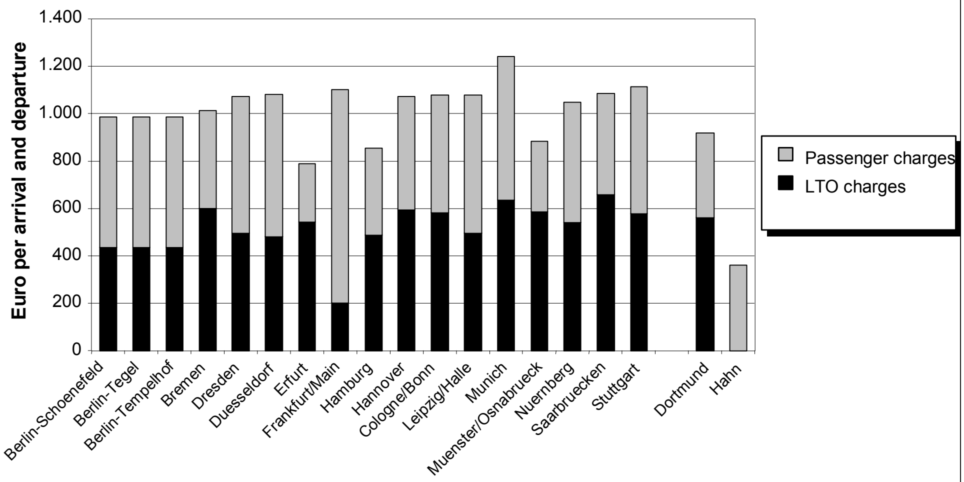
If one compares the level of LTO charges for a Boeing 737-300 for day and night (lower part of Figure 2; in each case take-off and landing during the day and at night), one sees that any differences occur only at four airports. In this respect it has to be borne in mind that at many German airports far-reaching night flight restrictions apply (see previous section). Of particular interest is the day/night difference of about 975 euros per take-off and landing in Hamburg.

Figure 2 LTO charges at German airports 2002: Boeing 737-300 in German domestic services

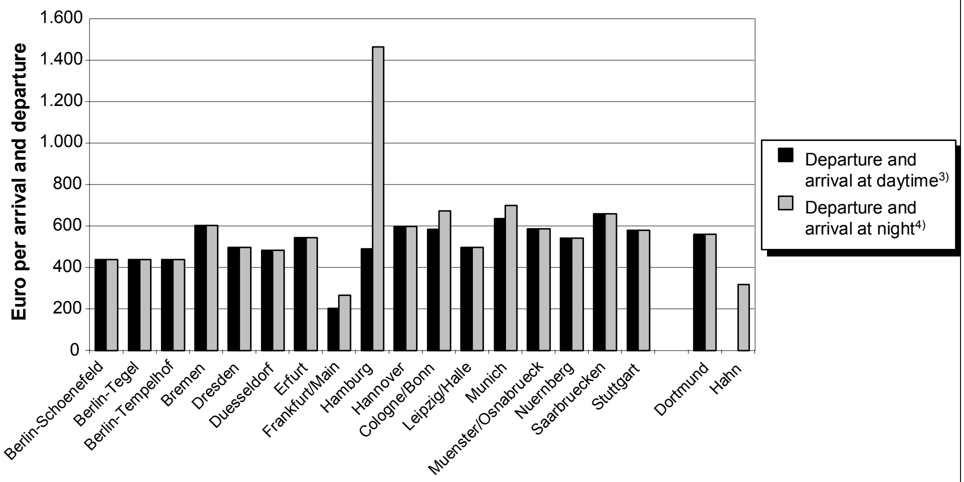
Airport charges[1)] at German Airports 2002

– B737-300 scheduled passage national:
63 t MTOM, 83 PAX[2)] –

LTO charges (including noise charge) and passenger-charges for one landing and one departure in the daytime [3)] – in Euro



Comparison of LTO charges (including noise charges) for one landing and one departure during the day and at night [4)] – in Euro



Notes: [1)] Under §43 LuftVZO subject to authorization charges by the aviation authority; without parking- and positions-charges. – [2)] 65 % workload. – [3)] In Saarbruecken and Stuttgart: 7:00-22:00; in Hahn: 5:00-23:00; all other airports: 6:00-22:00. – [4)] in Hamburg: 23:00-6:00; in Saarbruecken and Stuttgart: 22:00-7:00; in Hahn: 23:00-5:00; all other airports: 22:00-6:00.

In Figure 3 and Figure 4, cost savings and additional costs are shown for take-off and landing during the day and at night in euros and euros per passenger where a B 737-300 is replaced by an A 319 (low-noise aircraft) or an A 320-200 (comparable aircraft). At almost all airports, a modified choice of aircraft leads to additional costs in absolute terms, and this applies during the day and at night. Only in Hamburg does substitution of the B 737-300 with an A 319 result in cost savings in absolute terms (26 and 78 euros for day and night, respectively). Maximum additional costs of 200 euros per take-off and landing at other airports (on average much lower) remain within reasonable limits.

Additional costs are to be attributed to the fact that all the aircraft investigated belong to the "bonus group", but differ so far as MTOM is concerned. Both alternative aircraft have a greater MTOM than the reference aircraft. For this aircraft category, the MTOM-related share exceeds the noise-related share of the LTO fee also at Frankfurt, Munich and Stuttgart airports.

In the case of specific figures in euros per passenger a different picture emerges: At all airports, with the exception of Stuttgart and Hahn, the A 320-200 produces savings of 0.02 to 0.68 euros per passenger (relating to landing and take-off, with the exception of Hamburg and Hahn). This results from the fact that, compared with the B 737-300 as well as with the A 319, seating capacity is greater. Only at Hamburg airport is the A 319 more favourable than the B 737-300. At all other airports, with the exception of Hahn, replacement leads to additional costs of the order of 0.25 to 0.84 euros per passenger (relating to landing and take-off).

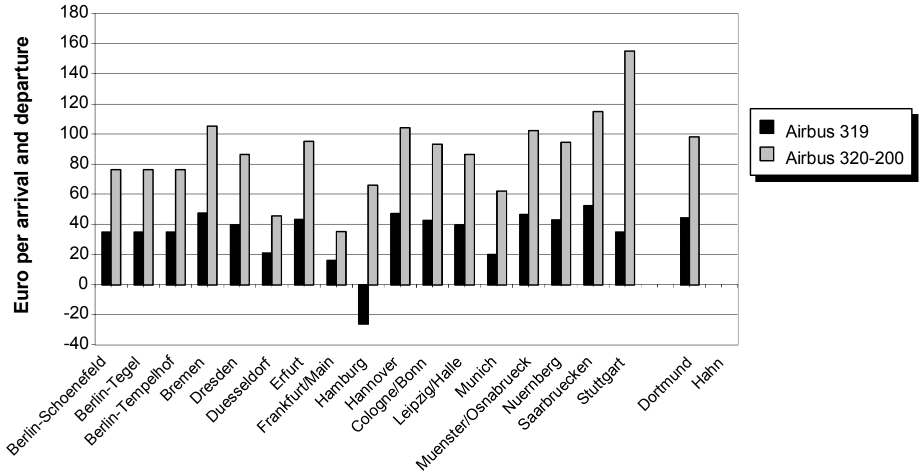
Figure 3 LTO charges at German airports 2002: Comparison of an A 319 and an A 320-200 with a B 737-300 in German domestic air services during the day

LTO charges[1] at German airports 2002:
Additional costs and cost savings, respectively, with different aircraft

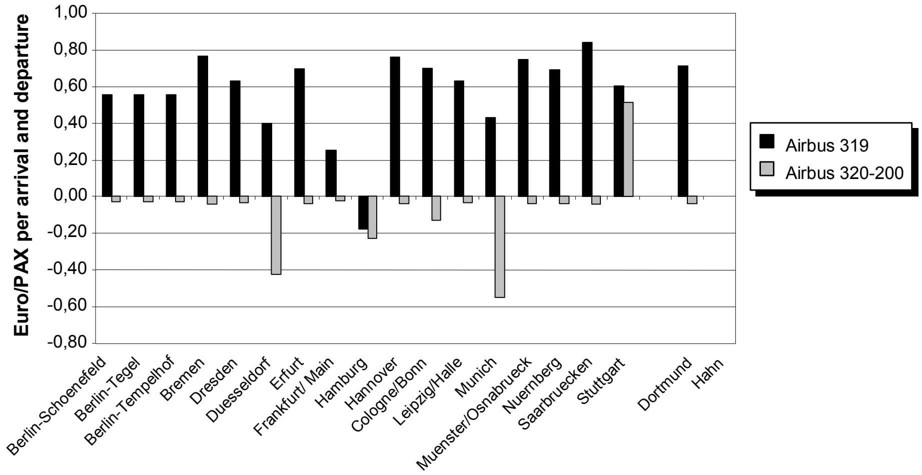
– Departure and landing during the day[2], scheduled passage national –

Comparison Airbus 319 and Airbus 320-200 with Boeing 737-300[3]

A) Absolute difference one landing and one departure based on B 737-300



B) Specific difference with one landing and one departure based on B 737-300



Notes: [1] Including noise charge. – [2] In Saarbruecken and Stuttgart: 7:00-22:00; in Hahn: 5:00-23:00; all other airports: 6:00-22:00. – [3] Airbus 319: 68 t MTOM, 81 passengers; Airbus 320-200: 74 t MTOM, 98 passengers; Boeing 737-300: 63 t MTOM, 83 passengers; assumption: 65 % workload.

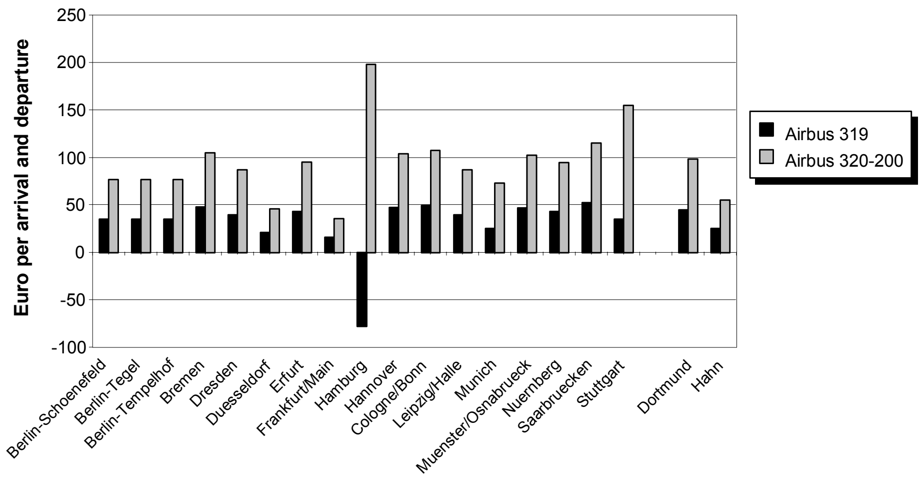
Figure 4 LTO charges at German airports 2002: Comparison of an A 319 and an A 320-200 with a B 737-300 in German domestic air services at night

LTO charges[1)] at German airports 2002:
Additional cost resp. reduction of cost by different air-planes

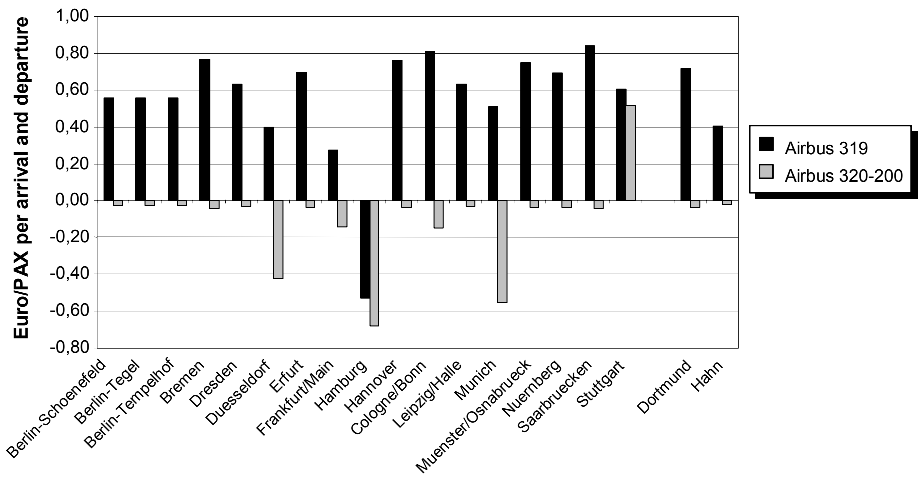
– Departure and landing at night[2)], scheduled passage national –

Comparison Airbus 319 and Airbus 320-200 with Boeing 737-300[3)]

A) Absolute difference one landing and one departure based on B 737-300



B) Specific difference with one landing and one departure based on B 737-300



Notes: [1)] Including noise charge. – [2)] In Hamburg: 23:00-6:00; in Saarbruecken and Stuttgart: 22:00-7:00; in Hahn: 23:00-5:00; all other airports: 22:00-6:00. – [3)] Airbus 319: 68 t MTOM, 81 passenger; Airbus 320-200: 74 t MTOM, 98 passenger; Boeing 737-300: 63 t MTOM, 83 passenger; assumption: 65 % workload.

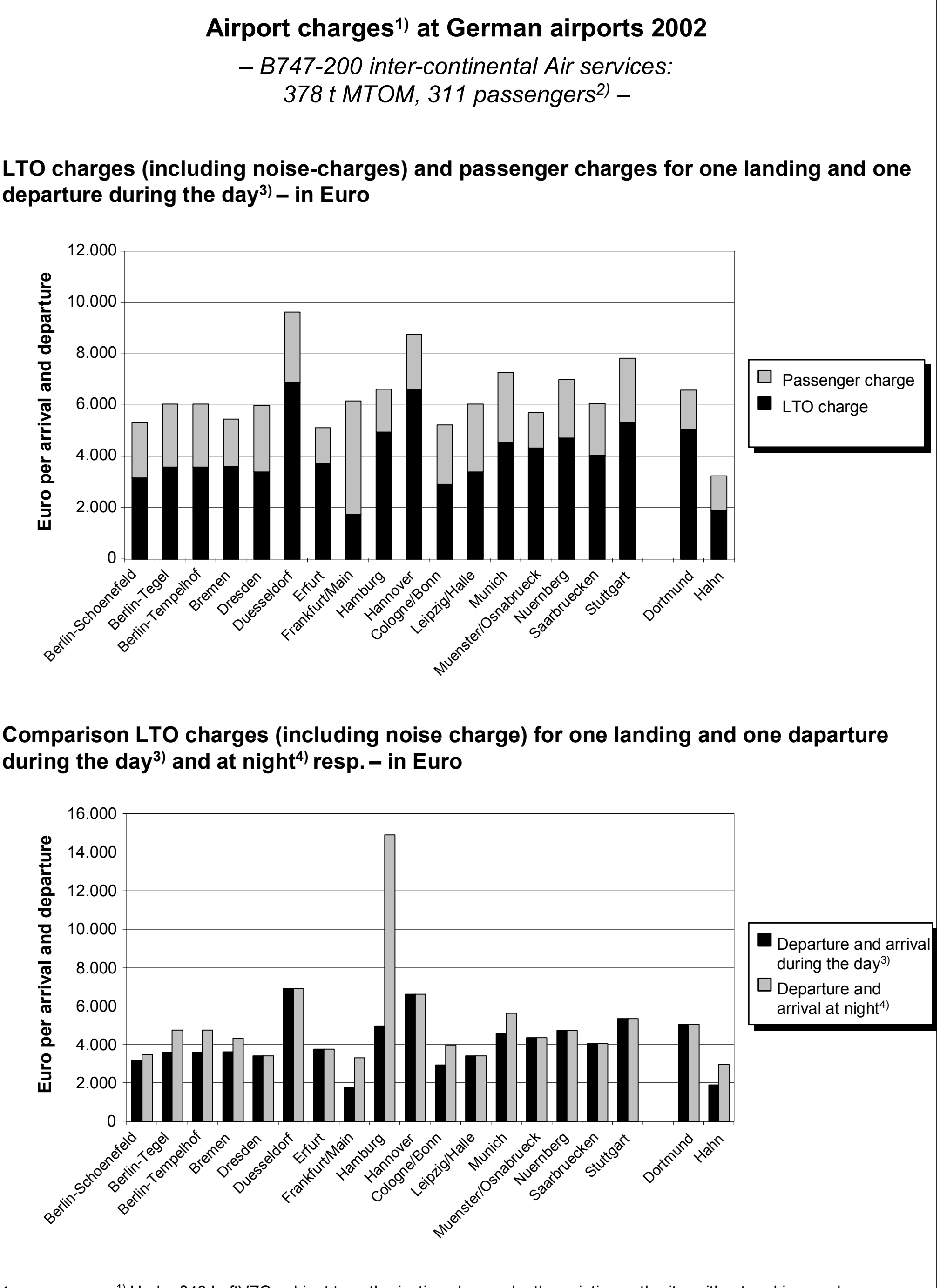
As already stated, the specific effects of a modified choice of aircraft in scheduled and holiday/charter services within Europe will not be dealt with at this point. It remains to be mentioned, however, that with these air services, too, savings and additional costs arising from a modified choice of aircraft are generally of the order of less than 1 euro per passenger, relating to take-off and landing. Analyses further show that the overlaying of the MTOM-related fee with the noise-related share leads to ecologically inconsistent results. The same applies to the calculation of specific values per passenger, due to the additional overlaying of the result with the number of passengers per flight.

Figure 5 displays LTO charges as well as passenger charges for a Boeing 747-200 operated in inter-continental passenger services. In contrast to the B 737-300 operated in German domestic services, the total of both charges varies very considerably from one airport to another. For a B 747-200 most airports impose a daytime LTO fee of between 5,000 and 7,000 euros per turnaround (landing and take-off), and in isolated cases up to 9,600 euros (Düsseldorf). As in the case of German domestic services, due to its different policy on charges Frankfurt airport has the lowest share of LTO charges in total charges (< 30 %).

In the case investigated, higher LTO charges at night – compared to daytime charges – are levied at Berlin, Bremen, Frankfurt, Hamburg, Cologne/Bonn, Munich and Hahn. Differences compared with daytime charges range from 310 euros to 9,940 euros per take-off and landing (see Figure 5). In interpreting this data it has again to be borne in mind that, on the one hand, the 747 cannot take-off and land at each of the airports covered due to the length of runways; on the other hand, a number of airports forego day/night differentiation on account of night-flight restrictions in force.

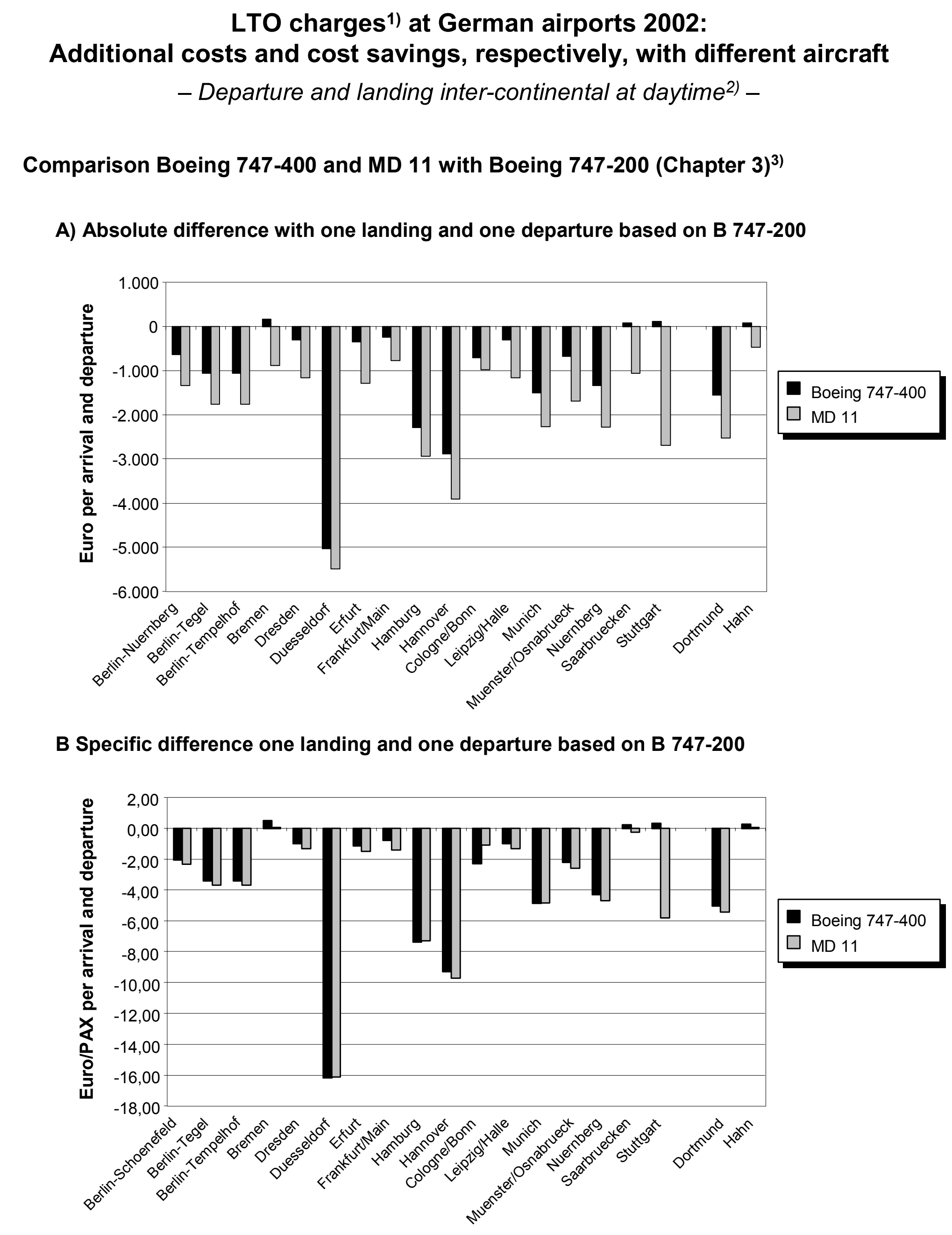
Cost savings as well as additional costs from LTO charges resulting from the use of more modern and thus less-noisy aircraft are displayed in Figure 6 for daytime flights and in Figure 7 for flights at night. Not only the B 747-400, but also the MD 11 results at most airports in savings of the order of around 0.20 - 22.00 euros per passenger and turnaround (mainly 1.00 - 7.00 euros). In absolute terms, savings range from 240 to 8,800 euros per landing and take-off. It is again conspicuous that with certain airports the MTOM share of the total fee more than covers the noise component and, in the case of the B 747-400, leads to additional costs (for example, at Bremen, Saarbrücken, Stuttgart and Hahn; see Figure 6 and Figure 7).

Figure 5 Airport charges at German airports 2002: Boeing 747-200 (Chapter 3) in inter-continental services



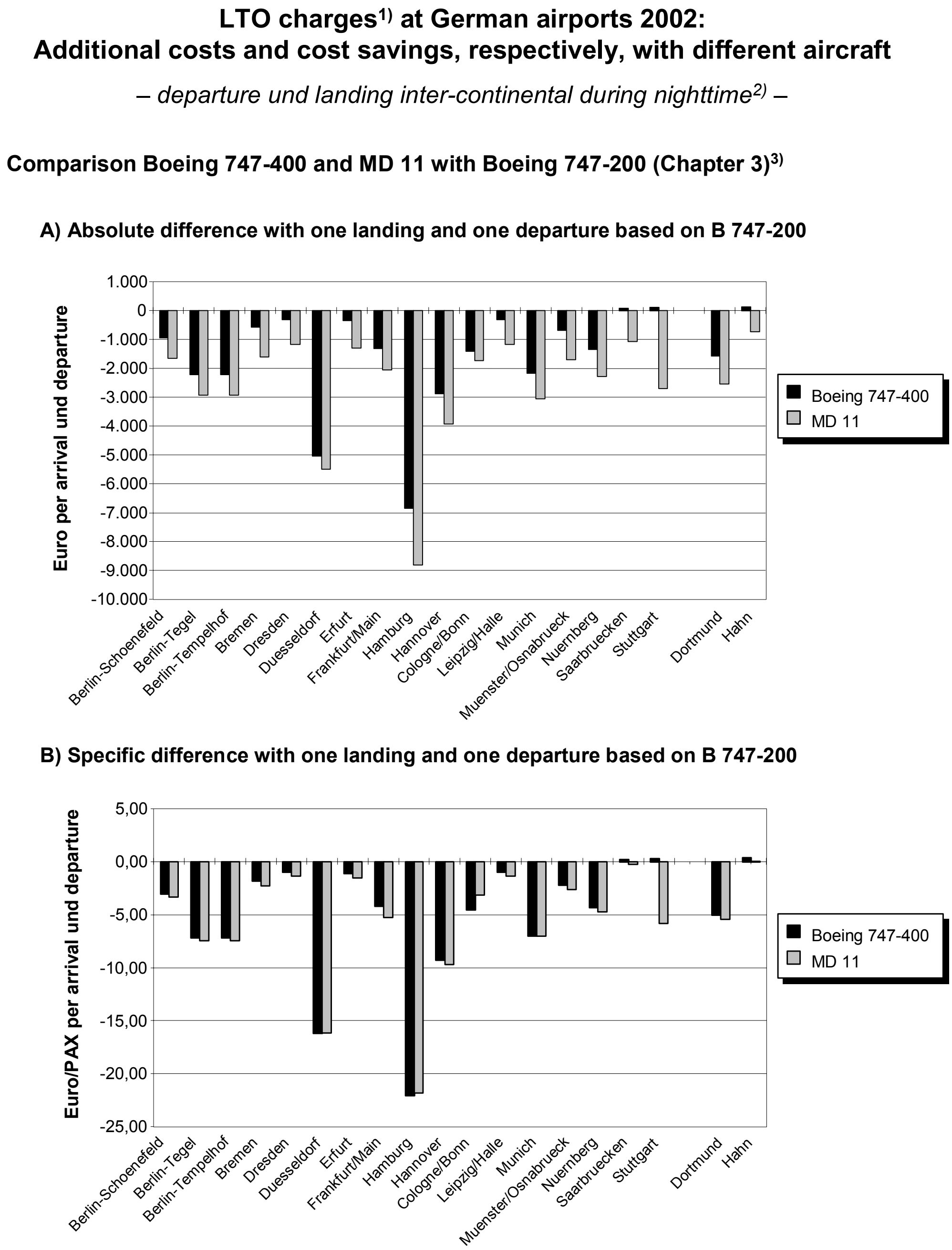
Notes: [1] Under §43 LuftVZO subject to authorization charges by the aviation authority; without parking- and positions-charges. – [2] 80 % workload; 20 % transit-/transferpassengers. – [3] In Saarbruecken and Stuttgart: 7:00-22:00; in Hahn: 5:00-23:00; all other airports: 6:00-22:00. – [4] In Hamburg: 23:00-6:00; in Saarbruecken and Stuttgart: 22:00-7:00; in Hahn: 23:00-5:00; all other airports: 22:00-6:00.

Figure 6 LTO charges at German airports 2002: comparison of a B 747-400 and a MD 11 with a B 747-200 in inter-continental services during the day



Notes: [1] Including noise charge. – [2] In Saarbruecken and Stuttgart: 7:00-22:00; in Hahn: 5:00-23:00; all other airports: 6:00-22:00. – [3] Boeing 747-400: 395 t MTOM, 312 passengers; MD 11: 286 t MTOM, 234 passengers; Boeing 747-200: 378 t MTOM, 311 passengers; assumption: 80 % workload; 20 % transit-/transferpassengers.

Figure 7 LTO charges at German airports 2002: comparison of a B 747-400 and an MD 11 with a B 747-200 in inter-continental services at night



Notes: [1)] Including noise charge. – [2)] In Hamburg: 23:00-6:00 Uhr; in Saarbruecken and Stuttgart: 22:00-7:00; in Hahn: 23:00-5:00; all other airports: 22:00-6:00. – [3)] Boeing 747-400: 395 t MTOM, 312 passengers; MD 11: 286 t MTOM, 234 passengers; Boeing 747-200: 378 t MTOM, 311 passengers; assumption: 80 % workload; 20 % transit-/transfer-passengers.

Inter-continental cargo services are not presented at this point, since the aircraft involved are of the same types as those in international passenger services and the conclusions are therefore identical. Figure 8 and Figure 9 therefore display the effects of a modified choice of aircraft exclusively for continental cargo services.

A comparison of the B 737-300 QC and the B 757SF (both quieter aircraft) with the Boeing 727 (Hushkit) shows the following picture: Whereas the B 737-300 QC achieves savings in costs at all airports, at least in absolute terms, with the B 757SF, compared to the B 727, partially higher costs arise. Also in this case, the MTOM-related share overlays the noise-related share. Large savings can be achieved through replacement with a B 727 Hushkit in particular at Düsseldorf and Hamburg, where alternative aircraft types save about 1,300 euros and 2,500 euros, respectively, during the day and about 1,300 euros and 8,000 euros, respectively, at night. Specific savings per tonne and turnaround (landing and take-off) are around 60 to 70 euros per tonne of cargo at Düsseldorf, and around 140 to 150 euros during the day and around 420 to 450 euros at night at Hamburg.

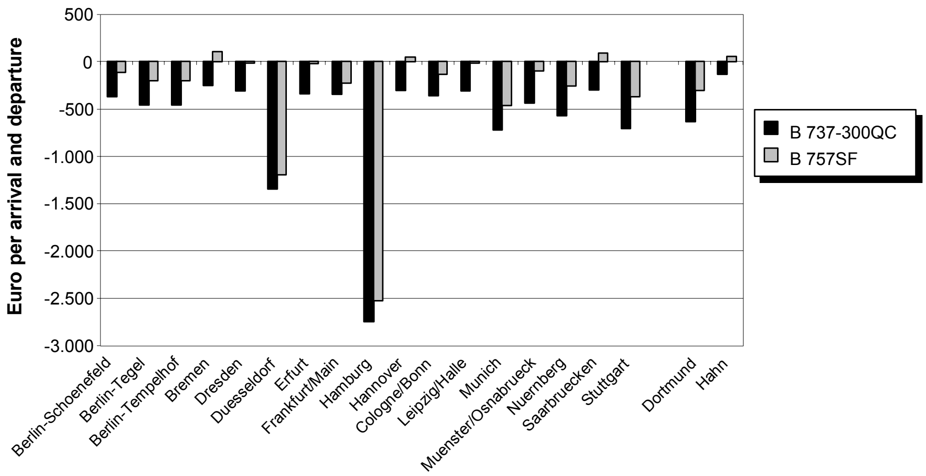
Figure 8 LTO charges at German airports 2002: comparison of a B 737-300QC and a B 757SF with a B 727 (Hushkit) in continental cargo services during the day

LTO charges[1] at German airports 2002:
Additional costs and cost savings, respectively, with different aircraft

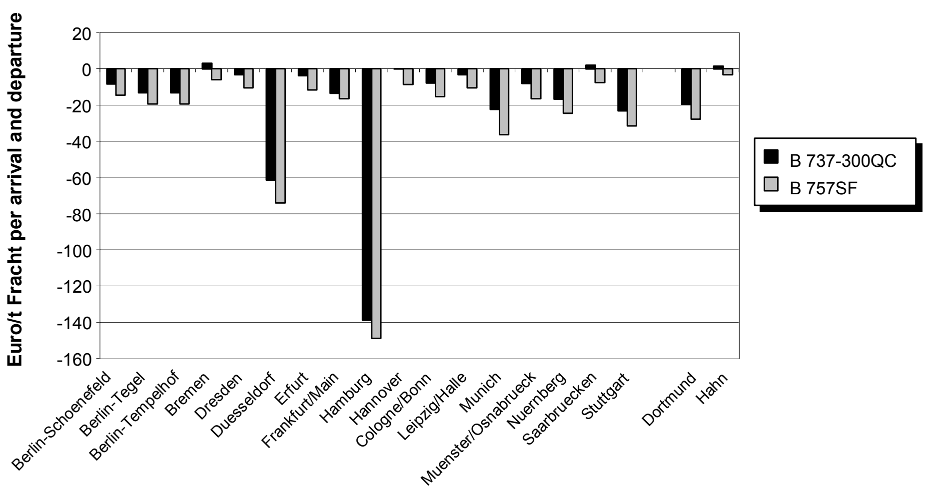
– departure und landing during the day[2], cargo services (europe) –

Comparison Boeing 737-300QC and Boeing 757SF with Boeing 727 (Hushkit)[3]

A) Absolute difference with one landing and one departure based on B 727 (Hushkit)



B) Specific difference with one landing and one departure based on B 727 (Hushkit)



Notes: [1] Including noise charge. – [2] In Saarbruecken and Stuttgart: 7:00-22:00; in Hahn: 5:00-23:00; all other airports: 6:00-22:00. – [3] Boeing 737-300QC: 63 t MTOM, 12 t cargo; Boeing 757SF: 100 t MTOM, 23 t cargo; Boeing 727 (Hushkit): 89 t MTOM, 18 t cargo; assumption: 80 % workloat.

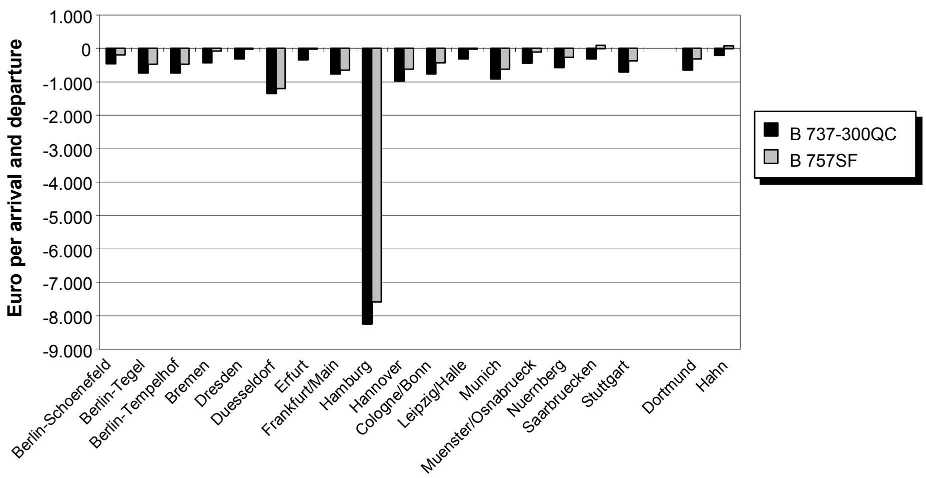
Figure 9 LTO charges at German airports 2002: comparison of a B 737-300QC and a B 757SF with a B 727 (Hushkit) in continental cargo services at night

LTO charges[1] at German airports 2002:
Additional cost resp. reduction of cost by different air-planes

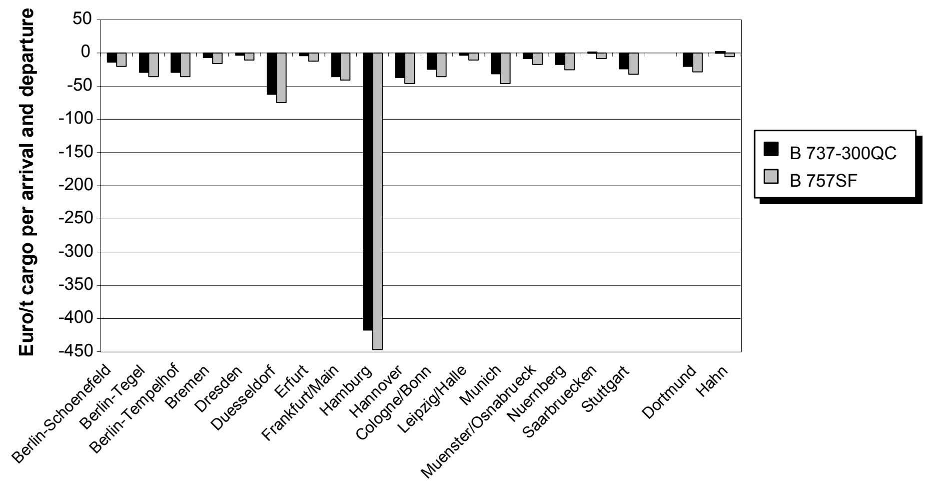
– departure and landing at night[2], cargo services (europe) –

Comparison Boeing 737-300QC and Boeing 757SF with Boeing 727 (Hushkit)[3]

A) Absolute difference one landing and one departure based on B 727 (Hushkit)



B) Specific difference one landing and one departure based on B 727 (Hushkit)



Notes: [1] Including noise charge. – [2] In Hamburg: 23:00-6:00; in Saarbruecken and Stuttgart: 22:00-7:00; in Hahn: 23:00-5:00; all other airports: 22:00-6:00. – [3] Boeing 737-300QC: 63 t MTOM, 12 t cargo; Boeing 757SF: 100 t MTOM, 23 t cargo; Boeing 727 (Hushkit): 89 t MTOM, 18 t cargo; assumption: 80 % workload.

4.1.2.3 Excursus: specific noise charges at Frankfurt Airport

With its notification of 26 April 2001, based on §6 of the Air Traffic Act, the Ministry of Economics, Transport and Regional Development of the State of Hesse obliged Fraport AG, the operator of Frankfurt airport, to carry out noise mitigation measures for night-time protection (2200 to 0600 hours). Within a defined night protection area,[87] passive noise mitigation measures have to be implemented in such a way that the maximum level of 52 dB(A) L_{Amax}[88] is achieved within the affected buildings or "rooms near the sleeper's ear". In all, around 17,500 residential units (about 40,000 people) in 14 places are covered by the noise mitigation programme, which has a total volume of about 76 million euros and a duration of 5 years.

To finance the noise mitigation programme, specific noise charges have been levied since 1. November 2002 at Frankfurt airport. These charges, designated "noise surcharge" and "noise-mitigation charge", are divided into a variable surcharge (0.50 euro per passenger on board at take-off and 0.25 euro per commenced 100kg of cargo on board per departure) and a fixed surcharge. The fixed surcharge is levied for each flight depending on noise category (analogous to the noise categories of noise-related LTO charges) and time of day (day/night). For noise category 5 – a B 747-200 for instance – a fee of 67.50 euros is payable for each take-off and landing at night (2200 to 0559 hours) in addition to landing charges; for noise category 4 (a B 747-400, for instance) the fee is 55 euros. The incentive effect of specific noise charges for the operation of quieter aircraft (for example, the substitution of a B 747-200 with a B 747-400), viewed in isolation, is therefore to be regarded as negligible.

If one compares the incentive effect resulting from noise mitigation charges with that of noise-related LTO charges, specific noise charges only play a role when the cost savings or additional costs of noise-related LTO charges are of a marginal nature (see Figure 10).

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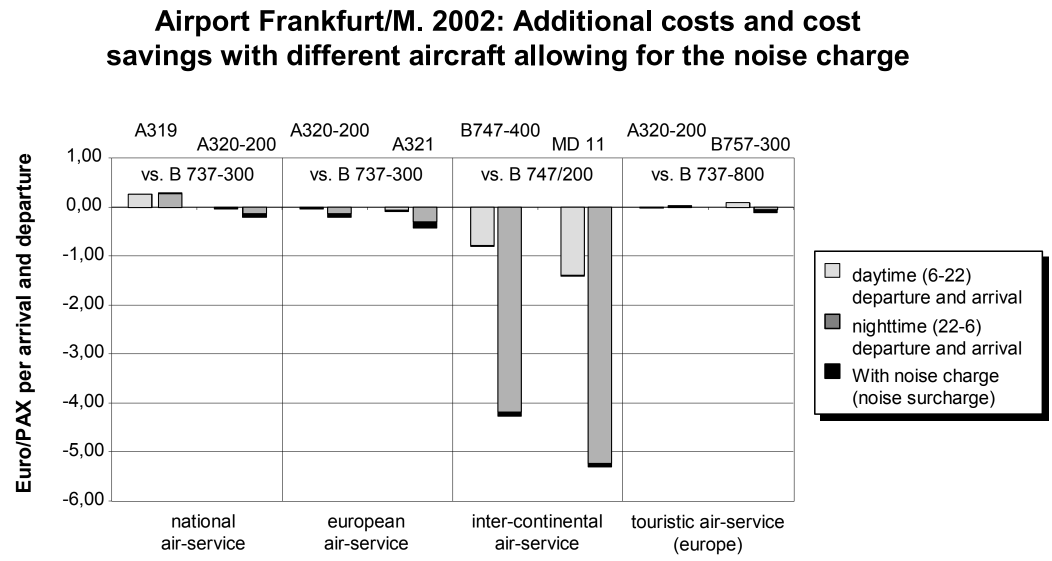
87 Area demarcation occurs on the basis of wraps around isophones 6x75 dB(A) L_{Amax} and 55 dB(A) $L_{eq(3)}$ (calculated according to the draft AzB with 100/100 rule and 150 flight movements in the period from 22.00 to 06.00 hours).

88 The maximum level applies near the "sleeper's ear" and may "not regularly" be exceeded.

Figure 10 Additional costs and savings from a modified choice of aircraft allowing for the LTO charges and noise mitigation charge at Frankfurt airport in the year 2002



Notes: Additional costs and cost savings include both LTO charges (Including noise charge) and charges for financing a passive noise abatement program (noise surcharge).

4.1.3 European airports

4.1.3.1 Structure of investigated LTO charging systems

In Table 5, the main structural components of noise-related LTO charging systems at international airports are summarized once again. The main element of the calculation formula is

(noise-related) basic fee (in euros) +
mass-related fee (in euros/t) x MTOM

Besides the addition of a noise charge, which is calculated in different ways depending on the airport (internal calculation formula, percentage surcharge and rebate etc.), so-called multipliers are applied (for example, in Paris and Brussels), which in the end correspond to a percentage surcharge or rebate on LTO charges. The only exception is London, where differentiated basic charges are applied depending on noise and weight categories, time of day and year (see Table 5).

Attention is drawn at this point to the calculation formula for the noise-related share of LTO charges. The calculation formula applied in Stockholm is very similar to the proposed directive of the European Parliament and the Council on the establishment of a Community framework for noise classification of civil subsonic aircraft for the purposes of calculating noise charges (EU 2001).

Many foreign airports have introduced their own noise categories as a basis for assessment. Only Zurich allocates aircraft to newly-defined noise categories on the basis of measurements at the airport.[89]

The object of assessment is

- landing only at London, Milan and Stockholm,
- landing and take-off at Amsterdam, Paris and Brussels, and
- landing at Zurich (with noise charges, take-off at night is separately accounted for).

[89] The classification of aircraft in noise categories at Frankfurt Airport is based on the Zurich procedure.

Table 5 Summary of noise-related take-off and landing charging systems in use at international airports in 2002

	LTO charges depending on				
	ICAO noise categories	**new noise categories**	**Day/ Night**	**MTOM[1]**	**Other**
Basic fee					
▪ London (LHR, LGW, STD)	X	x	x	x	own Chapter subdivision, time of year
[Basic fee + (fee rate x MTOM)] x fixed factor					
▪ Paris CDG and Orly					
- basic fee/fee rate				x	
- fixed factor		x	x		
Fee rate x MTOM x environmental factor x time-of-day factor					
▪ Brussels					
- fee rate in €/t				x	
- environmental factor		x			
- time-of-day			x		
Basic fee + fee rate x MTOM + noise charge					
▪ Zurich					
- basic fee / fee rate				x	
- noise charge		x	x		
▪ Stockholm					
- basic fee/ fee rate				x	
- noise charge		x			
Basic fee + fee rate x MTOM: subsequent percentage surcharge / rebate depending on noise categories					
▪ Amsterdam					Place of handling, cargo
- basic fee / fee rate			x		
- percentage surcharge/rebate		x			
▪ Milan					
- basic fee / fee rate					
- percentage surcharge	x				
▪ Seoul (without basic fee)					
- fee rate					
- percentage surcharge	x				

[1] All fee rates that have to be multiplied by MTOM are per se dependent on MTOM. The dependence displayed relates to the fact that the fee rate itself is again differentiated according to MTOM groups.

4.1.3.2 Comparison of the incentive effects of noise-related LTO charging systems

The comparison of noise-related LTO charges at international airports focuses solely on inter-continental passenger services. Besides LTO charges, specific noise charges are also considered (see Amsterdam, Paris and Frankfurt) in so far as their imposition is dependent on aircraft noise emission. In the following figures (Figure 11 to Figure 13), LTO charges are displayed both with and without specific noise charges (in Amsterdam and Paris as a noise charge, in Frankfurt as noise surcharge). Specific noise charges, which are independent of aircraft type and thus noise emission and therefore levied on the basis of passengers on board (Zurich and Frankfurt), are displayed for the sake of completeness in Figure 11 together with passenger charges. This kind of specific noise charge, however, has no control effect whatsoever. Analogous to special noise charges, for Stockholm and Zurich LTO charges are displayed with and without the emission charges that are levied at these airports.

In the following Figures, based on a Boeing 747-200, savings and additional costs are displayed for a Boeing 747-400 and a MD 11 for the selected international airports and also, for the purpose of comparison, for Frankfurt and Munich airports. For London-Heathrow (LHR) and London-Gatwick (LGW) LTO charges are separately displayed for peak and off-peak during the day. At night, the highest rate for LHR (1.5 x peak) is applied (indicated in the following Figures as LHR peak), and for LGW the off-peak rate that applies throughout the night. The following Figures therefore contain no off-peak rates at night for LHR and no peak rates at night for LGW (since in each case there are none).

In Figure 11, LTO charges as well as passenger charges are shown for the airports described in Section 4.1.3.1 in respect of a Boeing 747-200 with 311 passengers. At this point, attention is again drawn to the fact that comparison of charges between airports in absolute terms serves no purpose due to differing demarcation criteria (see Section 4.1.1) (ACI 2002). It is nevertheless apparent that airports in London, in particular, have such a low starting level for LTO charges that potential savings are limited due to the level of such charges in absolute terms.

In the lower part of Figure 11, LTO charges during the day and at night are compared. The greatest difference between day and night is demonstrated by Zurich, which also clearly exceeds the incentive effect at Frankfurt and Munich. It has to be borne in mind, however, that in the period between midnight and 06.00 hours there is a ban on night flights (delayed flights being exempted) in Zurich (Öko-Institut 2003). In comparison to other investigated airports, both German airports are therefore among the leaders. Airports without day/night differentiation are the Paris airports and Stockholm.

In Figure 12 and Figure 13, savings and additional costs are displayed at international airports with the operation of a Boeing 747-400 or MD 11 instead of a Boeing 747-200. Here, analogous to German airports, a distinction is made between day and night hours (in accordance with local definitions) as well as between absolute and specific changes (in euros or euros/passenger). With the exception of Amsterdam, Milan and

Stockholm (in the case of a B 747-400), savings, in absolute terms, arise with the use of both modern alternative aircraft; however, savings are in part very low (in particular for the London airports). In Amsterdam, Milan and Stockholm the higher MTOM-based component of charges compensates for the noise-related share due to the greater mass of the B 747-400.

With specific values, higher costs arise in the case of some of the investigated airports (for example, Brussels, London and Stockholm) with operation of the MD 11, partly as a result of reduced seating capacity. The incentive effect at both German airports is, compared to other airports, among the greatest; at night savings are only exceeded at Zurich. The night-time rates of 4 to 7 euros per passenger and turnaround are well above the leading group of the remaining international airports (around 1-2 euros per passenger; at Zurich around 7 euros per passenger). The comparison with German airports clearly shows that the incentive effect of the use of modern, quieter alternative aircraft at international airports, with the exception of Zurich, has to be regarded as negligible.

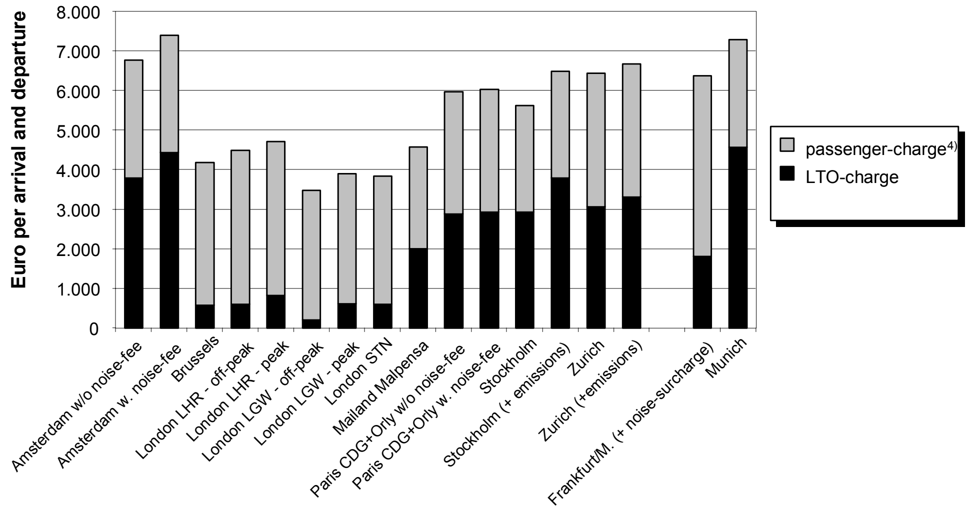
Specific noise charges, which are covered within the framework of this evaluation, have a recognizable additional control effect only in the case of Amsterdam. As a rule, the additional incentive effect associated with specific noise charges can be ignored (see, for example Paris).

Figure 11 LTO charges at international airports 2002:
Boeing 747-200 in inter-continental passenger service

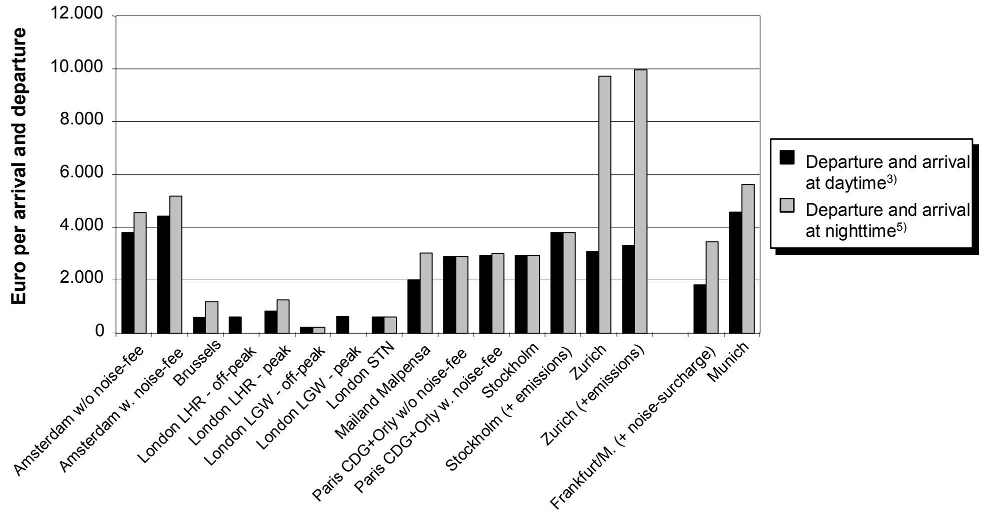
Airport charges[1] at European airports 2002

*– B747-200 scheduled passage inter-continental :
378 t MTOM, 311 passengers[2] –*

LTO charges (including noise charge) and passenger charges for one landing and one departure during the day[3] – in Euro



Comparison LTO charges (including noise charge) for one landing and one departure during[3] the day and at night[5], respectively – in Euro



Notes: [1] Without parking and positions charges. – [2] 80 % workload; 20 % transit-/transfer-passengers. – [3] In Amsterdam and Brussels: 6:00-23:00; Paris: 6:00-23:30; Milan, Zurich: 6:00-22:00; Stockholm, London STN: no day-night-differences; London LHR and LGW: behold text. - [4] Frankfurt/M. and Zurich inkl. noise surcharge. – [5] In Amsterdam and Brussels: 23:00-6:00; Paris: 23:30-6:00; Milan: 22:00-6:00; Zurich: 0:00-5:30; Stockholm, London STN: no day-night-differences; London LHR and LGW: behold text.

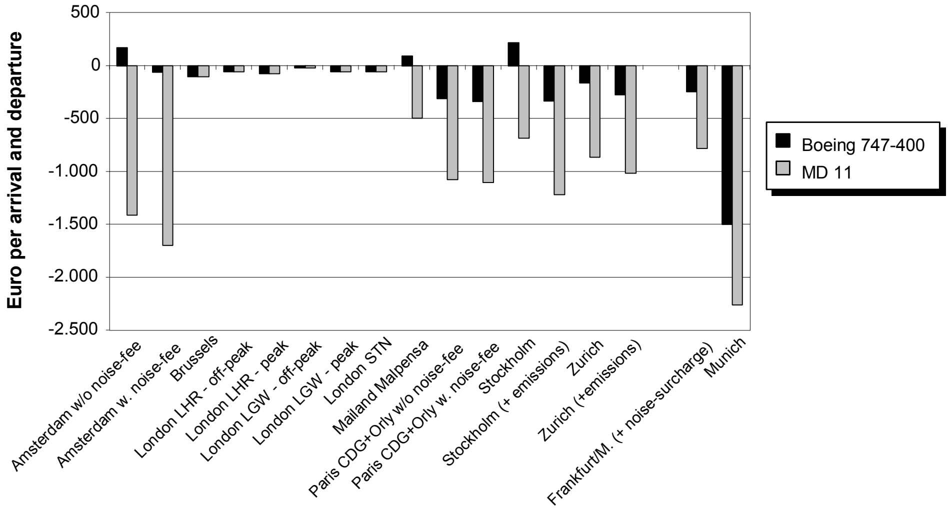
Figure 12 LTO charges at international airports 2002: comparison of B 747-400 and MD 11 with B 747-200 in inter-continental passenger service during the day

LTO charges1) at European airports 2002: Additional costs and cost savings with different aircraft

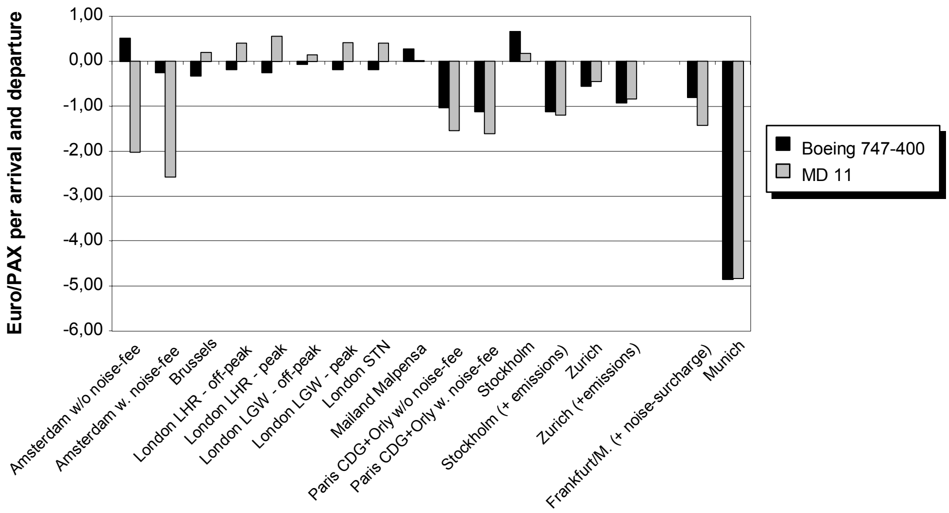
– Departure and landing during the day2), inter-continental passage –

Comparison Boeing 747-400 and MD 11 with Boeing 747-200 (Chapter 3)3)

A) Absolute difference one landing and one departure based on B 747-200

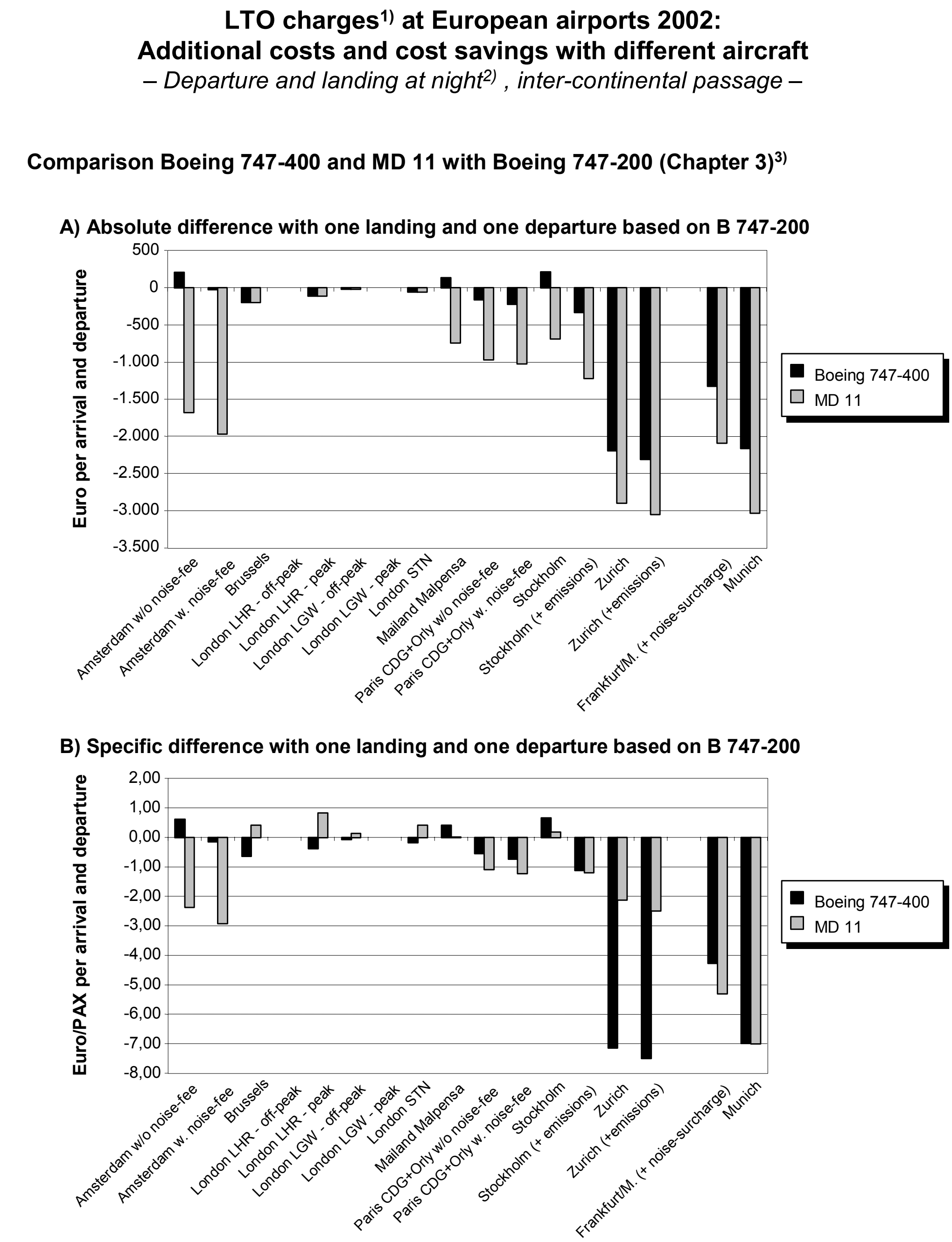


B) Specific difference one landing and one departure based on B 747-200



Notes: 1) Including noise-charge. – 2) In Amsterdam and Brussels: 6:00-23:00; Paris: 6:00-23:30; Milan, Zurich: 6:00-22:00; Stockholm, London STN: no day-night-differences; London LHR and LGW: behold text. – 3) Boeing 747-400: 395 t MTOM, 312 passengers; MD 11: 286 t MTOM, 234 passengers; Boeing 747-200: 378 t MTOM, 311 passengers; assumption: 80 % work-load; 20 % transit-/transfer-passengers.

Figure 13 LTO charges at international airports 2002: comparison of B 747-400 and MD 11 with B 747-200 in inter-continental passenger service at night



Notes: 1) Including noise charge. – 2) In Amsterdam and Brussels: 23:00-6:00; Paris: 23:30-6:00; Milan: 22:00-6:00; Zurich: 0:00-5:30; Stockholm, London STN: no day-night-differences; London LHR and LGW: behold text. – 3) Boeing 747-400: 395 t MTOM, 312 passengers; MD 11: 286 t MTOM, 234 passengers; Boeing 747-200: 378 t MTOM, 311 passengers; assumption: 80 % worklout; 20 % transit-/transfer-passengers.

4.2 Economic importance of LTO charging systems

4.2.1 Methodical comments

Aircraft-noise-related LTO charges are an important economic instrument of control in air transport that has been tested over many years. They are intended, as already mentioned, to set incentives to alleviate noise nuisance for the population residing around airports. The party involved is the respective airport, which attempts, through its charging policy, to exercise a direct influence on airline companies. The latter, to the extent that they are affected by appropriately designed charges, have a variety of response options (see below) at their disposal.[90] With such a charging policy, airlines will then ideally undertake action to reduce noise, as long as the cost of such action is less than the cost of non-avoidance (including the charges due). The "right" size of this kind of environmental levy is therefore of decisive importance.

In the air transport sector there are a number of parties that would be affected in a wide variety of ways by noise-related LTO charges, and interest in a strong noise-orientated charging policy is thus highly varied:

- Airports.
- Airlines as suppliers of passenger and cargo services.
- Population and business sector as users of passenger and cargo services.

It is the aim of *airports*, on the one hand, to achieve the highest possible earnings, and on the other hand, not to lose customers (passengers, cargo and airline companies) to other airports. The specific situation at Frankfurt airport shows, however, that it is important for general acceptance of flight operations to show consideration of the concerns of the population around airports. These interests are therefore in conflict. The incentives for an airport to introduce a strong, noise-related charging policy should increase to the extent that rival airports also make use of corresponding instruments.

So far as *airlines* are concerned, noise-related LTO charges of airports are part of their costs. Their reaction to increased LTO charges greatly depends on the extent to which a change in charges affects the cost structure of the airline company and thus, ultimately, its competitive position. The indirect *reactions of customers* are largely determined by the extent to which adversely affected airline companies are able to compensate increases in costs through internal measures (such as the use of quieter, more modern aircraft or by changing the time or location of flight movements) and whether they have to shoulder increases in costs onto passengers and cargo customers.

[90] Noise-reducing arrival and departure procedures as well as noise-reducing flight paths are further response options, but these are currently not being directly encouraged by noise-related LTO charges and have therefore been excluded from further considerations.

The size of charges in relation to other elements of costs is an important indicator for estimating the respective reactions of airline companies. The greater this ratio with airlines the greater the reactions to be expected, which can indirectly affect not only customers but also airports. The reaction of passengers and cargo customers, on the other hand, will be initially determined by the extent to which an increase in noise charges is added to ticket prices and cargo rates. Here it has to be borne in mind that long- and short-haul travellers as well as "low-cost" and "full-fare" travellers are just as variedly affected as private and business travellers.

The most important source of information for the analysis of the economic importance of LTO charges is the business reports of airports and airline companies; but they provide only sketchy information on the size and importance of landing charges. There is no separate item for "noise charges" or "noise-related LTO charges", largely because of their current marginal significance within the spectrum of costs and turnover of the respective companies. With airlines and airports, reporting and accounting practices as well as definitions and demarcations are highly varied, which considerably complicates comparability and "benchmarking". In many cases, only vague figures are provided or qualitative statements made with regard to the relative importance of noise-related LTO charges.

4.2.2 Airline companies

Significance of LTO charges for total costs

In 1997, Eurocontrol carried out a breakdown of costs on intra-EU routes of different airline companies (Eurocontrol 1999).[91] LTO charges accounted for a share of 6.6% in total direct and indirect operating costs of the airline companies. Here, with the exception of en-route charges, all kinds of charges are covered that are payable by airline companies to airports (see Table 6). Noise charges are not specified, but their share is likely to be negligible.

[91] See also www.aerocom-int.com/images/aircar4.jpg.

Table 6 Airline cost distribution on European routes, 1997

	Annual costs[1]	Share of total costs[1]
	In million €/year	*In %*
Airport charges[2]	***4,511***	***6.6***
En-route charges[3]	3,828	5.6
Ground handling	10,800	15.8
Personnel	8,271	12.1
Passenger service	5,468	8.0
Ticketing, sales, promotion	11,484	16.8
Overheads, administration	4,375	6.4
Fuel and oil	4,990	7.3
Leasing costs/depreciation[4]	8,476	12.4
Servicing, maintenance,	6,289	9.2
Total	**68,492**	**100.0**

[1] Average for ATC services – [2] (Noise-related) LTO charges, passenger charges, transfer passenger charges, security charges, aircraft parking charges, air-bridge charges, charges for terminal navigation as well as noise charges. – [3] Air traffic control. – [4] Aircraft costs.

Source: Eurocontrol 1999.

Table 7 Share of airport charges and ATC charges in the total costs of airlines on European routes, 2000

Airline	Airport charges[1]	Air traffic control charges[)]
	in %	*in %*
British Midland	15.9	5.0
Aer Lingus	11.9	3.9
Austrian	7.9	5.4
BA	7.1	4.1
Iberia	6.4	5.4
Finnair	5.8	5.0
SAS	5.4	4.5
Swissair	4.7	5.9
KLM	4.3	5.6
TAP	4.1	5.4
Lufthansa	4.1	6.3

[1] Airport charges. – [2] Navigation charges.

Source: AEA 2001.

The AEA has ascertained the share of airport charges and ATC charges in the total costs of different airlines in the year 2000 (see Table 8) (AEA (2001). The figures show a great difference between individual airlines: the corresponding shares lie between 15.9% (British Midland) and 4.1 % (Lufthansa). In the case of en-route charges differences are not so great, the corresponding shares ranging in 2000 between 3.9% (Aer Lingus) and 6.3 % (Lufthansa).

Table 8 Share of landing charges in the total operating costs of selected airlines, 2001

Airline	Operating costs	Charges	Share in operating costs	Explanation
Lufthansa *(in mill. euros)*	18,504	917	5.0%	airport charges[1)]
British Airways *(in mill. £)*	8,450	615	7.3%	landing and en-route charges
Air France *(in mill. euros)*	12,293	882	7.2%	landing charges and en-route charges
KLM *(in mill. Euros)*	6,626	524	7.9 %	landing and navigation charges
Finnair *(in mill. euros)*	1,667	122	7.3 %	traffic charges
Crossair *(in mill. CHF)*	1,668	59	3.5 %	LTO charges[2)]
Nortwest Airlines *(in mill. $)*	10,773	533	5.0 %	landing charges and other rents
Delta Airlines *(in mill. $)*	15,481	780	5.0 %	landing charges and other rents
Ryanair[3)] *(in mill. euros)*	461	85	18,4 %	airport charges and handling charges

[1)] Including LTO charges, passenger charges and noise charges. By comparison: ATC charges: 717 mill. €; handling charges: 738 mill. €. – [2)] Without ATC charges, handling charges and passenger charges. – [3)] Data for the financial year 2001/2002 (to 31.3.2002).

Sources: Airline business reports.

Research on different airlines by the authors of this report (reference year: 2001) – but for all routes of the airlines considered – confirms the results of the research presented above (see Table 8). Differing designations (such as "landing fees“, "traffic charges“, airport charges“) on the one hand, and varying demarcations (for example, in some cases with ATC and ground-handling charges) do not permit precise comparison. Furthermore, research allows the conclusion that LTO charges have a much greater effect on low cost carriers than on full-service carriers. This also applies to charter services, as the following figures for a German holiday airline prove: Variable costs per flight (direct route-costs) make up about 75% of total costs. Landing charges amount to 9% (LTO charges 2.25 %, passenger charges 6.75 %); handling charges (baggage, check-in) also total 9 % and ATC charges 7.5 %.

A structural investigation of operating costs was also carried out in respect of the largest US airlines for 2001 (see Table 9) (Heimlich 2003). LTO charges are considerably lower than in Europe, making up only 2.2% of total operating costs. In this connection, it has to be borne in mind – as already mentioned in Section 4.1.1 – that internationally important airports in the USA do not levy noise-related LTO charges.

Table 9 Breakdown of operating costs of the largest US airlines, 2001

Costs by category	Index	Share of operating costs
	(1982=100)	*%*
LTO charges	216	2.2
Personnel	206	36.6
Fuel	93	13.8
Aircraft depreciation	280	9.9
Other depreciation	244	5.1
Business services	2,902	8.2
Passenger service on board	81	2.0
Maintenance	107	1.8
Air traffic control ATC	79	0.2
Other insurance	585	1.0
Commissions	30	1.6
Communication/media	137	1.4
Advertising, promotion	39	0.7
Office material etc..	133	0.9
Other operating expenditure	169	14.5
Interest	55	insignificant
Total	**183.1**	**100.0**

Source: Heimlich 2003.

In summary it can be said that the costs of European and US airlines for the most part show a comparatively small share for LTO charges. These vary greatly, however, depending on the particular airline, the respective country of domicile as well as on the routes predominantly flown and destinations. Their share in total landing charges is, in any case, only marginal and under present conditions is unlikely to display a control effect.

Costs by kind

In comparison to full-service carriers (FSC), so-called low cost carriers (LCC) enjoy distinct economic advantages. According to Doganis (2002), specific seat/km operation costs of established full-service carriers exceed those of Ryanair by more than 100% (KLM is the exception; see Table 10). Various other studies (such Merrill Lynch 2002, Morgan Stanley 2002, Mc Kinsey 2002, Morrison & Co 2003, Kurth 2002) confirm these differences. Within the framework of analysis carried out by the Monitor Group, costs of 12 euro-cents per seat/km were determined for full-service carriers and 6 euro-cents per seat/km for LCC (Merrill Lynch 2002). Corresponding investigations have also been carried out for the USA: Southwest Airlines, the predominant low-cost carrier enjoys similar advantages compared with Delta, United and other full-service carriers.

Table 10 Specific operating costs on European routes (600-900 km) of various airlines, 2000

Airline	**Costs per seat/km** *in US cents*
Full-service carriers	
Air Lingus	15.07
SAS	13.86
Air France	12.85
BA	11.98
British Midland	11.58
Swissair	11.54
Alitalia	10.05
KLM	8.70
Low cost carriers	
Ryanair	5.04
easy jet	6.04
Source: Doganis 2002.	

An investigation by the European Cockpit Association (ECA 2002) came to the conclusion that low cost carriers have considerable advantages in almost all cost categories, which, as already mentioned (see Table), add up to cost savings of around 50%. The large cost advantages with respect to landing charges are conspicuous.[92] These charges are of greater relevance for LCC than for FSC, although in absolute terms they are well below those for full-service airlines. This has to do with the fact that the tertiary and quartic airports preferred by LCC have – as already shown in the case of Hahn in Section 4.1.2 – clear cost advantages with respect to fixed LTO charges. Moreover, certain airports appear to have concluded special arrangements with LCC on LTO charges, which investigations by the European Commission are currently trying to clarify. The regional airport of Charleroi, 70 km south of Brussels, is said to have concluded a contract with Ryanair, in which it is arranged, among other things, that Ryanair has to pay only 50% of landing charges (Berger 2003).

Irrespective of landing charges, LCC benefit from considerable savings – as displayed Table 11 – also in other areas. For instance, the personnel costs of LCC are on the whole lower and also much more flexible when there is a drop in demand. In addition, because LCC generally operate just one aircraft type, maintenance costs are lower. What is more, quick turnarounds and optimized marketing structures (Internet, telephone etc.) cut costs. FSC, on the other hand, have to fly their customers into large and, as a rule, expensive airports, have to offer a first-class service and, because of their hub status, have high-cost network standards (ECA 2002; McKinsey 2002, Kurth 2002).

92 See also www.eca-cockpit.com/LCC/f1.jpg.

Table 11 Advantages of low-cost carriers over full-service carriers

Cost category	Proportional savings in %	Cumulative savings in %
Closer seating	16	16
Higher A/C	3	19
Personnel costs	3	22
Cheaper airports /landing charges	6	28
Outsourcing of maintenance	2	30
Minimal handling/handling charges	10	40
No on-board service	6	46
No travel agent commissions	6	52
Reduced sales and reservation costs	3	55
Streamlined administration, fewer overheads	2	57

Source: ECA 2002.

Under otherwise unchanged conditions (same airports, same aircraft), noise charges and noise-related LTO charges (see definitions in Section 2.3) would more greatly affect low cost carriers than full service carriers; however, LCC generally operate a modern fleet, use airports with low charges and are considerably more flexible in their choice of routes and airports. Previous experience suggests that they could react much more flexibly to a stronger noise-orientated charging policy – in as much as they are affected at all by noise-related LTO charges at the airports they use. The picture would be different only if all airports were to impose cost-recovering charges and join forces with regard to a noise-orientated charging policy. Low-cost carriers would then only have limited alternatives. Because cost-saving potentials are mostly already exhausted, they would be more strongly affected than established full-service carriers, and would have to pass on almost all costs to passengers, who have much greater price elasticity than full-service carriers.

With *holiday and charter airlines*, cost structures are likely to be similar to those of LCC. At the same time, they cannot react as flexibly as LCC to a changed charging policy more strongly related to noise. They are more dependent on large hubs (feeders) and international airports. Because passengers of holiday airlines, like those of LCC, have great price elasticity[93], the airlines, however, much lower operational flexibility, it has to be assumed that under current conditions they would be far more affected than FSC and LCC.

Moreover, tougher competition between airlines as a result of over-capacity, greater price-sensitivity on the part of customers and the strong purchasing power of tour operators has already caused holiday airlines to extensively optimize their production

93 The strongest reactions to pricing policy measures in civil aviation (such as the introduction of a fuel tax or a pollutant-related emissions charge) are to be expected with holiday travel (to the countries of southern Europe) (TÜV/DIW/WI 2001).

costs. More far-reaching cost-savings are therefore limited. Apart from that, to reduce costs the number of daily turnarounds has, as a rule, been increased to such an extent that the first take-off and the last landing mostly occur at night (2200 to 0600 hours) (Jünemann 2001). Holiday and charter airlines are particularly affected by high LTO charges at night, since a change in the timing of flights is hardly possible. However, German holiday airlines already operate modern, less-noisy aircraft (for example, B 737-400/-800, B 757-200/-300; B 767-300, A 320-200), so that they should be able to keep possible additional costs at night within reasonable limits (Lufthansa 2002b; Hapag-Lloyd 2001; LTU 2000; Reuter 2003).

The information base concerning the cost structures of *air cargo carriers (ACC)* is negligible. According to a study for the year 1998, which deals with the operating costs of ACC (Johnson/Gaier 1998), significant differences exist compared to passenger airlines. There are no service costs, and the personnel costs of cargo airlines are much less because of the absence of crew and ground-handling staff. Insurance costs probably do not amount to much. On the other side, the average traditional cargo aircraft is significantly older than passenger aircraft. Typical cargo aircraft are, for example, the B 747-200 and the B 727 Hushkit (Jünemann 2001). This means higher maintenance costs, greater fuel consumption and, in particular, higher noise charges, in so much as they are imposed at a particular airport. Since cargo aircraft frequently fly in the evening or at night (night-haul, optimization of aircraft turnarounds), they have to pay high noise-related surcharges. These comments apply, in principle, also to *integrator services* (for example, DHL, FedEx or TNT).

According to an ICAO analysis, there were 11,636 passenger aircraft and 1,549 cargo aircraft in operation worldwide at the end of 1999 (Wickrama 2000). Both aircraft types were classified according to five different dB noise categories (see Table). It is obvious that cargo aircraft are much worse affected by a charging policy more strongly related to noise than aircraft operated in passenger services.

Table 12 Percentage of total aircraft worldwide for different noise categories, 1999

Noise categories	**Share of passenger aircraft fleet (Total: 11,636)**	**Share of cargo aircraft fleet (Total: 1,549)**
	in %	in %
Chapter 3	91	85
Chapter 3 minus 5 dB	78	36
Chapter 3 minus 8 dB	57	32
Chapter 3 minus 11 dB	47	27
Chapter 3 minus 14 dB	27	14

Source: Wickrama 2000.

Costs by flight distance

Relatively clear statements can be deduced from the consideration of costs for *different flight distances* (see Table)[94]. The shorter the route flown the higher the variable or direct operating costs. Classic cost units in this case, besides fuel, are airport charges, which, in the chosen example, differ by a factor of 3.

Where fixed costs (for example, depreciation or financing costs) and variable costs are related to so-called block-hours (the time from the closing of cabin doors before take-off to the opening of cabin doors after landing) or solely to airborne hours, variable costs for a specific route – in contrast to fixed costs – change only marginally.

Table 13 Costs of a long- and a short-haul flight

Cost by kind	**Short-haul flight**	**Long-haul flight**
	in %	*in %*
Charges	29	11
Capital	30	33
Insurance	1	1
Crew	12	20
Fuel	9	18
Maintenance	19	17
Total	***100***	***100***

Source: Mildt 2000.

In the following tables (see Table 14 and Table 15), typical direct operating costs of a small passenger aircraft on short and medium hauls and of a wide-bodied aircraft with extended flight range are displayed. With the short- and medium-range aircraft landing charges decrease with increasing distance from about 14% (500 km flight) to 3% (4,000 km). Landing charges in the case of the wide-bodied aircraft decrease proportionately from 6 % (4,000 km) to 2 % (13,000 km).

94 See also: www.ilr.tu-berlin.de/LB/fed/fed_sda/pdf/sa_mildt.pdf.

Table 14 Direct operating costs of a short- and medium-haul aircraft[1)] by flight distance

Distance in km	500	1,000	2,000	4,000
Operating time (hours per year)	3,481	3,456	3,779	4,424
Block hours	1.11	1.73	2.93	5.33
Flights/year	3,369	2,166	1,393	896
Fuel kg	2,126	3,443	6,119	11,865
	US $ per flight			
Personnel costs	290	684	1,607	3,781
Maintenance costs	778	1,021	1,481	2,398
En-route charges	224	359	629	1.167
Airport charges	530	530	530	530
Fuel	595	963	1,712	3,319
Flight operating costs	*2,417*	*3,556*	*5,958*	*11,195*
Insurance	91	141	220	342
Financing costs	1,381	2,149	3,341	5,193
Total direct operating costs	*3,889*	*5,846*	*9,519*	*16,731*
Fuel per passenger kg	14.18	22.95	40.79	79.10
	Shares in %			
Personnel costs	7.5	11.7	16.9	22.6
Maintenance costs	20.0	17.5	15.6	14.3
En-route charges	5.7	6.1	6.6	7.0
Airport charges	13.6	9.1	5.6	3.2
Fuel	15.3	16.5	18.0	19.8
Flight operating costs	*62.1*	*60.8*	*62.6*	*66.9*
Insurance	2.3	2.4	2.3	2.0
Financing costs	35.5	36.8	35.1	31.0
Total	**100.0**	**100.0**	**100.0**	**100.0**

[1)] Maximum capacity: 180 passengers, assumed load: 150 passengers.

Source: Boeing, Airbus, DIW calculations on the basis of varied references.

Table 15 Direct operating costs of a long-haul wide-bodied aircraft [1)] by flight distance

Distance in km	4,000	5,000	10,000	13,000
Operating time (hours per year)	4,178	3,905	5,482	5,674
Block hours	5.03	6.09	11.84	15.17
Flights/year	896	577	500	375
Fuel kg	34,992	43,830	91,278	125,741
		US $ per flight		
Personnel costs	4,610	6,337	19,997	36,160
Maintenance costs	5,538	6,210	11,257	14,004
En-route charges	2,494	3,080	6,099	7,897
Airport charges	2,632	2,632	2,632	2,632
Fuel	9,787	12,259	25,529	35,168
Flight operating costs	*25,061*	*30,517*	*65,514*	*95,861*
Insurance	1,136	1,227	2,038	2,342
Financing costs	17,012	18,357	30,497	35,057
Total direct operating costs	**43,209**	**50,101**	**98,049**	**133,261**
Fuel per passenger in kg	116.64	146.10	304.26	419.14
Personnel costs	10.7	12.6	20.4	27.1
Maintenance costs	12.8	12.4	11.5	10.5
En-route charges	5.8	6.1	6.2	5.9
Airport charges	6,1	5,3	2,7	2,0
Fuel	22.7	24.5	26.0	26.4
Flight operating costs	*58.0*	*60.9*	*66.8*	*71.9*
Insurance	2.6	2.4	2.1	1.8
Financing costs	39.4	36.6	31.1	26.3
Total	**100.0**	**100.0**	**100.0**	**100.0**

[1)] Maximum capacity: 380 passengers, assumed load: 300 passengers.

Source: Boeing, Airbus, DIW calculations on the basis of varied references.

From the cost structures presented in this section it can be concluded at this point that increased landing charges as a result of greater consideration of noise components will tend to have less effect on long-haul flights than on short- and medium-haul flights, due to greater consideration of noise components.

Response options to increased LTO charges

Airlines would be anxious, on the grounds of economic considerations and competition, to restrict the effects on passengers of increased noise-related LTO charges to a minimum; for instance by

- reducing all other operating costs,
- by increasing capacity utilization and seat load factor,
- through the purchase and operation of low-noise aircraft,
- by operational measures (flight management, improved routing),
- by the formation of strategic alliances,
- through optimization of the aircraft fleet with regard to the structure of charges at airports,
- by switching from costly to less-costly LTO times (for example, from the evening and at night to daytime),
- by switching to other airports (locational change)

Increased capacity utilization and the use of low-noise aircraft, for instance, can cut operating costs. Both measures reduce the production costs of airlines and thus also the potential increase in ticket prices, which would be expected from an increase in charging rates. The purchase and operation of less-noisy aircraft, bearing in mind the costs this would necessitate, must be unlikely. A new aircraft costs, according to size, from about 35 million euros upwards. Leasing charges would also be considerable, lying well above the higher LTO charges that might have to be paid. It is to be assumed that increased landing charges would be paid and airports switched, or an alternative optimization strategy pursued.

Here, response options on the part of specific airlines are decisive, such as

- flexibility in location and timing,
- profit situation and
- possibilities to cut or pass on costs.

Flexibility in location and timing (that is, switching flights to more economical times of day or airports) is likely to vary greatly between airlines. Large international airlines, which have established hubs in their countries of domicile and possibly also at reference airports, most likely have much less flexibility than smaller scheduled and charter airlines. Internal cost-cutting potentials must be lowest in the case of charter airlines.

Most airlines have tried hard in the past to cut costs as a result of increasing competition, and these efforts will continue, even if they will be limited. If air transport is made more expensive due to pricing policy measures, such as an increase in LTO charges, airlines will intensify such efforts in order not to lose customers. The potential exists, especially when one compares European passenger airliners with the cost structures of LCC or North-American airlines (see above).

4.2.3 Airports

Income from LTO charges

LTO charges are variedly applied by airports for financing and control purposes. Data published by airlines does not permit a detailed breakdown of fee income. Airport charging systems comprise a wide range of charges that are imposed in connection with the use of landing, apron, navigation, parking, security and fuelling facilities, as well as for the use of airport terminals and other facilities by aircraft, air passengers and cargo handling. The size of these charges varies greatly between airports. Aircraft mass, number of passengers, load mass, noise category, parking duration and other factors have a widely differing influence on airport charges, depending on the airport. The different factors influencing noise-related LTO charges and their effects have already been discussed in Section 4.1. Moreover, airport operating costs are often subsidized by rental income (shops, catering, duty free shops) and charges for other commercial activities, which are not directly connected to air transport (HG Verkehrsinfrastruktur Entgelte 1999). Airports are nowadays complex service enterprises that in some cases operate globally through subsidiaries or holding companies (see, for example, Fraport AG).

According to ADV data, around three-quarters of the total earnings of airports currently comes from fixed LTO charges and variable passenger charges (ADV 2003a). The share of these airport charges in the total earnings of German commercial airports shows a downward trend, falling between 1970 and 2001 from four-fifths to three-fifths (see Table 16). The emphasis shifted during this period in favour of variable passenger charges (see Table 16). As already discussed in Section 4.1, the result is risk minimization for airlines.[95] Only in 2001, when passenger revenue dropped strongly due to the terrorist attacks of September 11 and airlines had not yet adjusted their flight plans to demand, were fixed LTO charges higher than variable passenger charges (ADV 2003a).

95 Passenger charges only have to be paid for passengers on board, whereas fixed LTO charges are payable irrespective of passenger load.

Table 16 Development in earnings from LTO charges and passenger charges of German airports in the period from 1970 to 2001

	LTO charges (fixed component)		**Passenger charges (variable component)**		**Total**	
	Fee *in 1,000 €*	Share in total earnings *in %*	Charge *in 1,000 €*	Share in total earnings *in %*	Charges *in 1.000 €*	Share in total earnings *in %*
1970	70,633	33	19,599	9	90,232	42
1971	83,032	32	23,303	9	106,335	41
1972	93,968	30	27,263	9	121,231	39
1973	107,957	30	27,492	8	135,448	38
1974	115,560	29	30,430	8	145,990	37
1975	129,900	29	44,859	10	174,759	39
1976	151,588	29	52,459	10	204,046	39
1977	160,906	29	56,192	8	217,098	37
1978	171,412	28	61,464	10	232,876	38
1979	191,764	28	72,201	10	263,964	38
1980	194,232	26	71,221	10	265,453	36
1981	206,669	27	77,614	10	284,283	37
1982	201,411	23	78,141	9	279,552	32
1983	211,443	24	83,944	9	295,387	33
1984	225,987	24	92,912	10	318,899	34
1985	254,169	24	103,608	10	357,776	34
1986	278,068	23	109,342	9	387,410	32
1987	303,098	24	126,668	10	429,767	34
1988	335,733	24	139,253	10	474,986	34
1989	365,328	23	152,339	10	517,667	33
1990	416,019	23	170,491	9	586,511	32
1991	455,588	23	172,142	9	627,730	32
1992	506,702	23	197,189	9	703,891	32
1993	519,126	21	230,771	9	749,897	30
1994	532,188	20	279,945	11	812,132	31
1995	546,999	19	330,292	11	877,291	30
1996	543,783	19	365,224	12	909,007	31
1997	542,939	18	412,174	14	955,113	32
1998	470,172	15	448,163	14	918,335	29
1999	454,044	14	502,086	15	956,129	29
2000	471,828	13	560,491	16	1,032,320	29
2001	608,452	20	417,526	14	1,025,978	34

Source: ADV 2003a

A comparison of European airports shows a similar picture (see Table 27) (Odoni 2002).[96] With few exceptions, landing charges account for a share of about one-third. Handling charges and charges for the use of other services by passengers and airlines are of approximately the same order. Other earnings from rentals, leases and trade are now, with few exceptions, of a considerable size. In Frankfurt, earnings from non-

96 See also www.ardent.mit.edu/airports/ASP_current_lectures/Airport%20User%20Charges%202.pdf.

aeronautical areas already amounts to a share of two-fifths.[97] Further studies produce the same results (AEA 1998; Doganis et al. 1998.).

Table 17 Breakdown of earnings at a number of important European airports, 1999

	Aeronautical		Commercial		Other Earnings
	Aircraft[1)]	Handling[2)]	Trade	Other	
AENA (Spain)	60	3	10	21	6
Amsterdam	45		38	5	17
ANA (Portugal)	50		46		4
BAA (UK)	29		53	14	4
Dublin	17		39	27	17
Düsseldorf	35	33	24		8
Frankfurt	29	32	21		18
Hamburg	34	37	25		4
Copenhagen	46		51		3
Milan	25	49	18	3	5
Manchester	50	4	23	23	0
Munich	31	27	30		12
Paris	33	14	41		12
Rome	19	38	23		20
Vienna	33	38	17		12

[1)] LTO charges, passenger charges etc. – [2)] Aircraft handling, passenger and cargo services etc.
Source: Deutsche Bank 1999.

At the 30 largest airports in the United States, non-aeronautical earnings are of somewhat greater importance than in Europe (Odoni 2002). Airport charges make up only about one-fifth of total earnings (see Table 28).

Analyses show that, in the past, fixed LTO charges have declined in importance as a source of revenue for airports. At the same time, airports achieve ever-greater earnings through variable passenger charges and the non-aeronautical area. This applies both for German and foreign airports. However, the shift to variable passenger charges greatly restricts the possibility of using LTO charges to control the reduction of the adverse effects of noise and air pollutants at airports (DLR 2003).

97 By international comparison, Frankfurt has a lot of ground to make up in the non-aeronautical area. LTO charges will decline in importance as a classic form of income from flight operations in favour of non-aeronautical activities. At the highly competitive hubs of Amsterdam and London Heathrow, more than 50% of total earnings are achieved in the non-aeronautical area. Retail turnover per passenger is 9 euros at London, 3.50 euros at Copenhagen and 2 euros at Frankfurt. In this respect, Frankfurt has a considerable potential for improving its financial base and thus also its competitiveness (Chavanne 2002).

Table 18 Breakdown of earnings at the 30 largest US Airports by business activity

	Earnings	Share in the main areas	Share as a whole
	in million $	*in %*	*in %*
Aeronautical			
Airport charges	1,465	39.2	19.8
Airline buildings	1,741	46.6	23.5
Terminals / Apron	51	1.4	0.7
Fuel	70	1.9	0.9
Operating resources	160	4.3	2.2
Cargo	223	6.0	3.0
Sundries	30	0.8	0.4
All together	***3,740***	***100.0***	***50.6***
Non-aeronautical			
Rentals and leasing	267	7.3	3.6
Trade concessions	899	24.6	12.2
Car-park charges	1,184	32.4	16.0
Car rental	577	15.8	7.8
Catering	73	2.0	1.0
Interest	353	9.7	4.8
Sundries	300	8.2	4.1
All together	***3,653***	***100.0***	***49.4***
Total	**7,393**		**100.0**
Source: Odoni 2002.			

Competitive position of airports

The competitive position of airports is entirely different. Whereas small airports, such as Bremen, Hanover and Nuremberg, have a relatively small catchment area (that means, air passengers come mainly from the vicinity of the respective airport), international hubs such Frankfurt, Paris, London and Amsterdam have much larger catchment areas. It is to be expected that small airports could profit from a shift in traffic to other airports as a result of increased charges for loud aircraft. The situation is different, however, at the large hubs, which compete with each other. Charges are important in this connection, but other considerations very often play a more decisive role in airline decisions to fly into one or the other airport. These include

- the availability of slots,
- the number of direct connections,
- transfer times,
- capacity,
- time windows,
- night-flight restrictions,
- accessibility with land transport carriers.

With the isolated introduction of a LTO charging system, which imposes a heavy burden on loud aircraft, an airline switch to competing airports would be most likely. However, it always has to be borne in mind that at potential alternate airports appropriate slots have to be available.

A study by the Bavarian *Landesbank* established important competitive factors for Frankfurt airport – presented in Table – that are weighted proportionally regarding their importance (Horstmann 2003). According to the study, charging policy played an important but not the key role in decisions in favour of Frankfurt Airport.

Table 19	Factors of competition and their importance at Frankfurt airport.

Factor	Weighting
1. Location, position: population density, economic power	17.5 %
2. Size: hub of the most important national carrier; enormous handling capacity	17.5 %
3. Potential expansion of capacity: obstacles to development might call competitiveness into question	15.0 %
4: Quality of services: speed of transfer, delays, compliance with security standards	15.0 %
5. Customer quality: airport and airlines profit from each other's image	10.0 %
6. Diversification: Revenue mix is important, in order to compensate for fluctuations in earnings	10.0 %
7. Charging policy: charges that are excessive and not in line with the market could slow down expansion	7.5 %
8. Quality of staff: important for optimal operations and the functioning of operational procedures.	7.5 %
Source: Horstmann 2003.	

In a study by Cranfield University, commissioned by the Association of European Airlines (AEA), turnaround costs at European airports were compared for the period from 1.4.1997 to 31.3.1998 (see Table). Airport charges and ground-handling charges[98] were considered for three aircraft types (Boeing 737-400, Airbus 300-600 and Boeing 747-400). The analysis showed that in European comparison the hub airports of Frankfurt and Paris ranked among the airports with the highest turnaround costs. At Amsterdam and London Heathrow turnaround costs are much lower.

98 Turnaround costs are listed individually in Table 20.

Table 20 Turnaround costs[1)] (LTO) for three aircraft types at different European airports in the period from 1.4.1997 to 31.3.1998

	B 747-400		A 300-600		B 737-400	
	US $	Index: Ø=100	US $	Index: Ø=100	US $	Index: Ø=100
Vienna	18,850	145	9,952	152	5,123	144
Paris	16,223	125	7,682	118	4,342	122
Munich	16,097	124	9,339	143	4,173	118
Frankfurt	*15,672*	*120*	*8,482*	*130*	*4,394*	*124*
Zurich	14,230	109	6,740	103	3,740	105
Manchester	13,251	102	6,639	102	3,683	104
Amsterdam	13,215	101	6,906	106	3,749	106
Athens	13,016	100	7,446	114	4,047	114
Stockholm	12,879	99	6,522	100	3,371	95
Brussels	12,605	97	5,660	87	3,180	90
Copenhagen	12,397	95	6,313	97	3,822	108
Lisbon	11,775	90	7,184	110	4,076	115
Dublin	11,752	90	6,192	95	3,367	95
Madrid	11,739	90	5,906	90	3,020	85
London HR	11,342	87	6,533	100	4,056	114
London GW	9,511	73	5,029	77	2,789	79
Ø Europe	**13,029**	**100**	**6,533**	**100**	**3,548**	**100**

[1)] Included are airport charges (runway charge, passenger charge, transfer passenger charge, aircraft parking, air-bridge, terminal navigation, noise charges) and ground-handling charges (ramp handling package, passenger handling, special assistance, CIP lounge, bus, cleaning, ground power, push-back); without government levies and fuel costs.

Source: Doganis et al. 1998.

The international competitiveness of Frankfurt Airport has not suffered from these high charges. On the contrary, in the 1990s Frankfurt strengthened its position as an important European hub. Other factors are obviously more significant for the competitiveness of an airport.

A study by the Technical University (TU) Berlin[99] deals in depth with the intra- and inter-modal competition parameters of German airports (Beckers et al. 2003). Here, German airports are divided into *primary* (Frankfurt and Munich), *secondary* (Düsseldorf, Hamburg, Berlin and Stuttgart) and *tertiary airports* (Hanover, Dresden, Leipzig, Nuremberg etc.). The study comes to the following conclusions:

- There are very high legal and institutional barriers to market entrance by new primary airports that restrict potential competition. At the level of secondary and tertiary airports it is much easier for new entrants to set up business.
- The large hubs airports compete for transfer passengers at a European level. The number of competitors (Amsterdam, London-Heathrow, Paris CDG) of Frankfurt and Munich is relatively large. Dennis (1998) concludes that a

[99] See also www.wip.tu-berlin.de/de/index.htm.

traveller from Berlin to Los Angeles has a choice of eight hubs with different airlines. With secondary and tertiary airports, transfer passengers play a negligible role.

- Original traffic volume in the area around an airport is also important. The share of business travel is of particular relevance for primary and secondary airports. They therefore have much greater market power than tertiary airports, which, as a rule, are very much dependent on package tours and low-cost carriers, and are therefore exposed to stiff competition.
- Frankfurt and Düsseldorf airports have considerably enlarged their catchment areas through fast and direct rail connections, and as a result their competitive position is much better.
- In the case of large airports, inter-modal competition between air and ground transport is insignificant, but with tertiary airports it is comparatively great.
- In Frankfurt and Munich, Lufthansa has invested – irretrievably – a great amount of money in setting up networks, with the result that airports are in a strong position (for instance, in connection with charging policy) compared to this carrier, as well as compared to competing hubs in other countries; but to a limited extent they can be played off against each other – Frankfurt against Munich.
- Secondary airports are used by all European hub airlines and cannot be put under pressure by Lufthansa. Tertiary and, of late, also quartic airports are exposed to great competitive pressure because of their concentration on package travel and LCC. In the case of a charging policy at an increased level, these airports will have to reckon with considerable market pressure from package tour operators and LCC.
- Through a growing share of turnover in non-aeronautical areas, the market power of large airports is presumably not yet fully exhausted.

At a general level it has to be mentioned that competition among airports is becoming more intense. An active noise-related charging policy that drastically increases the level of noise charges, should have no noticeable adverse effects on Frankfurt because of its competitive position. With airports of second and third order, however, the situation would be different, since they have no market power compared to the airlines that use them and would be faced, should the occasion arise, with an exodus. The noise policy would probable be at the cost of earnings.

Simultaneous action on noise-related LTO charging systems on the part of as many airports as possible would have the best chance of ensuring that old noisy aircraft are retired and replaced by new aircraft. It is also not desirable for residents and communities at one airport to be relieved at the expense of residents and communities at competing airports. Beyond that, negative economic repercussions on individual airport operators can be clearly reduced through the simultaneous action of many airports. The pressure on aircraft manufacturers and airlines to develop or purchase and operate quieter aircraft grows as other airports follow the example of the pioneers.

4.2.4 Reaction of customers

Bearing in mind the matters discussed in previous sections (in particular in Section 4.1), practically no shifting of costs onto customers for aviation services is to be expected as a result of the current noise-charging policy.

Reactions would be conceivable only if noise charges were to be increased beyond normal status quo limits. Irrespective of legal obstacles, customer reactions would heavily depend on the extent to which the affected airlines could pass on their increased costs to customers. Not all pricing measures have a direct effect on demand.

If the intention were to use LTO charges as an effective means of reducing noise nuisance around airports, a fundamentally different charges structure and policy would be necessary. Related to Frankfurt airport, charging rates for all noise categories would have to be raised perceptibly. The order of magnitude involved is clearly indicated by the present traffic volume of around 50 million passengers and income from noise-related LTO charges of around 10-15 million euros (see Chapter 6). On average, a noise charge of 20 euro-cents is currently imposed on passengers (arriving, departing, transit and transfer passengers).

Even when aircraft of noise category 5 are used (the most unfavourable noise category for Chapter 3 aircraft), additional noise charges per person are low. In the case of a B 747-200 with an average passenger load (around 310 people), a noise surcharge of 7.5 euros would be payable for take-off and landing at night. Since it can be assumed that many business people with insignificant price elasticity use aircraft, it is obvious that these rates will trigger no reaction whatsoever from customers, neither on the part of airlines nor travellers. Assuming, at a theoretical level, that doubled charging rates were to be wholly passed on by airlines to their customers, an assumed ticket price of currently 500 euros would increase to 507.50 euros. No measurable reactions can be deduced from this example. Only in the case of low ticket prices of less than 50 euros, such as LCC offer, are marginal reactions conceivable. And here it has to be borne in mind that it is particularly LCC that operate more modern, low-noise aircraft, and that additional costs per person would be lower than with the example of a B 747-200.

4.3 Interim conclusion

The comparison of LTO charging systems, which was carried out at national and international airports in 2002, shows that noise-related LTO charges of airports in Frankfurt, Hamburg and Zurich – and to a certain degree also in Munich and Stuttgart – have purpose-related elements. Of particular relevance are:

- transparency of charging systems through clear differentiation of MTOM-related charges and separately shown noise components;

- greater orientation towards the polluter-pays principle through the separate registration of take-off and landing, higher pricing at night as well as greater differentiation of noise categories (compared to ICAO noise certification);
- consideration of the local noise-nuisance situation through, among other measures, the laying down of local noise-categories based on measurements at airports[100].

The spread of LTO charges between loud and quieter aircraft, and the intended incentive effect of encouraging the operation of less noisy aircraft, differ at the airports investigated. Basically, however, as far as the status quo is concerned the financial incentive per turnaround of up to 10 euros per passenger will, with few exceptions, be insufficient to bring about reactions on the part of airlines (for instance, the operation of quieter aircraft, or changing the timing or place of flight movements).[101] Analysis further shows that cost savings through the operation of quieter aircraft are often offset by the MTOM-related share of LTO charges. This has the result that alternative aircraft, which are less noisy but heavier, are on the whole more costly than louder and lighter aircraft.

That present noise-related LTO charging systems are hardly likely to have a control effect is confirmed by analysis of airline costs. The share of LTO charges in total airline costs is insignificant, amounting to just a few percentage points; noise charges, as a part of LTO charges, are therefore of only a marginal order.[102] Only in the case of short-haul flights, old and thus loud aircraft, as well as transportation segments with a high proportion of night flights (above all, cargo), can noise charges attain a perceptible order of magnitude.

Reactions on the part of airlines would only then to be expected were the noise component of LTO charges to be increased well beyond the limits in the status quo scenario. Since cost-saving potentials have already been extensively exploited by

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[100] These procedures take account of the fact that actual noise nuisance at a local level is not directly reflected in ICAO noise certification. Noise nuisance at an airport is dependent on a multitude of technical operational factors and local circumstances (including chosen arrival and departure procedures, actual topographical circumstances and weather conditions). Individual pricing on the basis of actually measured noise levels would have broader implications and be more strongly orientated towards the polluter-pays principle than the practice in Frankfurt, Hamburg or Zurich. In its draft Directive COM 2002/683, however, the EU Commission merely provides for consideration of certification values.

[101] Irrespective of the current status quo scenario, noise-related LTO charges in the past could well have encouraged the reaction of airlines. Noise-related LTO charges are regarded, for instance, apart from the legally prescribed phasing-out of Chapter 2 aircraft, as the main reason for the rapid increase in Chapter 3 aircraft at German airports (1990: 55.1% of commercial flight movements, 1995: 92.3%; 2002: 99.9 %) (ADV 2003; ADV 1997).

[102] That noise-related LTO charges represented in the past a discernible cost unit is shown by the example of British Airways (BA): BA had to make additional payments in its 1997/98 business year of around £10.7 million in respect of Chapter 2 aircraft, compared to Chapter 3 aircraft. Through the retirement of Chapter 2 aircraft and switching to less-costly airports, additional costs in the 1998/99 business year were cut to £3.1 million and in the following year to £1.6 million (BA 2001a).

airlines due to increasing competition in past years, only limited operational measures are still likely (for example, cutting other operating costs or increasing the seat load factor). Whether a substantial increase in noise charges would result in the purchase and operation of quieter aircraft or a change in the timing or place of flight movements, is, however, more than questionable. On the one hand, the response options of individual airlines strongly depend on their profit situation and their flexibility in terms of timing and location. On the other hand, part of additional costs can in all probability be passed on to customers without adverse reactions. Were noise charges for loud aircraft to be doubled, compared to the status quo scenario, the ticket price for an inter-continental flight per person and turnaround is likely to increase by less than 10 euros (related to a total ticket price of around 500 euros). Customer reactions, in particular on the part of business travellers, are therefore unlikely.

Even an isolated marked increase in noise charges should have barely noticeable adverse effects on hub airports such as Frankfurt, Paris, London or Amsterdam. In the case of secondary and tertiary airports, due to the market power of airlines, the situation is different. Here, an isolated increase in noise charges could lead to an exodus of airlines and thus to a drop in profits. To avoid such an adverse financial effect, harmonized action on the part of as many airports as possible should be striven for. Adverse economic repercussions for individual airport operators could this way be largely avoided.

5 Assessment of existing LTO charging systems

The aim of the assessment is the detailed investigation of the effectiveness of noise-related LTO charging systems with respect to the reduction of local noise levels. In supplementing status quo analysis, detailed assessment thus represents an essential basis for the development – in Chapter 7 – of guidelines for a practicable noise-related LTO charging system. Important procedures in this respect are

- the selection of airports (see Section 5.1) and
- the assessment of noise-related LTO charging systems (see Section 5.2)

The *assessment* of LTO charging systems is carried out with regard to

- operational effects and
- possible noise alleviation.

In the analysis of operational effects, traffic statistics of selected airports are investigated with regard to changes in aircraft fleet mix (for example, increased use of quieter aircraft) and time of operation (for example, switching flight movements from night-time to day-time). Within the framework of noise-related effect analysis, changes in measured and/or computed aircraft noise levels are examined at the airports under investigation. Whereas status quo analysis represents a momentary view of LTO charging systems currently applied in Germany and Europe (cross-sectional analysis), with effect analysis changes in traffic and noise in recent years are analysed (longitudinal analysis). This analysis centres on the identification of such effects as have resulted from fundamental changes in noise-related LTO charging systems.

A major difficulty in the assessment of charging systems lies in the fact that their intended effects of reductions in noise nuisance can frequently not be distinguished from the effects of other regulatory, technical and flight-operational measures. For this reason, interviews with experts (including airport operators) were carried out additionally, in order to allow greater differentiation and to avoid direct incorporation of measurable and ascertainable aspects (for example, acceptance) into the assessment.

Extensive and detailed bibliographical research has shown that very few scientific investigations of noise-related charges and virtually no assessments and effect analyses of airport charging systems are available. The investigated documents that have found their way into this report mainly describe the status quo of levies and charges at national and international airports at a particular point in time, and are restricted to the presentation and description of charging structures and levels (ACI 2002; de Wit/Cohn 1999; Doganis et al. 1998). These studies, with few exceptions (Fichert 1999; Morell/Lu 1999), do not focus on noise-related charges. For the following effect analysis, primary airport data was therefore first analysed and interpreted, and the results then evaluated and verified by means of interviews with experts and available literature.

5.1 Description of airports selected for detailed analysis

The selection of airports to be investigated was made after consulting the Federal Environmental Agency and is based, in the main, on the results of *status quo analysis* (see Chapter 4). Particular attention was paid to innovative noise-related charging systems as well as to the different functions of the selected airports (hub, airports with a large share of holiday or cargo traffic[103]). In addition, account was taken of the availability of data required for the description of the traffic and noise situation at the airports. The following airports were selected for further investigation:

- Frankfurt,
- Cologne/Bonn and
- Zurich.

These three aiports are briefly characterized below (see also Figure 11).

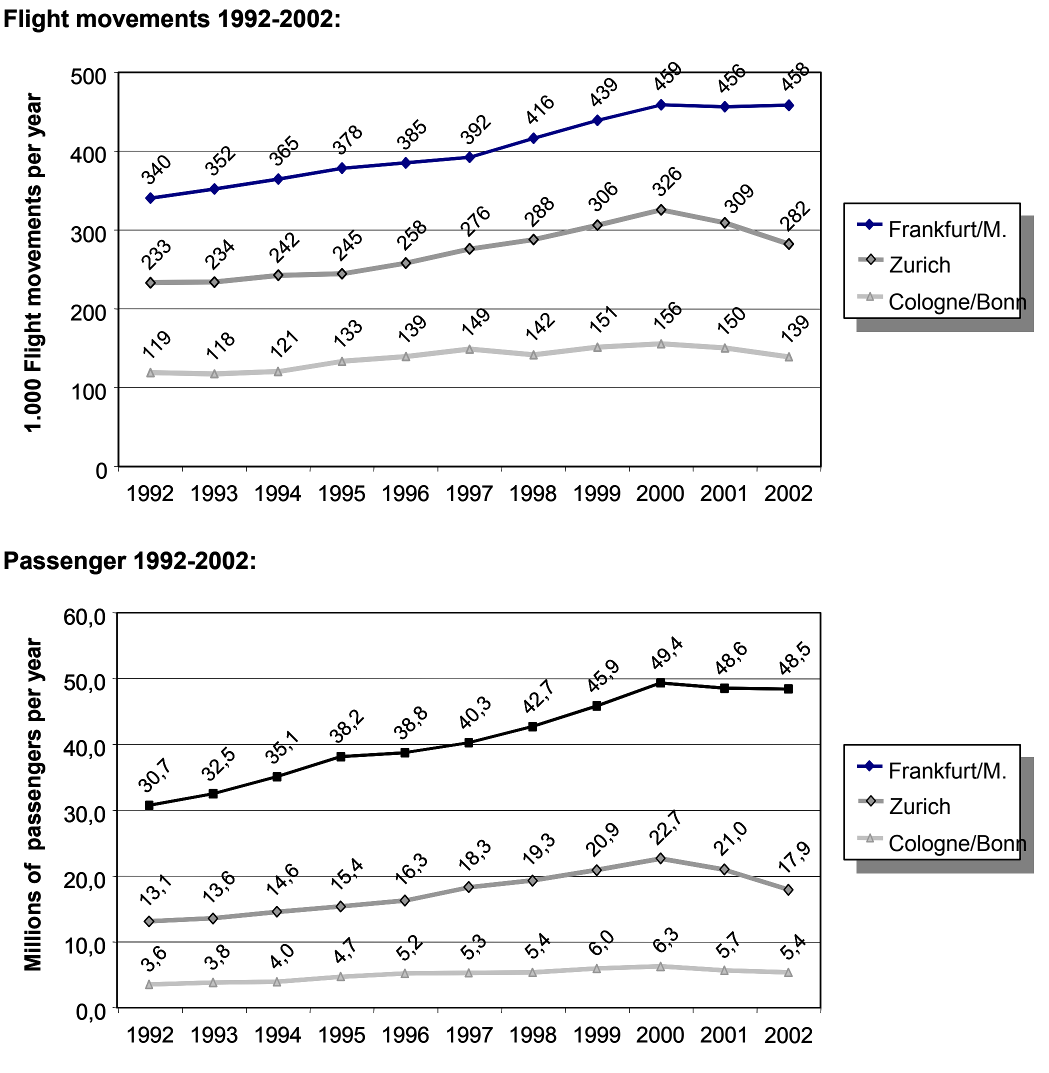
Frankfurt Airport

Frankfurt Airport is of outstanding importance in Germany as a national and international air transport hub not only with regard to the number of flight movements (2002: about one-quarter of all flight movements in Germany), but also in terms of passengers handled (2002: about one-third of all passengers in Germany). In international comparison, Frankfurt Airport also occupies a leading position.[104] (ACI 2002, Fraport 2003c).

[103] Due to these different functions, comparisons of airports within the scope of detailed analysis are not sound. This is also not the intention of detailed analysis, whose aim is rather – as already mentioned – the analysis of the effects, in terms of traffic and noise, of noise-related take-off and landing charging systems at each of the selected airports over a period of several years.

[104] In 2002, Frankfurt occupied in terms of passengers 2nd place in Europe and 7th place worldwide, in terms of cargo 1st place in Europe and 7th place worldwide and in terms of flight movements 3rd place in Europe and 17th place worldwide (see www.airports.org/traffic/history/traffic_main.htm).

Figure 11 Flight movements and passenger volume (total traffic incl. transit) at the selected airports from 1992 to 2002



Source: ADV 2002 Zürich Unique 2002.

Furthermore, a restructured charging system came into force at Frankfurt Airport on 1. January 2001, which is particularly distinguished by the classification of aircraft types occurs according to measured L_{AZ} values[105] and, compared with the former charging system, greater differentiation (see below). Frankfurt was selected for further investigation on account of its particular operational importance and the new structure of its charging system.

105 Single event sound level according to DIN 45 643 "measurement and assessment of aircraft noise"

Cologne/Bonn Airport

Cologne/Bonn Airport owes its importance – as well as its consideration within the scope of this study – to its large share of air cargo transportation (European hub of UPS and DHL), the large number of flight movements at night and the special structure of its charging system (key word: degressional value). This structure has the effect, among other things, that heavy aircraft are relatively better priced than small, light aircraft. Of the three airports selected, Cologne/Bonn has the lowest number of flight movements (around one-third of movements at Frankfurt) and the lowest number of passengers (11% of Frankfurt passenger figures, see Figure 11)

Zurich Airport

For international comparison the airport at Zurich-Kloten was selected, which lies, in terms of passengers handled and flight movements, between Cologne/Bonn and Frankfurt airports (see Figure 11). A special feature of Zurich Airport is its noise- and pollutant-emission-related charges, which have existed for several years. Noise charges have been levied at Zurich Airport since 1980, with gradual adjustments, especially in November 1993 and April 2000. The surcharge on pollutant emission has been levied since September 1997.

5.2 Analysis of the effects of existing charging systems

5.2.1 Frankfurt Airport

5.2.1.1 Detailed analysis of the charges structure

The basic structure of the LTO charging system that was introduced at Frankfurt airport on 1. February 2001 has already been described in Section 4.1.2. With the new charging system, in contrast to the former linear charging system, the following structural changes were made in the area of LTO charges:

- Charges previously imposed for landing are now levied separately for landing and take-off. This is intended to permit just allocation of night surcharges to individual flight movements.
- The mass-related (MTOM-dependent) share of charges remains, but is slightly reduced.
- The charging of noise and night / curfew surcharges according to MTOM and ICAO noise classification (ICAO Annex 16, Chapter 2 or 3) is replaced by the charging of fixed amounts per noise category; and this noise charge has to be paid in addition to the mass-related share of LTO charges.
- Aircraft are now assigned to seven noise categories on the basis of the noise level of each aircraft type as determined in measurements of aircraft noise carried out in 1999. The charging system is thus modelled on the Zurich system.

- Noise and night surcharges rise progressively from low-noise aircraft (noise category 1) to loud aircraft (noise category 7).

The declared objective of this new system of LTO charges is to impose a heavier burden on flights with loud aircraft, particularly at night (2200 to 0600 hours), compared to the charging system applied in the year 2000 (Rolshausen 2001). The charging system in force since 1 February 2002 has retained the structural changes and merely slightly increased charge rates. On 1 November 2002, Fraport AG – as already mentioned in Section 4.1.2 – introduced, in addition to LTO charges, a specific noise charge to finance a noise mitigation programme.

Figure 12 Modification of noise-related LTO charges (from 1.11.2002, including noise surcharge) for landing and take-off at Frankfurt airport

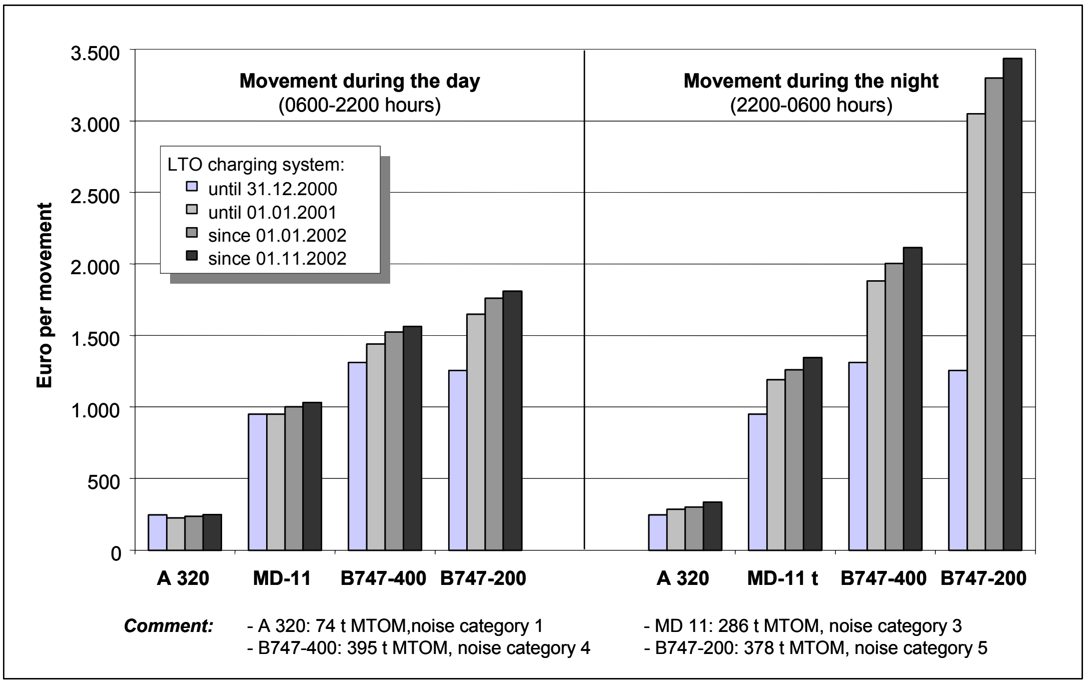


Figure 12 illustrates how LTO charges have changed for four exemplary aircraft types as a result of modifications made in the last few years. It is noticeable that the cost to loud aircraft of take-off and landing, particularly at night, has gone up considerably.

To what extent the new charges structure produces a control effect very much depends on the additional financial burden on airlines, and thus also on aircraft types that are particularly affected by the new charges. Table 21 displays the assignment of Chapter 3 aircraft to noise categories 1 to 5, as well as the noise charge payable at Frankfurt airport per noise category and flight movement. Due to the EU ban that came into force on 1. April 2002, Chapter 2 aircraft are not further considered. Since only Chapter 2 aircraft are assigned to noise categories 6 and 7, these two categories are not displayed in Table 21. Category 5, which has the highest noise surcharge (particularly at night), includes the Boeing 747-200, which is operated, among others, by Lufthansa Cargo and will be wholly replaced by the end of 2004 with the MD 11 (Lufthansa 2003; Jünemann 2001). Category 4 covers the Boeing 747-400, DC 10 and Boeing 727 Hushkits. Boeing 727 Hushkits are operated, among others, by DHL and Federal Express, and are currently being replaced with A 310F and B 757SF (FedEx 2000; DHL 2002; Deutsche Post 2003).

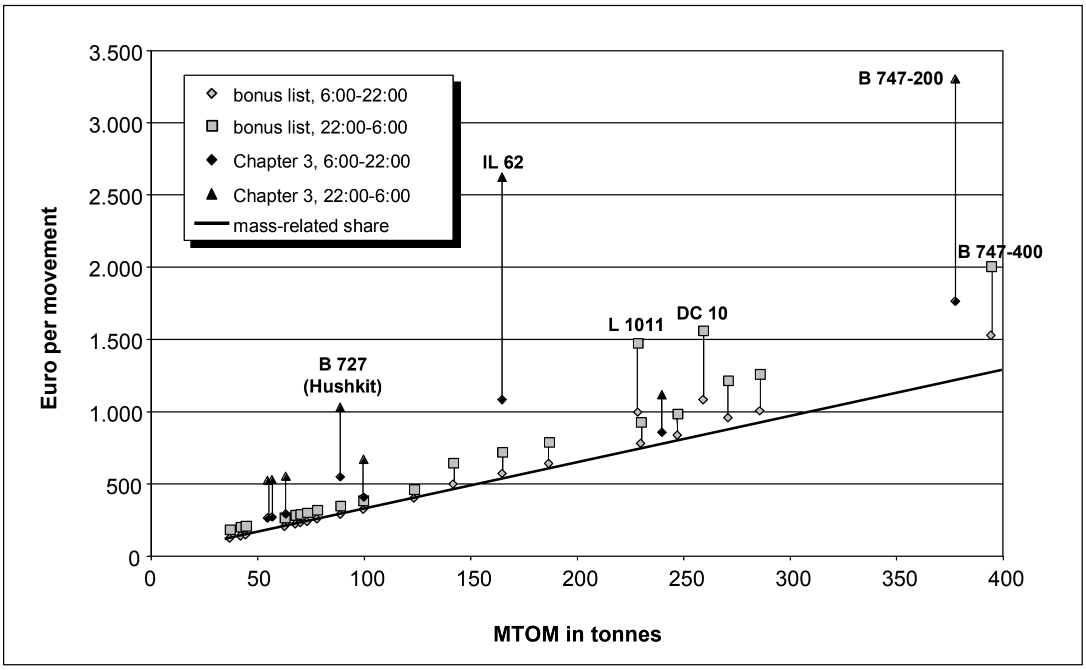
Table 21 Assignment of selected aircraft types (Chapter 3) to noise categories at Frankfurt Airport, 2002

Noise category/noise surcharge in € per movement	**Aircraft types**	
Category 1	all Chapter 3 jets < 34 t	Boeing B 737-300 to –900
- 0600 – 2200 hours: 0 €	all propeller-driven aircraft < 34 t	Boeing B 757
- 2200 – 0600 hours: 32,00 €	Airbus A 319	Fokker 70/100
	Airbus A 320/321	BAe146/Avro RJ
Category 2	Airbus A 300	Boeing B 737-200 Hushkit (Ch. 3)
- 0600 – 2200 hours: 20,00 €	Airbus A 310	Boeing B 767
- 2200 – 0600 hours: 95,00 €	Airbus A 330	Boeing B 777
	Boeing B 727 re-engined	
Category 3	Airbus A 340	McDonnell Douglas DC 8-70
- 0600 – 2200 hours: 42,50 €	Iljuschin IL 96	McDonnell Douglas DC 9 (Ch. 3)
- 2200 – 0600 hours: 172,50 €	Tupolev TU-154 (Chapter 3)	McDonnell Douglas MD 80 to 88
	YAK YK42/142	McDonnell-Douglas MD 11
Category 4	Boeing B 727 Hushkit (Chapter 3)	Tristar L1011
- 0600 – 2200 hours: 130,00 €	Boeing B 747-400/-S	
- 2200 – 0600 hours: 370,00 €	McDonnell-Douglas DC 10	
Category 5	Boeing 747-100/200/300 (Ch. 3)	
- 0600 – 2200 hours: 275,00 €	Iljuschin IL 62	
- 2200 –0600 hours:1045,00 €		
Source: Frankfurt Airport Charges (valid from 1. January 2002).		

For a better assessment of the effect of the new charging system, the most common aircraft types at Frankfurt (Chapter 3 aircraft) are displayed in Figure 13, with the MTOM of the aircraft plotted on the x-axis and the level of LTO charges on the y-axis. The level of fee is shown both during the day and at night.[106] Both charges are connected with a vertical line. In addition, "bones list" aircraft and Chapter 3 aircraft that do not fulfil "bonus list" criteria are specially marked. Furthermore, the share of the LTO fee that represents the mass-related charge (below the line) is marked with a black diagonal line.

106 In both cases, take-off and landing occur in the respective period of time.

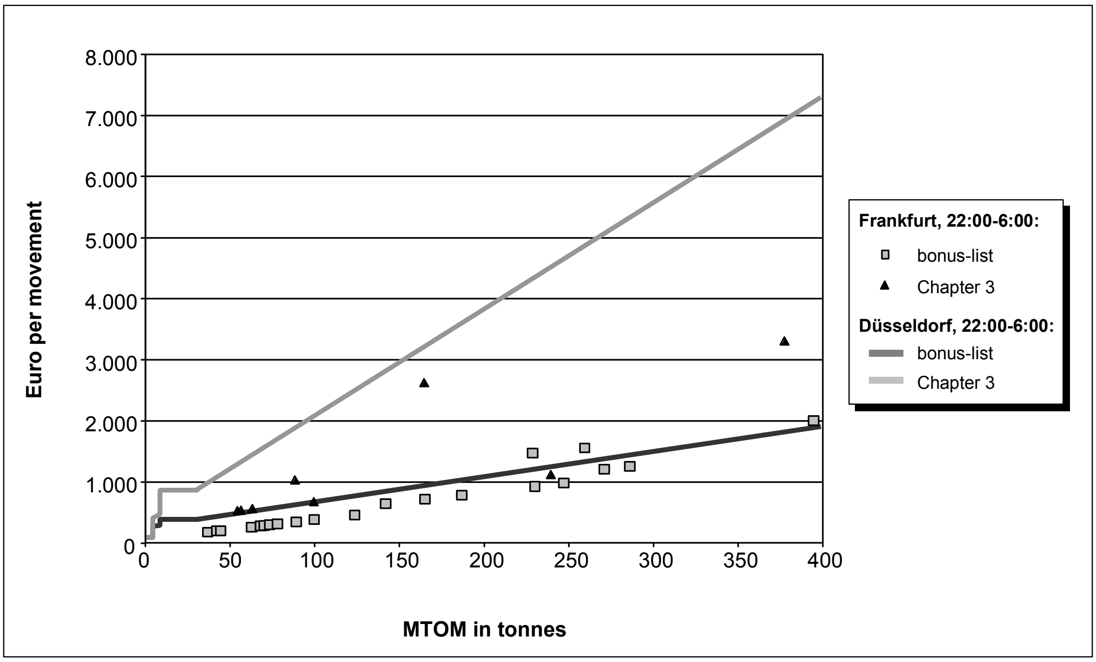
Figure 13 Allocation of LTO charges for the most common aircraft types at Frankfurt airport by MTOM, 2002



This presentation makes clear that with increasing MTOM, with few exceptions, the noise-dependent share is even less significant in relation to the total level of charges. It is also apparent that certain aircraft types are deliberately charged a high price under the new system, especially at night. This concerns, in particular, the B 747-200, IL 62 and B 727 Hushkit as well as the bonus list aircraft L 1011 and DC 10.

In Figure 14, all allocations of LTO charges for flight movements at night of the most common aircraft types at Frankfurt Airport by MTOM have been adopted from Figure 13; in addition, linear landing charges for Düsseldorf airport are marked for bonus list and Chapter 3 aircraft. This comparison puts the price spread introduced at Frankfurt into perspective. Had comparable standards been applied, the rise in charges could have been much greater, at least for the B 747-200. With this comparison it has to be borne in mind, however, that the profit margins of airlines at individual airports can vary greatly; therefore no statement on the control effect can be deduced solely from the level of charges. In other words, LTO charges of 3,300 euros for a B 747-200 at Frankfurt might greatly reduce airline profit margins, whereas charges of 7,000 euros at Düsseldorf might have no noticeable effect on profits.

Figure 14 Comparison of the charges structure at Frankfurt and Düsseldorf airports for flight movements at night (2200 – 0600 hours) in 2002



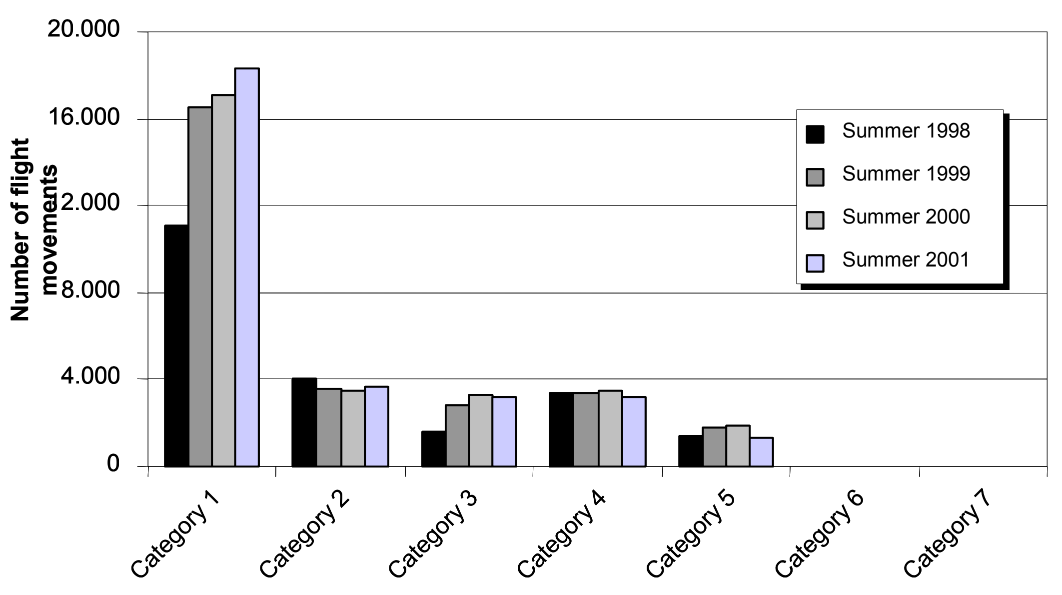
Referring to the above analysis, it can be said that the new charging system has led, in particular, to an increase in the noise charge for selected loud aircraft (for example, B 727 Hushkit, B 747-200). These are the aircraft that time and again in the past have been the cause of complaints at night by local residents. Comparison with other German airports (for example, Düsseldorf, Hamburg) also shows, however (see Section 4.1), that these aircraft types are partly charged higher rates than at Frankfurt. Nevertheless, a number of airlines that operate these aircraft (Federal Express, DHL and Lufthansa Cargo) have decided in recent years to purchase quieter aircraft. To what extent higher charges for loud aircraft in Frankfurt have accelerated this process of fleet replacement will be examined in detailed in the following chapter.

5.2.1.2 Operational effects

In order to examine in detail the effects on aircraft fleet modernization of the noise-related system of LTO charges that has been completely restructured since 1. January 2001, an investigation was carried out of the relative distribution of flight movements over the seven noise categories at Frankfurt Airport as well as of changes in the aircraft fleet mix.

Figure 15 displays, for summer flight plans for the years 1998 to 2001, the distribution of flight movements (excluding military flights) in the period from 2200 to 0559 hours over the seven noise categories. Data for the year 2002 is not presently available. The presentation shows that during the night noise categories 6 and 7 are insignificant for civil flights. In noise category 5 there was a decline in flight movements in 2001, which still lie, in absolute terms, above the level of 1998. The decline is attributable, on the one hand, to replacement of aircraft type B 747-200 with the MD 11 by Lufthansa Cargo. On the other hand, this development has to do with the greatly reduced night services of Lufthansa Cargo as a result of the present economic situation. In the case of noise category 4, which includes the aircraft type B 727 operated by integrator services, there were no noticeable changes in the period under investigation.

Figure 15 Distribution of flight movements at Frankfurt airport over the 7 noise categories in the night-hours (2200 – 0600 hours) of the summer flight plan, 1998 to 2001



Source: Fraport, Calculations by Öko-Institute

It has further to be considered that already today 60% of aircraft are assigned to noise category 1. Here, further differentiation would be useful and necessary. It is also important to mention that even *without* the new charges, which only came into force on 1. January 2001, a shift in aircraft fleet mix had already taken place, in particular towards noise category 1. This suggests, on the one hand, that the incentive for fleet replacement occurred without a corresponding system of charges, and, on the other hand, that the new charges structure led to considerable windfall gains (aircraft of noise category 1 pay only 32 euros per take-off or landing at night).

Table 22 Development of flight movements at Frankfurt Airport of selected aircraft types in the period 2000 to 2002

Aircraft type	Noise category	2000	2001	2002	Δ 2001 compared to 2000	Δ 2001 compared to 2000
		Number	*Number*	*Number*	*%*	*%*
Airbus A 300	Cat. 2	22,956	26,887	20,783	+17	-23
Airbus A 310	Cat. 2	14,167	13,426	10,330	-5	-23
Airbus A 330	Cat. 2	3,090	4,140	4,766	+34	+15
Boeing B 767	Cat. 2	15,364	11,782	12,494	-23	+6
Boeing B 777	Cat. 2	4,594	4,628	5,428	+1	+17
Airbus A 340	Cat. 3	14,607	17,603	18,185	+21	+3
DC9/MD80/87/90	Cat. 1: MD90; Cat. 3: MD80-88; DC 9 Cat. 4: DC 9 (Chap. 2)	15,441	15,000	12,377	-3	-17
MD 11	Cat. 3	7,455	7,602	6,595	+2	-13
Iljushin IL 86/96	Cat. 3: IL 96 Cat. 6: IL 86 (Chap. 2)	178	130	44	-27	-66
Tupolev TU-154	Cat. 3: Chapter 3 Cat. 5: Chapter 2	1,476	1,746	2,310	+18	+32
YAK YK42	Cat. 3	1,260	1,168	1,146	-7	-2
Boeing B 727	Cat. 4: Hush-Kit; Cat. 2: re-engined	2,016	1,186	1,428	-41	+20
Boeing B 747	Cat. 4: B 747-400/-s Cat. 5: B 747-100/ -200/-300	34,101	34,061	32,245	0	-5
DC 10	Cat. 4	1,399	1,326	1,644	-5	24
Tristar L1011	Cat. 4	628	234	494	-63	111
Subtotal of flight movements of above-mentioned aircraft types		***138,732***	***140,919***	***130,269***	**+2**	**-8**
Total of all flight movements		**458,731**	**456,452**	**458,359**		
Source: Fraport AG 2002; Frankfurt Airport Charges (valid from 1. January 2002).						

An analysis of flight movements at Frankfurt Airport for the period from 2000 to 2002, differentiated according to aircraft type, suggests that the new LTO charging system has only partly caused airlines to scrap loud aircraft or to switch them to other airports (see Table 22). A decline in some loud aircraft was recorded in 2001, compared to 2001, but this was compensated for, either wholly or in part (for example, B 727, DC 10, L-1011), in the following year. For certain aircraft (for example, TU-154), a continuous increase in flight movements was recorded. In the case of aircraft for which a continuous decline was recorded, it must be presumed that factors other than noise charges are responsible (for instance, for the IL 86/96 the EU ban on Chapter 2 aircraft; or for the DC9/MD80/87/90 group a normal process of fleet replacement).

Evaluation of the operational effects of noise-related LTO charges at Frankfurt airport shows that

- the potential effect of the charging system is overlapped to such an extent by "normal" aircraft fleet modernization that scientific estimates are not feasible;
- the effect of the charging system can contribute to the modernization process; and
- that due to the large proportion of aircraft in noise category 1, a greater control effect would require further differentiation of this category.

5.2.1.3 Noise-related effects

Operational developments and the resultant noise levels or noise alleviation are not clearly reflected in the results of aircraft noise monitoring at Frankfurt Airport, which produce a differentiated picture. While in the long term, since 1980, the computed size of footprints has clearly fallen (see Table 23), and the values of the equivalent continuous sound levels $L_{eq(4)}$ have decreased, or remain constant (see Table 24), continuous sound levels for the period 1998 to 2002 at different measuring points of the Fraport noise monitoring system also partly show changes for the worse.

Table 23 displays the respective area of footprints enclosed by the equivalent continuous sound levels ($L_{eq(4)}$) 62 dB(A), 67 dB(A) and 75 dB(A). Improvements in the size of footprints provide an indication of developments in the whole area around the airport over the past twenty years and are attributable, above all, to the technical progress of individual aircraft, the number of flight movements having doubled in this period.

Table 23 Aircraft noise levels at Frankfurt Airport in terms of footprint size[1)]

$L_{eq(4)}$ dB(A)	1980	1987	1995	1999	Changes 1999 to 1980
	in km²	*in km²*	*in km²*	*in km²*	*in %*
> 62	131	122	73	69	- 53 %
> 67	59	53	32	29	- 49 %
> 75	15	13	8	8	- 53 %

[1)] Footprint area as $L_{eq(4)}$ in dB(A).
Source: www.fraport.de/online/umwelt.

Comparison of the seven measuring points under consideration shows, in the period 1998 to 2002, a stabilized picture of noise levels (see Table 24). In the same period, the number of flight movements increased by about 10% (from 416,000 to 458,000), and though the higher number of movements is not directly reflected in average noise level, from the point of view of noise-effect research, however, a higher nuisance effect can result.

Table 24 Aircraft noise levels[1)] at seven stationary measuring points around Frankfurt Airport

Year	Offenbach-Lauterborn		Zeppelinheim		Raunheim		Kelsterbach		Neu-Isenburg, Rathaus		Büttelborn - Worfelden		Mörfelden-West	
	dB(A)	Δ[2)]	dB(A)	Δ[2)]	dB(A)	Δ[2)]	dB(A)	Δ[2)]	dB(A)	Δ[2)]	dB(A)	Δ[2)]	dB(A)	Δ[2)]
1998	60		50		59		55		55		56		58	
1999	60	0	51	+	61	+	54	-	56	+	57	+	58	0
2000	61	+	49	-	59	-	55	+	56	0	57	0	57	-
2001	61	0	51	+	60	-	55	0	56	0	56	-	58	+
2002	61	0	51	0	61	+	54	-	57	+	57	+	57	-

1) $L_{eq(4)}$ in dB(A) in accordance with the Aircraft Noise Act – 2) Trend compared to the previous year: - = decrease; 0 = unchanged; + = increase.

Source: Fraport AG Environmental Statements for the years 1999-2002.

The influence of the newly structured charging system of 1. January 2001 on the local noise situation can thus neither be identified nor proven; the figures presented rather reflect the trend of recent years of a shift towards modern and therefore generally quieter aircraft (see above).

5.2.1.4 Résumé

The new charging system that was introduced at Frankfurt Airport on 1 January 2001 offered distinct improvements in the area of LTO charges compared to the previous system:

- a switch in the basis for assessment to take-off and landing (user pays);
- classification of aircraft in noise categories, based on noise levels measured locally (instead of classification according to ICAO certification/ bonus list);
- greater differentiation of charges within the group of bonus-list aircraft as well as an increase in charge rates, especially at night;
- specific targeting of "problem aircraft" (for example, B 747-200, B 727 Hushkits); and
- clear separation of mass- and noise-related shares of LTO charges.

Comparison with restructured charging systems in Hamburg, Munich and Stuttgart shows, however, that there is an urgent need for further development, with particular regard to the spread of charges and the great differentiation of aircraft within noise category 1. The overlapping of MTOM-dependent charges with noise-related charges also leads, especially in the case of heavy aircraft, to misdirected assignment; here, too, there are possibilities for improvement.

Moreover, evaluation of operational and noise statistics has shown that in past years, due to aircraft fleet replacement, environmental improvements have been achieved at Frankfurt Airport. There is no evidence, however, of a connection between the new charging system on the one side and fleet modernization on the other; on the contrary, evaluations tend to suggest that successes achieved in the years 2001 and 2002 (for example, the replacement of the Boeing 747-400 with the MD 11) are not attributable to the charging system. To what extent the rise in aircraft costs through increases in LTO charges ultimately triggers reactions on the part of airlines, depends to a great degree on whether additional costs have a long-term adverse effect on profit margins. It is to be assumed that the current spread of charges at Frankfurt airport is unlikely to have such an effect.

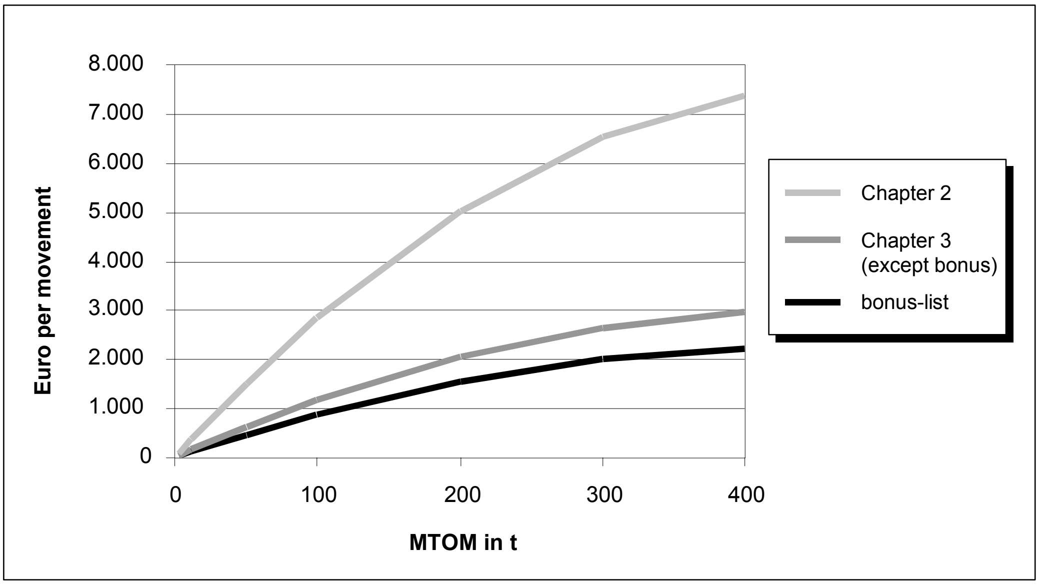
5.2.2 Cologne/Bonn Airport

5.2.2.1 Detailed analysis of the charges structure

The existing structure of charges at Cologne/Bonn Airport benefits heavy aircraft, since its so-called degression factor does not result in linear development of charge rates per tonne of MTOM (see Figure 16). The preferential treatment of large aircraft can be judged positively when this prevents a large increase in the number of flight movements of smaller aircraft. The noise level of a few large aircraft can be lower than that of a large number of smaller aircraft. It has to be assumed, however, that this charges structure allows for the fact that through the preferential treatment of heavy aircraft Cologne/Bonn Airport has made financial concessions to cargo airlines.

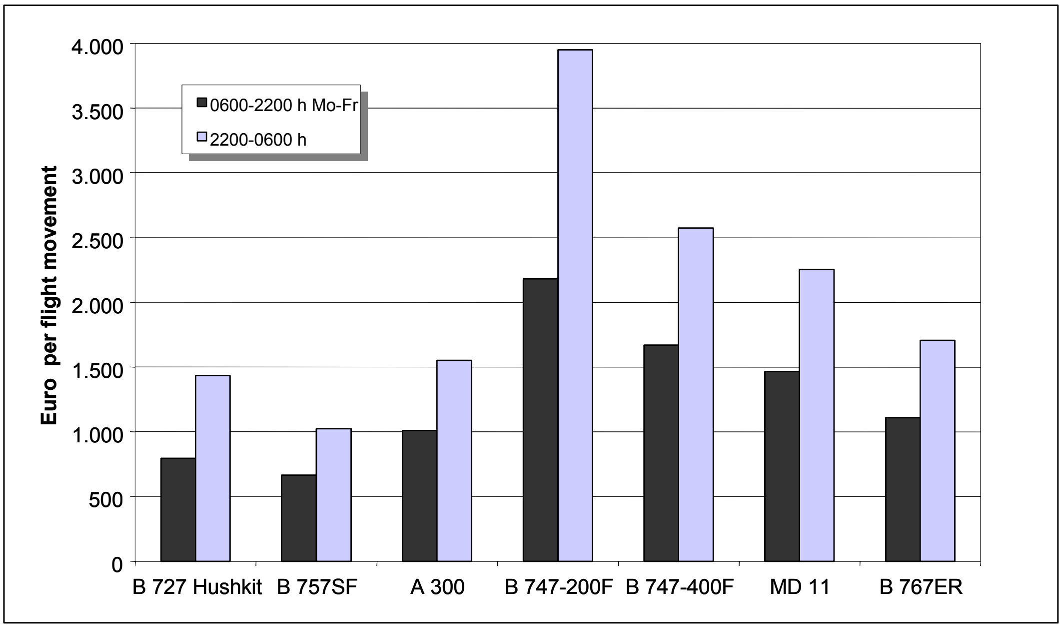
If one compares bonus-list aircraft with Chapter 3 aircraft that are not on the bonus list, the following picture emerges: these Chapter 3 aircraft are 32% more costly during the day (0600 to 2200 hours) and around 56% more costly at night than bonus-list aircraft (see Figure 16).

Figure 16 Development of LTO charges per landing and take-off at Cologne/Bonn airport during the day (0600 to 2200 hours) by MTOM in 2002



As an economic incentive to change the timing of flight movements Cologne/Bonn Airport levies a 15% higher LTO charge for bonus-list aircraft and a 35% higher LTO fee for other Chapter 3 aircraft at night than during the day. As a further incentive, pure cargo aircraft are granted a 25% reduction in the daily charge from Monday to Friday when take-off and landing take place during the day. In this case, the day-to-night disparity increases to over 50% for bonus-list aircraft and to about 80% for other Chapter 3 aircraft. This disparity is displayed in Figure 17 for important cargo aircraft that are used at Cologne/Bonn Airport.

Figure 17 LTO charges per turnaround (landing and take-off) at Cologne/Bonn Airport for selected pure cargo aircraft in 2002



5.2.2.2 Operational effects

The share of wide-bodied aircraft (for example, B 747, MD 11, A 330) increased at Cologne/Bonn from 8% in 1997 to about 11% in 2001.[107] In the same period, the share of flight movements of the B 737 dropped from 40% to 35%. Whether this development is attributable to the introduction of the degression factor cannot be finally determined in retrospect; it is more likely that it is linked to the expansion of Cologne/Bonn Airport into an important cargo transport hub.

Landings of typical cargo aircraft at Cologne/Bonn Airport – already displayed in Figure 17 – in the years from 1997 to 2001 are shown in Table 25. It can be seen that in this period loud cargo aircraft, which are not on the bonus list (B 727-100; B 747-100 to –300), rarely flew into Cologne/Bonn, but that, at the same time, the number of landings of potential replacement aircraft (shown in the table directly below the respective loud aircraft) increased.

[107] Traffic statistics for the year 2002 were not yet available and could therefore not be considered in this study.

Table 25 Landings at Cologne/Bonn Airport of selected cargo aircraft in the period 1997 to 2001

	1997	1998	1999	2000	2001	Δ 2001 compared to 1997
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
B727-100[1)]	5,567	2,379	2,534	2,444	2,196	-3,371
B 757	1,929	1,977	2,432	2,629	2,967	1,038
A 300	566	812	1,872	2,590	2,820	2,254
B 747-100/-200/-300	790	783	694	277	263	-527
B 747-400	0	8	9	2	15	15
MD 11	7	6	61	384	380	373
B767	867	1,133	1,257	1,101	1,201	334
Total Cologne/Bonn	***54,560***	***44,442***	***46,284***	***48,739***	***47,914***	***-6,646***

1) Predominant share B727-100 Hushkit.

Source: Traffic statistics of Cologne/Bonn Airport.

This development could be judged to be the result of a noise-related charging policy. It is more likely, however, that it is attributable to the night-flight regulation that came into force at Cologne/Bonn in October 1997, according to which only bonus-list aircraft may land and take-off between 2200 and 0600 hours. For aircraft not on the bonus list, which were in operation before the new regulation, there was a transition period up to 31. October 2002. This prompted many cargo carriers to replace non-bonus-list aircraft with quieter aircraft before the deadline. Examples of this (Lufthansa 2003; Deutsche Post 2003; DHL 2002; UPS 2000) are[108]:

- DHL: replacement of the B 727 with A 300 and B 757;
- UPS: replacement of B747-100/-200 with B 767 ER (as well as shifting take-off times to after 0600 hours;
- Lufthansa Cargo: replacement of the B747-200 with MD 11 and A 300.

5.2.2.3 Noise-related effects

Changes in the noise situation around Cologne/Bonn Airport can be examined with the help of the monthly average values of $L_{eq(4)}$. In the light of the exemplary months of January and June of the last four years (1999-2002) it becomes clear that developments can differ from one measuring point to another. Besides an increase in the monthly average noise level, improvements in the noise situation can also be deduced from Table 26.

108 See also www.fluglaerm.com/glossar.shtml (under fleet replacement programme).

Table 26 Aircraft noise level at nine stationary measuring points around Cologne/Bonn Airport

Year	Merheim	Rath	Bensberg	Kleineichen	Rambrücken	Lohmar	Hennef	Troisdorf	Porz-Grengel
January 1999	55.1	57.1	40.0	42.3	58.0	60.4	50.1	40.5	49.1
January 2000	40.0	56.9	31.7	39.0	-	58.0	49.1	-	46.7
January 2001	58.3	59.7	35.0	46.8	53.5	59.6	46.5	43.2	49.1
January 2002	57.1	58.4	38.2	46.6	58.0	59.4	49.5	39.9	46.4
June 1999	54.6	57.1	42.5	43.6	57.1	60.2	49.1	38.7	50.4
June 2000	51.4	55.9	40.4	39.8	54.3	56.3	51.4	25.1	51.6
June 2001	50.0	55.3	43.3	41.8	55.4	56.8	54.1	39..	52.5
June 2002	51.3	55.2	41.6	42.0	52.0	57.9	53.0	35.6	51.3

Note: L_{eq} in dB(A), examples of comparison of monthly average values January and June 2001 and 2002

Source: www.fluglaerm.com/ and written information from Cologne/Bonn Airport of 11.09.2002.

5.2.2.4 Résumé

At Cologne/Bonn Airport a shift in cargo traffic from loud aircraft (for example, B 727-100, B 747-100/-200) to quieter aircraft can be established; and this applies in particular at night. Detailed analysis shows, however, that this development has less to do with noise-related LTO charges than with the night-flight regulation with a transition period for non-bonus-list aircraft that has been in force at Cologne/Bonn since October 1997. The increased use of quieter aircraft cannot be directly substantiated, however, by the results of noise measurements in recent years. Increases and decreases in noise levels could also be explained by changes in flight operations as a result of new routes (for example, changes in 1999) or new flight navigation techniques (for example, the introduction of NeSS[109] in 1999).

5.2.3 Zurich Airport

5.2.3.1 Detailed analysis of the charges structure

Noise charges have been levied at Zurich Airport for more than two decades, and they have been considerably tightened up in two stages. The last change came into force on

109 NeSS: New Standard Departure and Standard Instrument Arrival Routes (DFS navigational procedure).

1. April 2000. In 2001, the noise-related surcharge at night (2200 to 0600 hours) was graded according to precise periods of time and a noise charge of 3.50 CHF per passenger was introduced. Three different kinds of noise charge are therefore levied at Zurich airport:

- an all-day noise charge additional to the MTOM-dependent landing fee;
- a noise-related night surcharge; and
- a passenger charge.

Receipts from all three charges flow into a specially created noise fund (AZNF: Airport Zurich Noise Fund) and are used exclusively for noise remediation and noise alleviation measures in the area around the airport (Unique 2003). These three noise charges are briefly described below.

The *noise charge* that is levied throughout the day is split into five noise categories, with the loudest aircraft being assigned to noise category I and the least noisy to category V. The assignment of each individual aircraft to one of the five noise categories occurs on the basis of average annual measured values. The level of charges and exemplary aircraft are displayed in Table 27. The maximum difference between two neighbouring noise categories amounts to 400 Swiss francs (for instance, with a B747-200 and a B747-400). The expected incentive effect is therefore to be rated as negligible.

Table 27 All-day noise charges in addition to LTO charges at Zurich Airport in 2002

Noise category	**I**	**II**	**III**	**IV**	**V**
Charge in CHF	1000	600	400	200	0
Exemplary aircraft:	B 747-100/200 B 747-300 DC 9 (o. HK) IL-86 TU 154/A/B TU 154 B1/B2	B 727-200 HK B 747-400 MD-80/81/82/83 DC 10-30 MD 11 L-1011-500 YAK 42	A 300 A 310-300 A 340 B 767 DC 10-10/40 L-1011-100 L-1011-200 TU-154 M	A 310-200 A 330 B 777 MD 87 IL-96M	A 319/320/321 B737-300 to B 737-900 B 757 MD 90 FK 70/100 EMB-145

Source: Zurich Airport Charging System, valid from 1.7.2001.

The level and structure of the *noise-related night surcharge*, which is levied separately for landing and take-off, are displayed in Table 28. The night surcharge for both take-off and landing doubles each half-hour in the period from 2200 to 2400 hours, and additionally in the case of take-off for each noise category (starting from category V). In contrast to all-day noise charges, a much greater control effect is to be expected from this night surcharge in terms of precautionary noise protection.

Table 28 Noise-related night surcharge at Zurich Airport in 2002, in Swiss francs

Noise category	Take-off					Landing
	I	II	III	IV	V	I-V
2200 – 2230 hours	800	400	200	100	50	50
2231 – 2300 hours	1,500	800	400	200	100	100
2301 – 2330 hours	3,000	1,500	800	400	200	200
2331 – 0000 hours	6,000	3,000	1,500	800	400	400
0001 – 0530 hours	9,000	6,000	3,000	1,500	800	800
0531 – 0530 hours	9,000	6,000	3,000	1,500	800	400

Source: Zurich Airport Charging System, valid from 1.7.2001.

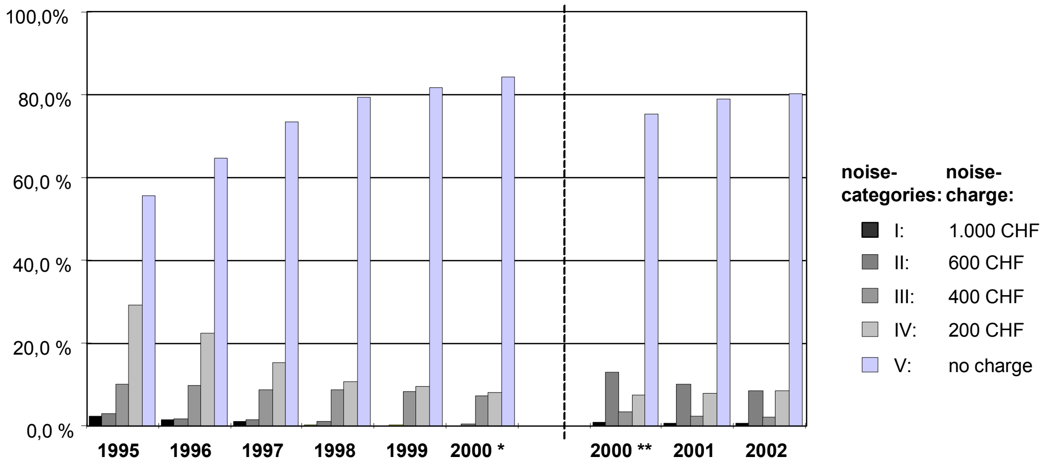
The third noise-related charge is levied per passenger irrespective of aircraft type. With the passenger charge no control effect is associated with the operation of quieter aircraft.

5.2.3.2 Operational effects

The development of the proportional distribution of flight movements in the five noise categories for the period 1995 to 2002 is displayed in Figure 18. For the year 2000, the shares of the noise categories are shown before and after changes to the charging system. For the period 1995 to 2000, a shift to low-noise categories can clearly be established. With the former charging system, more than 80% of flight movements in the year 2000 were assigned to noise category V. Noise category I was not occupied, and noise category II was also barely occupied. This highlights the fact that a change in the charging system, with revised assignment of aircraft to the five noise categories, was urgently required.

As a result of this new assignment of aircraft types, noise categories II and III are better occupied, noise categories IV and V, on the other hand, are less occupied (see Figure 18). However, in the period from 2000 to 2002 the share of flight movements of noise category V aircraft increased from 76% to 80%. The share of noise category II dropped in the same period from 9 % to 4 % (Unique 2003). Trends in the last two years suggest that the development is not related to landing charges, but rather reflects the general trend towards aircraft fleet modernization. It must be regarded as highly unlikely that the new charging system could have such a sustained effect on the aircraft fleet mix at Zurich Arport within such a short period.

Figure 18 Development of the proportional distribution of flight movements in the five noise categories at Zurich Airport in the period from 1995 to 2002



Notes: *Distribution before revision of the noise-charge model (noise surcharge for categories I to V: 800, 400, 200, 100 and 0 CHF). - **Distribution after revision of the noise-charge model

Quelle: Unique 2003; www.uniqueairport.com.

As far as noise charges are concerned, it can be concluded that with the restructuring of noise categories Zurich Airport pursued not only a control effect but primarily economic objectives. In the years 1998 and 1999, receipts from noise charges amounted to 3.7 million and 3.4 million CHF, respectively; yet in the year 2000 they increased to 11.6 million CHF. The new regulation on night surcharges and, especially, the introduction of the passenger charge in 2001 (3.50 CHF per passenger) saw recepits grow to a total of 40.1 million CHF (2.002: 41.5 million CHF) (Unique 2003, 2002; und 2001).

5.2.3.3 Noise-related effects

The noise indicator NNI[110], which has been laid down in Switzerland since 1973 as a measure of aircraft noise levels, shows – as already described in respect of Frankfurt and Cologne/Bonn airports – an uneven picture of noise levels in the area around Zurich Airport (ses Table 29).

On account of available measurements over the past three years and concurrent changes in flight operations, a general conclusion concerning improvement or deterioration in the noise situation in the vicinity of Zurich Airport cannot be drawn. Only

[110] NNI: Noise and Number Index is a measure of the nuisance value of air traffic at any point by combining the average noise level and the number of flights over that point. The equivalent continuous sound level L_{eq} has been used since 2001 for the assessment of aircraft noise at airports in Switzerland, so that long-term measurement series are not yet available. Current monthly publications of Zurich Airport take account of the measures of aircraft noise L_{eq} and NNI.

at a local level, at individual monitoring terminals, can a higher or lower sound level be observed; but once again, an explanation of changes does not appear to be possible in retrospect, and it is not possible to attribute them to the tightening up of the noise charging system.

Table 29 Aircraft noise levels at nine permanent monitoring sites around Zurich Airport [1)]

Year	Rümlang	Oberhasli-Oberglatt	Oberglatt	Hochfelden	Höri	Glattbrugg	Wallisellen	Furttal	Kloten
1998	51	45	43	31	41	53	40	34	39
1999	51	44	42	31	41	52	39	36	37
2000	52	45	43	30	43	52	40	38	36
2001	52	44	42	32	42	51	39	37	37
2002	51	44	41	30	41	50	38	36	36

[1)] Development of aircraft noise levels as NNI (Noise and Number Index).

Quelle: www.uniqueairport.com.

5.2.3.4 Résumé

As with the other two airports under consideration, a differentiated picture also emerges at Zurich in the assessment of changes in aircraft fleet composition and the noise situation. It is once again not possible to establish a direct connection between observed operational and noise-related changes on the one side and the tightening up of the noise-related LTO charging system on the other. The example of Zurich reinforces the suspicion that fleet modernization processes occurred independent of specific charges, and that noise-related charges produce a control effect only in isolated cases. At the same time, the example of Zurich also shows that noise charges and their collection in a fund can represent an important measure for the financing of noise mitigation and alleviation programmes.

5.3 Interim conclusion

Analyses carried out in previous sections show that the assessment of the effectiveness of noise-related airport charges on the basis of publicly accessible traffic statistics or noise measurements and calculations is hardly possible. One main reason for this is the overlapping of the effect of landing charges with the effect of other factors and noise-mitigation measures (for example, night-flight restrictions). This is confirmed by *Fichert*, who considers that a "general statement on the ecological effectiveness of noise-related differentiation of charges and noise levies (...) is not possible“ (Fichert 1999). Irrespective of the effectiveness of the instrument of noise charges, important conclusions can be drawn from detailed analysis concerning the design of efficient noise-related LTO charging systems.

For the improvement of transparency and comprensibility, standardization of charges with respect to the structure and scope of each component appears to be desirable. At the same time, despite the requirement of a uniform structure, possibilities should exist to take account of local conditions (local noise level, number of residents affected etc.) in the design of the charging system.[111] For this purpose, a structural, binding framework should be laid down. In the context of structural standardization, the noise charge should be separated from the MTOM-related LTO fee. Moreover, it should be precluded that the MTOM share offsets the incentive effect of the noise charge (see presentation on Frankfurt Airport).

Evaluations have also shown that at the airports under investigation the classification of aircraft types in noise categories should be further differentiated. A future charging system should therefore ensure that, on the one hand, "problem aircraft" are priced in such a way – especially at night – that a switch to quieter aircraft is economically attractive, and that, on the other hand, an incentive exists to operate the least noisy aircraft.[112]

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[111] This procedure would also satisfy legal demands (see Chapter 2). According to the EU Directive on operational restrictions, airports must be "able to continue current airport-specific noise mitigation measures". According to Article 4, of the directive, airport-specific "characteristics" have to be taken into account when considering operating restrictions (paragraph 2), and the environmental objectives for a specific airport provide the reference point for restrictions (paragraphs 3). The proposed Directive COM(2002) 683 on noise charges for civil subsonic aircraft also assumes that only the framework for noise charges and noise classification will be regulated by Member States, and that their specific design will be left to airports. The aim, according to Article 1, paragraph 1 of the Directive, is to lay down common criteria.

[112] At Frankfurt Airport more than 60% of flight movements are already assigned to the lowest noise category; in Zurich the figure is 80% of flight movements (see above).

Finally, possibilities for improved assessment should be created by providing more detailed documentation of changes within aircraft fleet structure as well as of noise levels. In this connection, long-term time series appear to be particularly helpful. Such observations of changes are, in the light of previous findings, only possible through longitudinal studies of every single airport. In the view of the project team, a monitoring system specifically designed to meet demands is an appropriate instrument.

The project team further proposes that a monitoring system be initiated that makes the effectiveness of noise-related LTO charging systems of individual airports transparent and objectively comprehensible. The main advantage of such a monitoring system would be that, on the basis of empirically validated findings, it would appear to be possible to identify and further develop successful noise-related LTO charging systems. The design of the monitoring system and first steps in this direction are discussed in Chapter 7.

6 Development of alternative noise-related LTO charging systems by means of scenarios

6.1 Introduction and procedure

Status quo analysis of the most important national and international noise-related LTO charging systems (see Chapter 4) and the evaluation of their economic, operational and noise-side effects (see Chapter 5) have shown that at none of the airports under investigation were appreciable incentive effects of a change in the noise-related components of LTO charging systems evident.

Continuing work on the definition and design of alternative noise-related LTO charging systems was therefore mainly directed at examining under which conditions, and in which form effectiveness – with particular regard to the possibilities of noise reduction – can be increased through the accelerated operation of less-noisy aircraft.

With the agreement of the Federal Environmental Agency, the project team decided to examine the influence of certain constraints and input variables with respect to the effects of noise-related LTO charging systems through the development and analysis of scenarios.

Scenarios are defined in this context as alternative bases for assessment for LTO charging systems, which are investigated as to their impact on economic, operational and noise-side effects, in comparison with the status quo of noise-related components of charging systems.

The aim of scenario analysis is to obtain indications for the definition and design of a LTO charging system, which is practicable and fundamentally in line with legal provisions, and which is likely to create appropriate incentives for the reduction of noise levels at airports through the operation of less-noisy aircraft.

The basic methodical procedure for scenario analysis was agreed with the UBA subsequent to evaluation and discussion of results in an interim report. Two scenarios were developed, both of which, following an initial orientating estimation,

- do not necessarily conflict ex ante with the legal framework of charging systems as described in Chapter 3, and
- have the most varied results possible – as far as this can be judged in advance – with regard to status quo analysis, as described in Chapters 4 and 5, and the subsequent assessment of existing charging systems, in order to be able to more easily identify and analyse possible differences in effect.

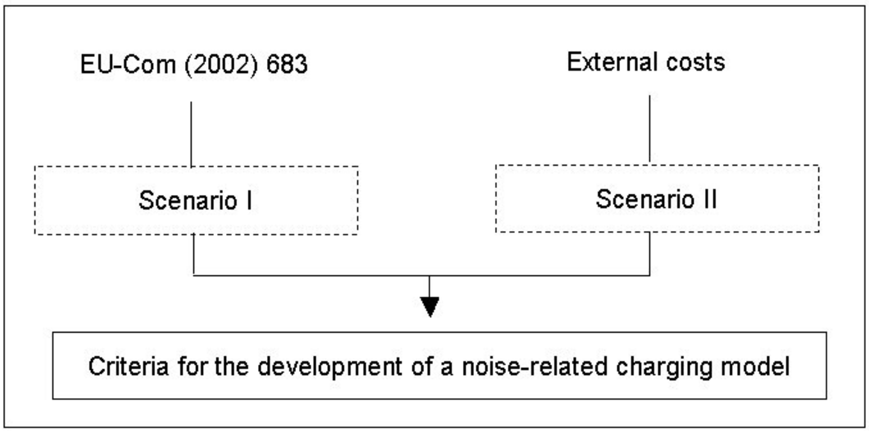
Since a systematic assessment of the consequences of the development and introduction of "new" noise-related LTO charging systems at a national or EU level was not possible within the framework of this study, due its enormous complexity, the noise-related LTO charging systems defined in both scenarios were analysed and assessed, in accordance with the terms of the UBA's project tender, "*on a model basis (…) at a German airport with a high traffic volume in agreement with the commissioning Agency.*[113]

Effect analysis aims primarily at the investigation of differences in modified charging systems on the basis of scenario assumptions in comparison with the status quo. On this basis, it was examined whether changes in the structure and level of noise-related LTO charges can also lead, by way of divergent economic effects, to operational or noise-side changes, in particular on the part of airline companies. Only then was conformity with the legal framework examined and the practicality of the noise-related LTO charges described in the scenarios considered.

In an excursus (see Chapter 6.4) the project team again explicitly examined the issue of the economic results that airline companies would have to expect from operational and noise-side effects.

Analogous to the illustration in Figure 22, and in agreement with the UBA, critical success factors were identified, on the basis of the analysis and assessment of both scenarios, as guidelines for the future design of a harmonized, practicable, legally conform and – in terms of noise reduction – effective noise-related LTO charging system. These are discussed in Chapter 7.

Figure 19 Schematic procedure with different noise-related LTO charging models



[113] See the Federal Environmental Agency's call for tenders for this research project of 10. September 2001, page 3.

6.1.1 Choice of scenarios

The most important prerequisites for the choice and precise design of scenarios have already been described in Section 6.1. To determine sensitivities with regard to the input variables and effects of LTO charging systems, the project team originally intended to determine operational effects, associated potential noise alleviation in the vicinity of airports and economic implications for three scenarios, which were defined as follows:

- ***Scenario I:*** Noise-related LTO charges produce the same revenue as current charging systems; low spread with regard not only to different noise categories but also to times of the day and days of the week;
- ***Scenario II:*** Noise-related LTO charges produce the same revenue as current charging systems; large spread with regard not only to different noise categories but also to times of the day and days of the week;
- ***Scenario III:*** Revenue from LTO charges is greater than that from current landing charges: medium to large spread according to noise category, time of day and day of the week.

Developments at the level of European Community legislation, in particular in the context of the proposed directive on noise charges (see Chapter 3.2.1), suggest that, within the scope of **Scenario I,** the **proposed Directive COM(2002) 683,** which is intended to represent a Community framework for EU Member States for the calculation of noise charges from April 2004 (for significant revision or newly-introduced systems of charges) and from April 2006 (for any system of noise charges), should be investigated in accordance with the aims of this research project. Against the backdrop of possible implementation of this draft directive the relevance of this scenario is obvious. The discussion concerning the effects of a large spread in noise-related charges, which was initially intended to distinguish Scenarios I and II, was incorporated into the analysis of Scenario I, so that, in the opinion of the project team and the commissioning Agency, it no longer appeared to be useful, as originally planned, to investigate three scenarios, and it was decided to concentrate on just two scenarios.

The proposal for a directive on airport charges, which was put forward by the Commission in April 1997 and revised in September 1998, provided the decisive impulse for the definition and design of **Scenario II.** Article 5 (1) of the proposed directive provides that the management of an airport may include external environmental costs due to air traffic in the calculation of charges. With reference to noise, the **external costs of noise at an airport** would therefore be internalized by means of noise-related LTO charges. There therefore exists a close link to the debate at the EU level on the financing of traffic infrastructure. The discussion on the reform of the pricing of traffic infrastructure, and on its use in Europe, was intensified with publication of the EU White Paper, "*Fair Prices for the Use of Infrastructure" (EC 1998).* While the debate initially focused on rail and road traffic, political interest was increasingly directed, against the backdrop of dynamic growth, to the pricing of aviation infrastructure. The discussion is highly dynamic, since the currently prevailing pricing system for the use of airports, flight security facilities and airspace is mainly based on average prices, whereas in the area of rail and road traffic, social marginal costs have increasingly become the focus of attention, particularly on the part of the EU, in the reform of infrastructure costs. In the view of the project team it was therefore interesting to examine to what extent the principle of *social marginal cost pricing* could be applied in aviation to the levying of noise-related LTO charges.

It appeared to be useful to pursue this approach in Scenario II. The underlying theses were:

b. The cost relatedness of a noise-related LTO charging system, required by legislation, is largely adopted but nonetheless still applicable.

c. A medium to large spread (as originally intended in Scenario III) results from this generally understood concept of cost, combined with allocation of the external costs of noise to the user (polluter pays).

That this approach might not be reconcilable with the demand for revenue neutrality was not further investigated ex ante. It was agreed among the project team, and also with the UBA, that a legal assessment of individual approaches would only be undertaken in the scenarios when this appeared to be useful and necessary for guidelines on the further development of LTO charging systems.

In developing alternatives for the future design of noise-related LTO charging systems, the implications of the following scenarios were examined in order to identify possible critical factors affecting the legally-conform, practical but also effective design of LTO charging systems:

Scenario I: proposed EU Directive COM(2002) 683

Scenario II: External costs of noise

A precise definition, account and structural description of the scenarios are to be found in Chapters 6.2.1 and 6.2.2.

6.1.2 Choice of airport for model application of the scenarios

In agreement with the UBA, the project team selected **Frankfurt Airport** as reference airport for the analysis and assessment of the effects of the alternative structure.

The main reasons for the choice of Frankfurt Airport were as follows:

1. With 458,359[114] flight movements, around 48.5 million passengers and a cargo volume of 1.514 million tonnes, Frankfurt Airport is Germany's most important airport in terms of traffic (Fraport 2003c).

[114] The data excludes military flight movements.

2. The change in the structure of noise-related LTO charges at Frankfurt Airport in recent years, as well as the existing charging system, were the subject of intense debate both in status quo analysis and in the assessment of existing charging systems. In comparative analyses with the scenarios, recourse can be made to existing evaluations of the charging system at Frankfurt.
3. One conclusion to be drawn from status quo analysis and the assessment of existing charging systems is that Frankfurt Airport already possesses an extensively differentiated noise-related LTO charging system, which is orientated towards measured noise. That is particularly interesting for comparisons with the scenarios under investigation.
4. An extraordinarily good, publicly accessible database has been created from discussions and proceedings (including mediation, regional forum, regional planning procedures) concerning the future development of Frankfurt Airport, which is not available for any other German airport.

The choice of reference airport is an important prerequisite for model application and effect analysis of the scenarios on alternative charging systems. Discussion of the transferability of statements occurs following effect analysis of individual scenarios.

6.1.3 Structure of effect analysis

Extensive analysis of the effect of alternative noise-related LTO charging systems, analogous to the structure of the scenarios, at an airport with an annual total of over 450,000 flight movements and 132 airlines operating scheduled air services (passengers and cargo) in the year 2002, would only be possible with the most complex modelling, which is not possible within the scope of this project.

For this reason, the following basic approach was selected. Estimation is focused on the difference in assumed charges in the Status Quo Scenario. This means that the starting point for the interpretation of the effectiveness of scenario assumptions is the difference between current charges at Frankfurt Airport and those in the scenarios. They are the starting point for the assessment of effects on

- economic impact allowing for changes in the cost structures of airport operators, airlines and users (in the passenger and cargo areas);
- traffic supply and demand at the airport (for example, aircraft fleet mix, use of low-noise aircraft); and
- target achievement (determination of objectives, with particular regard to noise levels in the vicinity of the airport) and effectiveness.

Analysis of the economic effects of the planned noise-related LTO system provides the basis on which repercussions on traffic supply (in particular, the flight schedule) and demand can be described. This data provides the basis for the analysis of the effects on aircraft noise levels and, as a result, for the verification of target achievement.

The cost structures of a number of airlines, selected as "representative" for aircraft noise, should be the starting point for the analysis of economic follow-up costs (see also Chapter 4.2), so that statements can be made on the extent to which modification of charges affects the cost structure and competitive position of an individual airline. Depending on the degree to which they are affected, there are many ways in which airlines can react. Individual response options have already been discussed in this study. Analogous to work within the scope of status quo analysis, only noise-related LTO charges (noise charges) will be discussed. The differences will be explained exemplarily for individual aircraft types. The **incentive effect of charges on the operation of less-noisy aircraft** thus again provides the focus of effect analysis. Analysis will prioritize the **potential control effect.** Other forms of effect will be treated at a subsidiary level.

Following exemplary analysis, and in the context of the harmonized introduction of modified charging systems, the practicability of systems developed in the scenarios will be discussed and assessed.

The project team appreciates that, within the framework of this research project, effect analysis can only be of an orientating nature. The degree of possible detail appears to be sufficient, however, bearing in mind the accuracy of scenario definition, to provide a basis for the formulation in Chapter 7 of guidelines for the further development of LTO charging systems.

It is therefore apparent that a detailed examination of the legal conformity of the described charging systems cannot be carried out at this stage. Important aspects, such as cost-relatedness and revenue neutrality, which were elaborated in Chapter 3, are examined, however, in the context of analysis. Examination of other aspects, such as non-discrimination of airport users, is not possible at the present stage of discussions.

Excursus: Doing without noise calculations

In accordance with the terms of the Federal Environment Agency's call for tenders and the project team's proposal for this report, the intention was to use noise calculations not only with regard to the assessment of the effects of existing landing charges on aircraft noise levels in the vicinity of an airport, but also for the examination of effects in the scenarios.

Preliminary analysis and assessment of charging systems with respect to the noise reduction achieved and changes in measured and/or computed aircraft noise levels at the airports under investigation had already shown, however, that a contribution by the charging system to changes in the noise situation could under no circumstances be identified retrospectively (see Chapter 5.2). It had also been shown that expected changes in aircraft fleet mix could not be described with the aircraft noise calculation procedure *AzB*[115] that is legally binding in Germany. This assessment on the part of the project team was confirmed in discussions with experts from the Hessian State Agency for Environment and Geology (*Hessisches Landesamt für Umwelt und Geologie*, *HLUG*) in Wiesbaden.

Forecast structural modifications and changes in aircraft fleets using a particular airport have no influence on input data for the calculation of noise in terms of *AzB*. Virtually all expected changes in the choice of aircraft take place within a single class of aircraft. Aircraft classes describe, for the purpose of simplification, characteristic aeronautical and acoustic parameters (for example, sound levels) of different types of aircraft. This compilation provides the standardization of underlying model assumptions required for this calculation method. *AzB (99)*[116] includes, for instance, in aircraft class S 7 (*3/4-engine jet planes with a MTOM >300 t, Chapter 3*) all model versions of the B-747, in aircraft class S 5.2 (*jet planes with a MTOM up to 120 t and a variable-cycle ratio >3, Chapter 3)* aircraft types such as the series A319, A320, A321 and B737-300 to 500.

All other possible methods for the assessment and presentation of forecast aircraft noise levels in the vicinity of airports are ruled out. Alternatively, there is the possibility of employing calculation methods that make greater use of differentiated input data, so that specific data of individual aircraft types and models can be considered. This option is offered, for example, by the INM (integrated noise model of the FAA, Office of Environment and Energy, USA) or the FLULA 2 aircraft noise simulation programme (developed by EMPA in Switzerland). Both models, however, have the distinct disadvantage that up-to-date, differentiated and extensive input data is required, which is generally not available and also difficult to forecast. Calculations or simulations with these tools are not attainable within the scope of this report and, due to the above conclusions, are also not regarded as useful.

115 *AzB: Anleitung zur Berechnung von Lärmschutzbereichen an zivilen und militärischen Flugplätzen nach dem Gesetz zum Schutz gegen Fluglärm (FluglärmG*) [Instructions on the calculation of noise protection zones at civil and military airports in accordance with the Aircraft Noise Act]; the AzB lays down details of calculation, supplementary to the annex to §3 Aircraft Noise Act *(GMBl* [Law Gazette]*. 1975 p. 126 ff)*

116 AzB(99): Draft AzB of 1999 taking account of nine aircraft models; Federal Environmental Agency

6.2 Scenario analysis

6.2.1 Scenario I: Draft EU Directive COM(2002) 683

6.2.1.1 Background

In its Communication on *Air Transport and the Environment: Towards meeting the Challenges of Sustainable Development* (COM(1999)640 of 1.12.1999) the European Commission recommended that greater incentives be set for the reduction of the adverse environmental effects of aviation through economic instruments such as environment levies. One possible form explicitly mentioned is a levy in connection with airport LTO charges. This is taken up in the proposal for a *Directive of the European Parliament and of the Council on the establishment of a Community framework for noise classification of civil subsonic aircraft for the purposes of calculating noise charges* COM(2002) 683 of 29.11.2002). It is also the objective of Directive COM(2002) 683 to harmonize charging regulations in the European Union by laying down uniform technical parameters that support internal market goals. With the proposed framework, the transparency, fairness of treatment and predictability of noise charges should be achieved throughout the Community.

The present proposed directive is based on a *Proposal for a Directive of the European Parliament and of the Council on the establishment of a Community framework for noise classification of civil subsonic aircraft for the purposes of calculating noise charges* COM(2001) 74 of 20.12.2001), which, following consideration of submitted comments, has been amended with respect to a number of points. Proposal COM(2002) 683 increases the maximum variation between the lowest and the highest charge within a given time period from a ratio of 1 to 20 in the original proposal to one of 1 to 40. At the same time, the lower threshold levels (T_a and T_d) have to be adjusted from 13d B to 16 dB below the upper threshold levels, in order to double the ratio to 1 to 40, which is analogous to an increase of 3dB on the logarithmic decibel scale. It was also specified that noise charges might be split into a maximum of three periods of time within a given 24-hour period, a provision that was not directly contained in Proposal COM(2001) 74. The differentiation of three time periods in the proposed directive is compatible with the EU Directive on environmental noise COM(2002) 49, which also uses three time periods: day (0700 to 1900), evening (1900 to 2300) and night (2300 to 0700). These standard periods may also be varied. Further differentiation of the three-period division – for example for weekends or public holidays – is not implicitly excluded, so that more far-reaching regulations are possible. In calculating the noise indicator L_{den}, a surcharge of 5 dB is applicable in the evening period and one of 10 dB at night. Further modifications, which have no effect on the technical structure, are to be found in Chapter 3.2.1.

Both the final version of the directive and its possible adoption by the European Parliament are still pending, and the timing of both events is not yet foreseeable.

According to Article 2 of the proposed Directive COM(2002) 683, a noise charge is interpreted as a noise-related LTO charge that "is designed to recover the costs of alleviation or prevention of noise problems and to encourage the use of less-noisy aircraft" (Article 2 (1a) COM(2002) 683). It is important to emphasize that, on the basis of the specified calculation formula (see Annex to COM(2002) 683), it is *not* the full charge for landing and take-off that is established, but only the noise charge.

Calculation formula

The present suggestion for the calculation of noise-related LTO charges, according to the proposed directive, is based on preparatory work by the technical subgroup *Transport Aircraft Noise Classification Group* (TANC) within the *European Civil Aviation Conference* (ECAC). Specifications for the calculation of noise charges are to be found in the Annex to the proposed Directive COM(2002) 683. The calculation formula is:

$$C = Ca * 10^{(La-Ta)/10} + Cd * 10^{(Ld-Td)/10)}$$

where C is the total noise charge for one arrival and one departure at a given airport

C_a, C_d are the unit noise charges at departures and arrivals at the airport under consideration

L_a, L_d are certificated noise levels at arrival and departure, respectively[117]

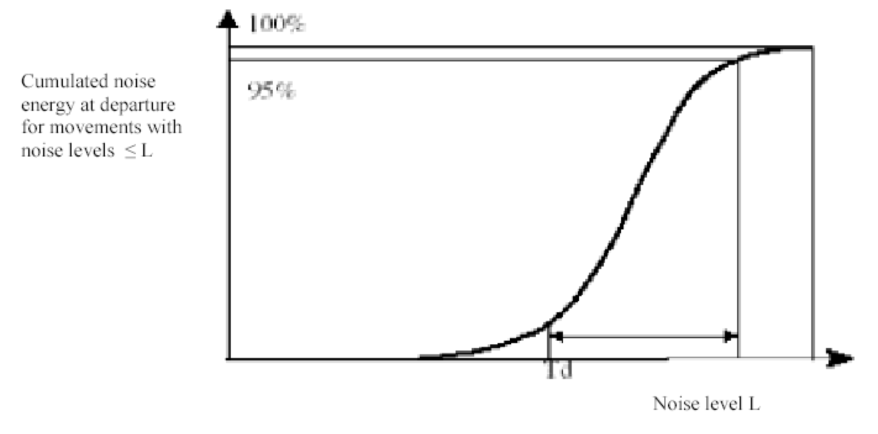
T_a, T_d are noise thresholds at arrival and departure

Unit noise charges C_a and C_d are determined for individual airports for each arrival and departure (for example, *Stockholm-Arlanda*: 30 Swedish Crowns (SEK) or 3.29 euros). The certificated noise levels L_a and L_d result from the certification that has to be carried out for each aircraft according to current ICAO regulations (ICAO Annex 16, Volume I)[118]. The determination of noise thresholds T_a and T_d is based on the noise energy emitted at the airport in question. These thresholds are separately determined for arrival and departure, and are fixed at "around 16 decibels below upper thresholds corresponding to 95% of the noise energy emitted at the airport“ (COM(2002) 683, Annex).

[117] The noise level at departure is computed as an arithmetic average of the certificated noise levels at the flyover and lateral measuring points.

[118] This ICAO guideline has been implemented in German law as *Lärmvorschrift für Luftfahrzeuge* (LVL).

Figure 20 Illustration of the determination of noise thresholds according to the proposed EU Directive COM(2002) 683.



Source: Proposal COM (2002) 683

The determination of noise thresholds is not further discussed beyond these comments, and should be deduced (for example, noise threshold at departure T_d) from Figure 20.

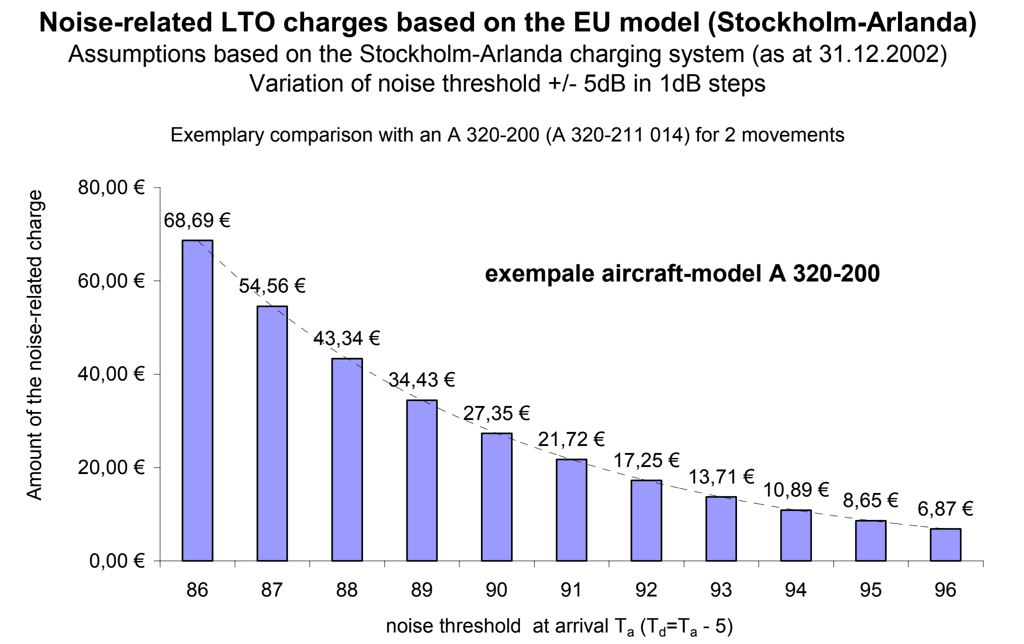
By mean of two "adjusting screws", which have to be laid down for each airport, the proposed calculation formula allows the possibility to influence the level of charges. On the one hand, the noise threshold (T_a, T_d) should be determined separately for departure and arrival from the cumulative noise energy (see above); on the other hand, the unit noise charge (C_a, C_d) is determined individually. These unit noise charges can also be zero. The influence of both variable parameters, on account of the underlying algorithm, is shown with the help of the following exemplary sensitivity investigations.

Noise threshold (Ta, Td)

In order to demonstrate the influence of noise (Ta, Td), in the following example the threshold is artificially varied. Based on the specifications of the Stockholm charging system (see Chapter 6.2.1.2), the thresholds are increased or decreased in 1 dB stages in order to observe the affect on the *noise charge* within the Stockholm charging system, whose structure is in line with the proposed EU Directive. On account of the logarithmic decibel scale, the increase or decrease of 3 dB in each case already indicates a doubling or halving of the underlying sound energy.

The structure of the underlying calculation formula already indicates that an exponential connection exists, in so much as the denominator of both exponents is reduced by a factor (noise threshold) through the variation of noise thresholds in each case. For the purpose of illustration, an exemplary analysis for the aircraft type A320-200 is shown below (see Figure 21, Starting point T_a = 91 EPNdB).

Figure 21 Noise-related LTO charges in accordance with the proposed EU Directive COM (2002) 683 with varied noise thresholds T_a and T_d.

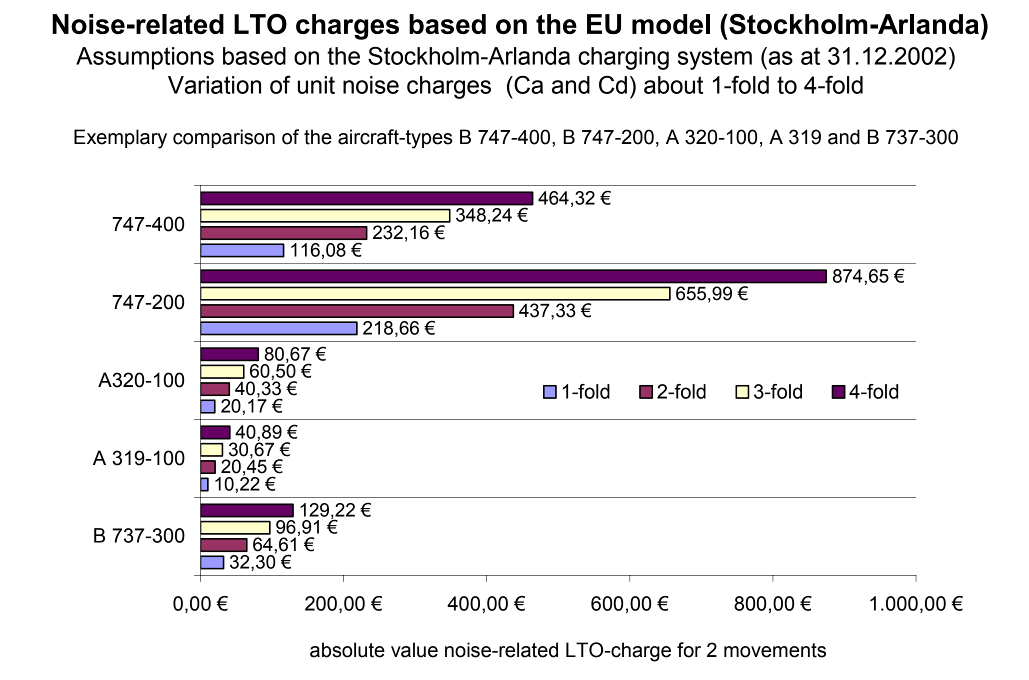


Note: Results represent the calculation of noise charges according to Proposal COM (2002) 683 on the basis of the charging system at Stockhol-Arlanda.

Unit of noise charge (C_a, C_d)

Differentiation of units of noise charge would be necessary, for instance, in the consideration of different periods of assessment. The effect of the structure of the calculation formula should be examined exemplarily by means of the following investigation of the Stockholm charging system. If the units of noise charge (3.28 euros are increased several times (one to four times), a linear increase in the noise charge is shown, in so much as it also multiplies by the same factor (see Figure 22).

Figure 22 Noise-related LTO charges with varied unit noise charges C_a and C_d



Note: Results represent the calculation of noise charges according to Proposal COM (2002) 683 on the basis of the charging system at Stockhol-Arlanda

In designing a charging system, the level of noise-related LTO charges can be more or less freely determined by means of one of the two "adjusting screws" in the calculation formula. Whereas noise thresholds (Ta, Td) are determined by means of measured certification values and the shares of individual aircraft types, the rate of the unit of noise charge (Ca, Cd) can be freely set. The proposed directive contains no specifications in this connection, apart from the guideline that the rates may be set at zero. It is further specified that noise charges should "correspond to the relative noise impact of arrivals and departures for populations around airports". Regarding the total noise charge, aircraft pricing can still be maintained at a high or low level. The maximum spread of noise charges (a ratio of 1 to 40), which has also to be considered, merely sets an upper and lower limit.

6.2.1.2 Design

Charging system at *Stockholm-Arlanda*

At *Stockholm-Arlanda Airport,* the charging system uses a calculation formula to determine the noise charge that is very similar to that in the proposed directive, and it will therefore be looked at in detail. *Stockholm-Arlanda Airport*, with 245,700 flight movements and 16,400,000 passengers (2002) ranks among the largest international airports in Europe and was included in the investigation of LTO charges at European airports in Section 4.1.3)

Further components of the Swedish charging system are the *landing charge*, *emissions charge* and the *passenger charge*, which have been considered in Chapter 4.1.3. The *emissions charge* is levied on the basis of certified emissions from the LTO cycle of hydrocarbons (HC) and nitrogen oxides (NO_x). For aircraft with an MTOM in excess of 25t, the *landing charge* comprises a mass-related charge and a fixed amount.

Table 30 Comparison of charging system components at Frankfurt, Stockholm-Arlanda and in the proposed EU Directive COM(2002) 683

<table>
<tr><th>Frankfurt/M.</th><th>Stockholm-Arlanda</th><th>EU-Proposal</th></tr>
<tr><td>noise surcharge</td><td>noise-charge</td><td>noise charge</td></tr>
<tr><td>LTO fee</td><td>landing-charge</td><td>-</td></tr>
<tr><td>parkig-charge</td><td rowspan="2">terminal navigation charge (TNC)</td><td>-</td></tr>
<tr><td>ground-services</td><td>-</td></tr>
<tr><td>passenger charge</td><td>passenger charge</td><td>-</td></tr>
<tr><td>aviation security charge</td><td>security charge</td><td>-</td></tr>
<tr><td>air navigation charge</td><td>air-navigation charge</td><td>-</td></tr>
<tr><td>-</td><td>emission-charge</td><td>-</td></tr>
<tr><td colspan="3">Quelle: Swedish CAA Tariff Regulations effective from 1 December 2001</td></tr>
<tr><td colspan="3">Fraport AG, Frankfurt Airport Charges, valid from 1.1.2002</td></tr>
</table>

The *noise charge* calculation formula is:

Calculation: $$Ctot = C \times \left(10^{[(La-Ta)/10]} + 10^{[(Ld-Td)/10]}\right)$$

Where:
- Ctot = Charge for one landing
- C = Unit noise charge
- La = Approach level of the individual aircraft
- Ta = Minimum Threshold at approach
- Ld = Average of the sideline and take-off levels of the individual aircraft
- Td = Minimum threshold at departure

This formula differs from the EU proposal in so much as landing provides the sole basis for assessment for landing and take-off, whereas in the proposed directive landing and take-off are separately accounted for. The noise thresholds for landing and take-off are:

- Noise threshold T_a 91 EPNdB
- Noise threshold T_d 86 EPNdB

Noise thresholds were established by the Swedish aviation authority (Swedish CAA *Luftfartsverket*) by plotting the total number of arrivals and departures for each airport (as a percentage of the total) in single dB units of EPN. Here, the criteria contained in the calculation proposal of the TANC working group of the ECAC are taken up. The starting point is a 95% noise energy limit and a 20-fold spread (13 dB). The unit of noise charge C, which appears in the formula of the proposed EU directive as C_a and C_d, is laid down as:

- Unit of noise charge C: 30 SEK[119] (corresponding to 3.28 euros)[120]

A distinction between arrival and departure is not made in the unit of noise charge, since this way, in the opinion of the Swedish CAA, further simplification and greater acceptance is achieved. Furthermore, an exemplary distinction between landing and take-off showed that there would generally be no substantial difference in nuisance effect, and on the other hand, a number of aircraft would be discriminated against due to great differences in noise charges.

The highest noise charge, according to the proposed charging system spread in Draft COM(2001) 74, is set at 20 times the unit noise charge C of 30 SEK (3.28 euros), so that a maximum of 600 SEK (65.60 euros) may be levied. The Swedish noise-charge model thus twice takes account of the spread factor specified in the directive, namely in establishing noise thresholds and in determining minimum and maximum noise charges. This upper limit is separately shown in the following investigations and presentations.

In a preliminary conclusion, the Swedish CAA stated that the practical applicability of the calculation formula has been confirmed, and that no major problems have occurred. It is also emphasized, however, that application of the method is difficult at airports with a low volume of traffic, where most flight movements are assignable to just a few noise categories, and that in these cases adjustments are necessary (*Swedish CAA*, 1999*)*.

[119] Charging regulation of the *Swedish Civil Aviation Administration*, valid from 1. Januar 2003

[120] With 1euro being equivalent to 9.14SEK (as at May 2003)

Charging system at Frankfurt (Fraport AG)

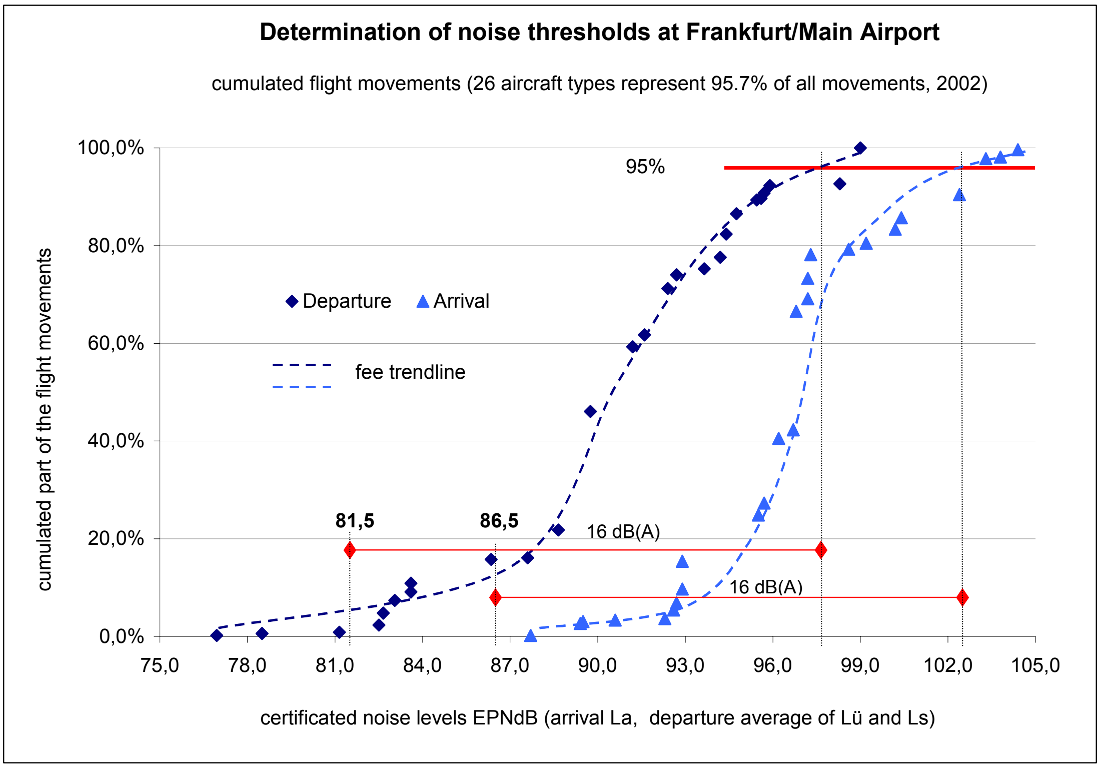
In the Fraport charging system, a noise-related LTO charge takes the form of a *noise surcharge*. This charge is levied on a differentiated basis according to assigned noise category (1-7), all-day flight movement (0000-2359) additionally per movement at night (2200-6000) (see Table 31). For further details of the Fraport charging system see Chapter 4.1.2.

Table 31 Noise surcharge for Chapter 2 and 3 aircraft in the Frankfurt charging system (2002)

24-hour noise surcharge per movement in euros						
Category 1	Category 2	Category 3	Category 4	Category 5	Category 6	Category 7
0.00	20.00	42.50	130.00	275.00	2,800.00	5,600.00
Noise surcharge per movement at night (2200 - 0559 local time) in euros						
Category 1	Category 2	Category 3	Category 4	Category 5	Category 6	Category 7
32.00	75.00	130.00	240.00	770.00	7,500.00	15,000.00
Source: Fraport AG, Airport Charges at Frankfurt Airport valid from 1. January 2002						

One way to determine exemplarily noise thresholds for Frankfurt is provided by Fraport traffic statistics and known EPNdB values from certification measurements for individual aircraft types. For 26 typical aircraft types at Frankfurt Airport in 2002, which cover 95.7% of flight movements, noise thresholds can be separately determined for arrivals and departures by assigning the proportional share of cumulated traffic volume to (rising) certification values (see Figure 23). Consultations with different experts (including HLUG, *Swedish CAA*) have confirmed that this method has proven to be useful, and that the proposed Directive COM(2002) 683 merely contains insufficient pointers. An almost identical method has been selected for the determination of noise thresholds at Stockholm-Arlanda Airport, so that the method appears to be comprehensible and plausible.

Figure 23 Determination of noise thresholds for arrival and departure at Frankfurt Airport (2002)



The following orientating noise thresholds arise for 2002 at Frankfurt Airport:

- Noise threshold, arrival T_a = 87 (86.5) EPNdB
- Noise threshold, departure T_d = 82 (81.5) EPNdB

The B 747, which had a share of 7.4% of flight movements at Frankfurt Airport in 2002, exceeds the threshold of 95% of emitted noise energy at departure. For arrivals, about 9.6% of flight movements (B 747, B 727, MD 11 and DC 10) are in this area; for departures about 1.7% of flight movements (Learjet 60, Cessna 525, Embraer E 135) are in the area of minimum noise-related LTO charges.

Comparison shows that between 2001 and 2002 noise thresholds separately determined for arrival and departure at Frankfurt hardly changed, and that there was only a marginal difference of about 1 dB (maximum 1.5 dB) compared to equivalent data for Stockholm-Arlanda. The negligible change at Frankfurt indicates that there has been no substantial change in the aircraft fleet mix. Comparison with Stockholm-Arlanda also demonstrates a similar distribution of aircraft types with regard to the noise level EPNdB. There is no question of an identical aircraft fleet mix, since the two airports are of varied operational significance on the international aviation market.

Table 32 Comparison of noise thresholds at Stockholm-Arlanda and Frankfurt

Airport	Arrival EPNdB	Departure EPNdB	Spread dB
Stockholm-Arlanda (since 2001)	88	83	16
	91	86	13
Own investigation for Frankfurt (2002)	87 (86.5)	82 (81.5)	16
	90 (89.5)	85 (84.5)	13
Own investigation for Frankfurt (2001)	87 (86.8)	82 (81.7)	16
	90 (89.8)	85 (84.7)	13
Source: Tariff Regulations Swedish CAA Stockholm-Arlanda 12/2001.			

An alternative option for rough determination of noise thresholds would be calculation on the basis of emission values from "Guidance on the calculation of noise protection zones (AzB)" and the accompanying data entry system (DES). Emitted sound energy can be roughly determined for each defined aircraft class, and then subsequently calculated for the selected period of time by way of the share of individual aircraft classes in total traffic volume.

6.2.1.3 Effect analysis

Presentation of the results of variants of Scenario I follows, which describe the range of available design options and present, in particular, the methodical and structural effects of the two different charging models (Frankfurt and EU model).

The existing charging system at *Stockholm-Arlanda* is used for the purpose of comparison. To begin with, the structure of current noise charges at *Stockholm-Arlanda* and Frankfurt is discussed, and subsequently, the way in which they differ is examined. Following this status quo comparison, it is also examined to what extent a higher spread (40-fold) in the Stockholm model influences the amount of LTO charges. Finally, an examination is made of the extent to which differentiation of noise charges according to time of day can be realized within the EU calculation model.

In this connection, it is only noise-related LTO charges that remain the subject of consideration. It has to be borne in mind that noise charges represent only a part of the complex system of charges that are connected with the turnaround of an aircraft. The problem of sectoral consideration was discussed in detail in Chapter 4.

Status quo comparison of Frankfurt and *Stockholm-Arlanda (20-fold spread)*

Existing charging systems at Frankfurt and *Stockholm-Arlanda* Airports are distinguished by structure (see Chapter 4). A direct comparison of noise-related LTO charges for selected aircraft models shows a differentiated picture, depending on the aircraft type selected and times of day. While, as a result of differentiation of day and night in the charging system at Frankfurt Airport, flight movements at night are subject to considerably higher charges (see, for example, Figure 24), for aircraft assigned to noise category 1 no noise surcharge whatsoever is levied. The following figures display, for different aircraft types, noise-related LTO charges for two flight movements within the same time period (one during the day, the other at night).

Figure 24 Comparison of noise-related LTO charges in the Frankfurt and EU models (scheduled service, passage, domestic, one movement during the day, one at night)

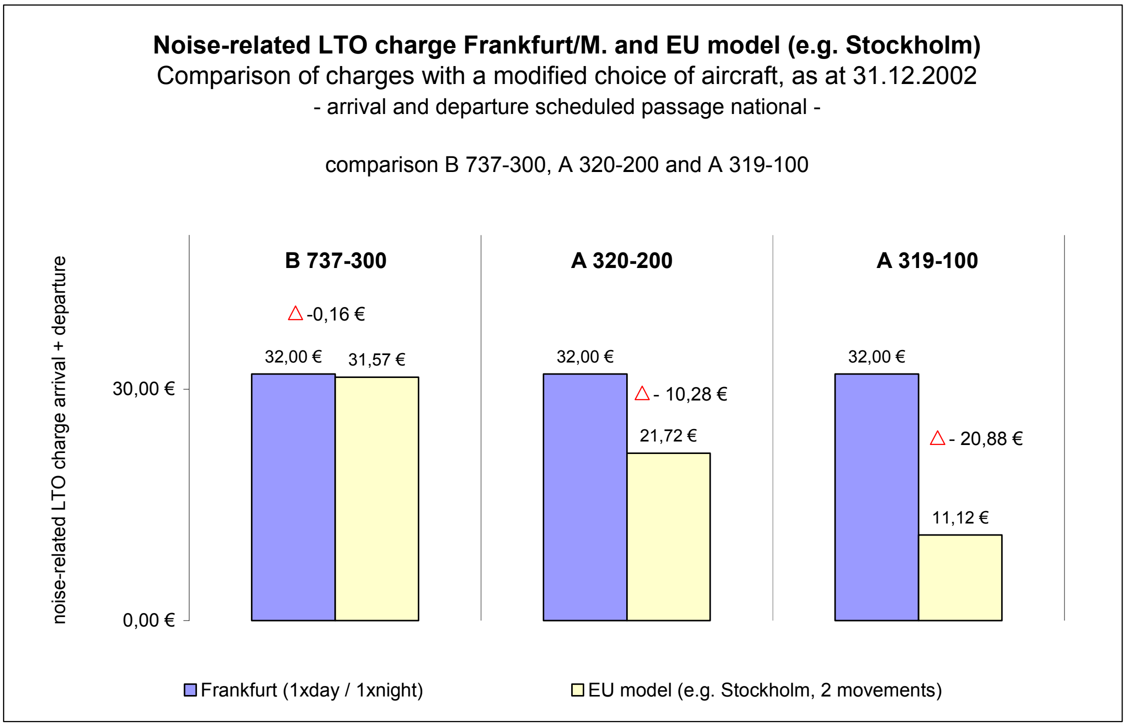
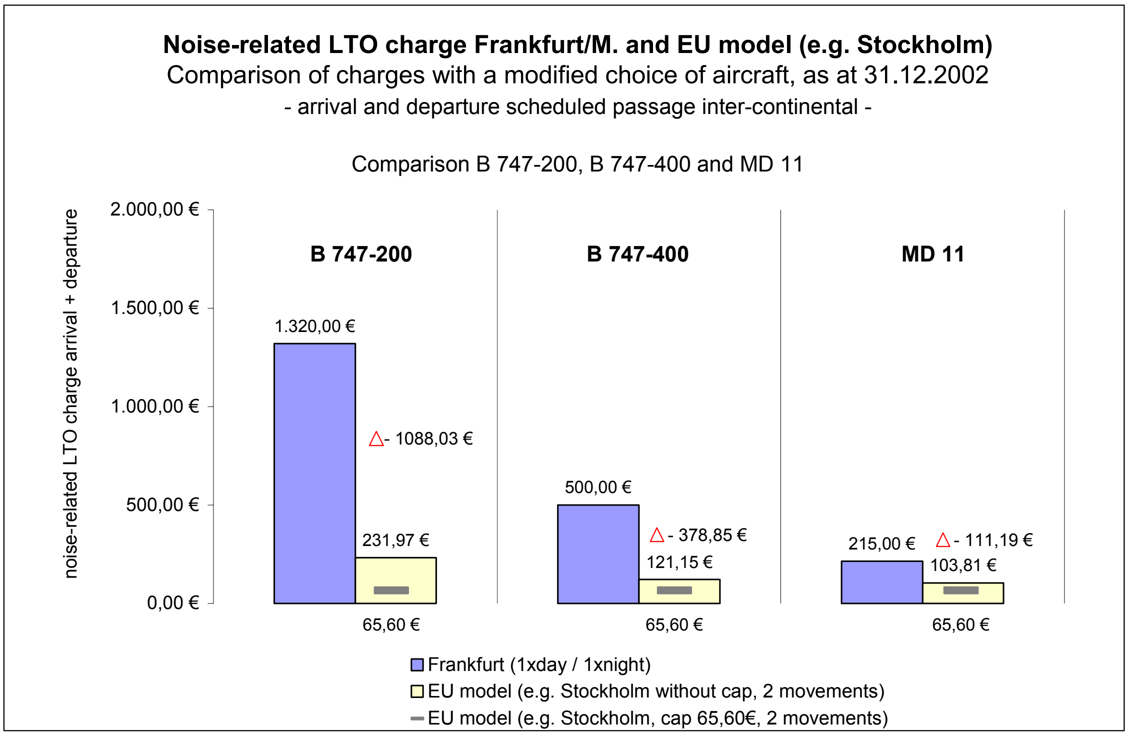


Figure 25 Comparison of noise-related LTO charges in the Frankfurt and EU models (scheduled service, passage, inter-continental, one movement during the day, one at night)



The following Figures display differences resulting from differentiation according to time of day, as provided for in the charging system at Frankfurt Airport. Whereas charges are constant throughout the day in the charging system at Stockholm-Arlanda, the level of charges at Frankfurt varies with the three aircraft types under investigation.

Figure 26 Comparison of noise-related LTO charges in the Frankfurt and EU models (cargo, inter-continental, two movements during the day)

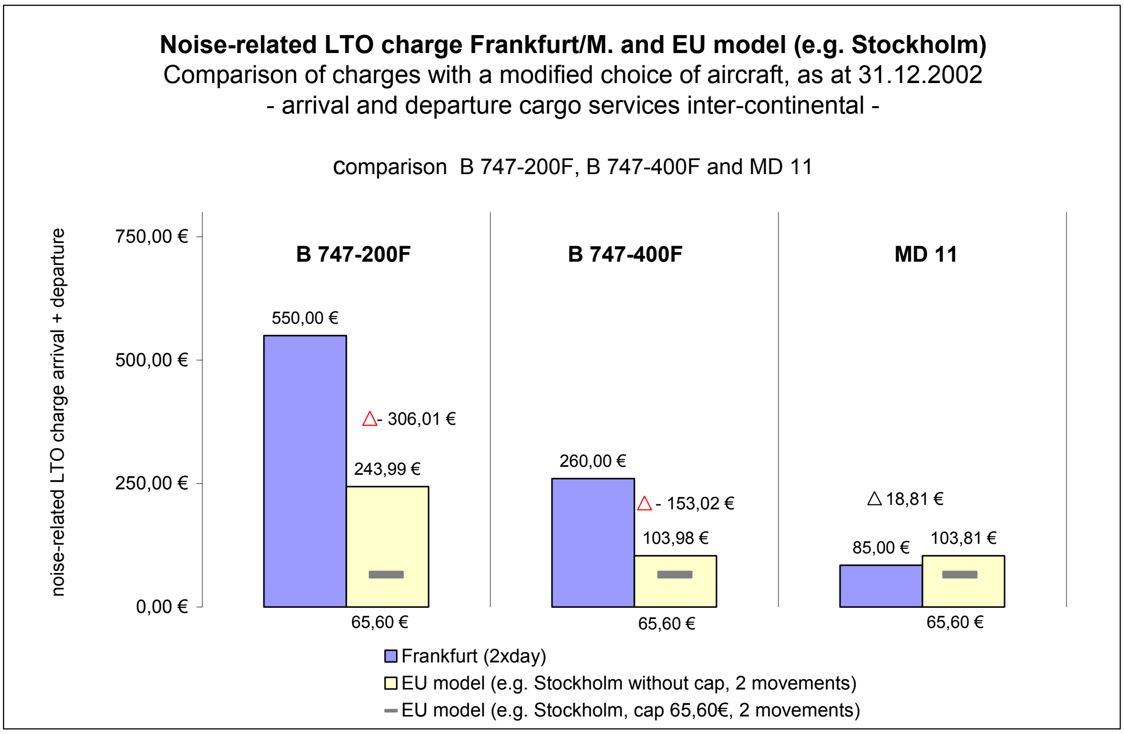
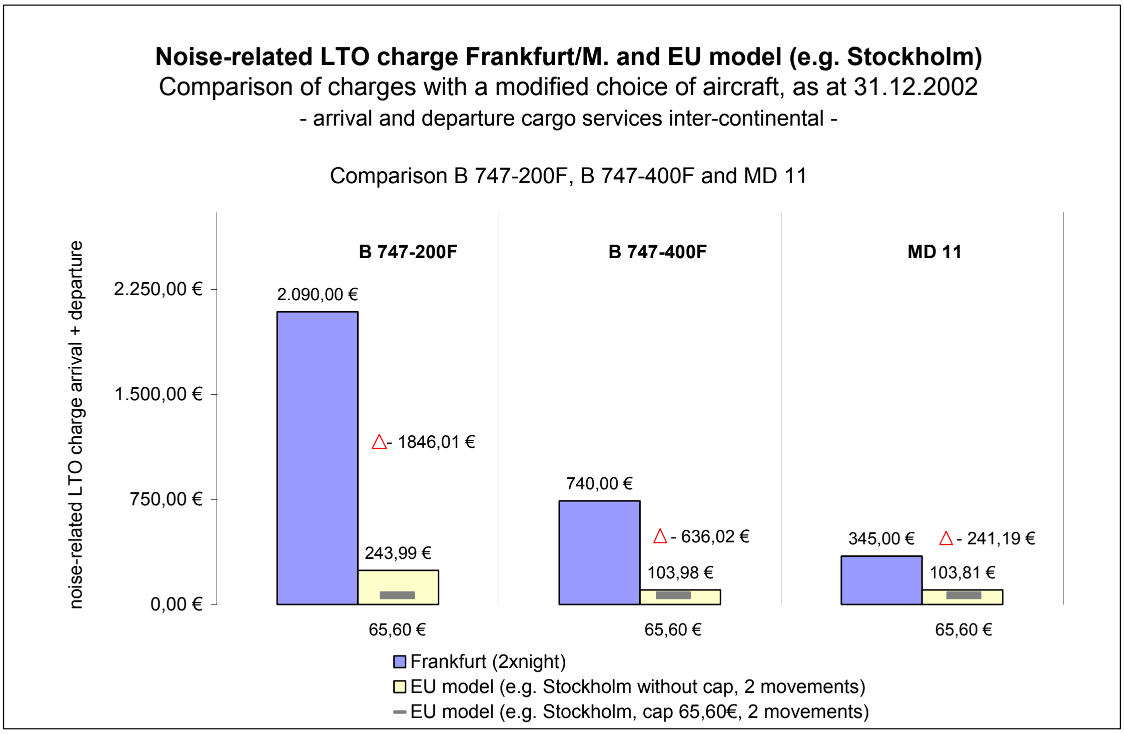
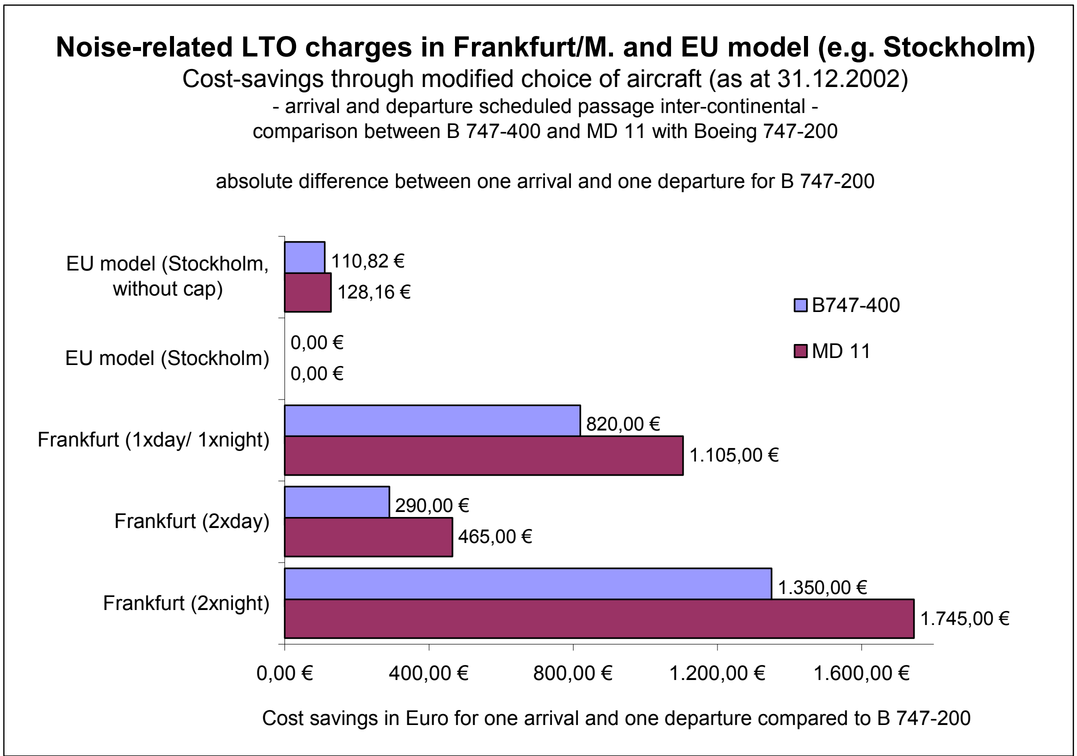


Figure 27 Comparison of noise-related LTO charges (cargo, inter-continental, two movements at night)



A further presentation, which demonstrates differences in noise-related LTO charges with the alternative choice of a modern, less-noisy aircraft from the same market segment, shows that, due to day/night differences, differentiation in the present charging system at Frankfurt is greater than at Stockholm. While in the Stockholm model alternative aircraft have low savings effects, in the Frankfurt system greater effects are to be achieved with flight movements at night (for the example of passage, international scheduled services, see Figure 28). This effect does not occur, however, in other segments under consideration (for example, national passage, continental holiday/charter and continental cargo), because the noise surcharge in Frankfurt charging system is lower or not applicable. Here, the three aircraft types under investigation are assigned to the same noise category, although in terms of age and noise emissions they should be variedly classified.

Figure 28 Differences between the Frankfurt and EU models with respect to noise-related LTO charges (scheduled, passage, inter-continental)



Status Quo comparison of Frankfurt and *Stockholm-Arlanda (with a 40-fold spread in charges)*

The previous comparison was made on the assumption that the existing 20-fold spread in charges is retained. The question now raised concerns the effect of the level of LTO charges were the Stockholm system to have a 40-fold spread, as provided for in the draft Directive COM(2002) 683. Due to the structure of the calculation formula, a reduction in noise thresholds basically gives rise to an increase in the rates of noise-related LTO charges. The effect on changes in noise thresholds due to the underlying structure of the calculation formula has already been shown in the form of an exponential development in charging rates (see Figure 21). At the same time, a reduction in noise thresholds by 3 dB gives rise to shifts in individual traffic segments, as the higher noise-related LTO charges of the Stockholm model exceed the noise component in the Frankfurt charging system. The spread, however, is still lower than in the Frankfurt system.

The effect of higher charge rates is an increase in revenue from noise-related LTO charges. Rough estimates indicate that annual revenue at Frankfurt is around double that achievable with a 20-fold spread (see Section 6.3).

Figure 29 Comparison of noise-related LTO charges in the Frankfurt and EU models (scheduled, national passage, 40-fold spread, 2 daytime flight movements)

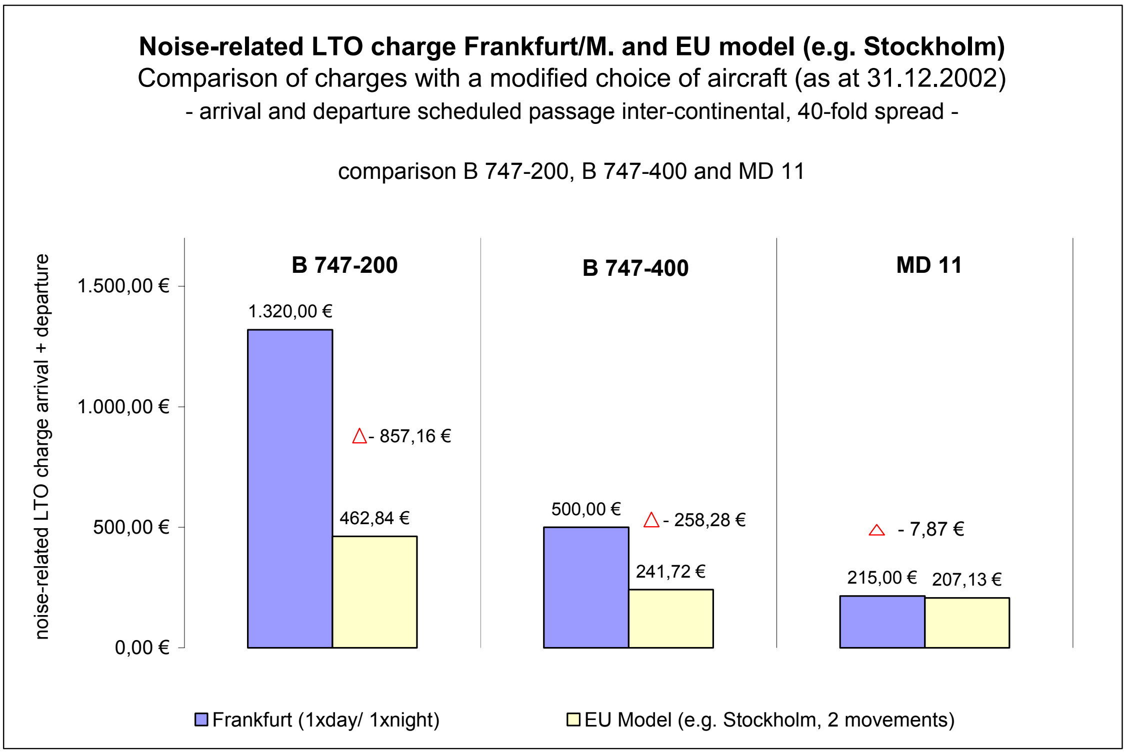
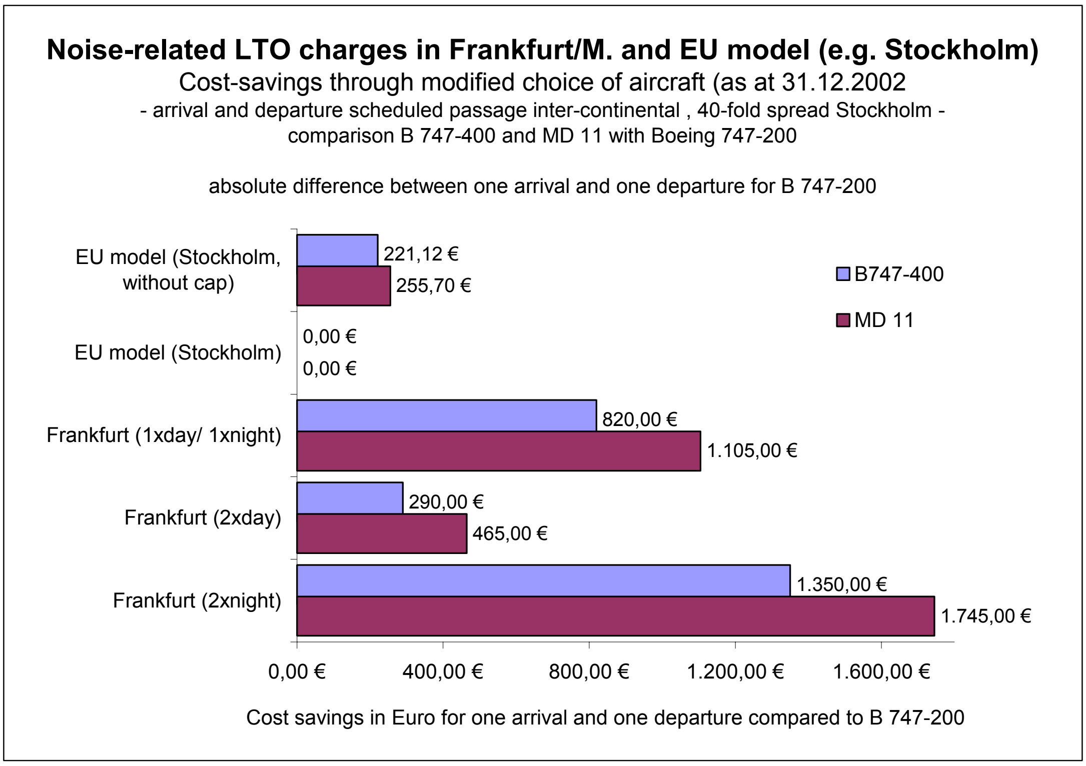


Figure 30 Differences between the Frankfurt and EU models with respect to noise-related LTO charges (inter-continental passage, 40-fold spread).



Differentiation of noise-related LTO charges by time of day

The proposed directive provides for the possibility to modulate noise changes by time of day, without establishing criteria for such modulation. It is merely laid down that the modulation of noise charges should occur "within a given part of a 24-hour period", subdivided "into a maximum of three periods (day, evening and night)". The structure of the proposed calculation formula offers several possibilities to allow for differentiation by time of day. Theoretically, units of noise charges or noise thresholds can be varied or adjusted according to time of day. Because of difficulties in the establishment of noise thresholds, which have already been discussed, this option does not appear to be useful. Moreover, major changes in the range of aircraft using an airport in the course of the day are unlikely to occur, so that no substantial changes in noise thresholds would occur.

What is conceivable is a reduction in noise threshold through the adoption of varying spreads at different times of day. This would take account of greater nuisance effects in the evening and at night as well as meet mitigation requirements, since lower noise thresholds would result in an increase in noise charges.

Three-fold differentiation of units of noise charges C_a and Cd in daytime, evening and night rates is in accordance with Directive COM(2002) 49 on environmental noise, which applies a supplement of 5 dB in the evening and 10 dB at night in line with the day-evening-night noise indicator L_{den}. This A-weighted continuous sound level applies for an assessment period of one year. If one allows for these supplements analogously with respect to the charging system at *Stockholm-Arlanda* for units of noise charge C_d and C_s with constant noise thresholds (T_d=86 EPNdB, T_a=91 EPNdB), charge rates arise that are equivalent in the evening to three times the daytime rate, and at night to ten-times the daytime rate (see Table 33). These multipliers arise from the corresponding multiplication of the number of acoustic sources with an increase in sound power level of 5 dB and 10 dB.

As a result, the following noise charges arise (see Table 33). Where the upper noise charge limit is exceeded, which with a 20-fold spread amounts to 65.60 euros, it is displayed in red. The differentiated charges for flight movements of given aircraft types are displayed for landing (above) and take-off (below).

Table 33 Modulation of noise charges by time of day according to the EU calculation formula

Aircraft type	**Model**	**Flight Movement**			
		2 x daytime	1 x daytime, 1 x evening	1 x daytime, 1 x night	2 x night
B737	3L9	€ 31.57	€ 43.78	€ 86.54	€ 315.69
				€ 65.60	€ 65.60
A 320	211 014	€ 21.72	€ 43.44	€ 119.47	€ 217.22
				€ 65.60	€ 65.60
B 747	430	€ 121.15	€ 252.04	€ 710.15	€ 1,211.47
		€ 65.60	€ 65.60	€ 65.60	€ 65.60
Unit of noise charge		€ 3.28 each	€ 3.28/ € 9.84	€ 3.28/ € 32.80	€ 32.80 each

Notes: Weighted as follows: day: single / evening 3-fold / night 10-fold
Charges in excess of the upper limit (€ 65.60) are displayed in red.
Source: Tariff Regulations *Swedish CAA* Stockholm-Arlanda 12/2001 and own investigations

In the analysis of differentiation by time of day it appears that the sequence of the two movements under consideration is important for the level of charges. Because of varying significance, noise-related LTO charges differ, depending on whether landing or take-off is involved. The example of a B737-300 shows clearly that arrival in the evening and departure during the day (107.95 euros) is more costly than arrival during the day and departure in the evening (49.89 euros). This effect does not occur in the case of an A320 (in each case, 54.31 euros). With a B747, the reverse effect occurs, namely, that the evening-day combination (288.25 euros) is less costly than the day-evening combination (317.48 euros). It thus becomes clear that arrival and departure are assessed differently, depending on the noise level of the aircraft type under consideration.

6.2.1.4 Assessment

In the view of the project team, appraisal of the calculation formula laid down in the proposed EU Directive COM(2002) 683 and investigated in Scenario 1 shows that, compared with the structures of existing charging systems (reference system: Frankfurt), no improvement is achieved. The intended goal of a greater incentive for the operation of modern, less-noisy aircraft for the purpose of precautionary noise mitigation is not likely to be achieved. Despite this negative outcome, the proposed approach has a number of aspects that must be assessed positively and borne in mind in further work.

Strengths

The intended and achieved uniformity of the calculation formula in keeping with the proposed EU Directive is to be welcomed. This common formula, which is adjusted to local circumstances with the establishment of noise threshold and unit of noise charge, offers the possibility of EU-wide uniformity and comprehensibility. A further advantage is that unambiguous, comprehensible and individual aircraft noise measurements are included. The application of measured noise certification values according to ICAO Annex 16 guarantees that noise emissions, in the form of noise disturbance levels, are considered and applied separately for each aircraft type. At the same time, a distinction is made between arrival and departure, which, on account of varying noise disturbance levels, is to be welcomed. A further advantage is that there is a smooth transition between the defined lower and upper limits, so that each aircraft is individually priced and the general disadvantage of classification is avoided. Classifications are rigid and have the effect that no distinction is made between the corresponding; and what is more, no incentive exists for loud aircraft within a particular category to take action on noise alleviation.

Finally, ICAO principles are considered. In particular, it is possible to safeguard the criterion of revenue neutrality by structuring the calculation formula accordingly. In addition, the criteria of transparency and non-discrimination as well as the principle of cost-recovery are met.

Weaknesses

The calculation proposal offers little transparency, due to its highly complex formula and a number of elements that are not immediately comprehensible. This concerns, in particular, noise thresholds (T_a, T_d), which are absolutely essential for the determination of noise charges. Further information for the determination of these thresholds is not contained in the current draft directive. This shortcoming was already raised in statements submitted (for example, by the Committee on Regional Policy, Transport and Tourism of the European Parliament) on draft Directive COM (2001) 74, but they were not taken up.

In order to determine noise thresholds in the required form, extensive information (noise data) is required for every single flight, which is neither freely available nor ascertainable. Application to the reference airport at Frankfurt for the calculation of noise thresholds is not possible within the scope of this report, since the required determination of "noise energy emitted at the airport" (proposed EU Directive 2002/683) is too time-consuming. Data from the master database, which contains all local flight movements and necessary data regarding certificated noise values, is not available. Were corresponding data to be available, the question of whether thresholds could be determined would remain unresolved. On the one hand, it is unclear in which form sound energy should be cumulated (and over which period?); on the other hand, it is unclear which noise levels should be used to plot "noise energy".

A further element, which has to be assessed negatively, is the planned spread, both in its form and kind. Besides the spread (20- and 40-fold) in the determination of noise thresholds, the incorporation of an additional spread in the rates of noise charges is also provided for. The maximum amount that may be levied is laid down – as implemented in the Stockholm model – as a multiple of units of noise charge corresponding to the intended spread. Due to this spread, noise-related LTO charges are lower in the EU model than in the current Frankfurt charging system. The additional upper limit on noise charges, contained in the Stockholm model, has the effect that a maximum rate of twenty times the basic charge can be levied. As a result, aircraft types such as the A300, B727, DC 10, MD11 or B747 will be subject to the maximum rate, although in this case further differentiation appears to be necessary on account of differing noise emissions. A smaller spread has a more limited incentive effect, so that no reaction is expected on the part of airlines. Without an upper limit in the form of a maximum charge, the noise thresholds determined for Frankfurt would produce, with the EU model, a spread not of 1 to 20, but of 1 to 90.

A further point of criticism is levelled at the possibility to set multiplication factors (units of noise charge Ca and C_d) at zero, which has the effect that no noise charge whatsoever is imposed. This option is provided for in the EU Directive, but has not been adopted, for example, in the Stockholm charging system. The minimum charge amounts to 3.28 euros (or 30 SEK).

It is also not clear to what extent the environmental costs of noise can be covered with cost-relatedness and revenue neutrality as required by ICAO guidelines. Up to now, scientific knowledge has been inadequate to the task of precisely calculating the environmental costs of noise. The external-cost approach used here represents a first attempt at internalizing the external costs of noise through noise-related LTO charges.

Finally, the theory contained in the proposed directive, namely that the sound energy level best reflects the "relationship between this incremental emission and aircraft noise level," since incremental noise is proportional to the noise produced, cannot be followed. Sound energy represents the physical energy of a sound source and is seldom used as a physical sound value; only to a limited extent does it provide appropriate emission data for the registration of noise impact or nuisance. Immission data (for example, sound pressure level, equivalent or rating level), which better reflects the noise impact on those affected, is preferable for this purpose. More recent findings from noise-impact research show that in determining the degree to which people are affected, single acoustic events (L_{Amax}) and, where possible, also the number of acoustic events (for example, as the NAT [number above threshold] criterion) should be additionally applied. The number of flight movements is not directly covered by the designated formula, so that important criteria for the assessment of noise nuisance are not represented.

6.2.2 Scenario II: External costs of aviation

6.2.2.1 Background

At the European Council meeting in Gothenburg it was emphasized, "*a sustainable transport policy requires the complete internalization of social and environmental costs"* (EC 2001). In order to guarantee equal opportunities for all transport carriers, taxation has to provide, on the basis of uniform principles, for a better apportionment of the costs of transport; that is, of those costs that are generally borne not by users but by society. In *Air transport and the Environment* (COM(1999) 640) it is emphasized that efforts towards fair conditions for competition within the overall transport system should be continued. In particular, greater incentives should be created for environmental improvements. In the view of the EU, internalization of external environmental and infrastructure costs, on the basis of the polluter-pays principle, has to be discussed in respect of all transport carriers.

While the debate on the determination and assessment of external costs in road- and rail-based transport has been conducted at the European level for a number of years, as far as air transport is concerned it has just begun. A research project on the "*External Costs of Aviation"* was carried out on behalf of the Federal Environmental Agency by the Dutch "Centre for Energy Conservation and Environmental Technology" (CE) (Dings 2002). The study focuses, however, on external environmental costs associated with the impact of climate change, and does not deal explicitly with external environmental costs at airports.

In November 2003, a study on external costs at an airport was carried out for the first time worldwide by the *Institut für Energiewirtschaft und Rationelle Energieanwendung* (IER) at Stuttgart University on behalf of the *Regional Dialogforum* (Friedrich 2003). This study, "*Ermittlung externer Kosten des Flugverkehrs am Flughafen Frankfurt/Main*", had the aim of determining quantitatively the external costs of air traffic (that is, monetarized negative external effects) at Frankfurt Airport[121]. The focus of the study was on external costs that have a local effect, including (technological) external costs that are directly apportionable – in accordance with the polluter-pays principle – to the user or operator of the airport (Friedrich 2003).

Beyond that, suggestions were also made on how external effects could be internalized and on the form in which they should be introduced into the discussion on the further development of Frankfurt Airport.

The term 'external costs' related in this study not only to external environmental costs, but also to unmet infrastructure costs. The subject of investigation was not only infrastructure facilities at Frankfurt Airport, but also the traffic handled at the airport.

Apart from **total external costs**, which can be brought into the discussion and assessment of alternative decisions, the **marginal external costs** of air traffic at Frankfurt Airport were also quantified within the scope of the study.

Such observations provide the prerequisite for differentiated internalization of external costs. Marginal costs were interpreted as those costs that arise as a result of a specific additional flight movement (take-off or landing) within the considered limits (LTO cycle)[122] (Friedrich 2003).

External costs of noise play a decisive role at airports. The discussion on internalization concerns the marginal external costs of noise.

The external costs of noise were described in the Friedrich study (2003) using the path of effect approach with the following modules:

- Noise emissions and noise dispersion.
- Exposure of the population
- Description of health effects by means of the dose-effect relationship.
- Monetarization of health effects and nuisance effect.

The calculation of external costs resulting from aircraft noise is based on modelled noise data of the Hessian State Agency for Environment and Geology (HLUG), which were provided for day (0600 to 2200) and night (2200 to 0600) time slices (expressed as $L_{Aeq(3)}$) for both LTO directions. The HLUG data model corresponds to a square with

[121] External costs were determined not only for the reference case, which reflected current traffic operations at Frankfurt Airport, but also for different stages of development (Friedrich 2003).

[122] A further, theoretically possible definition of marginal external costs would be marginal costs brought about by an additional passenger. As long as there was still room in the aircraft under consideration, this additional passenger would give rise to insignificantly-small marginal costs. In principle, however, a passenger whose demand would lead to the operation of an additional aircraft, would have to bear its total external costs. This passenger is, however, not clearly identifiable; the decision on the operation of additional aircraft rather concerns considerations of probability and risk. Since every passenger thus contributes equally to the decision on additional aircraft, marginal costs were interpreted in the study as the costs of the next additionally operated aircraft, which, allowing for average load, can then be converted to a value per passenger (Friedrich 2003).

an edge length of 70 km and a definition of 100 metres, so that for each case 490,000 data sets, and in total 4.9 million data sets had to be processed [123].

For the calculation of the marginal costs of noise, additional aircraft noise scenarios were necessary, which were computed from overall HLUG scenarios and IER aircraft noise models. With the help of the energetic addition of noise levels, new so-called marginal scenarios were computed from HLUG scenarios and model runs for each modelled aircraft configuration (Friedrich 2003). In order to consider thresholds in the computation of effect, the background impact of noise had to be taken into account. This concerned not only aircraft noise, but also other sound sources that the population is subjected to. In each case the total noise level was therefore computed, with further noise sources[124] being added energetically to overall noise scenarios.

The sound levels of the noise scenarios were computed in accordance with HLUG data on a 100 x 100 m grid, which was blended with population maps from the mediation process by means of a geographic information system (GIS), so that an average number of people affected could be computed (Friedrich 2003).

Health effects were applied in accordance with the World Health Organization (WHO) definition in '*Guidelines for community noise*'. The following effects were considered, which can nowadays be recorded quite reliably in quantitative terms:

- Heart disease (cardiac infarction, angina).
- Hypertension.
- Sleep disturbance at night.

At the same time,

- nuisance and
- disturbance of discussions

were also assessed. Monetarization of the effects was carried out, particularly for the assessment of different categories of nuisance, primarily with a traditional approach based on the indirect method of "*hedonic pricing*“. To supplement Directive 2002/49/EC on environmental noise, efforts are being made by the Directorate-General for Environment of the European Commission to assess noise economically. This should support the concept of cost-benefit analysis, which is carried out for noise abatement measures. An expert committee, which was concerned with health and socio-economic aspects of noise, presented the draft of a corresponding recommendation (WG HSEA 2003) on 21. March 2003. Based on the abstract from Navrud (2002) and allowing for existing uncertainties, a value of 25 $€_{2000}$ per dB (L_{den}) per household and year is recommended for the assessment of road noise. This value is applicable for a

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[123] Because noise levels, expressed as $L_{den,}$, are required as an essential value, they were computed from the two given noise indicators, under the simplifying assumption of equal distribution between day and night, with an additional 5 dB in the evening and 10 dB at (Friedrich 2003).

[124] Specifically, road noise, runway noise and ground noise.

threshold of 50/55 dB_{Lden}. Factors are recommended for the adaptation of these values to aircraft noise, but no specific values are mentioned.

Within the framework of the study on the external costs of Frankfurt Airport, adaptation was undertaken on the basis of differences in *Miedema's* nuisance curves (Miedema 2001) Even at low noise levels, aircraft noise is felt to be just as disturbing as road vehicle noise. The ratio between road noise and aircraft noise arising from the nuisance curves is 1 to 1.55.

On the basis of this information, and with a statistical average household size of 2.2 persons per household, a value of 18 $€_{2000}/dB_{Lden}$ per person for aircraft noise and 11 $€_{2000}/dB_{Lden}$ per person for road noise was deduced. These values were used to monetarize the nuisance effect of aircraft noise as a standard value. In the great majority of studies 55 dB_{Lden} is applied as the noise threshold. However, because nuisance effects doubtless also occur below this threshold, and the above recommendation mentions a range of 50 – 55 dB, alternative computations are also made with a threshold of 50 dB. Since the threshold should also influence the monetary value per dB – no findings are available in this respect - external costs tend to be somewhat "overestimated" with this threshold (Friedrich 2003).

Table 34 Valuation basis for the monetary assessment of noise at Frankfurt Airport according to Friedrich (2003).

$€_{2000}$/dB per person and year	Noise measurement	Threshold in dB	Deduced according to
18	L_{den}	50 and 55	Working Group on Health and Socio-economic Aspects

The "best estimate" resulted in external costs of noise from health and nuisance effects amounting to about 26 million euros, on the assumption of a threshold of 55 dB, and about 62 million euros with a threshold of 50 dB. That represents around 31% and 52%, respectively, of all external costs (Friedrich 2003).

While total external costs demonstrate the relevance of the problem, according to economic theory, marginal external costs are the important quantity for internalization. Moreover, they explain the causes and mechanism of different effects. Major influencing factors are:

- type of flight movement (take-off or landing),
- timing of the flight movement (day, evening or night),
- aircraft type, combined with engine type,
- take-off mass (in particular with heavy aircraft) and
- flight path.

Due to the enormous effort expended on modelling, the attempt was made to elaborate the influence of critical factors within the scope of work on external costs.

Marginal costs arise from exposure of the population to the noise of **the** last **additional aircraft**. Where, and at which altitude a departing aircraft leaves behind its characteristic footprint is not only dependent on the aircraft itself, but also on flight navigation, with particular respect to departure and arrival paths.

A number of results are presented below by way of example, in order to illustrate the computation of the marginal external costs of noise at Frankfurt Airport.

In Table 35 The results are displayed for take-off between 0600 and 1800 for different departure paths in the year 2000, with a valuation of 18 $€_{2000}/dB_{Lden}$ per affected person and a threshold of 50 dB_{Lden}. This shows to what the extent the marginal external costs of noise are dependent, on the one hand, on aircraft type (of which a selection is shown) and, on the other hand, on the choice of departure path.

Table 35: Marginal external costs for take-off during the day on different flight paths, 2000

Aircraft type	Route 07 N-L	Route 07 R-O	Route 18 KIR-K	Route 18 KIR-L	Route 18 KNG-K	Route 18 KNG-L	Route 25 TAU-L	Route 25 TAU-K
737-800	53.2	30	17.5	13.2	15.5	16.9	35.8	22.7
747-200	158.7	100.5	52.7	36.4	56.1	49	150.9	69.6
747-400	129.4	82.3	45.4	32.9	50.1	45	108.9	55.3
767-300	94	54	30.7	21.5	25.1	29.1	63.7	38.3
A300-62	41.3	23.8	13.8	10.5	12.1	13.2	27.7	18.1
A 319	13.7	7.3	4.3	3.3	3.7	3.9	8.9	5.9
A 320	21.6	12	6.9	5.3	5.9	6.5	14.4	9.4
A 340	45.4	28.2	15.5	9.7	14.8	13.8	42.1	19.1
ATR 72	44.8	27.2	13.9	8.5	14.4	13	35.7	16.7
DHC 8	1.2	0.5	0.3	0.2	0.3	0.4	0.8	0.5
EMB 145	2.9	1.6	0.9	0.7	0.8	0.9	2.4	1.3
MD 82	78.5	46.8	25.2	18.4	21.7	24.3	60.6	42.6

Note: Monetarization occurs on the basis of $€_{2000}/dB_{Lden}$ per person; threshold value 50 dBL_{den}.. Presentation is in euros per take-off. In practice, certain aircraft cannot depart on all flight paths for technical reasons. These figures are therefore hypothetical, but they are shown for the purpose of completeness.
Source: Friedrich 2003.

If one relates flight path values in each case to flight path 25 TAU-K, which was used in the investigation of 68 aircraft types, characteristic differences arise between flight paths that are applicable within certain limits for all aircraft and show how strong the influence of flight paths (irrespective of aircraft types) on the marginal external costs of noise actually is.

Table 36 Mean factors for the valuation of marginal external costs at Frankfurt Airport on different departure paths

Route 07 N-L	Route 07 R-O	Route 18 KIR-K	Route 18 KIR-L	Route 18 KNG-K	Route 18 KNG-L	Route 25 TAU-L	Route 25 TAU-K
2.09	1.20	0.68	0.49	0.63	0.65	1.58	1.00

Note: All values relate to Route 25 TAU-K.

Source: Friedrich 2003.

In Table 37 The marginal external costs of **arrivals** are also shown exemplarily on runway 07L for easterly traffic and runway 25R for westerly traffic in the year 2000 for a broad range of 12 selected aircraft types.

Table 37 Marginal external costs of arrivals in 2000.

Aircraft type	07L (easterly traffic)			25R (westerly traffic)		
	Day	Evening	Night	Day	Evening	Night
737-800	16.2	38.5	120.4	14.5	34.5	108.2
747-200	35.8	85.0	262.0	27.9	66.2	206.3
747-400	64	152.0	467.0	56.8	134.7	418.3
767-300	21.3	50.6	158.0	17.3	41.0	128.6
A 300-62	38.9	92.3	286.0	38.3	90.8	283.9
A 319	7.3	17.2	54.4	6.4	15.3	48.3
A 320	13	30.9	97.2	11.6	27.4	86.5
A 340	25.8	61.2	192.9	27	63.9	201.7
ATR 72	3.6	8.6	26.9	0.8	1.9	5.9
DHC 8	1.3	3.1	9.8	0.1	0.2	0.7
EMB 145	3.5	8.3	26.0	1.1	2.6	8.1
MD 82	4.6	10.9	34.3	1.7	4.1	13.1

Note: Monetarization is on the basis of 18 $€_{2000}/dB_{Lden}$ per person, threshold value 50 $dBL_{den.}$ Presentation is in euros per landing.

Source: Friedrich 2003.

The table illustrates, supplementing Table 35, the influence on marginal external costs of noise of take-off compared to landing. Beyond that, the table makes very clear the influence of the timing of flight movements on economic assessment. The relationship of evening to day, or night to day, can be reliably calculated with a factor of 2.35 and 7.38, respectively (resulting from the supplement for evening and night of 5 dB and 10 dB, respectively) (Friedrich 2003).

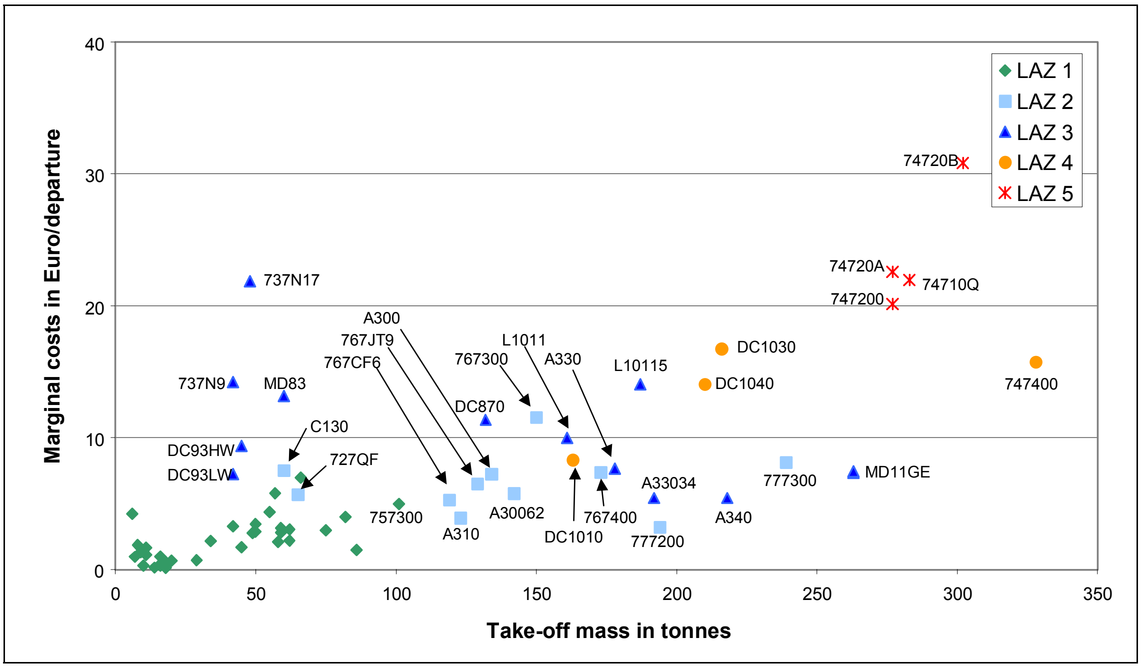
The implicit influence of aircraft mass is also clear: The costs of arrival from a westerly direction (07) are somewhat higher for heavy aircraft compared with arrival from an easterly direction. With a maximum take-off mass of less than 70 tonnes, however, a considerable difference can be ascertained. For these aircraft (for example, MD 82, EMB 145, ATR 72, DHC 8), costs for arrival from a westerly direction are reduced by two-thirds.

Correlation of marginal external costs and aircraft mass can, however, be barely established at Frankfurt Airport. This is made clear by an investigation undertaken by Friedrich (2003), in which aircraft types (combined with certain engine types), aircraft mass and assignment to L_{AZ} categories at Frankfurt Airport were set in relation to each other. This investigation was conducted on flight paths TAU 1F and N TAU 1G, with an assumed take-off mass of 80% of the maximum permitted.

The results are presented exemplarily with a value of 18 $€_{2000}$ per dB_{Lden} per person and a threshold value of $50dB_{Lden}$ in Figure 31.

Dependence of external costs of noise on take-off mass as well as assignment to L_{AZ} categories can only be established tendentially. This might be explained by the varied climbing profile of aircraft. It is therefore possible that an aircraft is louder at a particular measuring point, but that, as a result of its greater climbing capability, its footprint affects a smaller proportion of the population than less-noisy aircraft that climb less steeply (Friedrich 2003).

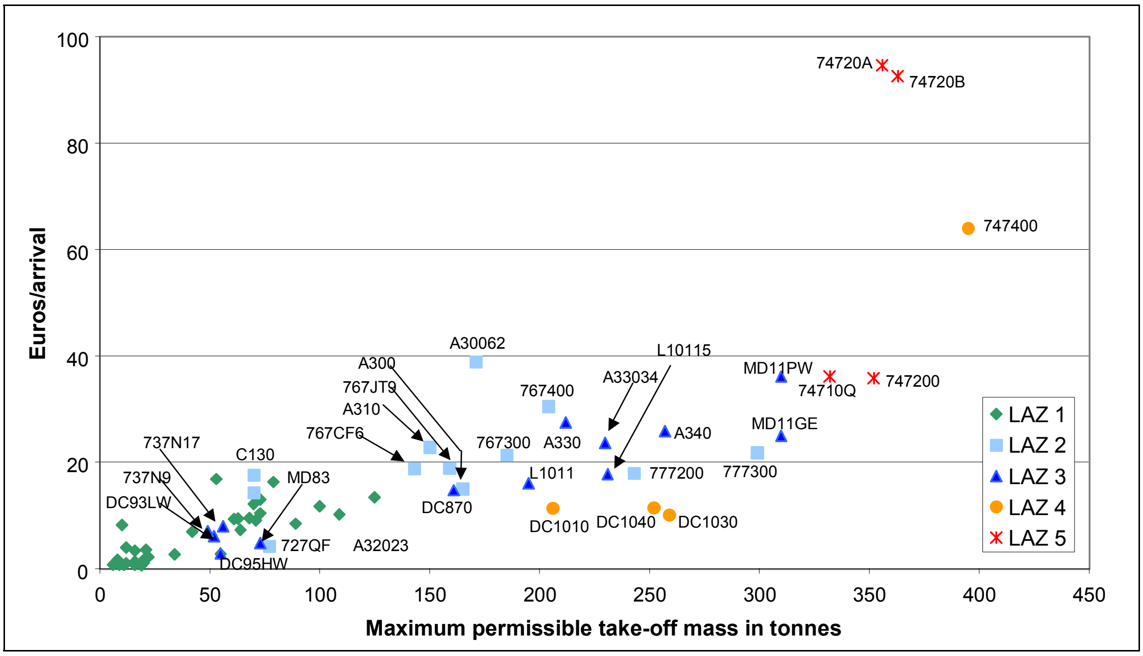
Figure 31 Marginal external costs of noise of different aircraft types for daytime departure depending on take-off mass



Note: Monetarization is based on 18 $€_{2000}/dB_{Lden}$ per person; threshold value 55d $BL_{den.}$ Presentation is in euros per take-off in the exemplary direction of the Taunus area, in categories of the airport charges system 2003 = L_{AZ} categories.
Source: Friedrich 2003.

The marginal costs of landing on runway 07 R for these aircraft types are displayed in Figure 32. Calculations were carried out on the basis of a standard gliding angle of 3° with an easterly approach, and are displayed dependent on aircraft size (maximum permissible take-off mass). The trend shows that external costs depend on aircraft size; aircraft of the same L_{AZ} category have – as already shown in the analysis of take-off – a broad spread of external costs (Friedrich 2003).

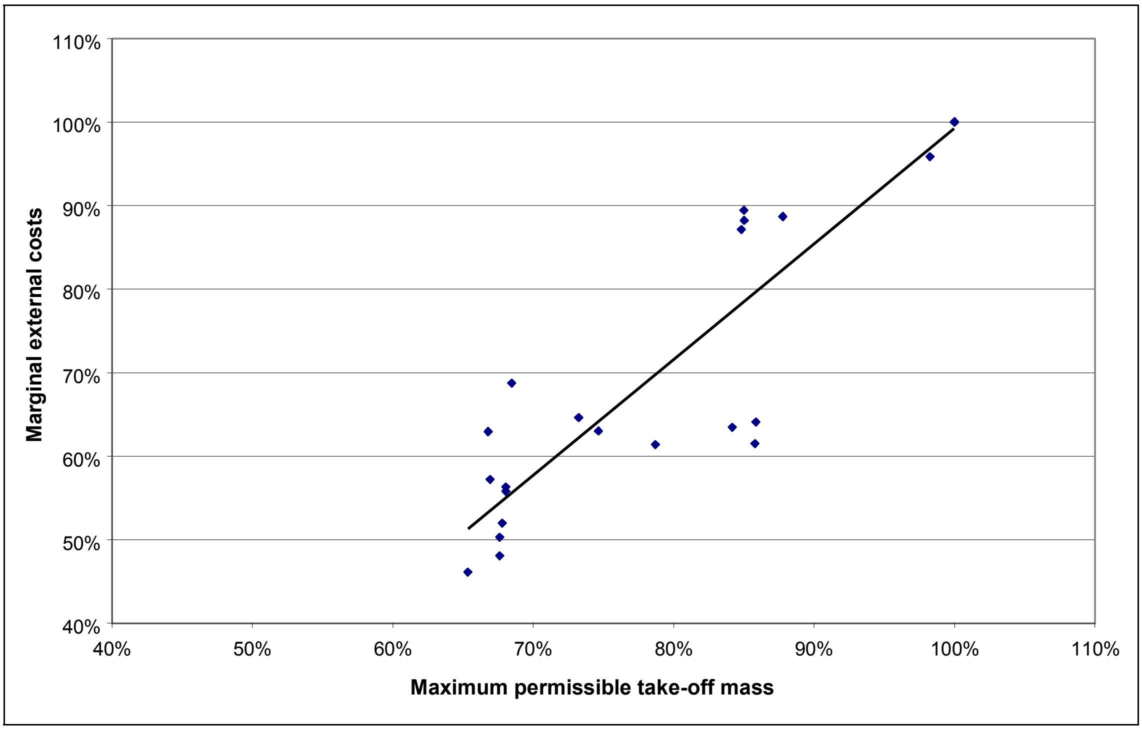
Figure 32 Marginal external costs of noise of different aircraft types for daytime arrival depending on maximum take-off mass



Note: Monetarization is based on 18 $€_{2000}/dB_{Lden}$ per person; threshold value 50d $BL_{den.}$ Presentation in euros per exemplary landing on runway 07R, in categories of the airport charges system 2003 = LAZ categories.
Source: Friedrich 2003.

The influence of actual take-off mass on marginal external costs was investigated in the case of different heavy aircraft with a maximum permissible take-off mass in excess of 230 tonnes. Beginning with a take-off mass of at least 70% of maximum take-off mass (MTOM), marginal external costs grew on average by about 14% for each 10% increase in take-off mass. Figure 33 displays the influence of the take-off mass of various large aircraft on external costs at take-off. Actual take-off mass in relation to maximum permissible take-off mass is plotted on the x-axis [%]. The relation between external costs with a particular share of maximum permissible take-off mass and external costs in the case of permissible total mass [%] is plotted on the y-axis (Friedrich 2003).

Figure 33 Influence of the take-off mass of various large aircraft on the marginal external costs of noise at take-off



Source: Friedrich 2003

The differentiation that is made possible by the quantification of marginal external costs appears to provide an attractive basis for a user-focused, noise-related charging system. Such a system should therefore be designed in such a way that differentiation characteristics can be discussed in effect analysis and in critical assessment.

6.2.2.2 Design

The varied user-focused options for the differentiation of marginal external costs suggest that marginal external costs of noise should be investigated as a basis for assessment for a new Scenario II, to be able to analyse effects and, in the assessment, to weigh up the pros and cons of this basis for assessment of noise-related LTO charges.

The assessment should be carried out separately according to:

- type of flight movement (take-off or landing),
- timing of the flight movement (day, evening or night),
- aircraft type, combined with engine type,
- take-off mass (particularly in the case of heavy aircraft) and
- flight path.

The calculation can be carried out within the scope of this study in accordance with Friedrich's research (2003) on the basis of the path of effect approach/method with corresponding monetarization. A critical methodical appreciation will be undertaken in the course of validation.

6.2.2.3 Effect analysis

As already discussed in principle in Section 6.1, effect analysis concentrates on the incentive structure of noise-related LTO charges based on external costs, compared with the status quo of the noise-related charging system at Frankfurt Airport[125]. The comparison of incentive structures follows methodically the discussion in Chapter 4.1.3.2. In the view of the project team it enables an initial orientating interpretation of the extent to which a system based on the marginal external costs of noise is suitable for improving the structure of incentives for the operation of less-noisy aircraft at corresponding airports.

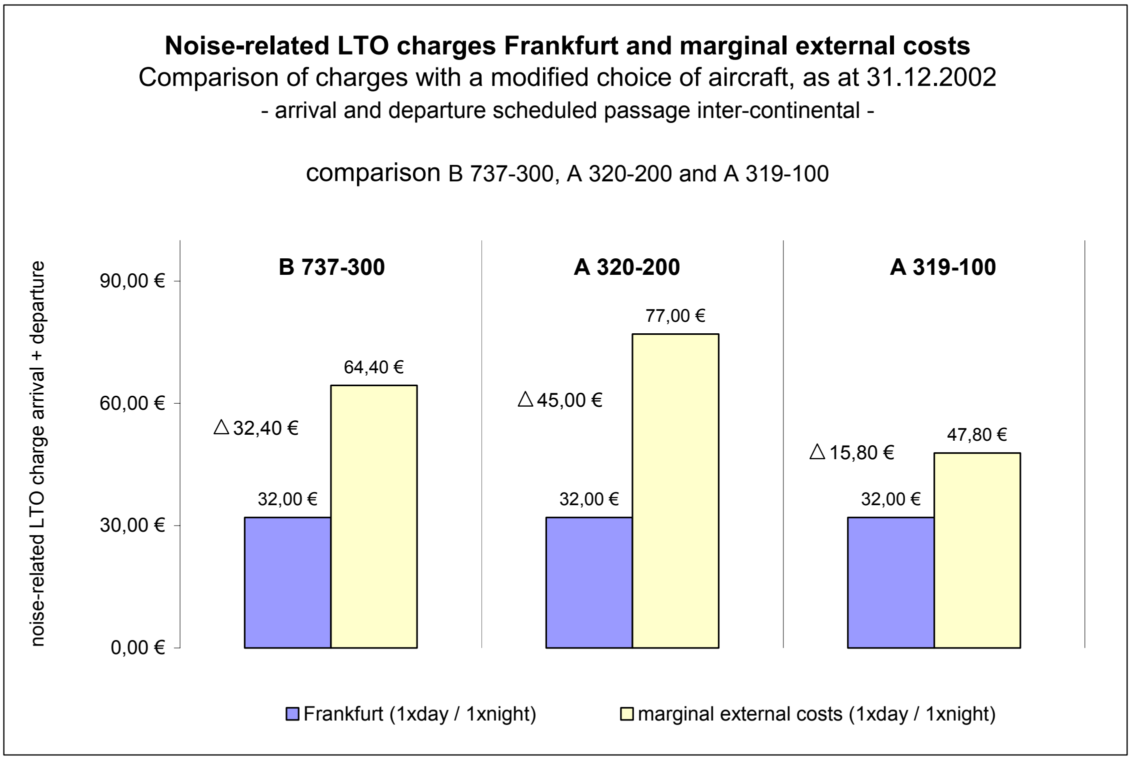
Comparison of incentive structure is carried out, analogous to the investigations in Chapter 4.1.2.2, in this part of the study on the basis of the most representative exemplary calculations,

- on the one hand, for a B 737-300 compared to an A 319 and an A 320 in German domestic air service (Figure 34), and
- on the other hand, for a B 747-200 compared to a B 747-400 and MD 11 in inter-continental service (Figure 35).

Calculations on marginal external costs are carried out exemplarily for arrivals from an easterly direction (07) at night, and for aircraft departure in a westerly direction towards the Taunus radio beacon on flight path TAU 1F during the day at Frankfurt Airport.

[125] The incentive structure of the noise-related LTO charging system at Frankfurt Airport was examined in Chapter 4.1.3.2.

Figure 34 Comparison of noise-related LTO charges at Frankfurt Airport and the marginal external costs model (scheduled service, domestic passage, one daytime movement and one movement at night)



The figure makes clear that in the current charging system marginal external costs exceed charges for all types of aircraft by a factor of 1.5 to 2.4. Paradoxically, in the case investigated, the external costs of a less-noisy A 320-200 (in relation to the certificated noise level) are higher, compared to the B 737-300. The difference, which results from consideration of external costs, is unlikely to produce incentive effects, in particular because of the insignificant amount in absolute terms. It is nonetheless interesting to observe that in the case of the three types of aircraft under investigation, which are presently assigned to the same noise category at Frankfurt Airport, appreciable differences emerge in external costs. In the opinion of the project team, such differences should be reflected in future in the modulation of noise charges. This basically argues in favour of a **dynamic structure of noise-related LTO charges**; that is, an **escalating structure** on the basis of which the level of noise charges also increases in the course of time.

Figure 35 Comparison of noise-related LTO charges at Frankfurt Airport and the marginal external costs model (scheduled service, inter-continental passage, one daytime movement and one movement at night)

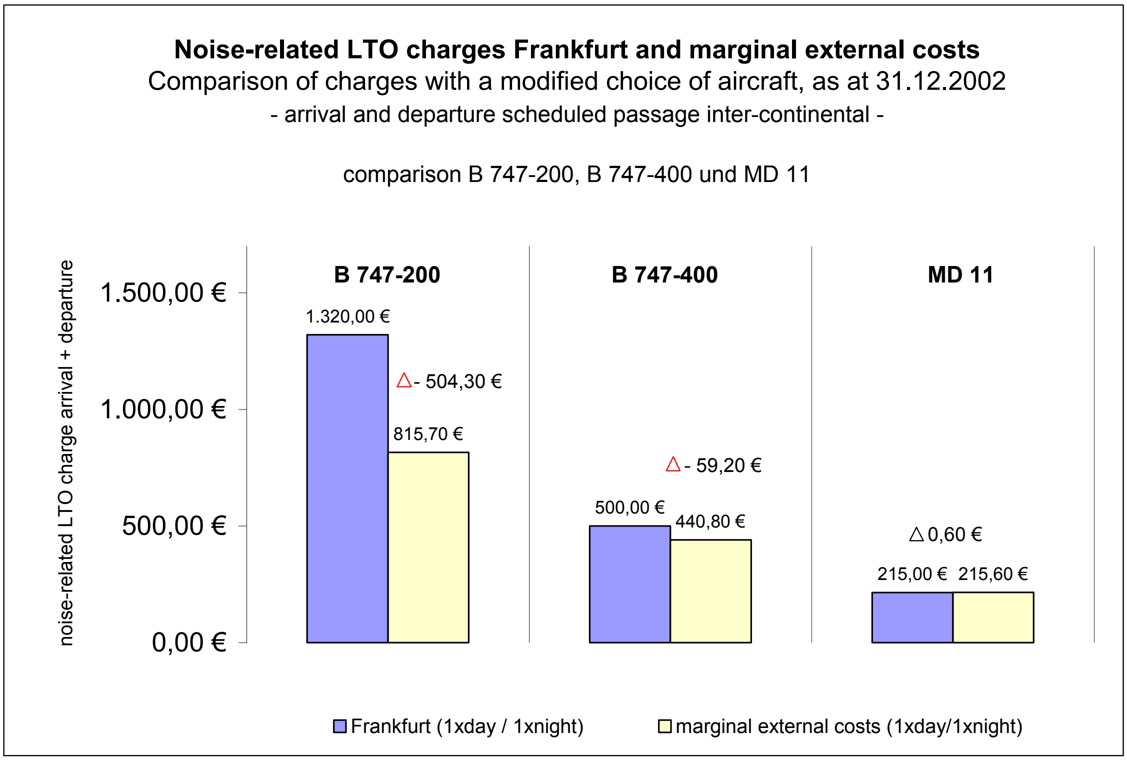


Figure 35 displays results, analogous to assumptions for the model comparison of types of aircraft in German domestic services, as regards alternative aircraft types in inter-continental service. Compared to German domestic services, the results for aircraft in inter-continental services are reversed. That means the marginal external costs of noise are below – in part, considerably so – noise-related LTO charges currently levied at Frankfurt Airport. This effect is particularly noticeable in the case of the B 747-200, which is listed at Frankfurt in noise category 5. The difference between noise-related LTO charges currently levied at Frankfurt and the marginal costs of noise decreases in the case of aircraft types that are assigned to other noise categories (B 747-400 in noise category 4; MD 11 in noise category 3). These results are counter-productive from the point of view of noise reduction, for were one to switch noise-related LTO charges to marginal costs of noise, a more limited incentive effect would arise compared to the charging system currently applied at Frankfurt Airport.

In general terms this means that, even including results in respect of aircraft types operated in domestic services, in using the marginal external costs of noise as a basis for noise-related LTO charges, a **smaller spread** is to be observed than with the status quo. This applies at least for the structure employed in this study.

Since already in status quo analysis and the assessment of the charging system at Frankfurt no substantial effects of noise-related LTO charges could be demonstrated (see Chapter 5.2.1), it has to be assumed that no far-reaching incentive effects are to be expected from a changeover to marginal external costs for the purpose of precautionary noise mitigation. On the contrary, a smaller incentive effect is to be expected. This result comes as a surprise and will be dealt with once again in the assessment of this scenario.

6.2.2.4 Assessment

Within the framework of Scenario II it was investigated to what extent the marginal external costs of aircraft noise could present an appropriate basis for assessment in establishing noise-related LTO charges at commercial airports. In addition, on the basis of a number of computational examples, the (incentive) effects were discussed that could possibly evolve from a changeover from existing noise-based LTO charging systems to a system based on the marginal costs of noise. A conclusive assessment cannot yet be made, but, in the view of the project team, basic **strengths** and **weaknesses** can be deduced that should be considered in the further development of an effective and harmonized noise-related LTO charging system in Germany or Europe.

Strengths

One positive aspect lies in the fact that calculations of marginal external costs are based on the ICAO noise levels of certification measurements in accordance with *Annex 16*[126]. These form a uniform basis by applying defined flight conditions (take-off: MTOM, landing: permitted landing mass). Classification in noise categories, as embodied in many existing noise-related charging systems, is neither useful nor necessary. Besides ICAO certification values, an approach based on the marginal external costs of noise shows that further useful differentiation criteria can be considered:

1. **Type of flight movement:** Friedrich's research has shown (2003) how greatly the marginal external costs of noise of a particular aircraft at a given time of day can vary between **take-off** and **landing**.
2. **Day- and night-time flight movement:** Applying the marginal external costs of noise allows modulation of charges on the basis of day- and night-time flight movements, which is useful also because of varied noise nuisance.
3. **Type of aircraft and engine as well as take-off mass:** Besides aircraft and engine type, take-off mass is also a factor in establishing the marginal external costs of noise nuisance, and thus charges. Take-off mass determines flight profile and thus aircraft noise, which could also justify modulation of charges.

[126] See *Annex 16 To The Convention On International Civil Aviation, Volume I Aircraft Noise* and accompanying supplementation by the ICAO document, "*Environmental technical manual on the use of procedures in the noise certification of aircraft*“ (Document 9501)

4. **Flight path:** A noticeable result of Friedrich's research on Frankfurt Airport (Friedrich 2003) is the significance of the strong dependence of marginal external costs of aviation on the take-off and landing pattern, and to a greater extent on flight paths in the close vicinity of the airport. These determine to a considerable degree the nuisance effect of noise.
   On the one hand, this justifies to a certain degree modulation of noise-related LTO charges on the basis of marginal external costs. However, any incentive or control effects, in contrast to other differentiation criteria, are difficult to define.
5. **Airport-specific concernment and nuisance effect:** What distinguishes the approach using the marginal external costs of noise is the consideration of concernment at aircraft noise and its nuisance effect at a specific airport, which is ascertained by way of the size of the resident population within certain isophones. Furthermore, airports can ultimately be characterized individually, including – indirectly – the size of an airport (number and type of flight movements, proximity to the resident population, population density). In the view of the project team, concernment, in particular, has up to now only been inadequately considered in the establishment of noise-related LTO charges (see Chapter 4). In this respect, consideration of the marginal external costs of noise sets new standards, since these take account of criteria for concernment that could be compared at different airports. This approach therefore creates conditions for a uniform and harmonized system, which is nonetheless able to take account of specific features at individual airports.

The monetarization approach is suitable for consideration and, if necessary, transparent presentation of all useful differentiation criteria. Moreover, through the external costs approach the opportunity exists, where required, to integrate further additional external effects of aviation in the vicinity of airports (for example, external effects of air contaminants, risks of accidents). Up to now, effects at European commercial airports have been considered, at best, in the design of environmental charges for take-off and landing. The external costs approach offers the chance of integrated consideration of the different external effects of aviation at airports. Through the integration of different effects, the incentive can be increased for the operation not only of less-noisy but also of otherwise environment-friendly aircraft, in contrast to the isolated consideration of the marginal external effects of noise.

It is important to mention once more that the requirement for cost-relatedness of noise-related LTO charges can be fulfilled with this approach. Against the backdrop of broader problems with this approach (see below), a precise legal examination does not appear to be useful at present.

Weaknesses

The method adapted by Friedrich (2003) for the **calculation of the marginal costs of noise** at any airport has to be closely scrutinized: The marginal costs of noise describe the external costs of an additional flight movement (take-off or landing) with existing background noise. While in economic theory it is generally assumed that marginal costs rise with increased environmental impact, in the case of noise – to begin with, in terms of figures – this is not necessarily so, since with a high background noise level an additional noise source increases the noise level to a lesser extent than with a low background noise level. This means, by way of illustration, that the additional nuisance caused by an additional aircraft with a generally high volume of air traffic would, in terms of figures, be assumed to be less than with low air traffic volume. More flight movements would therefore result in lower marginal external costs (with increasing total costs). This theoretically-deduced result contradicts, however, general understanding of the disrupting and damaging effect of noise.

In order to discuss this problem, Friedrich established marginal external costs with a modified background scenario of total noise, for which purpose background noise was reduced by 2 dB (Friedrich 2003).

A calculation was made for a daytime departure of an A 340 on the flight path 25-TAU-L. Assessment with 18 $€_{2000}$/(person and dB) and a threshold value of 50 dB_{Lden} produced a value for the marginal external costs of noise that was only 4% higher than the reference case. This relatively low increase in marginal costs can be explained as follows: By reducing background noise by 2 dB, the difference between background noise and the noise level of the additional aircraft is now higher. This effect is compensated in part, however, by the circumstance that the number of people affected – that is, those living within isophones above the threshold level of 50 dB – is about 30,000 less than in the reference case. Through the reduction in background noise level, a proportion of those affected have slipped so far below the threshold of 55 dB that the additional noise level no longer flows into the assessment.

This cast doubts, of course, on whether this approach with a threshold and a linear valuation proportional to the noise level above the threshold value adequately reflects the nuisance effect of aircraft noise. Other methods are conceivable; for example direct monetarization of the number of people who are affected in different categories (strongly affected, etc.). In this case, researchers have to rethink their methods. As long as a satisfactory solution is not found, marginal external costs of noise cannot be recommended as a basis for the establishment and levying of noise-related LTO charges (see also Chapter 7).

The flat-rate monetarization approach that Friedrich (2003) applies (see above), for lack of alternatives, must also be closely examined.[127] Whether the assumed and adjusted values are applicable in the way described to all airports has to be doubted. In particular, the values do not reflect differentiation criteria for the consideration of the

[127] Considering existing uncertainties, a value of 25 $€_{2000}$ pro dB (L_{den}) per household and year is recommended for the assessment of road noise. This value is applicable for a threshold value of 50/55 dB_{Lden} (WG HSEA 2003). The application of adaptation factors is recommended for adjustment of this value to aircraft noise, but no precise values are mentioned (Friedrich 2003).

external costs of individual flight movements. Before recommendation for use, these problems have once again to be critically examined.

But apart from methodical challenges: the weaknesses of the method selected in this scenario evidently lie in the area of **practicality** and **practicability**. The multitude of airport-specific differentiation criteria, which are currently necessary for the determination of the marginal external costs of noise, make it extremely difficult if not virtually impossible to determine the marginal external costs of noise at all airports. This would be essential for the harmonized introduction of this kind of basis for establishing and levying noise-related LTO charges. Data that is publicly available through the mediation procedure, the *Regionale Dialogforum* and also through formal processes hardly exists in the case of another airport. For other airports, initial registration would itself involve an enormous effort that would be difficult to quantify precisely. The modelling of marginal costs demands substantial financial and personnel resources.

Despite the identified weaknesses, in the opinion of the project team it is interesting whether and how the approach involving the external costs of noise can be used for the assessment of noise-related LTO charges and their quantification (see also Chapter 7).

It will be a huge challenge to find simplified algorithms that reduce work on calculations, yet still permit useful differentiation. It is also a matter, however, of finding a way of dealing with differentiation that is not useful: Flight paths used on arrival and departure should not have, according to Friedrich (2003), a varying effect on the level of charges, even when they have a major influence on the level of external costs. The reason is that from the airlines' point of view these are, on the one hand, dependent on incidental influences that are not foreseeable, and on the other hand, actual charges due could then only be calculated subsequently, which appears to be unsatisfactory from the user's point of view. It is to be assumed that air traffic controllers often allocate departure paths flexibly and at short notice in reaction to wind direction, weather conditions, delays or *force majeure*. The matter would have to be assessed differently, if the "desired runway" could be reserved in advance. Average charges should decrease, however, when the spread of selected flight paths shifts to flight paths with less external costs (Friedrich 2003). Such cases have to be taken into account with any further methodical development.

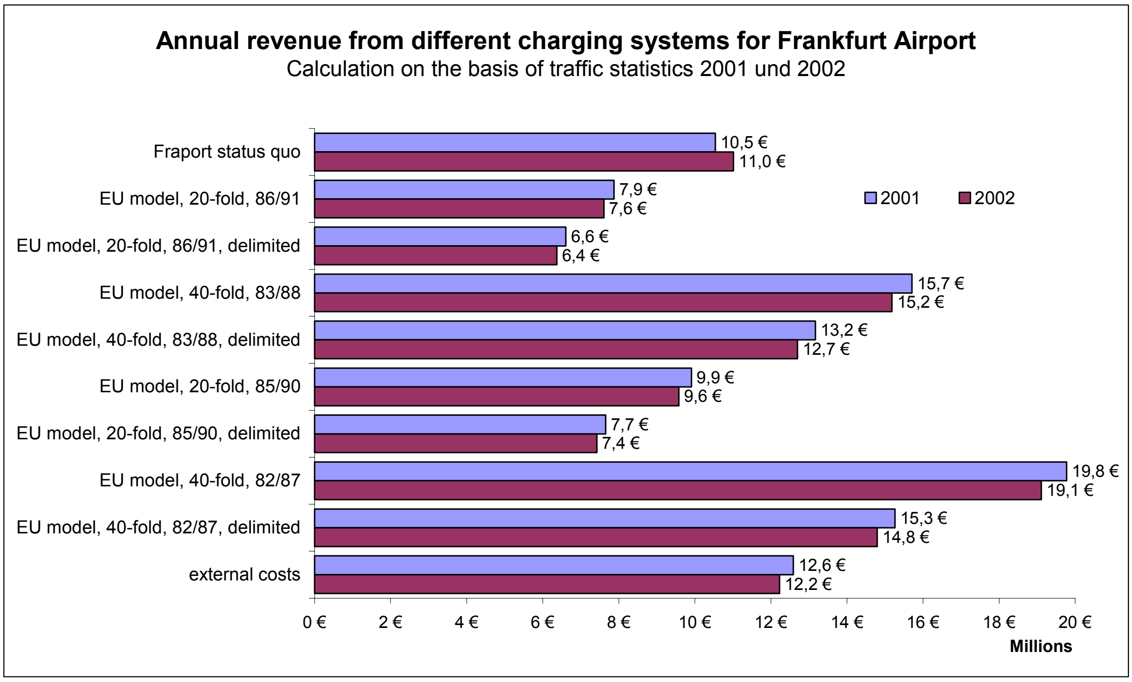
6.3 Scenario analysis in the contentious area of effect and revenue neutrality

Examination of the potential annual revenues of investigated charging systems should show whether and to what extent the criterion of revenue neutrality is met and taken into account. For this purpose, assumptions are made for the calculation of annual revenues based on available traffic data (2001 and 2002) for the most frequently handled aircraft at the reference airport in Frankfurt. In each case, extensive data on noise-related LTO charges is collected for all relevant aircraft types, with well over 90%

of operated aircraft being covered. A typical aircraft model (for example, the 737-300) is selected as representative of an aircraft class (for example, the 737). The share of night flight movements is set at 10.2 % (2001) and 10.4 % (2002). These values arise from the analysis of the average number of flight movements between 2200 and 0600 in 2001 (127) and 2002 (130). Furthermore, the latest Fraport noise surcharge rates are also taken into account.

On the basis of assumptions concerning the traffic situation at Frankfurt Airport, rough estimates of annual revenue were made according to the specifications of the underlying Stockholm model. The form and size of changes in annual revenue from noise-related LTO charges on application of the described variants of the EU calculation proposal are examined and pointed out. In addition, the influence of local noise thresholds for Frankfurt is also examined. In the case of variants that take account of marginal external costs these have also been roughly estimated for the calendar years 2001 and 2002. The selected spread of aircraft movements in the evening is the same as during the day.

Figure 36Calculation of annual revenue from different charging systems for Frankfurt Airport (2001 and 2002)



The survey of annual revenues, based on aircraft actually handled at Frankfurt Airport in 2001 and 2002, shows that among the assumptions made the size of revenues varies widely. The *noise-charge* model partly achieves noticeable additional revenue with application of a 40-fold spread (about +50% with adoption of Stockholm noise thresholds and +100% with application of Frankfurt noise thresholds). Almost identical receipts are achieved using the EU calculation formula for a 20-fold spread (without upper and lower limits for charges). The model that takes account of the external costs of noise shows that annual revenue increases by about 20% compared to the status quo. Limitation of noise charges to a maximum amount of 65.60 euros (20-fold) and 131.20 euros (40-fold) gives rise to a 16% to 23% reduction in annual figures.

Differentiation in arrival and departure in the following Table 38 indicates that the EU calculation proposal provides for weighting, with the effect that computed annual revenues vary by +/- 6 %. In the current Fraport charging system no differentiation is made, landing and take-off being equally priced. For application of the Stockholm model differentiation is undertaken, in so much as the existing formula is considered separately for arrival and departure. Finally, the marginal external costs for arrivals and departures are shown separately.

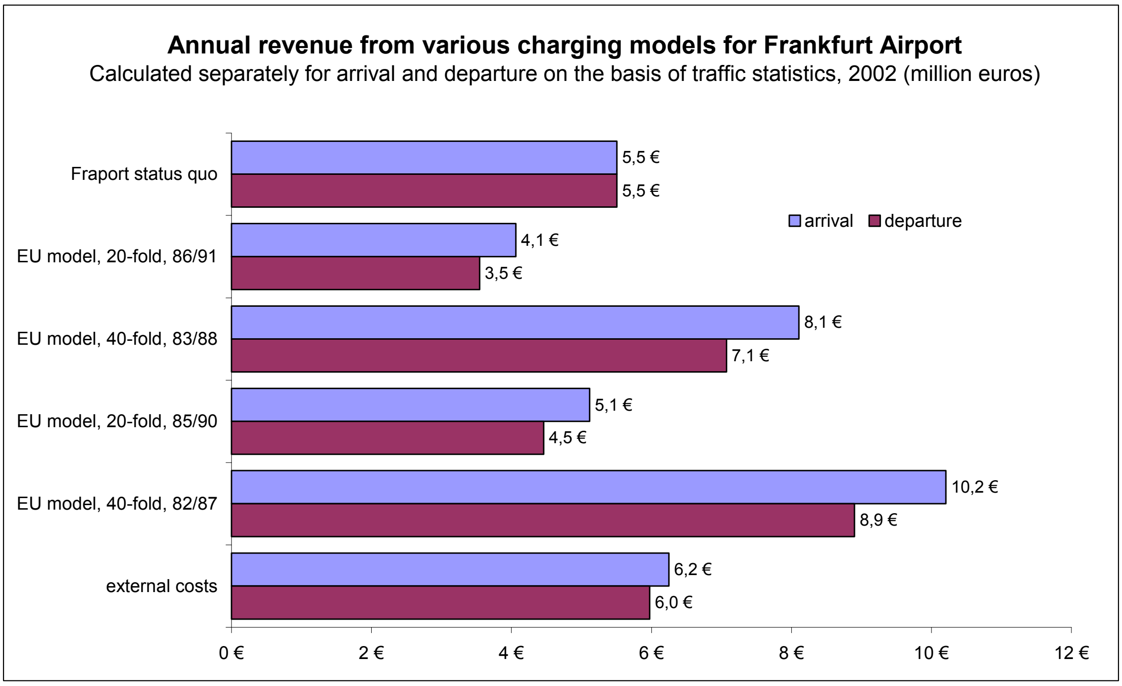
Table 38 Annual revenue from noise-related LTO charges at Frankfurt Airport calculated separately for arrival and departure (2002)

Reference year 2002	Arrival	Departure	Total
FRA Status Quo	5,506,890 € 50%	5,506,890 € 50%	11,013,780 €
Stockholm Model for FRA 20-fold spread	4,063,485 € 53%	3,544,120 € 47%	7,607,605 €
Stockholm Model for FRA 40-fold spread	8,107,719 € 53%	7,071,448 € 47%	15,179,167 €
Stockholm Model for FRA FRA noise thresholds 20-fold spread	5,115,625 € 53%	4,461,782 € 47%	9,577,407 €
Stockholm Model for FRA noise thresholds 40-fold spread	10,207,014 € 53%	8,902,426 € 47%	19,109,439 €
Marginal external costs of noise	6,249,687 € 51%	5,974,554 € 49%	12,224,240 €

Note: 458,359 flight movements in 2002

Source: Fraport Traffic Statistics 2002 and Öko-Institut calculations

Figure 37 Annual revenue from various charging models for Frankfurt Airport, calculated separately for arrival and departure (2002)



6.4 Excursus: LTO charging systems that affect demand

Reference has already been made in Chapter 4.2 to the difficulty of estimating the economic effects of the change in noise-related LTO charges that would be necessary to trigger operational and noise-side effects. This question could also not be resolved by way of scenario analysis. The project team therefore decided to examine this issue once more, against the backdrop of the existing political and legal framework. The key question is: *At which level of noise-related LTO charges are demand effects caused and how can this level be determined?*

The search for an answer to this key question begins with research by DIW Berlin together with the Wuppertal Institute [for Climate, Environmental, Energy] and the TÜV [Technische Überwachungsverein] Rheinland on non-technical measures for the reduction of pollution from civil aviation (TÜV/DIW/WI 2001), which was carried out on behalf of the Federal Environmental Agency. The aim of the study was to indicate ways of stabilizing CO_2 and NO_x emissions; a reduction of CO_2 emissions in the growth industry of aviation is inconceivable. The alternative measures discussed were a fuel tax and an emissions levy, each in a low and high variant. Beyond that, a scenario was developed from a combination of fuel tax, emissions levy and supporting measures.

The effects of the introduction of a moderate fuel tax, which were investigated at that time, correspond closest to the model of a notional increase in noise charges. A fuel tax was adopted whose level corresponds to the fuel tax rate currently applicable in Denmark. It was assumed that this fuel tax was introduced throughout Europe in 2002 at a rate of 0.08 DM/l, and that it increases annually by this rate up to 2010, so that in 2010 the fuel price would be 0.90 DM/l in real terms. After that, only a minimal rate of increase was envisaged, with an average price per litre in the year 2020 of 1.01 DM in real terms.

To quantify the effect of the measures it was assumed that the fuel tax was introduced throughout Europe. In order to largely preclude evasive reaction on the part of passengers or airlines, it was further assumed that all airlines are affected. The response options already outlined elsewhere (such as further exploitation of internal cost-reduction potentials, increasing load, use of modern aircraft and operational measures) have the effect that fuel tax need not be passed on in full to passengers. The effects were similar in the case of a drastic increase in noise charges.

Assuming that a medium-haul aircraft flies 4,000 km to a southern European holiday area, fuel consumption, depending on aircraft type, would be around 12-14.000 litres. Under current conditions (no fuel tax), fuel costs would be about 3-4,000 euros. Assuming that a fuel tax is introduced in Germany on the same scale as the currently levied fuel tax in Denmark, around 6,000 euros would have to be paid additionally for fuel. These additional costs are not passed on in full to passengers, but are partially compensated by internal cost-reduction potentials, such as higher load, reduction in fuel consumption and other cost-reducing measures.

Within the framework of the study carried out at the time, response options were initially examined that give rise to a reduction in consumption. These include organizational measures (for example, the avoidance of stacking) but above all increased aircraft load and, on a limited scale, the use of aircraft with lower fuel consumption. Furthermore, other cost-reducing measures beyond the trend were considered. Both forms of action mitigate the rise in prices that has ultimately to be borne by passengers and cargo customers. In a final step, the reactions of customers and airlines to the measures (price elasticity) were estimated.

Since the measures do not have an immediate effect on ticket prices, but rather one that varies widely depending on the route, primary markets were formed for which all response parameters were varied. The results for these submarkets were then distributed to individual destinations taking account of major factors, such as share of business travel, distance, load/flight frequency and trend in average consumption. With the formation of sub-markets, passenger traffic was also split into business and private travel, as well as travel distance and target regions. Holiday flights are therefore conducted under different conditions to those of scheduled flights. Segmentation was carried out according to five primary markets:

- German domestic,
- European scheduled,
- European charter,

- Inter-continental 7,000 km (e.g. Atlantic) and
- Inter-continental 10,000 km (e.g. Far East).

The estimation of response parameters involved, of course, great uncertainties, since empirical findings for such intervention in price structures are largely lacking. Additional and extensive sensitivity computations (minimum, maximum variants) were therefore carried out. In economics, elasticity is frequently used as a parameter for the dependence of a value on the development of a variable. Elasticity is the relationship of the relative (proportional) change in demand to the relative change in the variable (in this case, price). Elasticity of -1.5 means that an increase in the variable of 2% gives rise to a reduction in demand of 3%. The assumed elasticity results from extensive bibliographical research (BRTE 2003). The range of estimates of elasticity is huge and has therefore been supplemented with considerations of the holiday budgets of private households and experts' assessments (Table 39 and Table 40).

Table 39 Assumption concerning the price elasticity of private travel

		Moderate fuel tax		High fuel tax		Moderate emissions levy		High emissions levy		Package of measures	
Market		2010	2020	2010	2020	2010	2020	2010	2020	2010	2020
German domestic	Min	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90
	Mean	**-1.20**	**-1.20**	**-1.20**	**-1.20**	**-1.20**	**-1.20**	**-1.20**	**-1.20**	**-1.20**	**-1.20**
	Max	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20
European scheduled	Min	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90
	Mean	**-1.10**	**-1.10**	**-1.10**	**-1.10**	**-1.10**	**-1.10**	**-1.10**	**-1.10**	**-1.10**	**-1.10**
	Max	-1.10	-1.10	-1.10	-1.10	-1.10	-1.10	-1.10	-1.10	-1.10	-1.10
European charter	Min	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70
	Mean	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**
	Max	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
Inter-cont. 7.000 km	Min	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70
	Mean	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**
	Max	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
Inter-cont. 10.000 km	Min	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70
	Mean	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**	**-0.80**
	Max	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00

Source: DIW calculations and estimates

The situation in respect of air cargo is even more difficult to judge. The meagre bibliographical information available has been processed and varied with the project team's own estimates. In this connection, account was taken of the fact that around half of air cargo is carried as payload in passenger aircraft, and is affected by the measures only to the extent that the additional load leads to increased fuel consumption. For goods transported in pure cargo aircraft, lower price elasticity is assumed, since it is mostly particularly urgent and less cost-intensive goods that are transported.

Table 40 Assumptions concerning business travel

		Moderate fuel tax		High fuel tax		Moderate emissions levy		High emissions levy		Package of measures	
Market		2010	2020	2010	2020	2010	2020	2010	2020	2010	2020
German domestic	Min	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	Mean	**-0.20**	**-0.20**	**-0.20**	**-0.20**	**-0.20**	**-0.20**	**-0.20**	**-0.20**	**-0.20**	**-0.20**
	Max	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
European scheduled	Min	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	Mean	**-0.15**	**-0.15**	**-0.15**	**-0.15**	**-0.15**	**-0.15**	**-0.15**	**-0.15**	**-0.15**	**-0.15**
	Max	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
European charter	Min	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	Mean	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**
	Max	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30
Inter-cont. 7,000 km	Min	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	Mean	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**
	Max	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30
Inter-cont. 10,000 km	Min	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	Mean	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**	**-0.10**
	Max	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30

Source: DIW calculations and estimates

The greatest changes occurred in European charter/holiday traffic. As a result of a high load and, in part, closer seating, holiday airlines had a comparatively low consumption of 4.4 l/100 pkm (passenger kilometre) already in the analysis year. Possibilities to internalize price increases are therefore negligible. Moreover, compared to business travellers, holiday travellers are much more price-sensitive. The increased costs considered in this case amounted in the "without adaptation response" case to around 6,000 euros or 35%. All the same, only minor passenger reactions were noted compared to the trend development, since only a part of increased costs were shouldered onto passengers on account of the adaptation responses of airlines.

Table 41 Pricing measures in air transport and effect according to primary markets

Market		Trend		Moderate fuel tax		High fuel tax		Moderate emissions levy		High emissions levy		Package of measures	
		2010	2020	2010	2020	2010	2020	2010	2020	2010	2020	2010	2020
German domestic	Min.			18.1	22.1	13.8	17.1	18.1	22.2	13.9	17.2	13.2	16.0
	Mean	**19.7**	**24.1**	**19.2**	**23.5**	**16.9**	**21.0**	**19.2**	**23.5**	**16.9**	**21.0**	**16.8**	**20.6**
	Max.			19.6	24.0	18.6	22.9	19.6	24.0	18.7	22.9	18.6	22.8
European scheduled	Min.			20.3	27.3	13.7	18.9	20.4	27.4	13.7	19.0	13.3	18.4
	Mean	**23.1**	**30.9**	**21.6**	**29.0**	**17.0**	**23.6**	**21.6**	**29.1**	**17.1**	**23.8**	**17.2**	**23.8**
	Max.			22.8	30.5	19.0	26.1	22.8	30.5	19.1	26.2	18.9	26.1
European charter	Min.			17.9	21.3	10.4	12.8	18.0	21.5	10.4	12.8	9.6	12.0
	Mean	**21.4**	**25.7**	**19.2**	**23.1**	**13.8**	**16.9**	**19.3**	**23.2**	**13.8**	**16.9**	**13.5**	**16.7**
	Max.			19.9	23.8	14.6	18.0	20.0	23.9	14.7	18.1	14.4	17.8
Inter-cont. 7.000 km	Min.			14.3	20.6	11.2	16.5	14.3	20.6	11.3	16.5	11.1	16.3
	Mean	**15.4**	**22.2**	**15.1**	**21.8**	**13.3**	**19.4**	**15.1**	**21.9**	**13.4**	**19.4**	**13.4**	**19.3**
	Max.			15.6	22.4	13.7	19.8	15.6	22.5	13.7	19.8	13.8	20.0
Inter-cont. 10.000 km	Min.			5.2	8.3	3.6	6.1	5.2	8.3	3.6	6.1	3.5	6.1
	Mean	**5.7**	**8.9**	**5.4**	**8.6**	**4.3**	**7.1**	**5.5**	**8.6**	**4.3**	**7.2**	**4.2**	**7.0**
	Max.			5.7	9.1	4.6	7.6	5.7	9.1	4.6	7.6	4.5	7.6
Source: DIW calculations and estimates													

If one wanted to apply the instrument of elasticity to noise-related LTO charges, it would first of all be necessary to ascertain the share of noise-charge costs on which airlines base their calculations of ticket prices for each route. For this, no data is available. On the basis of a hypothetical example, however, both the size of noise charges and their significance for airlines' operating costs and for ticket prices should be illustrated.

In Chapter 4.2.2, the direct operating costs of medium-haul aircraft are presented depending on distance. The share of LTO charges in total direct flight operating costs declines, depending on distance, from 13.6 % to 2.6 %. In the case of a flight of more than 2,000 kilometres, the corresponding share amounts to 5.6% or 530 US dollars. According to the current charging system at Frankfurt Airport, neither for a Boeing 737 (300-900) nor for an Airbus A 319 (-21) would noise charges be payable for daytime take-off and landing. Only for a night-time flight movement would a noise surcharge of 32 euros be payable. In the chosen example, the "noise component" in LTO charges would be at least 5%, and in total direct operating costs 0.3 %. Apportioned to passengers, with 100 passengers per flight, this would amount to a charge of about 30 euro-cents per flight and passenger. Since a large proportion of flight movements take place during the day, the average noise charge per passenger of a particular aircraft type would at any rate still be below the level of perception.

Assuming the theoretical case that at Frankfurt Airport noise-related LTO charges should be applied that trigger reactions on the part of airlines and passengers, similar to those following introduction of a moderate fuel tax,[128] in the noise categories in which any revenue whatsoever is achieved nowadays (categories 1-5), charge rates would have to be increased many times over (for example, in category 5 with daytime take-off by a factor of 20, in category 3 by a factor of almost 50 and in category 2 by a factor of 300). For Frankfurt, a revised assignment to noise categories would be theoretically possible, but legally and politically probably not realizable. Were one to get rid of noise categories 1 to 3, thus beginning with the present category 4, one would not even have to increase the rates for categories 4 to 7. However, many airlines might then stay away, since they would be unable to compensate or pass on the higher charges. In Frankfurt, increased charges could presumably compensate revenue losses from absent airlines; but every appropriate international authority (ICAO, IATA, EU, WTO, BARIG) would be up in arms against such a noise-charges policy and would ensure that it was not introduced. For this reason, against the original intention, it was decided not to carry out elasticity calculations. The conclusion to be drawn is that under given legal, economic and political conditions, noise charges can only be applied to a very limited extent as an instrument for the alleviation of aircraft noise in the vicinity of airports.

The theoretical effects of drastically increased noise charges would diminish with increasing flight distance. They would be greater in the case of holiday/charter airlines and LCC than with scheduled airlines, due to their greater share in total costs. Pure cargo carriers, which operate comparatively old aircraft and frequently fly at night, would probably also be greatly affected.

128 Cf. TÜV Rheinland Sicherheit und Umweltschutz GmbH (TSU), Deutsches Institut für Wirtschaftsforschung (DIW) und Wuppertal Institut (WI): Table 4.6, p.134; Table 4.8.ff., p.139ff.

7 Guidelines for the development of a harmonized system of noise-related LTO charges

The aim of the project "*Economic measures for the reduction of the environmental impact of aviation: noise-related landing charges* was "*to develop guidelines for an effective noise-related charging system*, because – in the view of the Federal Environmental Agency – "*at German airports a noise-related landing charge is levied that provides aircraft operators with no perceptible incentive for the use of low-noise aircraft.*"

Through analysis of the national and international legal framework of charging systems, the description of noise-related charges at German and international airports and the assessment of the effect of noise-related LTO charges, a number of critical factors were identified that could in future enable effective (further) development of noise-related LTO charging systems for the purpose of noise mitigation.

From vague objectives and precise instruments to clear objectives and flexible instruments

An important guiding principle is that in the future, noise-related LTO charging systems should focus more strongly than in the past on the objective of noise mitigation. It appears, in the view of the project team, to be both useful and necessary to create a harmonized approach at an EU level – or at least at a national level – to the design and levying of noise-related LTO charges, which should clearly explain, with greater transparency than in the past, to airport users – the airlines – but also to the affected population around airports how noise-related LTO charges are determined and levied, and how noise mitigation is to be promoted. Harmonization of charging systems should support the following objectives:

1. Strengthening the **incentive effect** of LTO charges for the operation of less-noisy aircraft and the switching of flight movements to times of the day that are less sensitive to noise.
2. Strengthening the **financing function** of noise-related LTO charges as an instrument of active and passive noise mitigation at particular airports.
3. Strengthening the **communicative function** of LTO charges as an instrument of noise mitigation; improvement in communication with those affected by noise, also to encourage acceptance of developments in flight operations (*licence to operate*).

Uniform structure for securing noise mitigation in competition between airports

A harmonized system for levying noise-related LTO charges should not only be capable of supporting more strongly the objectives of noise mitigation at airports in Germany and within the European Union than is currently the case. In the view of the project team, a more harmonized system and a uniform basis could also improve medium- and long-term planning security for the most important airport users, the airlines.

Moreover, standardization of systems and harmonization of bases for assessment are also necessary for fair competition between airports. Further development of charges for the purpose of noise mitigation, in particular at highly-frequented hubs, should not open the door to undesirable reactions on the part of airlines at the cost of noise mitigation, such as switching flight movements to secondary or tertiary airports, where the same fair basis for the levying of charges does not apply (see Section 4.2).

Critical success factors for the effective and efficient design of noise-related LTO charging systems are discussed below.

Harmonization of the basis for assessment: certification levels against maximum levels at individual airports

The assessment of noise-related LTO charges should be carried out, in the opinion of the project team, on a largely harmonized basis, which ought to be based on the actual noise emissions of aircraft. The blending of the noise characteristics of an aircraft with other characteristics, such as MTOM, does not lead, in the opinion of the project team, to transparent levying, particularly as MTOM is not always congruent with the noise characteristics of an aircraft (see Section 6.2.2.1). At the present time, the noise component cannot be considered at many German airports in isolation from the MTOM-related share of charges (see Section 4.1.2.1). In the future design of a harmonized system of noise-related LTO charges this overlapping should be abolished; and this is already being pursued at certain international airports.

In accordance with the latest findings of research on the effect of noise, the project team favours using the local maximum noise level (L_{Amax})[129] measured at individual airports – that is, actual noise emissions and the corresponding disturbance – as the basis for assessment. This basis for assessment has been applied, for instance, at Hamburg Airport since the restructuring of the LTO charging system with respect to noise. Other airports that have updated their noise-related charging systems in recent years (for example, Frankfurt and Zurich) make use of other single sound levels – but also measured locally – as the basis for assessment. The disadvantage of this basis for assessment, which is to be preferred, particularly as far as the maximum noise level is concerned, is that considerable demands are made on the system for the measurement of noise, which are not met at all airports. With particular regard to the desired harmonization at the European level, the practicability of locally-measured noise values as the basis for assessment for noise-related LTO charges must be questioned, at least in the medium to long term. Furthermore, the present proposed EU Directive COM (2002) 683 final on noise charges does not provide for locally-measured

[129] As long as a corresponding noise level is not measured locally for new aircraft types at an airport, certification levels can be used for the assessment of noise-related LTO charges.

noise values as a basis for assessment. The proposed directive mentions ICAO certification values in accordance with Annex 16 as an appropriate, harmonized basis for assessment. Certification values also appear to provide an appropriate basis for assessment, particularly in terms of practicability, which can be implemented in the medium to short term at all airports. The disadvantage is that, depending on the airport, different noise levels can occur with the same aircraft type, which can therefore not be used for the calculation of charges. These differences are to be explained by the conditions of flight operations (weight, weather etc.), and the result is that certification values cannot be maintained by all aircraft types in real operating conditions. Certain distortions are therefore possible.

Harmonization of noise measurements at European airports should be aimed for in the longer term, so that locally-measured maximum noise levels can also be used as a basis for assessment. This long-term objective could be encouraged by obliging airports to use the revenue from noise-related LTO charges to finance the construction of a noise-measurement facility that would allow appropriate and comparable measurement of maximum noise levels (see below). Until then, however, the assessment of LTO charges should be possible on the basis of certification values, which can function in the short and medium term as a practical and sufficiently reliable basis for assessment. The project team is aware that complete harmonization is thus not possible in the short term, and that the design of transition regulations is time-consuming and requires further detailed preliminary investigations. But the long-term perspective of the installation of noise measurement facilities at airports in Europe, based on the latest developments in technology, which allow the assessment of LTO charges on the basis of locally-measured maximum noise levels rather than certification levels while permitting a practical solution in the short to medium term, can serve as justification.

The classification of aircraft in noise categories – understandable on the grounds of simplification – that is carried out at many German and European airports, should in future be abandoned. In the view of the project team there is much to be said in favour of calculating noise-related LTO charges by means of a constant feature that is dependent only on measured noise values (see below). Exemplary analyses of noise categories at Frankfurt Airport have shown that, in certain categories, aircraft with potentially widely differing noise emissions are grouped together. Particularly in categories of less-noise aircraft, appreciable differences are thus concealed (see Section 6.2.2.1), which should be reflected in a future noise-related LTO charging system. Transparent differentiation can be achieved, in the opinion of the project team, by levying charges on a fixed basis, without affecting practicability. Examples for this are the proposed Directive COM (2002) 683 and existing practice in Stockholm.

The success factor of spread: progressive design

Extensive analytical work on the proposed Directive COM (2002) 683 has shown that restricting the spread between the highest and the lowest noise charge for a given period within a 24-hour period of time to a ratio of 1 to 40 (the present proposal) can be counter-productive with respect to any incentive for the operation of less-noisy aircraft. Even when this maximum spread is only a recommendation – in certain well-founded exceptions a greater ratio than 1 to 40 may be applied – such a regulation does not appear to be useful with respect to noise mitigation. Scenario analysis has shown that the spread in the system currently applied at Frankfurt Airport is greater than that provided for in the proposed directive. The incentive effect with application of the draft directive would therefore probably be less than that with the Fraport regulation, although even with the Frankfurt regulation demonstrable effects of incentives could hardly be found (see Section 5.2.1).

The spread in charges is, in the opinion of the project team, one of the most important success factors for an effective noise-related LTO charging system. The project team makes a clear recommendation in favour of a progressive design; that is, a design with an exponential increase in noise charges for loud aircraft types. Since the aircraft mix, or aircraft type mix, at individual airports can differ widely, and charging systems have therefore to be designed for specific airports, it should also be possible in the future to vary the level (in absolute terms) and spread of charges between airports.[130] The introduction of any upper or lower limit to noise-related LTO charges should be designed in such a way that as few aircraft as possible exceed or fall short of applicable criteria, in order that a large number of different aircraft types are not indiscriminately grouped together at the lower and upper ends of the scale of charges.

Dynamization of charging models

Besides progressive design, the project consortium recommends for the future the dynamization and tightening up of noise-related LTO charging systems. Basically, today's low-noise aircraft are to-morrow's loud aircraft. Assuming a steady annual reduction in noise at an airport through further technical developments, resulting in changes in the aircraft fleet mix, this has to be considered in the medium and long term in the design of LTO charging systems. For example, if the average certification value of the aircraft fleet at an airport drops by 0.5 dB per year, the incentive for operation of less-noisy aircraft could be enhanced by treating an aircraft in the following year as if the certification value was 0.5 dB higher. This way, a dynamized incentive could result. Alternatively, regular revision of charging systems (for example, every two or three years) should be prescribed when a substantial shift occurs in the less-noisy sphere. Something comparable at Zurich Airport is described in Section 5.2.3.2.

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130 The theoretically possible extreme case is that a noise-related LTO charging system designed in this way would lead to incentives being created for the replacement of a large loud aircraft with two smaller, less-noisy aircraft, thus resulting in more flight movements at airports, which could be counter-productive from the point of view of noise mitigation. This example shows that in terms of active noise mitigation at airports it is necessary and useful to combine different instruments of active and passive noise mitigation. In the case mentioned, a combination of noise-related LTO charges and a quota-fixing regulation could secure an effective degree of noise mitigation at airports.

The longer the term of such a dynamically designed system the greater the incentive to acquire less-noisy aircraft and the greater planning security for airlines. At the same time, it has to be considered that continuous improvements in the noise characteristics of aircraft fleet mix naturally depend on a number of factors beyond the noise-related structure of LTO charging systems, which are difficult to forecast, so that periodic observation is essential to allow corrective action through adjustments to the charging system.

Differentiation according to time of day, take-off and landing

Analytical investigations – particularly those for the scenario concerning the marginal external costs of noise – have shown that a noise-related LTO charging system can and should distinguish between

- the type of flight movement (landing and take-off) and
- the timing of the flight movement (day, evening, night)

(see *inter alia* Section 6.2.2). This way, especially with regard to the communicative function of the charging system, the fundamentally different nuisance effects of landing and take-off noise are highlighted. Combined with differentiation of charges according to time of day, an incentive could arise for switching the timing of flight movements. Differentiation by time of day (for example at Frankfurt) or differentiation of take-off and landing (for example at Zurich, with night surcharges) is already provided for in the charging systems at certain airports. Differentiation according to summer and winter is also conceivable and supported by research on noise impact, since the time of year influences the perception of aircraft noise nuisance, people basically spending more time outdoors in the summer.[131] However, such differentiation would hardly give rise to an additional incentive, since reactions on the part of airlines appear unlikely. Such differentiation would in any case have a communicative effect on those disturbed by noise. In addition, it could also have a financing function (see below). As a consequence of its lack of an incentive effect, such differentiation is regarded merely as an option.

Consideration of local concernment and disturbance

Analytical work on existing charging systems at selected national and international airports has made clear that the effect of noise on the population in the immediate vicinity of airports has previously in no way been systematically considered in the design of a noise-related charging system. In the view of the project team, concernment has up to now been only inadequately considered in the design of noise-related LTO charging systems (see Chapter 4). Scenario analysis of external costs (see Section 6.2.2.1) has illustrated the significance that local concernment can acquire. The approach involving the marginal external costs of noise is distinguished by

[131] This also applies at weekends, compared to working days (especially in the summer). Weekends must therefore also be judged to be noise-sensitive periods, during which differentiation can be justified.

the fact that concernment at aircraft noise and the nuisance effect at individual airports – which is determined in the end on the basis of the size of the population within particular isophones – can be taken into consideration. Furthermore, airports can be characterized individually, since, indirectly, the size of the airport, the number and type of flight movements, noise dispersion, the proximity of the airport to the resident population and settlement density are all covered. In this respect, examination of the marginal external costs of noise sets new standards, since it considers nuisance criteria. These should also be comparable between airports and be able, in future, to distinguish between affected (A %) and highly affected (HA %) groups of people. In the view of the project consortium, it would be possible to incorporate local concernment or nuisance effect as a fixed multiplier into the charging system when a certain number of people live within a defined isophone. Such differentiation of the LTO charging system still needs to be specified, however.

Effectiveness and transparency through monitoring and reporting

Even if, in future, further differentiation criteria can be better incorporated into a transparent and harmonized noise-related LTO charging system than at present, on the basis of current knowledge it is not possible to foresee whether an appreciable incentive can be produced for the operation of less-noisy aircraft or for a shift in the timing of flight movements. The analysis and assessment of existing noise-related charging systems in Europe, together with the analysis of legal frameworks (see Chapter 3 and Section 4.1) confirm rather than refute these doubts. Basically, there is a lack of transparency with regard to the general effectiveness and precise effects of different charging systems as well as to their specific design at individual airports. This is attributable, on the one hand, to a lack of transparency with regard to the cost structures of airlines and to the influence of airport charges – in particular, noise-related LTO charges – on possible airline reactions (see Section 4.2). On the other hand, effect mechanisms – with respect to airline companies but, above all, to individual airports – are highly complex, so that analytical investigations are able to produce only limited new insights.

To deal with this problem, the project team recommends that, in future, a harmonized system of noise-related LTO charges should be linked with a **monitoring and reporting obligation**. Within the scope of monitoring, airports should be obliged to stipulate and publish the precise objective of any changes in the structure and/or design of noise-related LTO charges. At regular two- to three-year intervals, airports should also be required, on the basis of yet-unspecified indicators, to record the precise effects of and modifications to noise-related LTO charges, with particular regard to noise emission, and to present such information for public discussion against the backdrop of specific achievements. The project team sees in this proposal an effective means of providing the discussion of assumed effect mechanisms and precise effects of noise-related LTO charges with more transparency. In other words: should it not be possible to introduce such a monitoring and reporting system, and beyond that, to describe the precise effects of this economic instrument, its potential for initiating a control effect must be subject to even more doubt.

As a first step in this direction, the project team recommends the initiation of a national workshop to discuss the economic, operational and noise-side effects of current noise-related LTO charging systems at German airports. Such a workshop could represent an important step towards making the air community more sensitive to the harmonized and optimized further development of this economic instrument for reducing the impact of noise at airports. Such a workshop could produce, on the one hand, important empirical knowledge concerning the effectiveness of this instrument at German airports. On the other hand, important critical success factors could be deduced for the optimization of further developments and for the assessment of the potentials and limits of this instrument against the background of empirical results of "longitudinal studies" at individual airports.

On the basis of initial experiences at a national level and an appropriate response, it is also suggested, for the purpose of European harmonization, that a comparable initiative be launched in the European Union.

Noise-related LTO charges with a financing function

Against the background of uncertain assessment of the current and future incentive effect of noise-related LTO charges, with particular regard to the operation of less-noisy aircraft, the project teams recommends further measures to strengthen the financing function – and also the communicative function – of this instrument. An important element could be the use of revenue from noise-related LTO charges at individual airports for noise mitigation. Where revenue from noise-related LTO charges is used to finance general maintenance measures and the servicing of airport infrastructure, this indicates that the financing function with regard to noise mitigation is also inadequate. The project team therefore recommends that noise-related LTO charges be coupled with the application of revenue for specific purposes. Revenue from charges should be used as far as possible for measures in the area of active and passive noise mitigation (for instance, development and expansion of noise monitoring, regional noise alleviation planning, constructional noise mitigation). The system at Zurich Airport represents a possible approach for further development, where revenue from all noise charges – at Zurich three types of noise charge are levied – flows into a specially-created noise fund (*Airport Zurich Noise Fund - AZNF*) and is used exclusively for noise remediation and noise alleviation measures in the area of the airport (Unique 2003; see also Section 5.2.3.1). A comparable design is regarded as an important element for strengthening not only the financing function, but also the communicative function, whose importance should not be underestimated. The demand for specified use of revenue from noise-related LTO charges leads once again to two points regarding the political and legal framework:

1. The demand for revenue neutrality can, on a narrow interpretation, impede the development of an incentive or control effect for more noise mitigation from noise-related LTO charges, since it limits the level of charges in absolute terms and, to a certain extent, also the possibilities of spread, which are to be regarded as critical success factors for the incentive effect of charges.
2. With respect to cost-relatedness, restrictions on the use of revenue can accordingly have at least a supportive effect in the mitigation at airports, if not by way of incentive then at least by means of the financing function.

From this point of view, the trend toward financing noise mitigation measures by means of passenger charges, which is currently to be observed at large airports in Germany, should be critically discussed, in particular with regard to interpretation of the polluter-pays principle. The project teams favours financing by means of noise-related LTO charges.

In the opinion of the project team, the perspectives and principles of the further development of the economic instrument of noise-related LTO charges can be summarized as follows: **Standardization** and **harmonization of structure, systematics and bases for assessment** is necessary, in order to place greater emphasis on the objective of noise mitigation and to make the levying and effectiveness of charges more transparent, without competition between airports at the cost of noise mitigation. **Differentiation** of landing and take-off as well as of the timing of flight movements through the spread and level of charges in absolute terms, as well as the time-related **dynamization** of the system and **consideration of the nuisance effect** in the vicinity of an airport, are necessary in order to define the specific circumstances at individual airports. Effective **monitoring** and **reporting**, as well as the strengthening of the financing function, can encourage the **transparency** and **effectiveness** of the instrument in the medium and long term.

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Directive 2002/30/EC of the European Parliament and the Council on the establishment of **rules and procedures with regard to the introduction of noise-related operating restrictions at Community Airports**, Official Journal L 85/40 of 28.03.2002.

8.3 German legislation

Act against Restraints on Competition *(Gesetz gegen Wettbewerbsbeschränkungen* – *GWB*), as published in the revised version of 26. August 1998, which came into force on 1 January 1999, BGBl. I, p. 2546, last amended by Article 7 of the *Gesetzes zur Umstellung von Gesetzen und Verordnungen im Zuständigkeitsbereich des Bundesministeriums für Wirtschaft und Technologie sowie des Bundesministeriums für Bildung und Forschung auf Euro (Neuntes Euro-Einführungsgesetz* [Act on the Conversion to Euro of Acts and Ordinances within the jurisdiction of the Federal Ministry of Economics and Labour and the Federal Ministry of Education and Research (Ninth Act on the Introduction of the Euro)] of 10. November 2001, which came into force on 1 January 2002, BGBl. I, p. 2995.

Chicago Convention on International Civil Aviation 7.12.1944, ratified with Act of 7.04.1956, printed in the Federal Law Gazette (BGBl) 1956 II, p. 411.

Aircraft Noise Act *(Gesetz zum Schutz gegen Fluglärm* – *FluglärmG)*, as published on 30 March 1971, BGBl I, p. 282, last amended by Article 46 of the *Siebenten Zuständigkeitsanpassungsverordnung* of 29 October 2001, BGBl. I, p. 2785.

Instructions on the calculation of noise protection zones (Anleitung zur Berechnung von Lärmschutzbereichen – AzB) at civil and military airports in accordance with the Airport Noise Act of 30 March 1971 (BGBl. I p. 282) – *Anleitung zur Berechnung (AzB)* – of 27.02.1975 (GMBl. Nr. 8 p. 162).

Ordinance on the levying of charges for the use of **en-route air navigation services and facilities (*FS-Strecken-Kostenverordnung*** – (***FSStrKV)*** of 14 April 1984 (BGBl. I p. 629); last amended by Article 2 of the Ordinance 8 December 1999 (BGBl. I p. 2408).

Ordinance on the levying of charges for the use of **ATC services and facilities on arrival and departure (*FS-An- und Abflug-Kostenverordnung – FSAAKV*)**, of 28 September 1989 (BGBl. I p. 1809), last amended by Article 1 of the Ordinance on 8 December 1999 (BGBl. I p. 2408).

Ordinance on the costs of air traffic management *(Kostenverordnung der Luftfahrtverwaltung - LuftKostV)* of 14 February 1984 (BGBl. I p. 346), last amended by the Ordinance of 12 October 2000 (BGBl. I p. 1470).

Air Traffic Act (*Luftverkehrsgesetz - LuftVG*) of 1.8.1922 (RGBl. I p. 681) as published on 27 March 1999 (BGBl. I p. 550).

Air Traffic Licensing Regulations (Luftverkehrs-Zulassungs-Ordnung - LuftVZO) of 19 June 1964 (BGBl. I p. 370) as published on 27 March 1999 (BGBl. I p. 610), last amended by Article 2 of the Ordinance of 4 February 2000 (BGBl.I p. 98).

Noise mitigation regulation for aircraft (Lärmschutzvorschrift für Luftfahrzeuge - LVL) of 1 July 2003, published in Nachrichten für Luftfahrer (NfL) II-65/03, amended in NfL II-77/03 and last amended in NfL II-05/04