Willkommen
Welcome
Bienvenue

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Aircraft noise calculations with sonAIR

CSA annual workshop
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- Introduction
- sonAIR

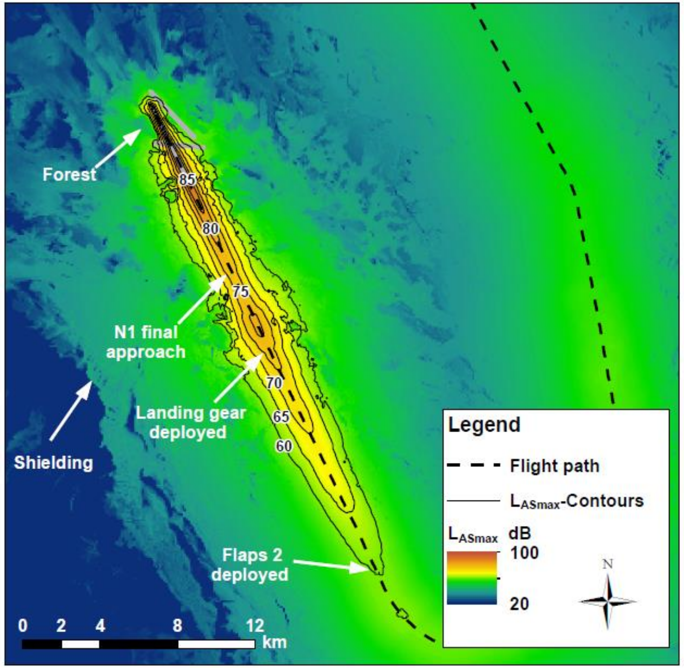
- Future prognosis
- Case study Geneva
- Flight tests at Zurich airport

} Applications

- Conclusions

Introduction

- Why aircraft noise calculations?
  - Thousands of microphones are impractical an expensive
  - Monitoring of the noise around airports
  - Explain and show changes
  - Predict future development
  - Protection of residents
    - Sound insulation
    - Land use planning
    - Health effect studies



Introduction

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Balanced Approach to aircraft noise

Reduction of noise at source
- Ban of old and loud aircraft
- Noise related charges to promote quieter aircraft

Future prognosis

Land-use planning and management
- Noise monitoring / zoning
- Sound insulation program

Case study Geneva

Noise abatement operational procedures
- Noise preferential routes
- Reduced power / Reduced drag techniques

Flight tests at Zurich airport

Operating restrictions
- Night time restrictions
- Partial restrictions for a time period and runway

Source: ICAO Doc 9829 AN/451, «Guidance on the Balanced Approach to Aircraft Noise Management», 2nd edition, 2008

Introduction

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- Best-Practice models
  - ➔ Defined by law or recommended
  - ➔ Focus on yearly air traffic and prognoses (mean values)
  - ➔ Fast algorithms on the costs of simplifications
  - ➔ Influence of airspeed, configuration or sometimes even thrust not or insufficiently modeled
- Scientific models
  - ➔ Focus on single flights/procedures
  - ➔ Current and future aircraft types
  - ➔ Complex algorithms and computational expensive
  - ➔ Full scenarios are possible with todays hardware

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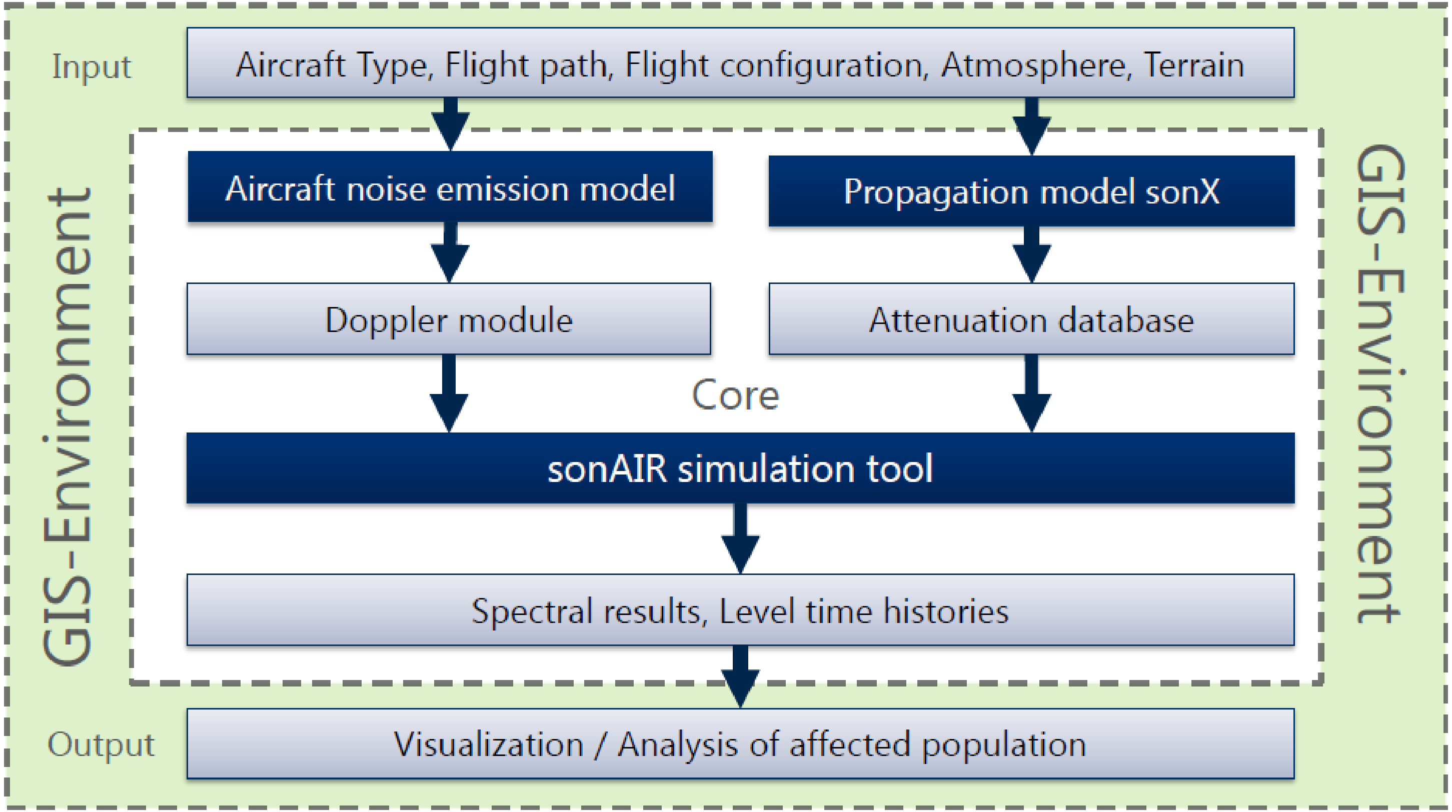
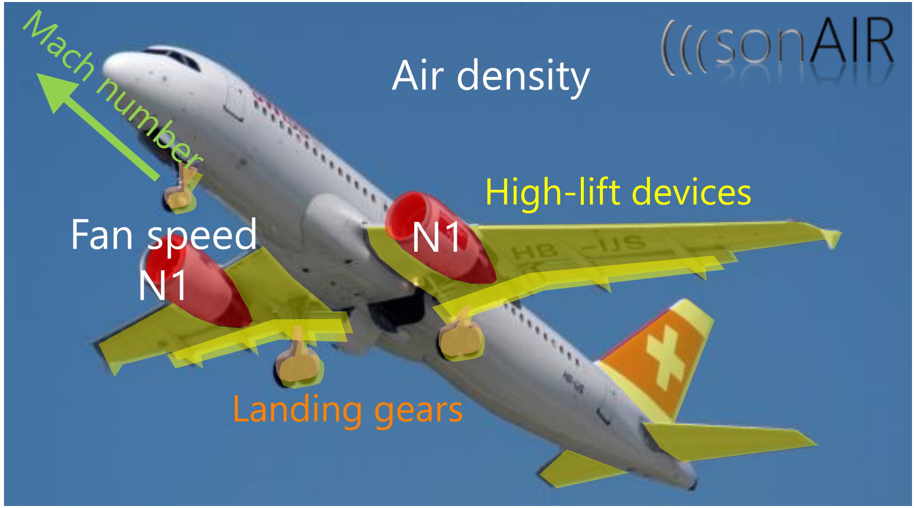
- sonAIR

sonAIR Overview



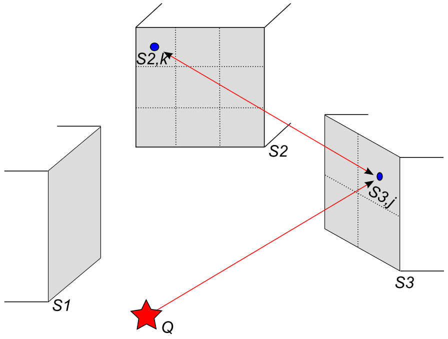
Aircraft noise emission model

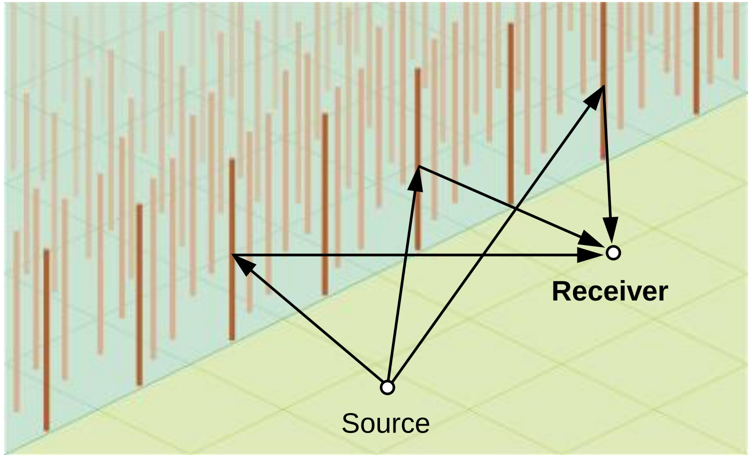
- One-third-octave bands from 25 Hz – 5 kHz
- 3D directivity pattern
- Separation of engine and airframe noise
- Noise emission depends on flight parameters



The sonX propagation model

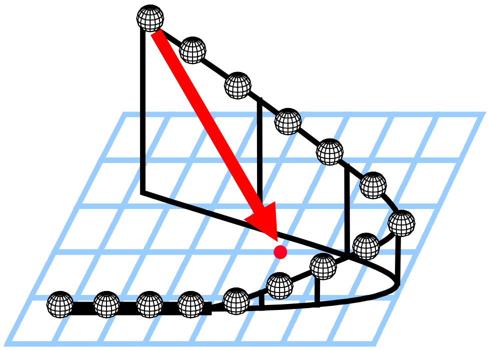
- In one-third-octave bands from 25 Hz – 5 kHz
- Direct sound calculation under the assumption of a homogeneous atmosphere
- Three optional refinements:
  - METEO: Correction for meteorological effects
  - REFLECT: Reflections at buildings and walls (specular reflections and scattering)
  - FOREST: Diffuse reflections from forest edges and cliffs

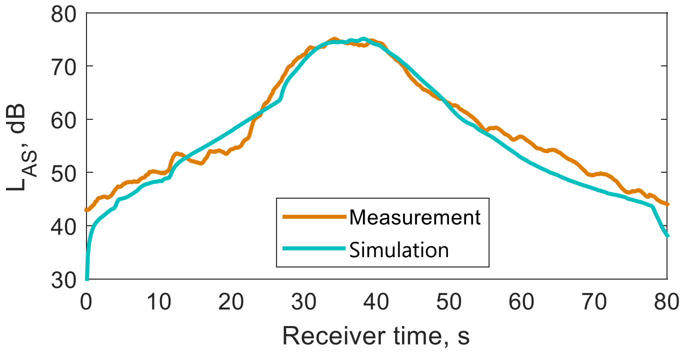




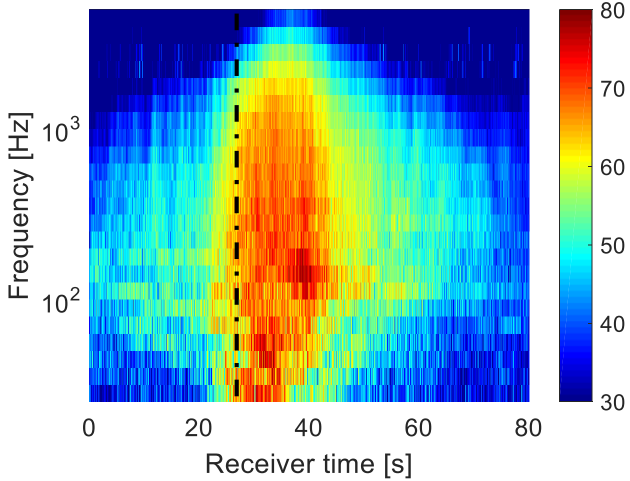
Time-step simulation

- Simulation of each single path with a time-step method
- Sound emissions are read and interpolated from a lookup table
- Attenuations are read from a database (sonX) or directly calculated for simple situations

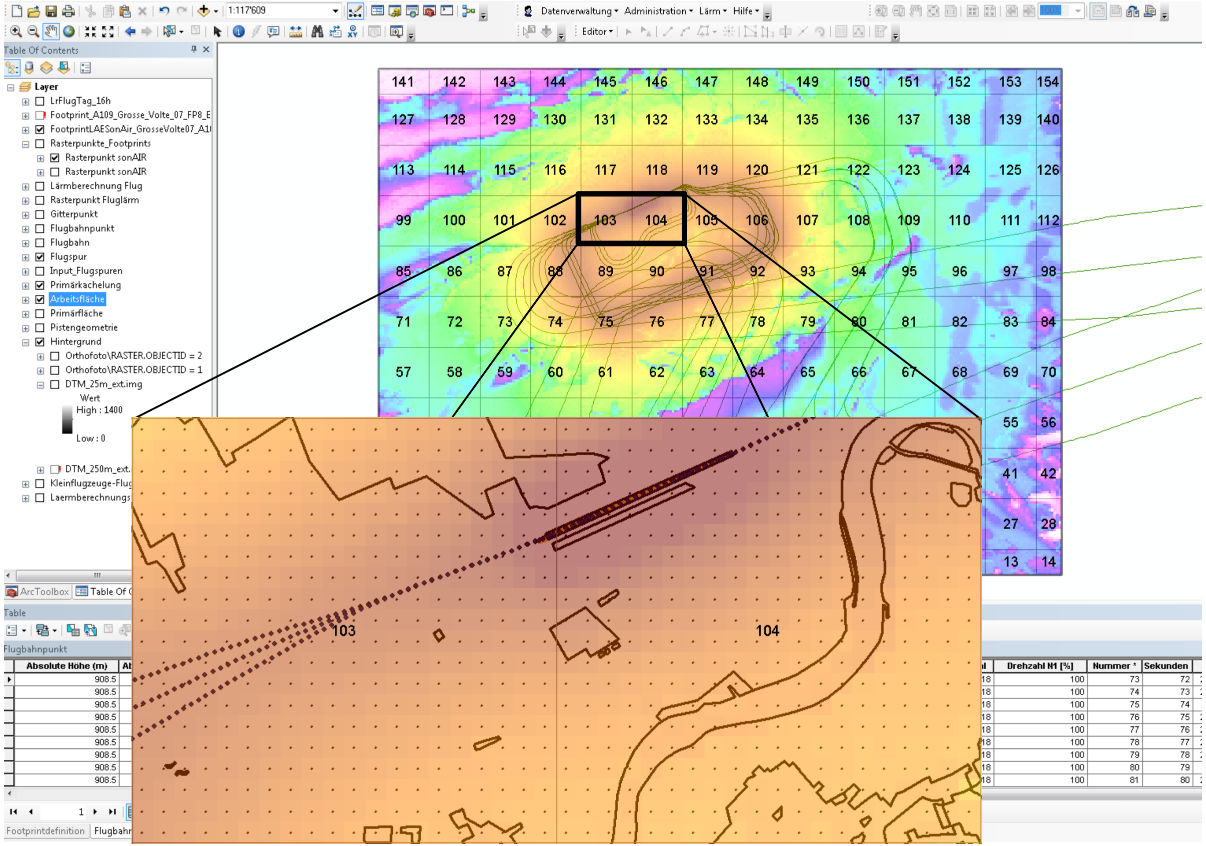




Measurement



Calculation example



- Future prognosis

Background

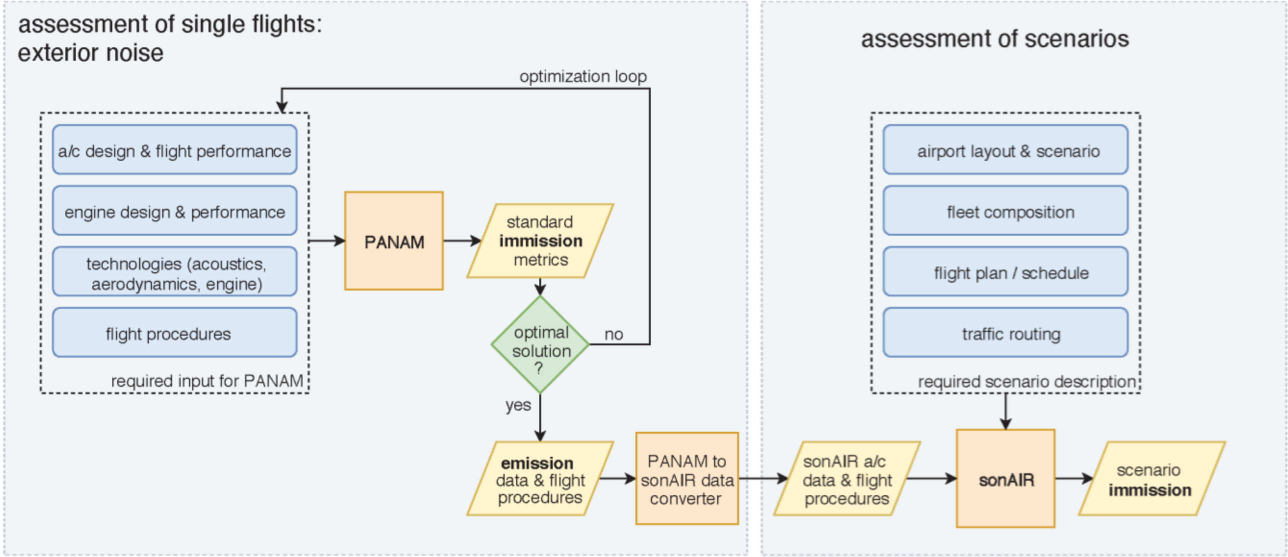
- New generation of high-bypass-ratio turbofans
- Promising 15% less fuel consumption and 50% reduction of noise
- Over 1 000 deliveries, more than 11 000 orders
- Production rates Airbus: 60 per month / Boeing: currently huge problems

- **How does this development change the ground noise exposure of a single-runway airport (near future)?**

Method

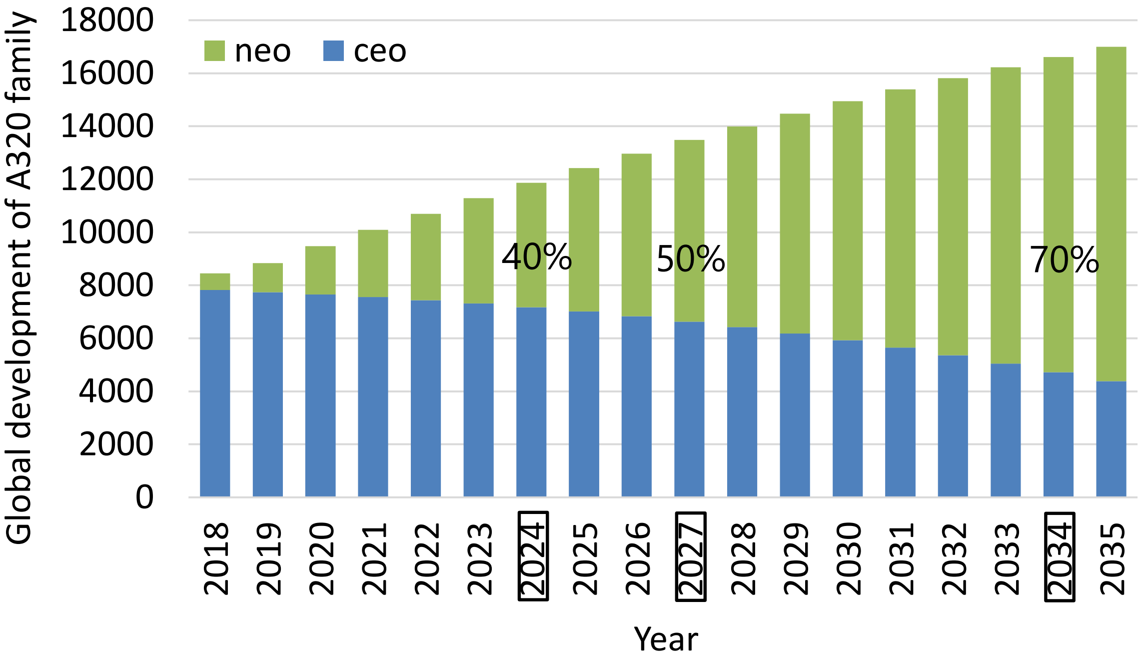
J. Delfs et. al. (2018), *Aircraft Noise Assessment—From Single Components to Large Scenarios,* MDPI Energies.

- Combination two scientific tools for aircraft noise calculations
- PANAM predicts the noise emission of novel aircraft concepts
- sonAIR assesses scenarios and adds emission models for current aircraft types



Development of A320 family

- Retirement of ceo via age structure and survivor curve
- Introduction of neo with 60 aircraft per month



2025 vs. 2015

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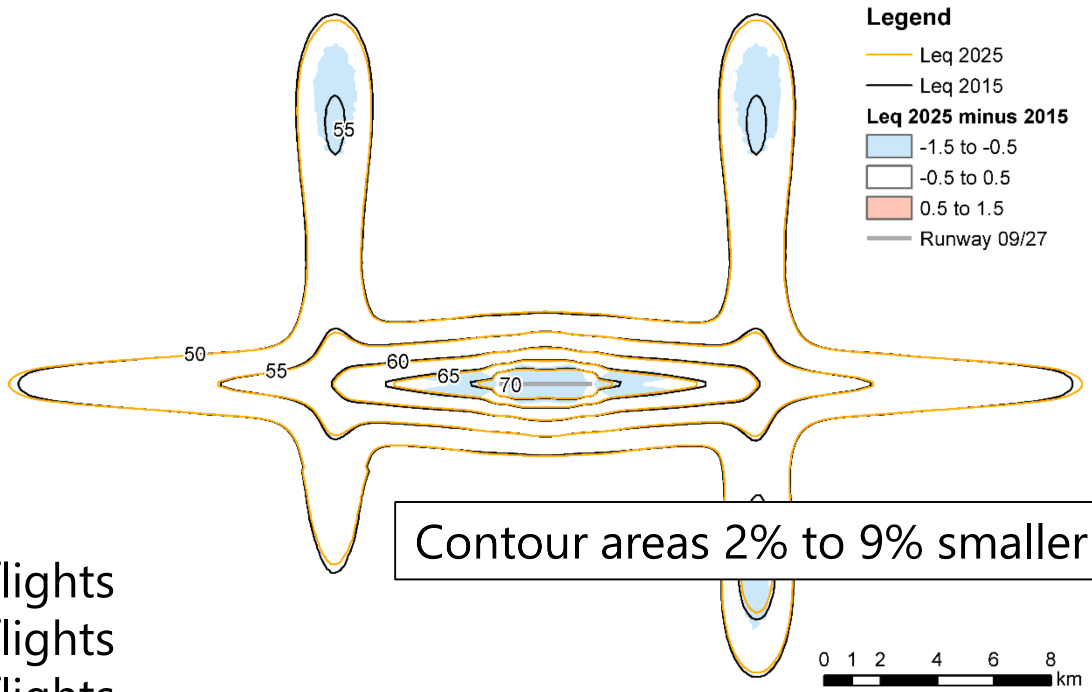
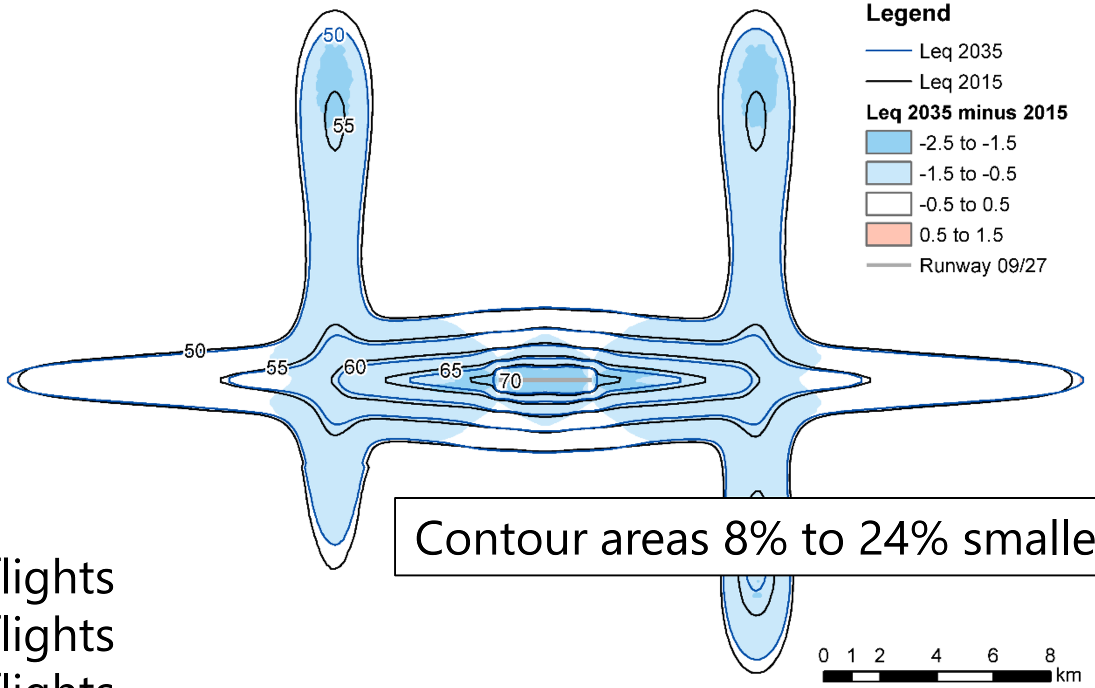


Contour areas 2% to 9% smaller

2015: 160 000 flights
2025: 186 000 flights
2035: 205 000 flights

2035 vs. 2015



Contour areas 8% to 24% smaller

2015: 160 000 flights
2025: 186 000 flights
2035: 205 000 flights

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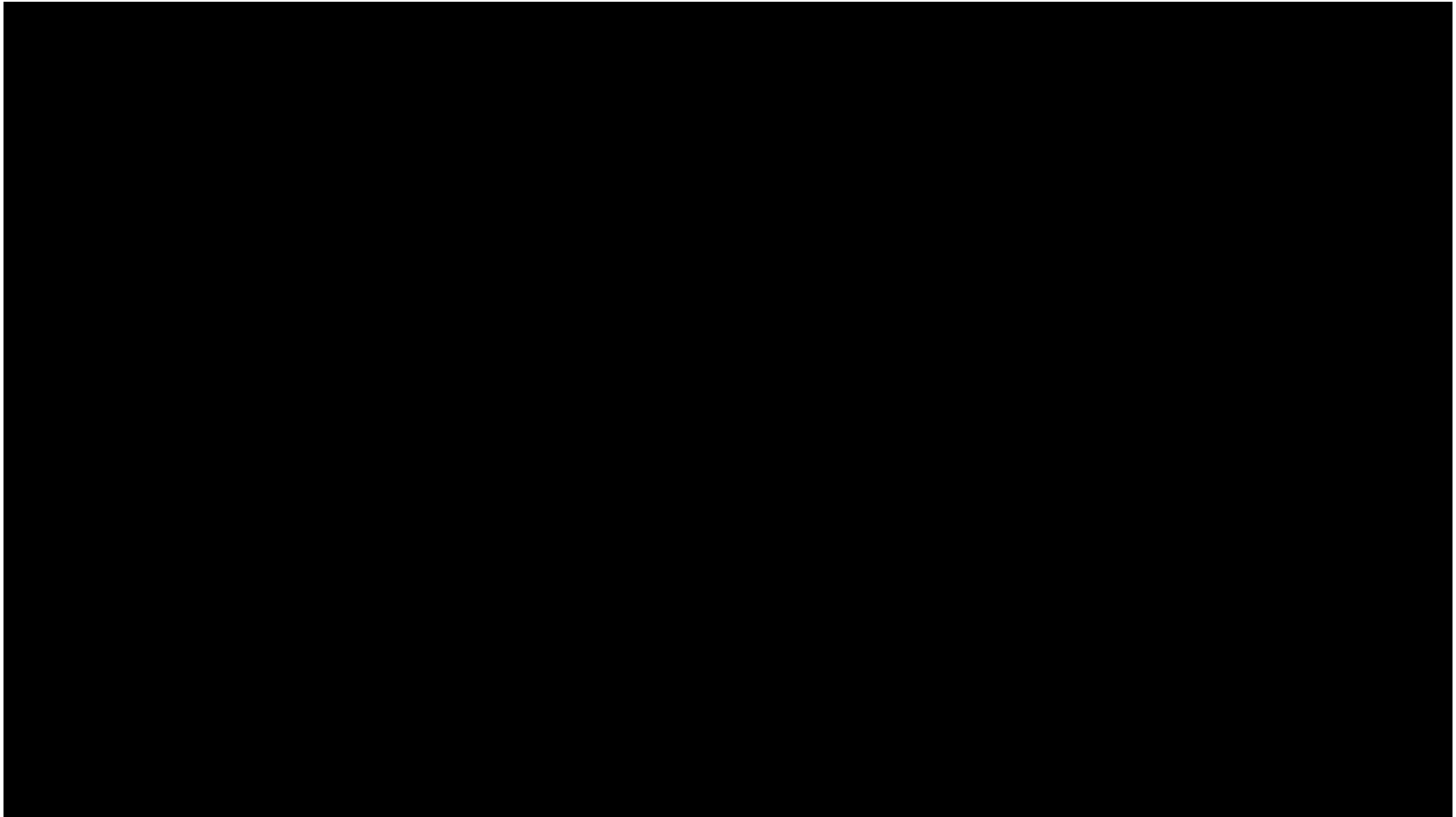
- Case study Geneva

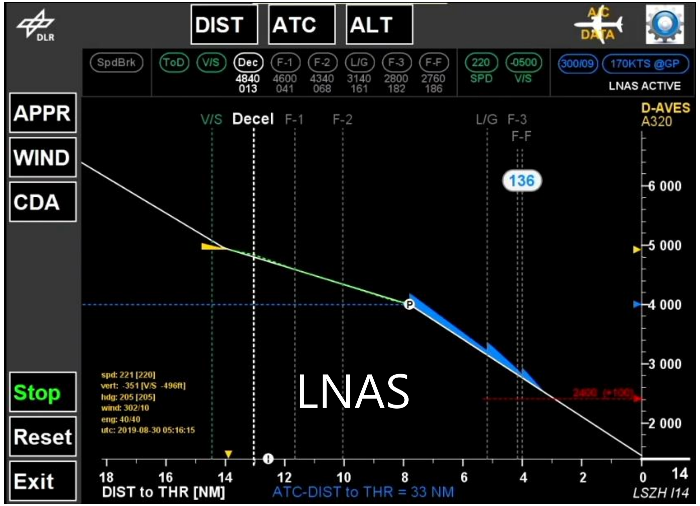
Case study Geneva

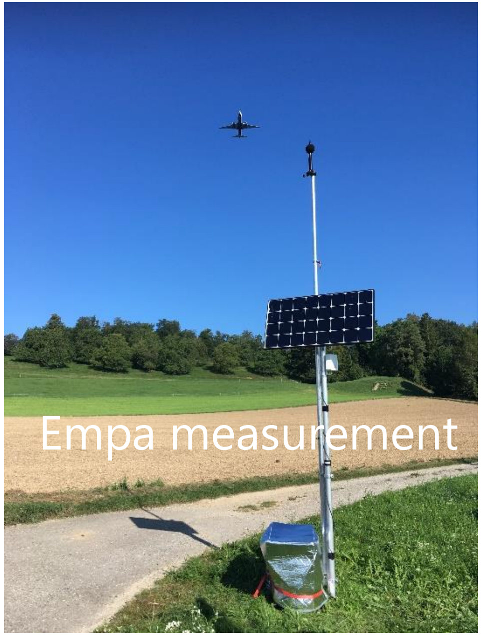


- Flight test at Zurich airport

Flight test at Zurich airport

- CDA approach using Low Noise Augmentation System (LNAS)
- Cooperation of Skylab, DLR and Empa





Project scope

- Today: high variations in altitude, speed and configuration
  - Imprecise information of the expected distance to touch down
  - Speed restrictions
  - Altitude restrictions
  - → Compromise between efficiency and reserve
  - → Rules of thumbs are used

- Scope: automatize the approach to reduce
  - Noise
  - Fuel
  - Work load

Example approach with early landing gear

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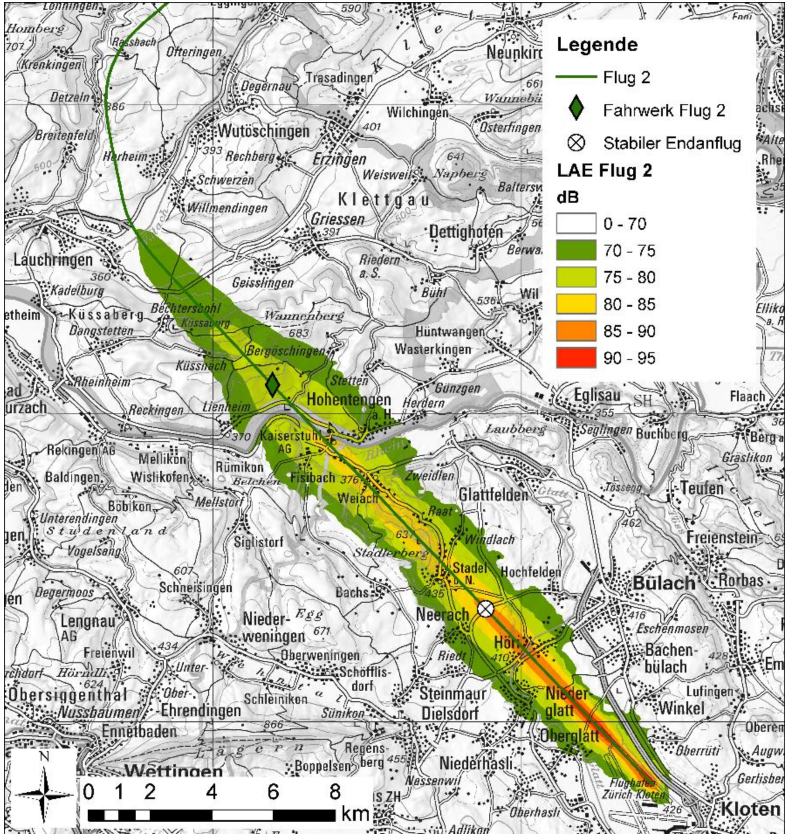
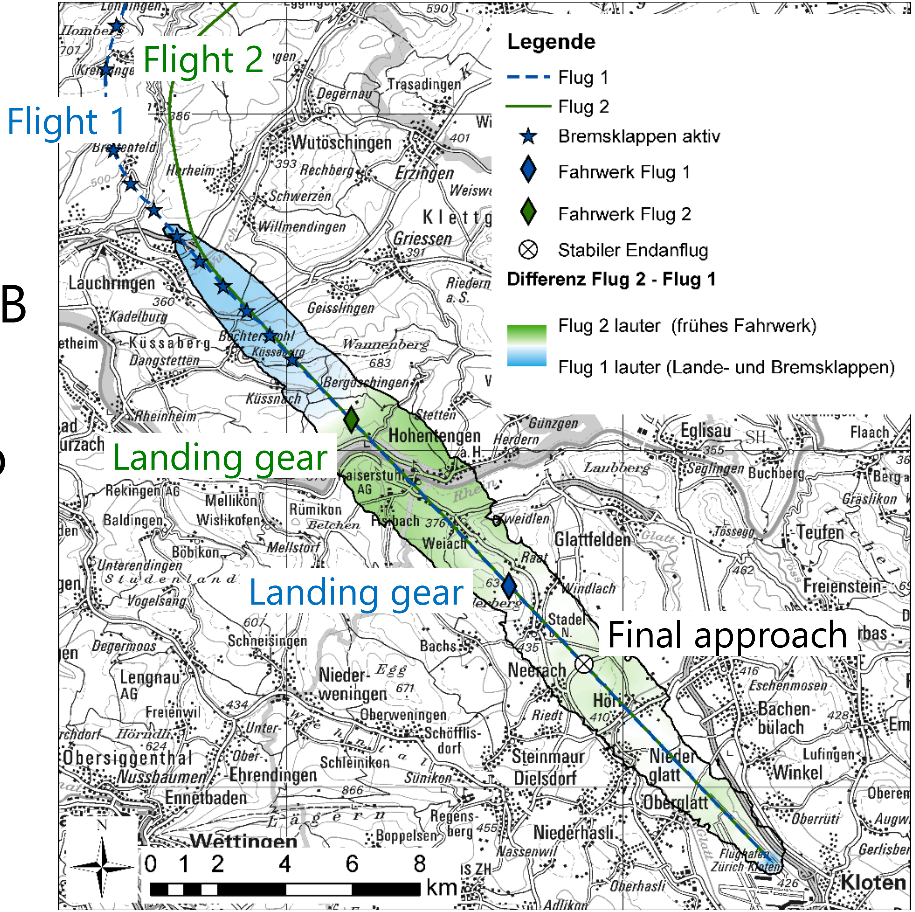
Acoustic Footprint



Potential

- Two outliers compared:
- Landing gear 6’800 m / 76 s later
- Sound exposure differs up to 4 dB

- Spoiler and early flap setting also add up to 4 dB
- → Potential for reductions with LNAS
- Analysis is ongoing



Conclusions

Conclusions

- Scientific models and collaboration are needed to tackle measures of the balanced approach, e.g. to
  - improve the prediction future developments,
  - calculate reflections and shielding in densely populated areas,
  - assess new flight procedures and low-noise systems.

- Visualization helps to communicate changes/improvements and complicated topics


Questions?
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- Backup

Results: Contour areas

Compared to 2015

- Slight improvement for 2025 despite growth of traffic
- Reduction potential of 8% to 24% of the noise contour area was found for the year 2035

L_{eq} dB	2015	2025	Δ_{2015}	2035	Δ_{2015}
50	192.4	189.2	−2%	176.6	−8%
55	64.0	59.5	−7%	53.7	−16%
60	27.1	25.8	−5%	23.4	−13%
65	11.3	10.3	−9%	8.6	−24%
70	4.0	3.7	−9%	3.1	−22%

Backup: Influence of land cover and terrain