ICANA 16
4th International Conference on Active Noise Abatement

Measures and Instruments of Active Aircraft Noise Abatement

(Maßnahmen und Instrumente Des Aktiven Schallschutzes beim Fluglärm)

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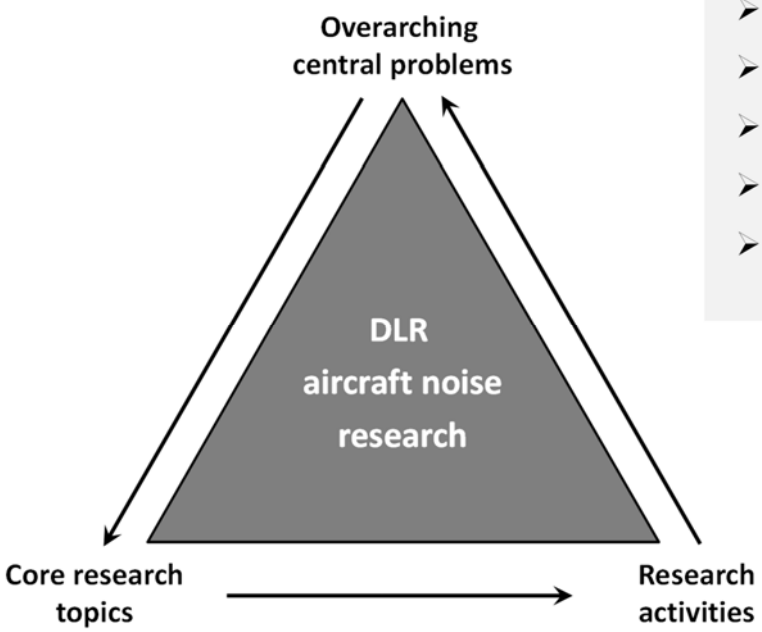
DLR

DLR aircraft noise research



Core research topics

- Aircraft configuration
- Sources of aircraft noise
- Trajectories and ATM procedures
- Aircraft noise effects
- Aircraft noise modelling & interdisciplinary questions

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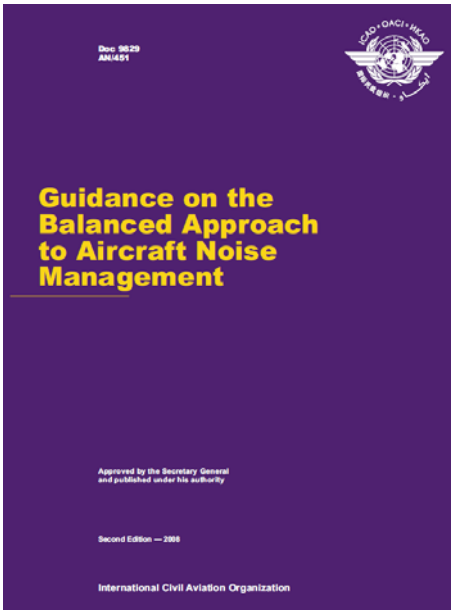
Aircraft Noise Mitigation and Management

Measures of ICAO's "Balanced Approach"

- **Reduction of noise at source**
- **Land-use planning and management**
- **Noise abatement operational procedures**
- **Operating restrictions** (ultima ratio)



Prerequisite 1: Knowledge on noise effects

- Relationships between noise exposition and effects
- Noise descriptors and noise indices

Prerequisite 2: Modelling capabilities

- Aircraft noise sources
- Sound propagation effects
- Operational procedures and air traffic systems
- Behaviour of socio-economic systems

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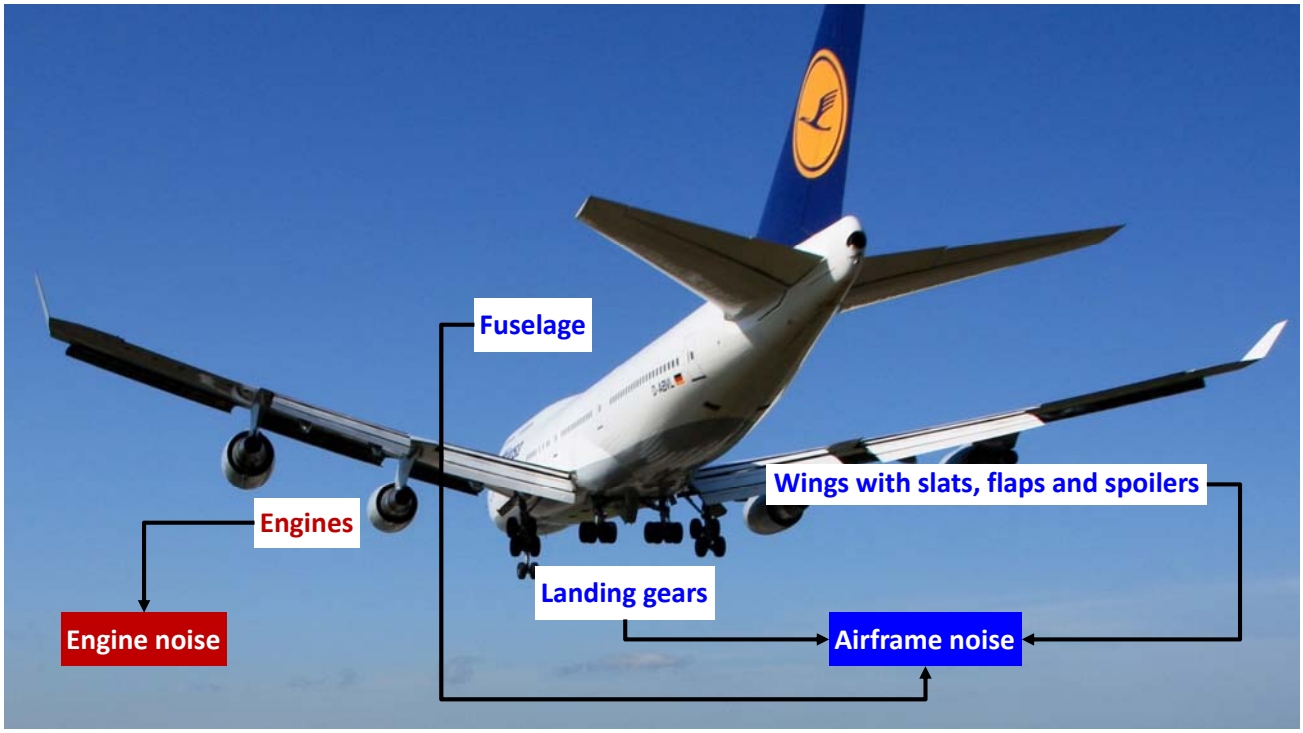
Reduction of noise at the source



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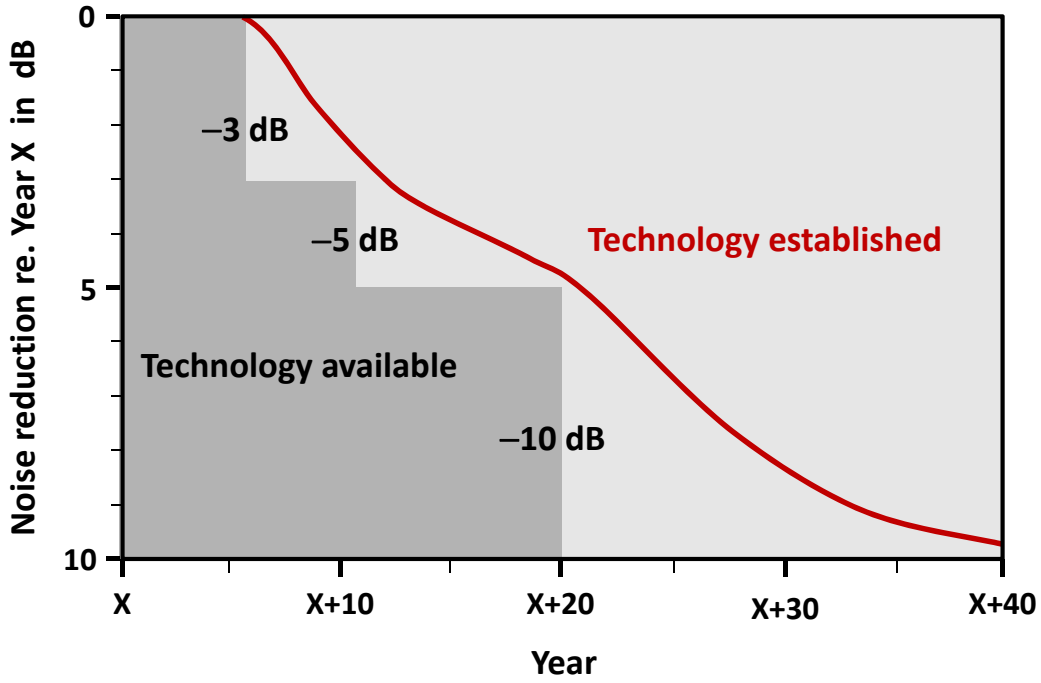
Launching of new aircraft technologies (schematically)

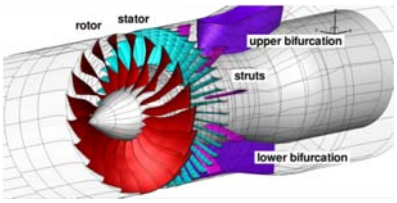


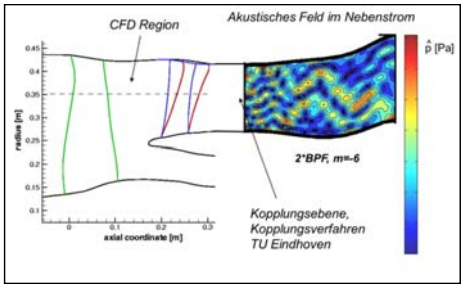
DLR engine noise research

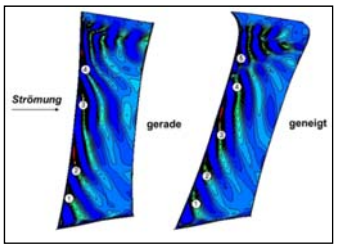
Simulation:

Computational Fluid Dynamics

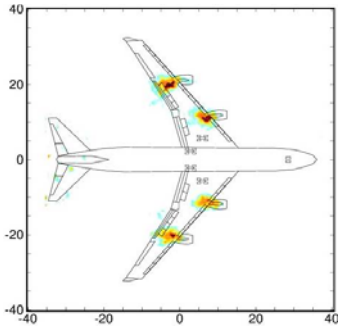
Computational Aero Acoustics







Testing methods & experiments

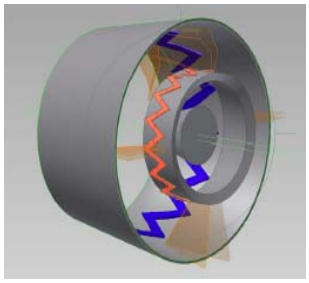


Research on short-/mid-term measures – engine retrofitting

Spliceless inlet liner

Hotstream liner

Chevron nozzle (2004)



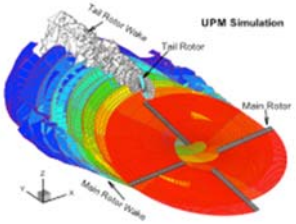
Vortex generator concepts

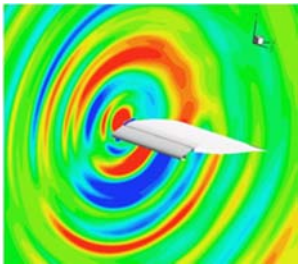
DLR research on configurations and airframe noise

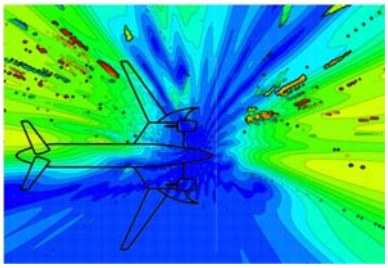
Simulation:

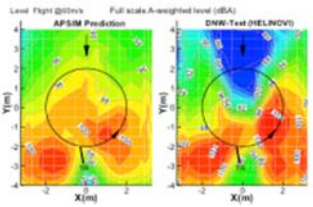
Computational Fluid Dynamics

Computational Aero Acoustics

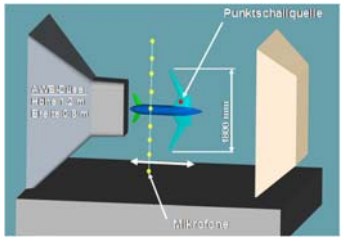


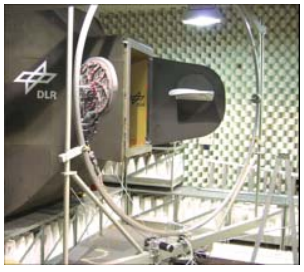






Testing methods & experiments



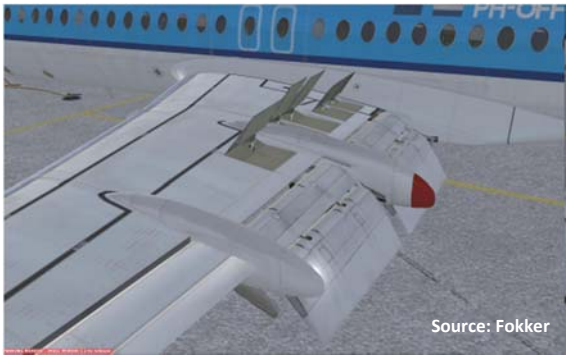


Research on short-/mid-term measures – aeroacoustic retrofitting

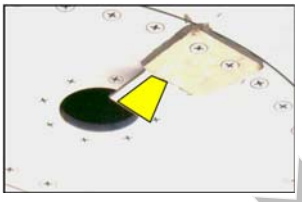
Landing gear
Fairings

Porous side flap
side edges

Spoiler
splitter plates



The vortex generator – an example of technical realization



Experimental version
(DLR project "Quiet Air Traffic", 2004)

Final version
(Supercraft, 2014)

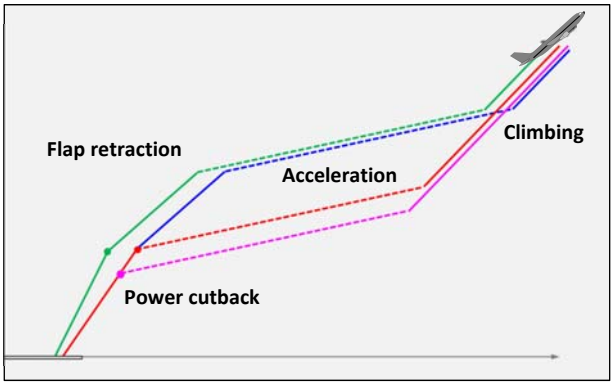
Installed version

- Retrofit of aircraft in service is possible
- Generator is installed on new aircraft
- Noise measurements at Frankfurt Airport attest noise reduction potential

Noise abatement flight procedures

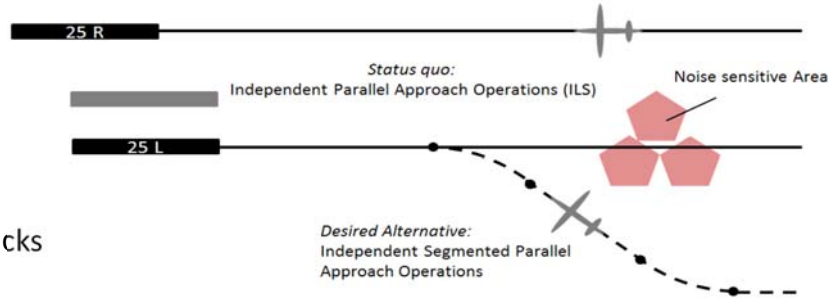
Vertical optimization
by variation of:

- Aircraft altitude
- Aircraft speed
- Engine power setting
- Configuration (flaps, slats, gear)



Horizontal optimization
by variation of:

- Flight track design
  („minimal noise routing“)
- Bundling / spreading of tracks



Departure goal: Gain speed and altitude

How to depart as quiet as possible ?

- **Reduce engine power** (decrease sound emission)
  - ⇒ less climb performance
  - ⇒ less acceleration performance
- **Fly as high as possible** (increase sound propagation distance)
  - ⇒ decrease acceleration
- **Fly as fast as possible** (decrease noise duration)
  - ⇒ decrease rate of climb

Rule: **Source noise reduction is the most efficient measure !**
Effect of steep climb decreases with increasing lateral distance !

Approach goal: Reduce speed and altitude

How to approach as quiet as possible ?

- **Fly idle as long as possible** (low engine noise)
- **Fly high as long as possible** (increase sound propagation distance)
  - ⇒ steep final approach ⇒ fast
  - ⇒ need to decelerate ⇒ flaps/spoilers ⇒ drag
- **Fly as slow as possible** (low aerodynamic noise)
  - ⇒ shallow glide angle ⇒ low altitude
  - ⇒ if too slow ⇒ power increase needed
- **Fly with low drag** (low aerodynamic noise)

Rule: **Source noise reduction is the most efficient measure !**
Fly idle as long as possible an deploy flaps and gear as late as possible !

Noise abatement flight procedures are always a compromise …

Noise reduction potential

- For departures mainly spatial re-distribution of noise
- For approaches additional “real” noise reduction potential
  (byoptimal utilization of gravity with minimized drag)
- Optimized procedure design has to account for the local building structure

Limiting requirements

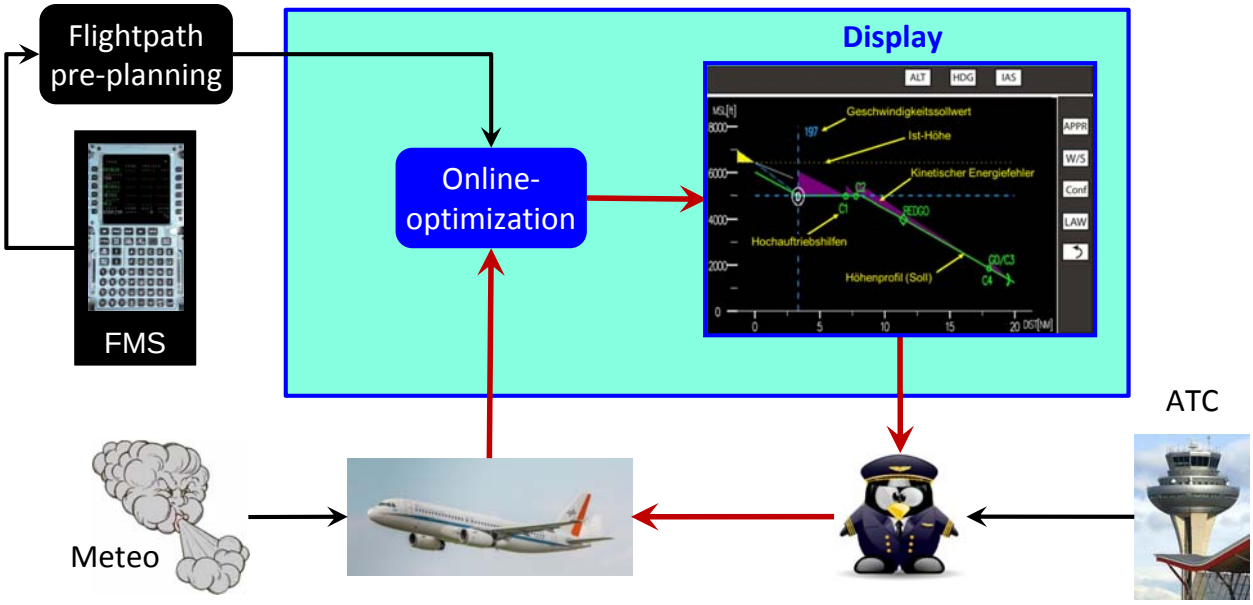
- Don’t violate safety
- Avoid disturbances of ATM
- Implement procedures excactly

of special importance for approaches

- Technical factors (aircraft equipment)
- Human factors (pilot / tower)

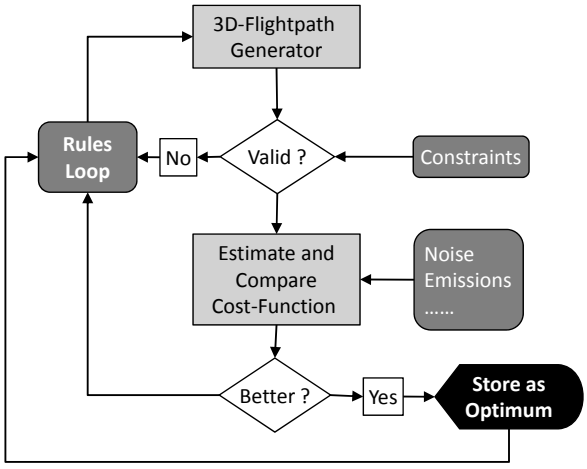
MIDAS – Low Noise Advisory System (LNAS)

Pilot advisory system to increase the vertical precision of approach profiles

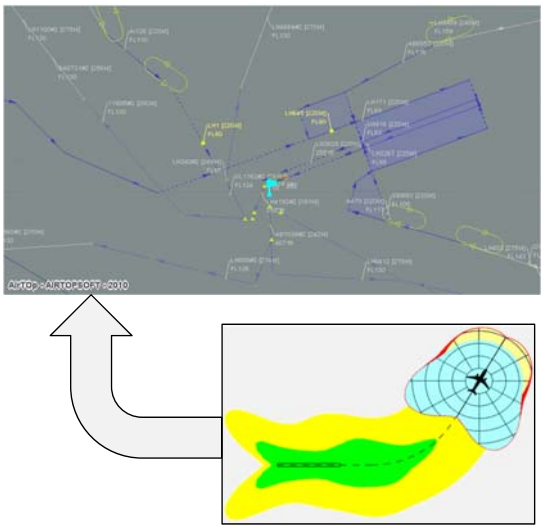


MIDAS – two approaches of combined optimization

3D optimization of routes & procedures



Coupling of fast-time air traffic simulation with suitable noise model



Challenge: Find the suitable noise model w.r.t.

- processing speed
- data amount and availability
- model accuracy

Measures of land-use planning and noise management

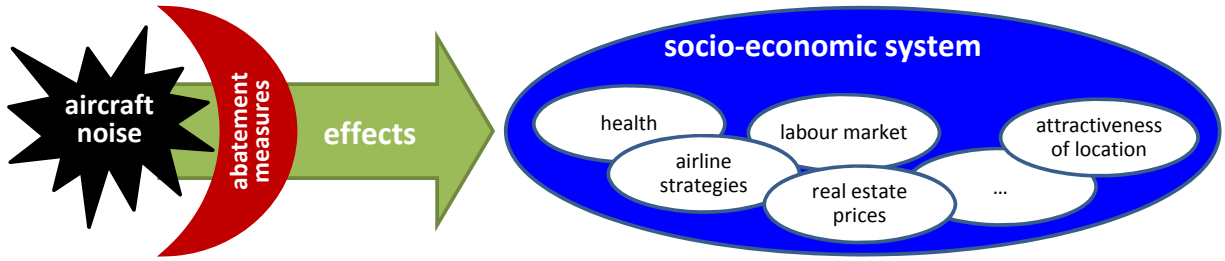
- **Optimized land-use**
  - Noise protection zones
  - Rules for urban land-use planning
- **Financial instruments**
  - Incentives to use quiet aicraft (e.g. noise related landing fees)
  - Compensation payment for residents
  - Real estate purchase programs
- **Passive noise protection**
  - Sound insulation
  - Construction bans
- **Communication**
  - Noise monitoring und **information**
  - Complaint management

Noise related operating restrictions

- **Flight bans**
  - during noise-sensitive periods (morning, evening, night)
  - for noisy aircraft
- **Movement contingents**
  - for overall traffic
  - during noise-sensitive periods only
  - for noisy aircraft only
- **Noise contingents**
  - Area allocation (areas of reference noise contours)
  - “Noise volume“ limitation (noise quota point systems)
  - Noise effect related quotas (Frankfurter Tag-/Nacht-Index, Zürcher Index)

MIDAS – Work package on regulatory measures

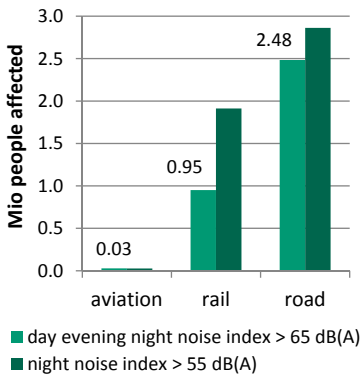
How to find additional criteria to evaluate aircraft noise effects more comprehensively ?



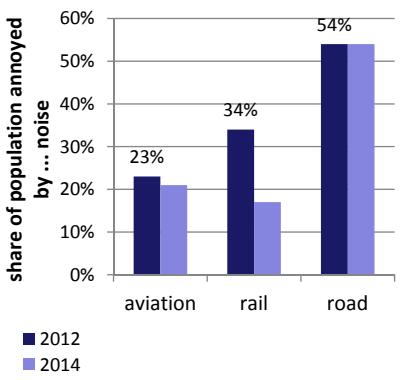
- **Build a comprehensive system model (method of system dynamics)**
  - include feedback between areas
  - account for time lags between causes and effects
  - use causal directional relationships only
- Insert different regulatory **noise abatement measures** in model
- **Identify key variables** for system behaviour ⇒ **potential evaluation criteria**

MIDAS – Work package on communication

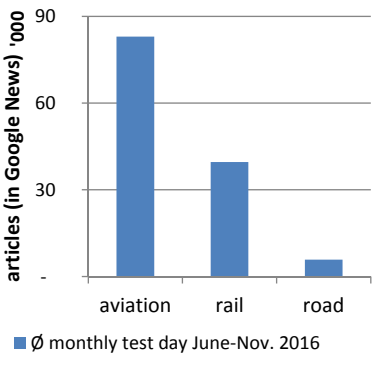
Population affected
by vehicle noise in 2015
(source: UBA)



Population annoyed
by vehicle noise in 2012/14
(source: UBA)



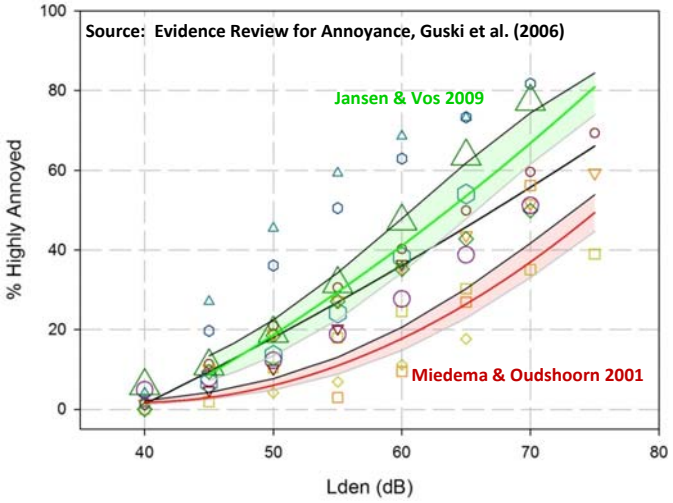
Press articles
on vehicle noise



Aircraft noise communication is over-proportionately present, i.e. more intensely discussed than other vehicle noise.

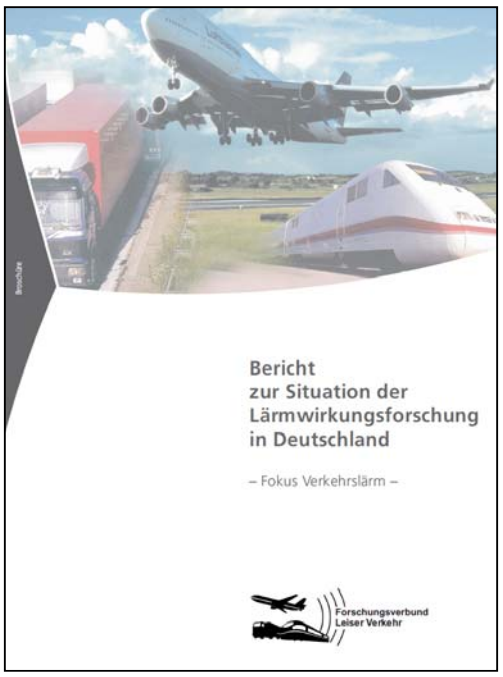
Knowledge on aircraft noise effects is fundamental

Example: Annoyance



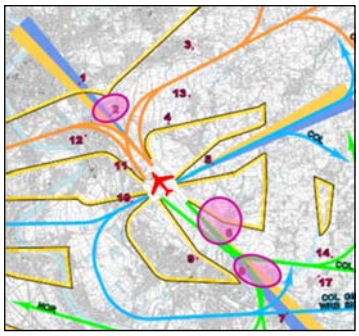
- **Do we really understand this behaviour ?**
- **Do we really understand equivalent sound levels ?**

Position paper on noise effect research in Germany



MIDAS – Noise effects on sleep of children (field study)

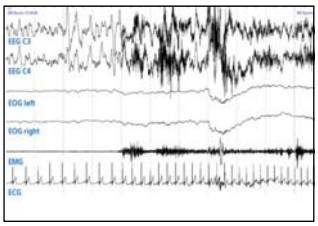
Cologne/Bonn Airport



First test period (June - October 2016)

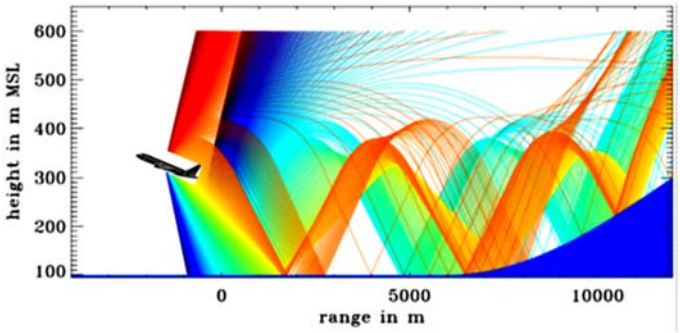
- 30 children (15 girls / 15 boys)
- 4 test nights each
- Positive feedback from fchildren & parents

Method: Polysomnography



Adequate noise modeling is essential

From simple models …



… to noise prediction for complex sound propagation conditions.

Fundamental rules for noise modelling:

- Choose the appropriate model for a particular task
- Keep it as simple as possible and as exact as necessary
- Harmonize model and database

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"Rubbish in – rubbish out" – the fundamental role of databases

- **Primary database types (aircraft specific)**
  - Aircraft performance database
  - Aircraft noise database
- **Degree of detail limits the noise model structure**
- **Number of aircraft included limits the field of application**

- **Supplementary data (scenario specific)**
  - Radar tracks
  - Flight data recorder information
  - Meteo data
  - Topography and obstacles data
- **Data should be chosen suitably to the setting of the task**
  (more detailed data should increase reliability of results)

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