EXPERT COMMITTEE REPORT

ON ACTIVE NOISE ABATEMENT

FIRST PACKAGE OF MEASURES FOR ACTIVE NOISE ABATEMENT AT FRANKFURT/MAIN AIRPORT

Contents

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Figures

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Description of the first recommended package of measures

1. Foreword

by Peter Gebauer and Manfred Ockel

(Chairman and co-chairman of the expert committee on active noise abatement, EG AS):

With the signing of the joint declaration dated 12 December 2007, the aviation stakeholders at Frankfurt Airport showed that they are willing and ready to examine and develop measures to harness potentials for active noise abatement as effectively as possible. The aim is to achieve a noise reduction which is effective both at the present and in the future situation up to 2020.

Aviation noise and the burdens resulting from it are an emotional issue in the Rhine-Main region. The constant further development of the Frankfurt/Main airport as an important economic factor for the region, the associated increase in flight movements, and the resulting noise burden are in conflict with the rights of the residents in the neighbourhood of the airport to peace and quiet.

Active noise abatement is an effective means of reducing the burden on local residents from flight noise. Various measures are applied here in an attempt to avoid or reduce noise directly at the source, or to ensure a more even distribution of the noise burden. Such measures are both complex and costly – in terms of their conception, implementation and in their effects. It must also be emphasised that the possibilities of these measures are based on the premise of safe flight operation.

Active noise abatement in aviation is therefore an ambitious and difficult challenge, and requires the joint efforts of all stakeholders in order to systematically harness the potential available. It is

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therefore no surprise that this form of noise abatement has not so far played the role that its noise-reduction potential would justify.
Changing this situation and tapping into the potential of active noise abatement is the task and the self-perception of the expert committee for active noise abatement of the Forum Airport and Region. With this committee, representatives of the aviation industry, communities, the flight noise commission, authorities, practitioners and scientists have joined for the first time in the history of the Federal Republic of Germany to engage in trusting and result-oriented collaboration.

The report presented here lays the foundation for the achievement of an even greater balance between the needs of the residents for active noise abatement and the interests of the flight operations. The committee describes an initial package of measures which, from the point of view of those concerned, could be introduced by the end of this year.

Alongside the concrete arrangement of this initial package of measures, the expert committee on noise abatement also looked at the medium to long-term perspective for possible measures. This is seen as a starting point for further work and development which the parties concerned wish to support intensively by active involvement.

This willingness of the parties involved is an example for the atmosphere in which the work of the expert committee on active noise abatement took place. Great commitment was shown in an open and trusting dialogue on the pros and cons. The commitment with which the members of the expert committee went to work goes far beyond the expected scope, and merits unrestricted respect.

As chairpersons of the expert committee we would thus like to take this opportunity to thank all of the members of the committee and the experts consulted for their collaboration. The members made our job as chairpersons easy. Working with them was a pleasure. We thus look forward with anticipation and optimism to further collaboration.

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At the same time we would like to express our thanks to the staff at the Umwelt- und Nachbarschaftshaus (UNH) and at the Öko-Institut e. V., Darmstadt for their smooth organisational preparation and their support in terms of content. Such conditions are essential for a pleasant and productive atmosphere. We also owe a special obligation of gratitude to Ms. Regine Barth from the Öko-Institut.

The will to continue our joint path in this form will be the engine for further success and will give the region a chance of extended active noise abatement.

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2. Introduction

2.1. Elaboration of an initial package of measures for active noise abatement

The expert committee presents in this report an initial package of measures with proposals for active noise abatement for the Frankfurt/Main airport. These proposals are aimed at providing relief for as many people as possible affected in the region by flight noise, and at keeping additional burdens as low as possible after the extension of the airport. One possible approach is to fly less frequently over densely populated areas. Another involves the reduction of the noise development in the aircraft itself. Providing relief for especially highly affected areas was a further aim of the joint work carried out.

The committee agreed that this initial package should contain measures for both day and night. This was in order to achieve as broad a relief as possible as most of the individual measures only work within relatively limited ranges.

Not all measures of active noise abatement are combinable. This is why various package options were examined to find the best solution for the parties concerned from the various possible combinations, i.e. the lowest possible overall burden on the region. One criterion here was that each measure on its own would lead to an overall reduction of the noise in the region. A series of measures, however, has a noise-distributing effect, so that although the measures have an overall burden-reducing effect in most of the region, they can also lead to local increases in noise. One aim of the package formation is to compensate for this as far as possible by other burden-reducing measures.

In the course of the consulting and approval process which will follow the submission of the report, some of the measures have to be observed individually for formal reasons and balanced out. The concept of the mutually coordinated bundle of measures must not, however, be lost from sight.

The expert committee examined two basic categories of active noise abatement.

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1. Technical measures on the aircraft which reduce the noise generated by the aircraft itself.

2. Operative measures based on altered flight profiles, flight procedures, routes etc. which reduce the level and/or the effects of the flight noise generated and/or increase the distance between the emission source and the immission location.

The reduction of the effects of noise by measures on the side of those affected by the noise (passive noise abatement, e.g. installation of noise-protection windows) was not the subject of the work on active noise abatement.

2.2. Tasks and mode of procedure in the expert committee

The expert committee on active noise abatement (EG AS) was a fixed element within the organisational structure of the "Forum Airport and Region" (FFR) from the very start and began its work in December 2008.[1] [2]

Pursuant to the rules of procedure of the FFR, the EG AS has the following tasks (see also section 15 ff.):

(1) The expert committee on active noise abatement identifies and examines measures for active noise abatement which are suitable to reduce flight noise or the effects thereof and shall also examine measures which could be implemented already before the start-up of the new runway at Frankfurt airport. […]

(2) […]

[1] Alongside the EG AS, other committees within the FFR include the Coordination Council, the Convent Airport and Region and the Umwelthaus/Nachbarschaftshaus and the citizens' office.
[2] For an overview of the FFR and other committees: http://www.forum-flughafen-region.de/forum/ffr/

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(3) The activity of the expert committee on active noise abatement does not replace the legally prescribed procedures of approval authorities, air-traffic control and the flight noise commission.

An important basis for the activity of the expert committee on active noise abatement are the agreements reached between various actors before the foundation of the FFR and the appointment of the EG AS, as well as the works of other actors from the institutions concerned with this issue. These include:

- Conclusion of the regional dialogue forum Frankfurt/Main Airport (RDF) and the anti-noise pact elaborated within the framework of the RDF at the initiative of Prof. Dr. eng. J.-D. Wörner dated 14 September 2007,

- Joint declaration of the Hessen Regional Government and the aviation industry dated 12 December 2007,[3]

- Resolution of the Hessen parliament dated 11 December 2007 of the "extension of Frankfurt Airport – realising the anti-noise pact" (Drs. 16/8364),

- Working program of the Commission for the prevention of flight noise (Flight Noise Commission Frankfurt am Main Airport).

In addition to this, the work was also able to build on important preliminary works within the framework of the mediation process and of the RDF. In particular the "Small Group for Active Noise-Abatement" and the "Small Group for Immediate Measures" collected information over the course of many years of discussions in the RDF, in some cases supporting concrete measures up to implementation and thus contributing valuable preparatory work.

[3] The signatories to the declaration are the Hessen Minister President Roland Koch, Prof. Dr. Johann-Dietrich Wörner (Regional Dialogue Forum), Dr. Stefan Schulte (Fraport), Stefan Lauer (Lufthansa), Ralph Riedle (DFS) and Martin Gaebges (BARIG)

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The members of the expert committee on active noise abatement were appointed by the Hessen first minister. Chairman of the EG AS is Peter Gebauer (Deutsche Flugsicherung GmbH), co-chairman is Manfred Ockel (Mayor of Kelsterbach). The executive business of the expert committee is the responsibility of the chairman in consultation with the co-chairman. Both chairpersons are supported organisationally in their work by the Umwelt- und Nachbarschaftshaus and in terms of content by the Öko-Institut e. V. It was also expressly agreed that the EG AS can, as required, consult other external experts in order to examine or clarify individual special matters.

The expert committee on active noise abatement is made up of:

Nominated member	Affiliation
Peter Gebauer, chairman	DFS Deutsche Flugsicherung GmbH
Lord Mayor Manfred Ockel, co-chairman	City of Kelsterbach, representative of the communities
Stefan Mauel	Representative of Fraport AG
Marcus Pauly	Representative of Deutsche Lufthansa AG (DLH)
Martin Gaebges	Representative of the Board of Airline Representatives in Germany e. V. (BARIG)
Dr. Holger Sewering	Representative of the Hessen State Chancellery
Dr. Thilo Muthmann (until 31.03.2010)	Representative of the Hessen Ministry

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Kai Peters (from 01.04.2010)	for the economy, transport and regional development (HMWVL)
Dr. Lothar Ohse	Representative of the Hessen Regional Office for the Environment and Geology (HLUG)
Lord Mayor Thomas Jühe	Chairman of the Flight Noise Commission (FLK)
Georg Müller	Flight noise abatement officer of the Land of Hessen
Frank Lumnitzer	Representative of the pilots' association Cockpit (VC)
Dr. Mathias Basner (until 11/2009) Dr. Ullrich Isermann (from 12/2009)	Representative of the German Centre for Aviation and Aerospace (DLR)
Carl Sigel	Expert for the aviation industry
Dr. Stefan Schmitt, City of Frankfurt	Expert for the communities
Ewald Anton	Expert for the communities

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Regular guests:

- **Michael Kraft**, DFS
- **Anja Wollert**, Managing Director of Flight Noise Commission Frankfurt
- **Helmut Tolksdorf**, DLH
- **Daphne Goldmann**, Fraport AG
- **Günter Lanz**, CEO of Environment & Community Center (ECC)
- **Jochen Schaab**, City of Kelsterbach
- **Kurt Müller**, expert
- **Dr. Karsten Baumann** (from 1/2010), Federal Supervisory Office for Flight Safety (BAF)

Technical and organisational support

- **Regine Barth**
- **Nathalie Hahn** (until 10/2009)
- **Silvia Schütte** (from 2/2010), all from the Öko-Institut e. V.
- **Henning Arps** (until 3/2010), AMT-Ingenieurgesellschaft

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The noise calculations for the committee were carried out by Kurt Müller (formerly of the Hessen Regional Institute for Environment and Geology, HLUG, now free-lance expert) and Dr. Lothar Ohse (HLUG).

The necessary investigations were comprehensive and time-intensive. For example, the development of new safe flight procedures is very complex even at the planning stage. In some cases safety valuations had to be and have to be carried out. There were countless simulations and workshops to test the procedures and to develop improvement proposals. An important aspect was the inclusion of pilots and air traffic controllers. For some sub-aspects, external, independent assessors were engaged.

Profound discussions were held in additional working groups. These temporary working groups passed on their results to the EG AS for discussion. The following working groups have been so far created:

- **Noise index** (development of recommendations for extension of the noise index)

- **Noise calculation** (coordination of the necessary bases and assumptions for the noise calculations for assessment of the measures),

- **Incentives** (discussion of possible measures with medium to long-term perspectives and financing options for cost-intensive active noise abatement measures)

- **Small group for additional mitigations for the safety assessment of the tailwind component** (mitigations refers to risk-reducing measures)

- **Editorial group** (preparation and coordination of the present report).

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3. General conditions

In order to harness the potentials for active noise abatement as effectively as possible, it is necessary to consider the often competing requirements of noise reduction on the one hand and safety or capacity on the other. Safety is obviously the most important consideration in the implementation of flight operations in the interests of all stakeholders and parties concerned, and must thus continue to be ensured in the future. This basic principle should not stop us, however, from examining possible alternatives in order to achieve the aim of noise abatement.

The following sections deal with the relevant aspects which had an influence on the elaboration and the evaluation of the measures. They also describe how and why they were taken into consideration.

3.1. Flight operation capacity

Demand for flights and capacities in flight operations exist in an operative interaction. If demand increases and the operative capacity is not available to cope with this demand in a smooth and orderly manner, this leads to delays and hold-ups in flight operations. From the point of view of the aviation industry, this is not acceptable for various reasons, as delays and hold-ups ultimately result directly and indirectly in additional costs. Inadequate capacity to deal with the given demand is, however, also a problem in terms of the noise and emissions burden, as delays and hold-ups lead to holding patterns and/or longer flight routes and thus higher emissions and immissions.

The investigations into active noise abatement assume that within the framework of the approved and available capacity of the Frankfurt/Main Airport, the demand for flights will continue to be fulfilled with a high degree of punctuality. As a concession to the issue of active noise abatement, longer flight routes are at least sometimes accepted insofar as the airspace users regard this as reasonable. The long-term aim is ultimately to apply the operative measures of active noise abatement whenever reasonably possible in terms of operations. The current demand

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for flights and the respectively available capacities must be taken into consideration as well as technical measures which will be realisable in the future (e.g. in the area of flight guidance). This means that it will initially only be possible to apply a series of measures within a limited framework in an initial phase, so that they can then be extended successively by further optimisation over further development stages.

A further aim was the creation of plannable noise breaks. For this purpose operating concepts were drawn up aimed directly at achieving noise-reduction effects, e.g. by changing runway usage or avoiding constellations which are particularly unfavourable in terms of noise development.

3.2. Operating times

The basic aim of the signatories to the declaration dated 12 December 2007 is to implement measures of active noise abatement as comprehensively in terms of time as possible, ideally over the complete operating period, i.e. 24 hours a day.

As the applicability of the measures depends on the demand for flights, the weather conditions, operational sequences and economic considerations, the implementation of some measures is not or not always possible over a twenty-four hour period. In order to allow, nonetheless, the initiation of new forms of operative noise abatement measures and at the same time the most extensive possible implementation of the measures, individual measures were allocated to certain operating times. In each case it must be ensured that the application of the procedures according to the given general conditions do not lead to any sacrifices in capacity. Insofar as measures of active noise abatement affect neither the safety nor the requirements in terms of operating capacity, the basic conditions are fulfilled to apply them on a 24-hour basis. Reasons for exclusion then only arise due to specific circumstances (e.g. restrictive weather conditions etc.).

Measures, on the other hand, which restrict the operational capacity in principle, are only suitable initially for application during the off-peak times at night.

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The initially applicable time period depends on the respectively expected capacity impact of the measure. In its investigations and assumptions, the expert committee assumed that this low-traffic period under the current system would initially be between 23.00 and 05.00 hrs. In a subsequent development phase, the extension of the time will be examined on the basis of the experience gained.

With regard to flight movements in the "mediation night" (i.e. the period resulting from mediation for a night-flight prohibition after the extension of the airport) after the new NW runway goes into operation, the expert committee was not able to make any substantiated assumptions due to the fact that the number of permissible flight movements in the time between 23.00 and 05.00 hrs has yet to be clarified in the appeal proceedings before the Federal Administration Court.

The committee thus focussed on the evaluation of the noise effects in the current status and has not yet elaborated any package scenario for the time after the extension.

A joint aim was to realise noise-abatement options before the extension for the low-peak time during the night in which flight movements are currently permissible. During this low-peak time there are special options which would not be realisable for flight operational reasons during times with higher movements. In addition to this, on the basis of the operational experience with the measures, the future extension of the times for the noise abatement measures are to be examined in a further step and, if possible, incrementally realised. This leaves at least the option of applying the measures in the event that no flights were permitted between 23.00 and 05.00 hrs. Even if the Federal Administration Court decides that flights are to be allowed after the expansion of the runway from 23.00 to 05.00 hrs, the planned measures are still available. The same applies in this case for the aim of extending the times for the application of the measures.

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3.3. Legal requirements

Technical measures

Every aircraft has to comply with certain construction regulations defined especially for aviation in order to receive the so-called type certificate. Type certificates are also available for individual assemblies, for example engines or propellers. Without a valid type certificate no aircraft is allowed to fly. If changes are made to an aircraft within the framework of technical measures for noise abatement, the necessary inspections have to be carried out to ensure that the aircraft is still airworthy and complies with the strict requirements for operational safety.

The type certificate for the assembly alone is usually not sufficient, as the component concerned also has to be approved for the installation and operation in the respective aircraft model. Inspections are carried out to ensure that the components – e.g. a new type of engine or a modified engine – can also be operated safely with the respective aircraft model. The type certification is necessary in principle for every technical change to a civil aircraft and is both time and cost-intensive.

The time needed for the development and approval of technical measures for noise abatement is considerable. Aerodynamic modifications in particular require prolonged investigations and flight trials. Periods of one to three years are realistic.

The actual modification of the aircraft generally takes place in the course of routine maintenance. For most of the necessary modifications, the maintenance modules with down-times of 3 days and longer are used. These so-called C, IL or D checks take place every 20 months, 6 or 12 years. This means that it usually takes several years before an extensive fleet can be completely modified..

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Operative air traffic control measures

Operative air traffic control measures based on altered flight profiles (lateral and/or vertical), flight procedures etc. are the subject of a multi-phase approval process which is dealt with in the following.

The international and national bases for this are the regulations of

- the International Civil Aviation Organisation (ICAO)
- the EU (as relevant)
- national aviation law and the official decisions made on this basis.

The basis for the actual procedure planning is the ICAO document ICAO DOC 8186/611 "Procedures for Air Navigation Services – Aircraft Operations" which comprehensively describes the basic principles for the development and planning of instrument arrival and departure procedures in two volumes over approximately 1000 pages. In individual cases this document may also be supplemented by so-called "Guidance Material".

When the DFS (Deutsche Flugsicherung GmbH – the body responsible for air traffic control in Germany) develops new procedures, these are initially focussed on the air traffic control and flight operations needs. In the case of noise-relevant air traffic control procedures such as approach and departure routes, the various versions developed are balanced against each other in terms of noise, capacity and other operational aspects.

In the case of departure routes, the measures include the system NIROS (Noise Impact Reduction and Optimization System) which is used to detect the resulting noise impact. By looking at alternatives, it is possible to identify the version which has the lowest noise impact and can thus be described as the "minimum noise" route. Alongside the noise level distribution and other data, the population distribution is also taken into account.

NIROS works solely with acoustic values and the population, and thus, in contrast to the Frankfurt indices FTI and FNI, makes no reference to effects.

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Before introducing a new flight procedure, the DFS has to balance all of the relevant aspects (operational aspects, noise impact etc.). The result of this balancing process is then the basis for further steps. Even though the DFS was extensively and actively involved in the work of the expert committee, this type of collaboration or a broad consensus on the package within the EG AS is no substitute for the necessity of independent consideration. In the course of the approval procedure, the DFS will thus independently consider and substantiate whether and why it is of the opinion that a procedure can be introduced in terms of safety, capacity and noise abatement aspects.

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3.4. Necessity of a safety assessment

Safety is indisputably the highest priority in aviation. In order to achieve it, there are extensive national and international regulations which have to be complied with. Essential elements of these regulations are the standards on which they are based. Deviations from these standards are possible, and indeed in some cases unavoidable. However, such deviations from the standards are then subject to very strict criteria. In particular, it must be documented that a deviation from standards will in no way endanger the safety of the aviation system.

Alterations in the air traffic control system, e.g. for arrival and departure procedures, require a verification of safety, i.e. either

- the documentation of the lack of safety-relevance or
- verification that the change conforms with ICAO standards or
- a safety assessment which shows that the risks are acceptable

If processes and procedures deviate from the standards and recommendations, they are examined within the framework of the safety assessments in terms of their impact on the safety in the aviation system. For this purpose the specific (deviating) process sequence (e.g. a arrival procedure) is broken down into its individual components. In this way, possible events which could trigger or promote a fault in the observed process sequence (e.g. breakdown of an engine) can be identified, the probabilities of occurrence calculated and the possible impact assessed. If statistical material is available, this is also used. If statistical material is not available or not sufficient, expert assessments are used either on their own or as a supplement. The occurrence probabilities and the extent of the damage ultimately provide a risk value which can be allocated to various categories in a scaled risk matrix, e.g. from A to D, such as that used by the DFS. In the further course of the assessment, possible countermeasures are examined as necessary in order to mitigate the risk related to the change. They are then evaluated, and the resulting risk potential re-calculated.

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The safety assessments, their legal foundations, their basic structure and the procedure are governed on the European level by the directive (EC) No. 2096/2005 (legal codification of the EUROCONTROL Safety Regulatory Requirements 4 – ESARR 4).

3.5 Criteria for package formation

In order to assess the noise impact of the measures, the expert committee based its considerations mainly on the respective calculation of the flight noise index. This means that the noise impact (acoustics), the noise effect (impact on the people concerned) and the settlement structure of the region were also taken into account in the deliberations. But it was not only the index values relating to the whole observation region which were considered, but also local noise assessments (in some cases on the basis of additional burden values). This was to ensure that no possible negative effects were overlooked (see also Section 4.3).

The expert committee based its work on the following criteria:

- Safety and the capacities necessary for the respective periods must be guaranteed.
- Measures which have only relieving effects and no burdening effects should be introduced with priority.
- The aim is the most substantial reduction possible of the indices, whereby in fulfilment of this aim, the extent and the number of persons affected by new burdens must be kept as low as possible.
- Providing relief for highly affected parties has priority over parties suffering from lower impact. Equally, additional burdens on parties already suffering from high impact should be avoided even if the measures would provide relief for persons subject to a lower burden. This may also mean that the maximum possible reduction of the indices cannot be achieved.

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- If different, mutually contradictory measures are being discussed, such measures should be given preference with which further relief effects can be achieved in the medium or long term, for example by extension in the scope of application, the application times or by optimisation measures.

- The measures to be introduced in the short term should be such that they can be applied, as far as possible, for all airspace users. If further measures are introduced or extended in the medium and long term, there may be further requirements in terms of equipment/training of the aviators.

- The package should also contain measures in the first implementation step which are effective during the day.

- The package should contain measures which can be implemented immediately as soon as the corresponding approvals have been granted. Furthermore, it should be clear that there are different implementation timeframes for different measures, and additional potentials may be identified at a later date following continued examination.

The application of the criteria set out above does not substitute either the considerations of the DFS itself or the instruments and procedures which it is required to deploy within the framework of the necessary deliberations in the planning of flight procedures and the execution of administrative procedures.

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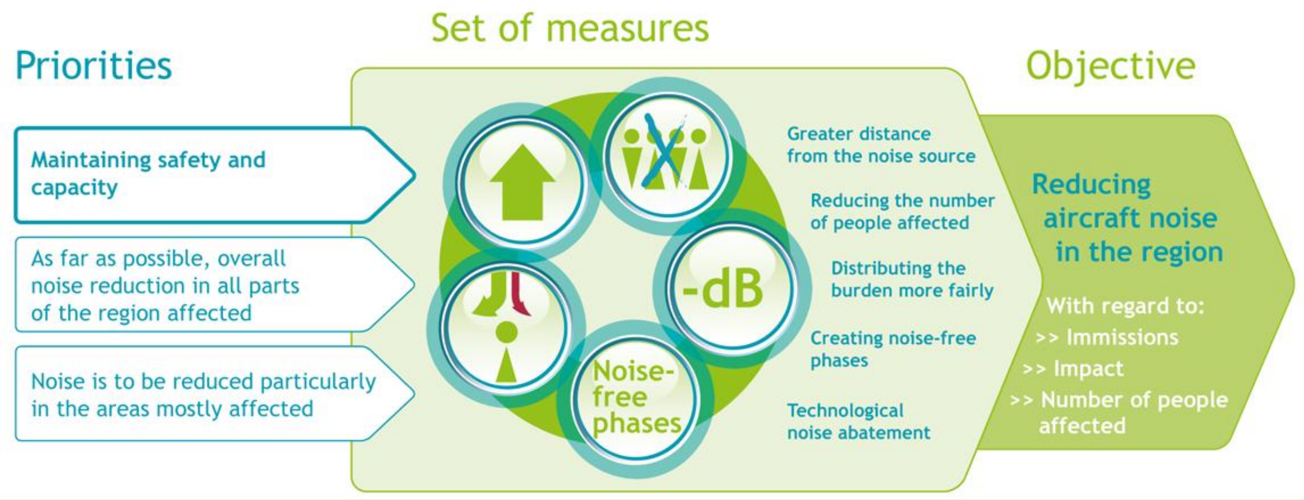

Figure 1 Concept of package formations

4. Description of the first recommended package of measures

4.1. Constituent parts of the package of measures

The first package of measures for active noise abatement contains a total of seven measures:

Before start-up of the new NW runway

1. Vertical optimisation of departure procedures
2. Fleet modification at Lufthansa
3. Increase of the proportion of time with west operation
4. Introduction of a new arrival procedure (Segmented RNAV (GPS) Approach)
5. DROps Dedicated Runway Operations

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6a Optimisation of CDA (Continuous Descent Approach) Phase 1

After start-up of new NW runway

6b Optimisation of CDA (Continuous Descent Approach) Phase 2

7 Trial of 3.2 degrees glide angle on NW runway

Two of the operative measures can be applied both by day and by night. In addition to this, there are plans to reduce the noise from certain aircraft by technical modifications. This technical measure has a permanent noise-reducing effect and also works over the whole operating period. Two further operative measures of the package are planned initially for the night. Another measure refers to the operation direction distribution, i.e. whether the airport is approached from east or west according to the wind conditions. Detailed technical descriptions of the respective measures and various test results can be found on the Internet (http://www.forum-flughafen-region.de/forum/expertengremium-aktiver-schallschutz/).

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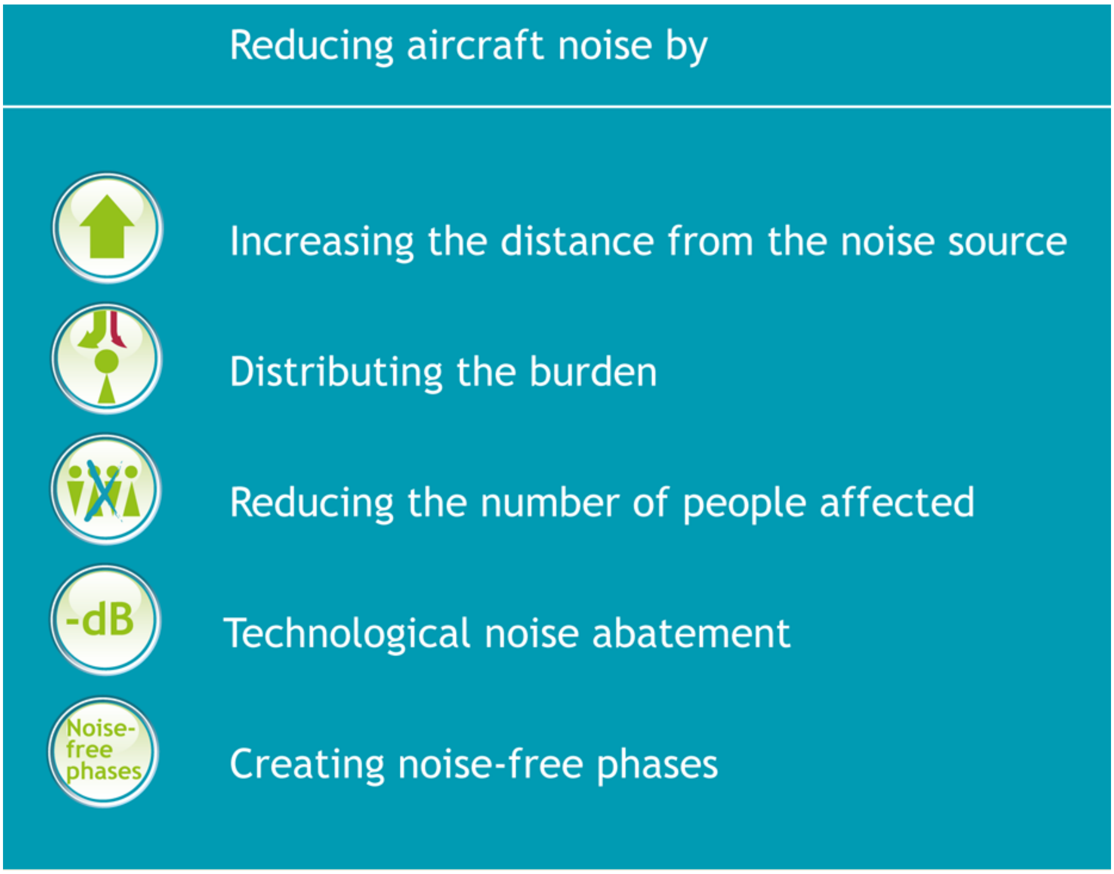

4.1.1. Vertical optimisation of departure procedures

The aim of the optimisation of departure procedures is to gain greater distances from the residential areas as quickly as possible. The measure also has the advantage that the departure routes can be complied with more precisely. Vertically optimised departure profiles were examined for all flight routes to see if they would be suitable for application here for noise-abatement in view of the settlement structure, as this measure also has a noise-distributing effect. For most of the routes the result was positive, so that speed limits were developed for these routes. These maximum speeds mean that the thrust by the engines has to be converted more quickly to height, so that the aircraft ascends more steeply. The optimised departure procedures are to be used both by day and by night.

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Some departure routes in a southerly and south-easterly direction at operation direction 25 (starts from the runways 25 R / 25 L and 18 W) were already optimised in 2008 in terms of the departure procedures.

Now, for further implementation, the departures at operating direction 07 and from the Runway West are to be flown using optimised procedures in a one-year trial. In the course of this it is to be examined whether the height gains expected from the speed specifications can be achieved, and whether this leads to the expected noise abatement.

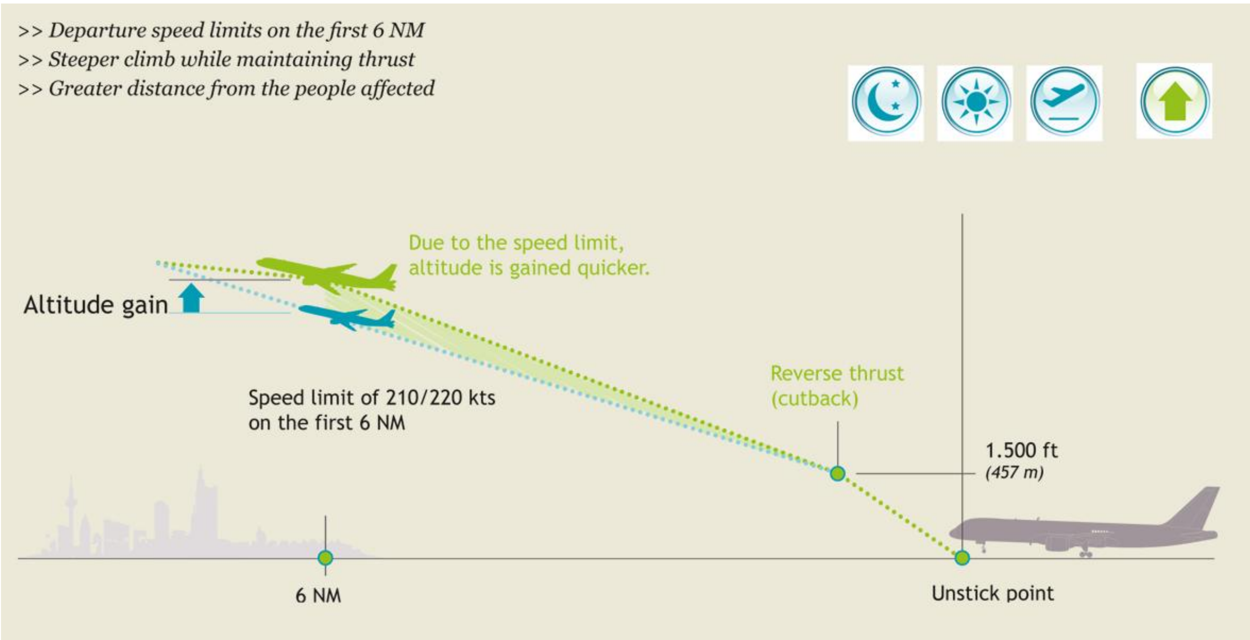

Figure 2 Measure 1 –vertical optimisation of departure procedures

4.1.2. Modification of Lufthansa's Boeing 737 fleet

Since 1999 Lufthansa has carried out numerous research and development projects in collaboration with the Deutsches Zentrum für Luft- und Raumfahrt (DLR). The aims included the identification of noise sources on the aircraft by overflight measurements, the trial of low-noise modifications on the aircraft, and cooperation with manufacturers in the development of modification solutions. A noise-reducing measure for the Boeing 737 with CFM-56-3 engines

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has been developed to maturity: the exchange of twelve "acoustic panels" at the intake of the engine make both departure and arrival with this aircraft less noisy. During departure up to the thrust reversal at 1500 feet there is a noise reduction of around 0.5 dB, in the further course of the flight a reduction of approximately 1.5 dB. The modification allows a noise level reduction in the intermediate and final approach of up to 2.4 dB. Lufthansa has decided to implement this measure by the end of 2011 for the B737 machines stationed in Frankfurt.

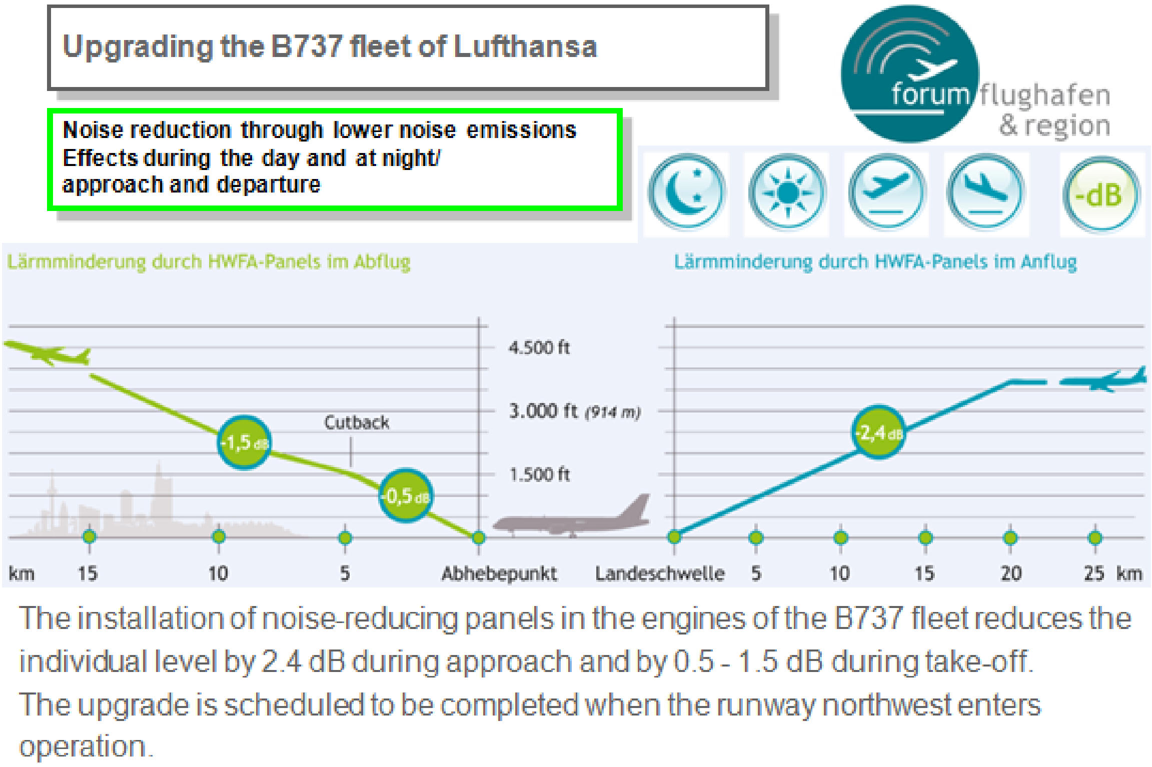

Figure 3 Measure 2 –modification of the B737 engines

4.1.3. Optimization of the operating direction change depending on the tailwind

The departure and arrival direction (operating direction) is basically determined by the direction of the wind, as planes generally land and take off against the wind. As, in particular in the case of changing or turning winds, it is not possible to keep changing the operating direction

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accordingly, arrivals are also possible to a certain extent with a tailwind component. At present the limit is at 5 knots tailwind component, corresponding to around 9 km/h. Experience shows that occasionally even at lower tailwind components the operating direction is changed.

As a number of residential areas are located to the west of the airport, and arrivals cause especially low overflights, it has been attempted only to approach the airport where possible from the east, and to take off to the west (west operation, so-called operating direction 25). Over the yearly average this is the case in around 75 % of the operating time.

Attempts are being made to increase the proportion of flights in operating direction 25. This is to happen in two steps:

- In the first step the existing arrangements according to which the arrivals may only be executed at a maximum of 5 knots tailwind are to be used more efficiently. Experiences regarding the stability of the arrival approaches are to be evaluated. The potential with regard to the thus additionally achievable operating days at operating direction 25 is currently being examined.

- In a second step the permissible tailwind component is to be raised to 7 knots (ca. 13 km/h) so that approaches from the east can take place more frequently. As this exceeds the tailwind components approved by the ICAO, the consent of the BMVBS/BAF first has to be received for an exception. The DFS has carried out a safety assessment in this regard. Taking into consideration risk-reducing measures, this assessment identified risks which both the DFS and Lufthansa regard as acceptable overall. The pilot association Cockpit objects to the measure.

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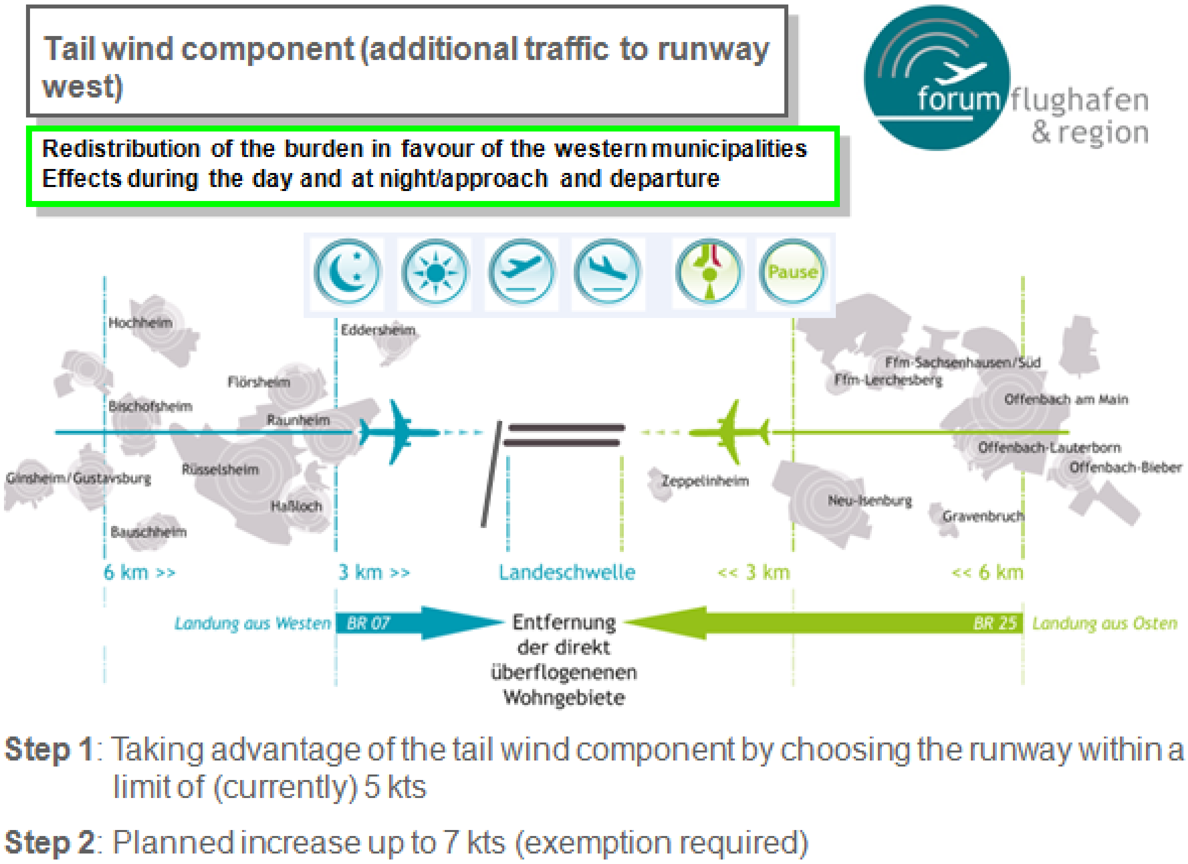

Figure 4 Measure 3 – optimisation on operation direction change depending on the tailwind

4.1.4. Introduction of a new arrival procedure:

Segmented RNAV (GPS) Approach

In this measure, satellite-aided approach procedures were defined for both operating directions (west and east operation). Here the aircraft are first guided to the south of the centreline and only turn at approximately 5nm (approx. 9.3 km) before the arrival point to the centreline in the direction of the runway course. This means that aircraft can circumvent settlement areas in the final approach area (Mainz, Offenbach, Hanau). The measure has an impact on capacity and is to be tried initially in the off-peak times during the night. In advance of the trial operation, the capacity effects and thus the possible application times for the procedure are being examined (up to now a time from 23.00 to 5.00 hrs has been assumed). In order to use this procedure, the aircraft need special technical equipment and approval for area navigation. According to

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assessments carried out, at least 80 % of the aircraft of the airlines flying by night fulfil the technical conditions.

It must also be mentioned that it was possible to integrate the low-noise approach procedure CDA practised up to now in the new approach procedure, and that its noise-reducing effects are retained. For more about CDA, please see section 4.1.6.

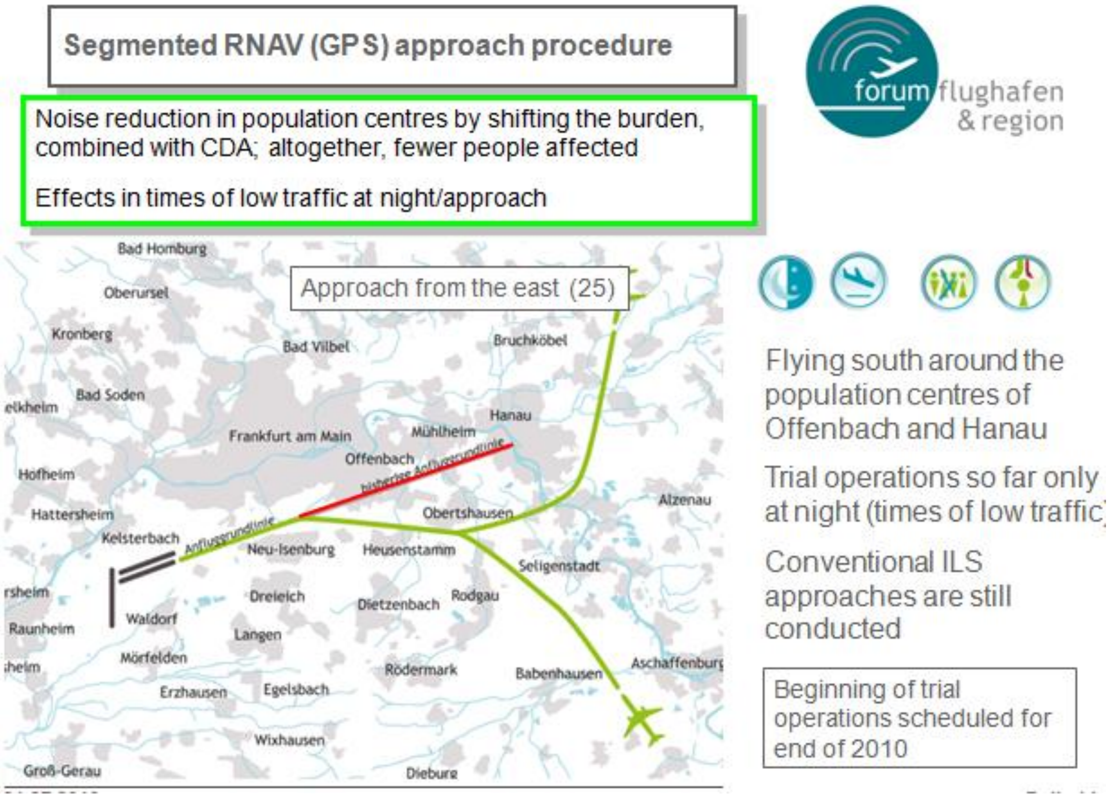

Figure 5 Measure 4 –Segmented RNAV (GPS) Approach - BR 25 arrival from the east

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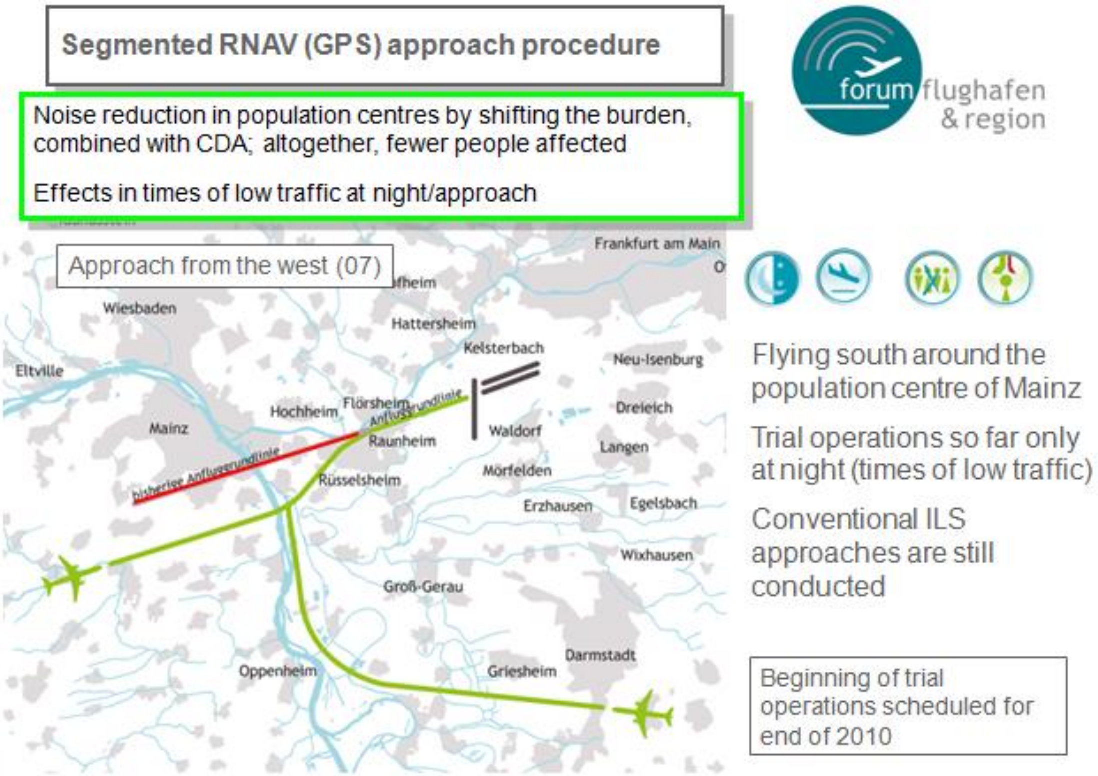

Figure 6 Measure 4 –Segmented RNAV (GPS) Approach - BR 07 arrival from the west

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4.1.5. Dedicated Runways Operations (preferred runway usage, DROps)

In the course of this measure, starts or departures are bundled on certain runways or departure routes in such way that the overall burden is at its lowest.
As this is a noise-distributing measure, special attention must be given to any local additional impact. The investigations have shown that an approximately 50 per cent use of the DROps concept leads to the best overall result for those most highly affected. This means that there is a lower local additional burden compared with the unchanged operation concept, but that substantial relief can be achieved in many areas of the region.

The measure can only be applied in low-traffic times during the night, but is to be used for as many departures as possible (at least all departures from 23.00 to 05.00 hrs). On days with an uneven date DROps is to be used, and on days with even dates the conventional operation concept, so that the respectively affected parties at least have breaks from the noise. There are no plans to change the operating concept during the night but this may be necessary under certain circumstances for operational reasons (e.g. closing of the runway).

The DROps concept for east operation provides for an alternative operating scenario in which all departures are moved to the Runway West during the low-traffic night period. For this purpose an additional departure route in the northerly direction was defined running to the east of the airport. This is meant to avoid unnecessarily long flight paths and the resulting emissions, while the connection to the air route network is optimised.

As an alternative operating scenario, the DROps concept for west operation would handle the starts via the parallel runway system so that the Runway West would not have to be used.

In addition to this, in the second half of 2010, in an as yet not fully elaborated step, it is to be examined whether a new departure route can be developed which avoids overflights of Büttelborn and other localities affected by flights from the Runway West. Further optimisation potentials for DROps are also to be elaborated.

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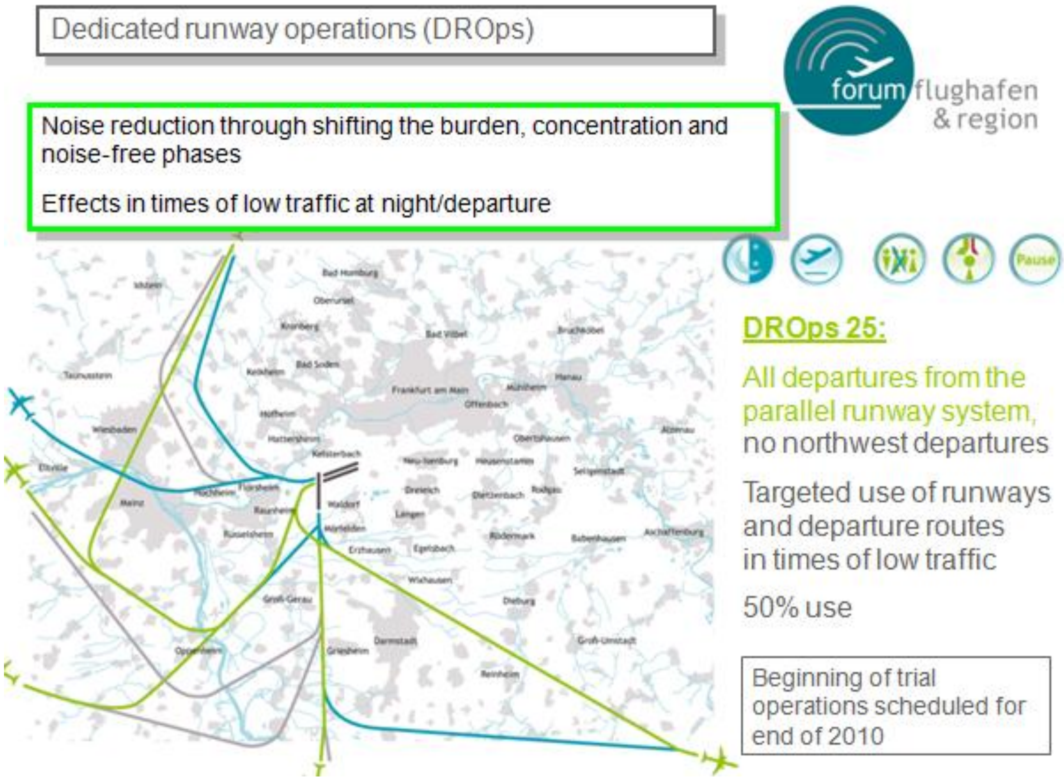

Figure 7 Measure – 5 preferred runway usage (DROps 07) – taking off towards the east

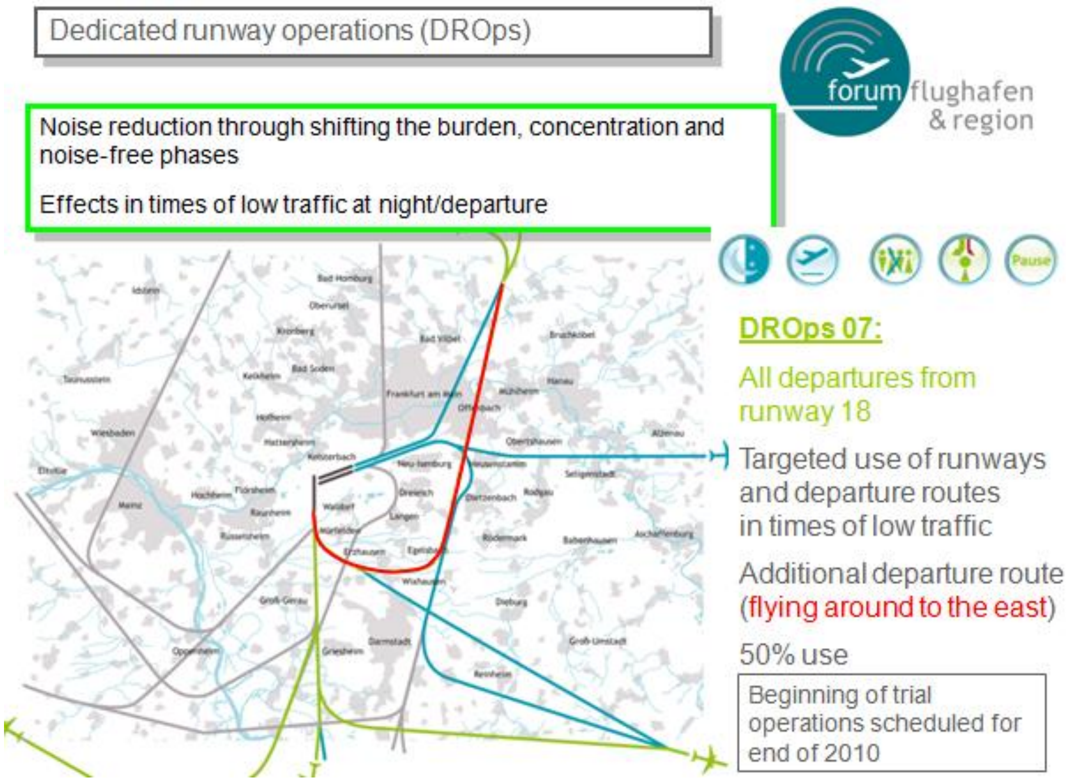

Figure 8 Measure 5 – preferred runway usage (DROps 25) – taking off towards the west

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4.1.6. Optimisation of the Continuous Descent Approach (CDA)

Arrivals at an airport with a continuous descent approach, dispensing largely with horizontal flight segments, and in which the engines are on "idling", i.e. working without or with very little thrust, come under the category of CDA. They end when the approach with the aid of the instrument arrival system begins. CDA saves fuel and avoids noise.

CDA has already been in use at Frankfurt Airport for some years now during the night, generally from 23.00 to 05.00 hrs. The approaching aircraft are guided onto an interception line at 7,000 feet (approx. 2100 metres). The distance of this interception line to the arrival threshold corresponds to a descent angle of 3 degrees. From the interception line the aircraft are transferred to the instrument arrival system which begins at a height of 5,000 feet (approx. 1500 m) and not only at 4,000 or 3,000 feet.

In practice, however, there is a whole series of factors which make an ideal CDA to the full extent impossible, and not all approaches can use this procedure. The application is also restricted by the fact that for an ideal CDA for the particular aircraft, the vertical profile can vary depending on aircraft type, load, weather, etc. so that it cannot be exactly determined for the air traffic control. In the proximity of a densely frequented airport this scattering means that due to the inability to exactly determine the profile, more airspace has to be kept free for the aircraft so that fewer useable height bands are available. This leads to capacity limitations. This is why scheduled continuous descent approaches are used mainly at off-peak times. With the implementation of the noise abatement package the continuous descent approach practised up to now will continue to be used. The application frequency and precision are to be optimised in two steps:

- In a first step this is to be achieved by a "distance to go" instruction of the air traffic controllers to the pilot. The intention is to increase the capacity utilisation of the CDA procedure through the DFS supplying the pilots with distance information which supports the observance of the optimum CDA profile.

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- In a second step after the start-up of the new NW runway, a so-called “transition and profile” procedure is to be established. By determining descent approach profiles and courses, the degrees of freedom for the air traffic controllers is to be made easier to calculate. The basis for this is the introduction of navigation procedures which involve both lateral and vertical guidance. It is expected that this will improve the manageability of the continuous descent approach even in times with more traffic so that the procedure can also be used at higher traffic densities.

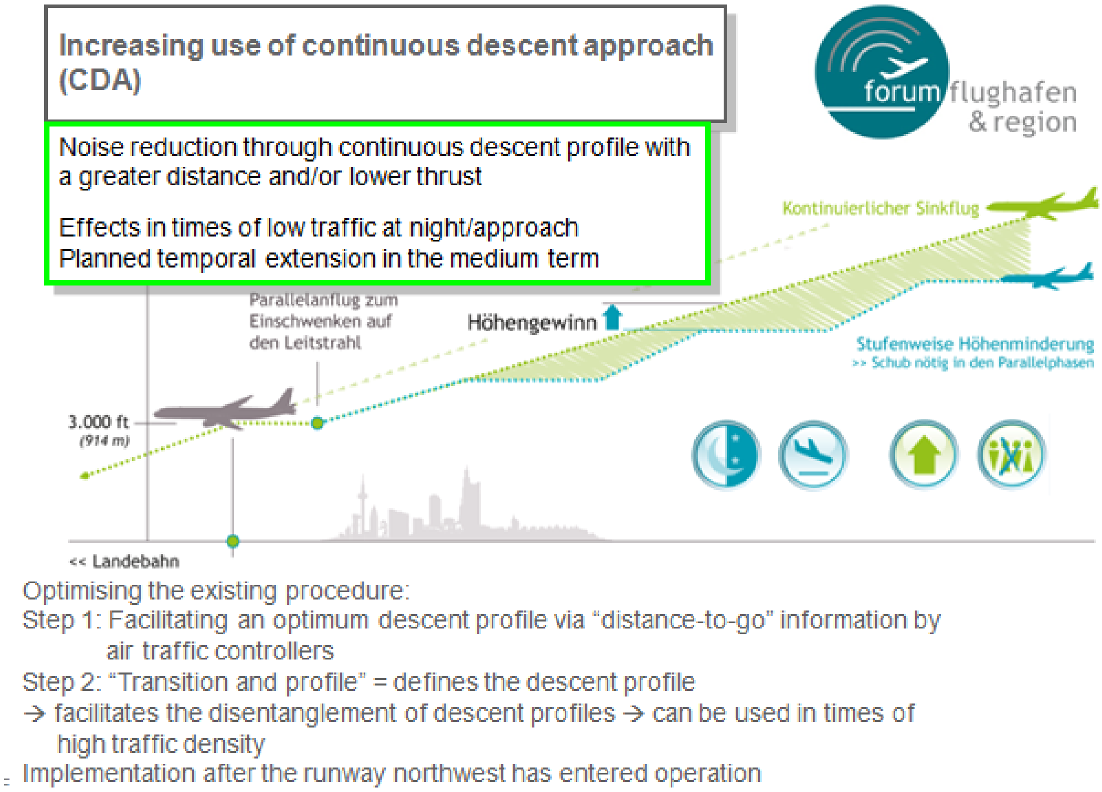

Figure 9 Measure 6 – Optimisation of the Continous Descent approach (CDA)

4.1.7. Increasing the approach guide angle to 3.2 degrees on the future NW runway

Approaches take place as standard at an angle of 3 degrees. When this angle is raised, i.e. made steeper, the distance at which the residential areas are overflown is also increased. This helps to reduce the noise burden on the residents. On the basis of simulation results, it is also assumed

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that the slightly altered angle also results in other noise reductions. There are, however, uncertainties as to whether changes in the time of opening the flaps or extending the arrival gear may not also actually increase noise. This is why trials are to be carried out with this procedure accompanied by a measurement program.

The measure is associated with a whole range of restrictions so that it cannot be used at all times and not on the whole runway system. For safety reasons, for example, it is only possible to fly the steeper angle when there is no tailwind and when the weather conditions are good. In the case of West Operation (i.e. departures to the west, arrivals from the east; so-called operating direction 25), the evaluation of weather data shows that it will be possible in approximately 60 % of the operating time, in the case of East Operation (takes-offs to the east, arrivals from the west, so-called operating direction 07) in almost 100 % of cases.

Instrument arrivals systems (ILS) are still required for arrivals. A guide beam is sent by radio for the respective descent angle which is received by the approaching aircraft and allows it to fly as precisely as possible at this angle. As, for safety reasons, the conventional angle of 3 degrees is to be retained for approaches with tailwind, a arrival runway has to have two ILS, one for 3 degrees and one for the increased angle of 3.2 degrees. For various reasons this is only possible for the new NW runway. In the long term, however, modern, satellite-based navigation technology could mean that the use of an ILS could be dispensed with. At this as yet unknown time it might also be possible – if the measure proves itself in trials – to approach the parallel runway system with steeper approach angles. As the use of a higher glide angle is not in compliance with ICAO due to noise-abatement reasons, the BMVBS has to grant an exception approval for the introduction of the measure.

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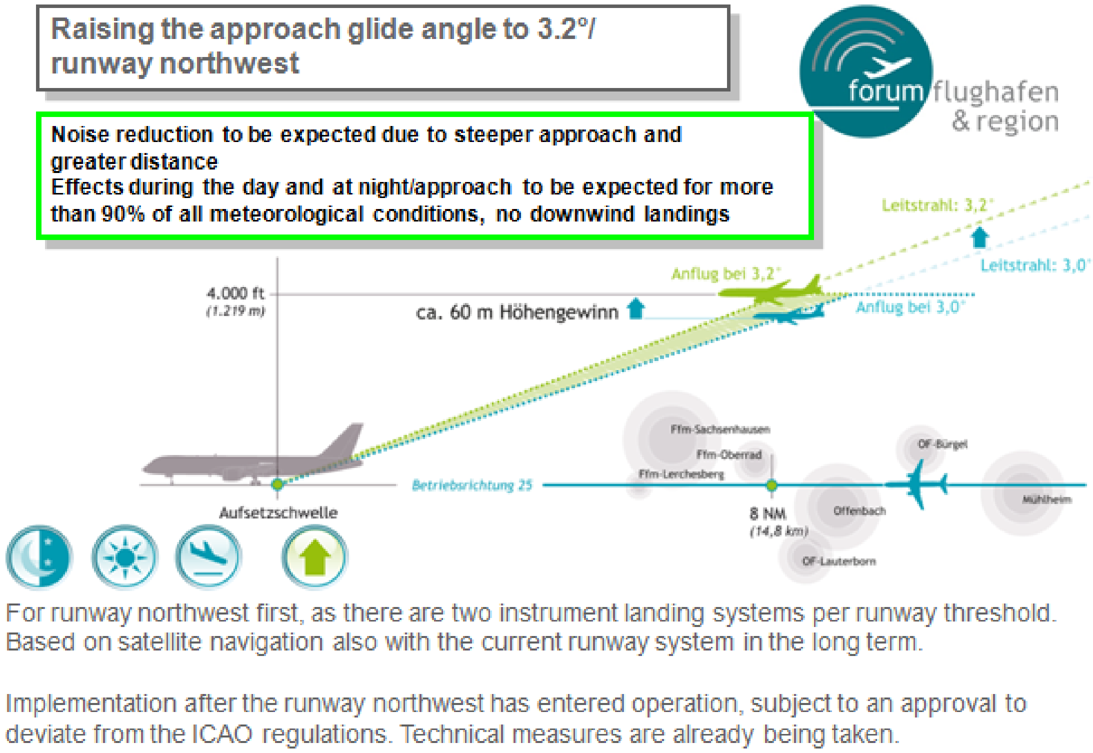

Figure 10 Measure 7 – Raising of the approach glide angle to 3.2 degrees on the future NW runway

4.2 Schedule

In the opinion of the expert committee, the realisation of the measures should begin as soon as possible. However, we still have to wait for the consultations in the Flight Noise Commission as well as a number of approval steps, and it is not yet foreseeable how long this will take. The horizons given in the following are subject to the proviso that the consultations and approvals proceed briskly (for the necessary steps see section 3.3) and that no further obstacles arise.

In the second half of 2010 the expert committee will continue its work with the focus on

- work on the abovementioned further developments, examination of other measures which partially can only be realised in the medium term (first step: alternative RNAV departure routes)
- examination of the implementation of the package

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- design and implementation of monitoring instruments to examine whether the measures are having the expected noise-abating effects.

	Measure	Time schedule
1	**Optimisation of departure procedures**	At the latest by end of 2010
2	**Modification of B737 fleet**	End of 2011
3	**Optimisation of operating direction change depending on the tailwind**	2011
6	**Optimisation of the continuous descent approach**	**"Distance to go" information to pilots**: in a few months **Transition and profiles:** after start-up of the NW runway
4	**Segmented RNAV (GPS) Approach**	End of 2010
5	**DROps Dedicated Runway Operations**	End of 2010
7	**Increased ILS glide angle of 3.2 degrees on the NW runway**	After start-up of the new runway

Figure 11 | Estimate of the time required

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4.3. Impact of the package on noise development

4.3.1. Basic principles

The aim of the noise-abatement measures is to relieve the region as far as possible from flight noise. Various evaluation indicators can be used to assess the relief or burden due to changes of the arrival and departure procedures. A central role was played here by the indices Frankfurt Day Index (FTI) and the Frankfurt Night Index (FNI) developed within the framework of the work of the FFR and introduced to the public in December 2009 in the Convent of the FFR. In addition to this, purely acoustic values were also compared, for example which increases or decreases were registered in the permanent noise levels. Figure 12 shows the main terms used in this section.

4 Schreckenberg, D., Meis, M. (2006): Annoyance due to flight noise in the area of Frankfurt Airport – final Report. For the definition of the FTI, the dose-effect relationship was newly calculated on the basis of flight noise calculations according to the AzB 08 using the available data.

5 Basner, M., Isermann U., Samuel, A. (2005): The results of the DLR study and their implementation in the noise-pathology assessment for a night protection concept, Magazine for noise abatement 52(4), 109-123

4.3.2. Brief description of the Frankfurt Day Index (FTI) and the Frankfurt Night Index (FNI) used as assessment instruments

This section sets out briefly how the indices are calculated and which result can be achieved by the respectively proposed package of measures in the region and in the affected communities. An exhaustive technical representation and the derivation of the indices can be downloaded from http://www.forum-flughafen-region.de/forum/expertengremium-aktiver-schallschutz/ . In order to assess the effects of the active noise-abatement measures, the following parameters were used:

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- The noise levels which reach the people (noise immission).
- A quantitative description of the effect of these noise immissions on the basis of scientifically calculated dose-effect relationships.
- The number of persons living in regions with certain noise levels in the delineated examination area.

The two indices FTI and FNI especially developed in the FFR take all three parameters into account. They are calculated for an examination area (index area) in the region Rhine-Main which covers (fully or partially) around 30 communities. The delineation of the index area is established for each calculated scenario, i.e. with or without certain measures, newly and solely on the basis of noise-related criteria and not on the basis of geographical aspects. The operation scenarios, i.e. which different situations with or without active noise abatement measures were calculated in each case, are described below.

In the noise calculations it was first calculated and represented in each case how the FTI or the FNI are changed by the measures. In a second step, especially "highly affected" parties within the index area were defined in order to evaluate in the analyses separately just how the measures affect this group. This was to ensure that the declared aim of the expert committee, to relieve the most highly affected as a priority, can also be achieved.

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	FTI – Frankfurt Day Index	FNI – Frankfurt Night Index
Observation period	06.00 to 22.00 hrs	22.00 to 06.00 hrs
Procedures for noise calculation	AzB 2008[6] (with some modifications)	AzB 2008 (with some modifications)
Acoustic input parameters	Energy-equivalent permanent noise level LAeq, Day according to the flight noise act	All A-assessed maximum noise levels in an average night of the 6 peak-traffic months
Represented effect	Number of persons highly annoyed by flight noise in the examination area calculated on the basis of the dose-effect relationship according to the RDF annoyance study 2005	Number of flight noise-induced wake-up reactions in the examination area per average night on the basis of the dose-effect relationship in accordance with the DLR sleep study 2005
Delineation of the area in which the index is calculated	Area in which an LAeq, Day of at least 53 dB is reached	Area in which the probability of a flight noise-induced EEG WR amounts to 75 % or more
Assumed distribution between east and west operation	In the case of area delineation: average distribution over ten years taking into account the triple positive standard deviation (Sigma regulation in accordance with the flight noise law) In the case of calculation of the noise values in the index area for evaluations of active noise-abatement measures: average distribution over ten years	
Definition of the "highly affected" within the index area	Persons who live in areas with a permanent noise level LAeq, Day of at least 60 dB,	Persons who live in areas with a permanent noise level LAeq, Night of at least 53 dB and/or with per average

[6] Instructions for the calculation of flight noise; first ordinance for the implementation of the law on the protection against flight noise (ordinance on data collection and the calculation procedures for the determination of noise-protection areas – 1.FlugLSV) dated 27 December 2008. Federal Law Gazette I, page 2980

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	calculated in accordance with the Sigma regulation (corresponds to the day protection zone 1 pursuant to the flight noise protection act for new building and substantial alteration of an airport up to the end of 2010).	night 6 or more exceedings of maximum levels LAmax of at least 72 dB, calculated in accordance with the Sigma regulation (corresponds to the night protection zone 1 pursuant to the flight noise protection act for new building and substantial alteration of an airport up to the end of 2010).

Figure 12| Overview of important benchmarks for FTI and FNI

The noise assessment was drawn up for the measures or packages of measures for the actual situation using the year 2005 as an example or on the basis of the traffic prognoses used in the official planning procedure for the extended status in the year 2020.

How highly people are actually affected by certain noise values depends on many individual and often subjective factors. Every assessment method has to restrict itself to general findings for a certain location which have been gained in the course of scientific studies involving a large number of people and from which then a mean value can be formed. Individual reactions cannot be reproduced in this. A central advantage of the assessment method over effect-related indices is that different degrees of effect can be compared in accordance with objective, scientific criteria.

The three following graphics show the area delineations for the day
(2005 and 2020) and for the night (status 2005) without further measures for active noise abatement. The area defined as “highly affected” is also shown in each case.

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4.3.3. Procedures for noise calculation and observed scenarios

There is a whole series of methods available to calculate changes in the acoustic burden as a result of active noise abatement measures, but there are no established standards. All of the calculation methods used up to now, including the AzB, have advantages and disadvantages in terms of the precise representation of active noise abatement measures. In all cases, either important basic data for the precise representation of some aspects of active noise abatement measures are missing or are only available for certain aircraft models. The expert committee decided to carry out the calculations with the AzB from 2008. This is the method officially recognised in Germany for the calculation of noise protection zones pursuant to the flight noise protection act. This is to allow the greatest possible degree of comparability with other noise calculations. In addition to this, it is relatively easy to modify the input parameters in order to represent completely different types of measures. In a dedicated working group it was examined jointly for each measure which input data and procedure definitions would be used. In cases where no concrete data was available, assumptions were made.

For the noise calculations two data collection systems were used as the basic framework for the calculations: the traffic density for the six highest traffic months in 2005 and the prognosis for 2020 (according to the planning procedure [PFV]), each with standardised operating direction distribution. These data sets contain all of the flight movements, which route they took and which category in the AzB the aircraft used can be allocated to. A distinction was made between flights from 06.00 to 22.00 hrs (day, 2020 and 2005) and 22.00 to 06.00 hrs (night, only 2005). In order to estimate the effects of measures which initially can only be applied during low-traffic times at night and which are to be introduced before the extension of the runway, an evaluation was made (in deviation from the AzB) of which flight movements in the night 2005 took place between 23.00 and 05.00 hrs. In the example of 2005 this was around 40 % of all departures and descents in the night. For these flight movements it was assumed that they were carried out with the measures provided for low-traffic times (Segmented RNAV (GPS) Approach and Drops). For the reasons cited in section 3.2, no calculation was made of possible effects of active noise abatement measures for 2020 in the night.

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The noise calculations were then carried out for three scenarios per package of measures:

- **Original scenario** without measures with standardised (i.e. average) operating direction distribution between east and west operation
- **Scenario with package of measures** with standardised operating direction distribution
- **Scenario with package of measures and** simultaneously the assumption that on **six days** west operation[7] is flown **more** than in the hitherto average.

4.4. Uncertainties and implementation risks

With the development of this package the expert committee was in many respects entering new territory. Not every aspect, not every noise impact and not every practical implementation issue can be assessed in advance with certainty. In addition to this, most of the measures still require approval by the relevant authorities. This is why it is also impossible to give precise time schedules.

After the measures are introduced it will be necessary to examine as thoroughly as possible in each case, for example by measurements, whether the assumed noise reductions have actually been achieved. Depending on the results, it may be necessary to re-adjust some of the measures. An important aim is to further optimise in the future the measures whose success has been confirmed as assumed, and to increase the times of their application. Before this, however, we have to gain more experience with the new measures.

One important restriction has to be emphasised: The available instruments for calculation or estimation of noise all have their limits. The task of predicting exactly how high the noise is and how it will change is so complex that we always have to work with simplifications and for many

[7] This simulates the possible effect of an altered tailwind component. As the operating direction distribution depends solely on the weather conditions, and fluctuates from year to year, this assumption for the expected mean effect of the changed tailwind component was developed on the basis of an evaluation of weather data from the past.

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questions there are still no input data available. The noise behaviour of every aircraft depends on so many factors which vary again depending on the perspective flight procedures (e.g. type of engine, weight, angle, flap position, engine output, speed, height, wind), that any prediction can only be as precise as the present state of science and the availability of data allow. This is why the monitoring of noise, the use of available new calculation methods etc. will play an important role in the future.

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5. Outlook

Medium-term outlook

In addition to the package proposed here, the expert committee can also envisage a series of further approaches and believes that they have a good chance of being implemented in the medium term following further examination.

With the aid of measurements, further monitoring measures and evaluations of new scientific findings it will be continually examined whether the measures actually achieve the expected noise reductions, whether there are any negative effects for safety and capacity, and whether there are any further possibilities for optimisation. Insofar as this proceeds positively, the extension or the further optimisation of DROps, CDA and Segmented Approach to other time zones is to be attempted. This will also include, for example, the creation of new departure routes on the basis of area navigation (subject to legal clarification). There may also be an option in the future of making arrivals on the parallel runway system at 3.2 degrees. Improvements may also be achieved by the use of low-noise aircraft.

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Measures to Lufthansa's existing fleet

The DLR and Lufthansa carried out overflight measurements with aircraft from the A320 fleet and with the types MD11 and Boeing 747. Here it was possible to identify further noise sources and potential measures for noise reduction. The results were made available to the manufacturers for further research and, as applicable, development of a modification solution. Whether such modification solutions will actually be developed to implementation maturity is still unknown. Further research will be carried out jointly with the DLR and manufacturers.

Noise reduction through fleet roll-over at Lufthansa

The largest fleet renewal program in the history of the Lufthansa company with an investment volume of around 13 billion Euro (list price) between 2010 and 2016 is expected to add 146 new aircraft to the group.

New aircraft models, the Airbus A380 and the Boeing 747-8, will be introduced in the long distance fleet. These will have substantially lower noise emissions than older long-distance planes. The Frankfurt location will be extended as the home airport of the A380 fleet and the 747-8 is also expected to be stationed here. In summer 2010 the first four of the 15 A380s ordered by Lufthansa will go into service. According to the manufacturers the wide-body aircraft are supposed to produce considerably less noise than comparable existing models. According to the latest manufacturer information, the A380 is around 5 EPNdB quieter than the B747-400 on departure and arrival. A look at the noise carpet shows the clear reduction of the noise contours in the 85-dB(A) range (with the B747-8 as an example). This contour is reduced in the new wide-body aircraft by around 30 % compared with the currently used models.

- New aircraft models with new technologies will also be introduced in the short and medium range. The Embraer 190/195 has already gone into service and Bombardier, Mitsubishi and other manufacturers are also offering new aircraft models which are

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expected to be used in Frankfurt in the medium term. These will feature new technologies such as the geared turbo fan which will lead to substantial noise reductions.

Overall, the billions invested by Lufthansa (and other airline companies) will lead to a substantial reduction of noise per flight event and to a decoupling of noise development from passenger growth. However, the relief potentials of the Lufthansa flight renewal are not shown in the noise prognoses in the present report.

Long-term outlook

In recent years the issue of CO2 emissions in aviation has become increasingly the subject of discussion. Emission trading in aviation has been decided, at least for the European region. This is why in recent years the discussion about the impact of aviation on the environment, alongside flight noise, has also started to focus more on the subject of toxic emissions.

Even though the focus here is on saving fuel, many of the associated measures also offer the chance of reducing flight noise as they are related to the reduction of the engine output.

Fuel-saving procedures with noise-reduction potential

- **Optimized Profile Descend (OPD) in Los Angeles**

The OPD procedure is very similar to the CDA. According to Los Angeles Airport (LAX), around 300 to 400 arrivals are currently flown daily using the OPD procedure. The procedure itself begins at heights up to flight level180 (FL 180), this corresponds to ca. 5400 m.

The solution approach consists in a kind of "cluster formation of airplane groups on the basis of comparable aircraft performance parameters", supplemented by thorough detail analyses. According to the information available the OPD procedure made it possible to reduce the time

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proportion for the horizontal flight phase from an average of four minutes to one minute. The resulting fuel saving is estimated at an average 80 kg/descent. From the development of the procedure to its operative introduction took seven years.

- **Tailored Arrivals (Boeing Phantom Works)**

Boeing Phantom Works is pursuing an approach similar to the OPD with the tailored arrival. Even though the aim of this procedure is to optimise the sequence of descending aircraft, the solution approach represents not only a saving in fuel, but also has potential for noise reduction. Up to now aircraft have to fly diversions in order to receive the optimum sequence and arrival separation. These diversions are to be avoided by a later descent profile to achieve optimisation. The later descent profile corresponds to the CDA approach "higher for longer".

- **Future Air Ground Integration (FAGI)**

The conclusion presentation for this research project took place on 2 February 2010 at the DLR in Braunschweig, a continuation is in the planning stage. Representatives of Fraport AG and the DFS from the expert committee on active noise abatement also took part.

FAGI combines the relative late conjunction of the lateral flight routes with a time-based separation on the descent routes. This means that it could also represent an approach for the expansion of CDA use at peak traffic times. As described above, different aircraft with different descent and speed profiles ultimately reduce the airspace capacity, as the separation can then only be maintained with greater intervals. The FAGI concept may offer a suitable solution approach here.

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