



Dedicated to innovation in aerospace

NLR
90 years



Sustainable Aviation NLR and Partners Research

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Various reasons for sustainable aviation

- Worldwide attention for climate change impact
- Fossil fuel is limited
- Cost reduction due to fuel efficient operations
- Environmental impact around airports
- Acceptance and trust of surrounding communities



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European goals for sustainable aviation



Vision 2020 / ACARE goals

- 50% reduction in CO2 per passenger kilometer
- 50% reduction in perceived noise per flight
- 80% reduction in NOx
- Minimise the industries impact on the global environment

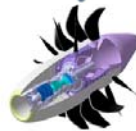
Example: 50% CO2 reduction

Expected contribution by innovation of:

- Aircraft: 20-25%



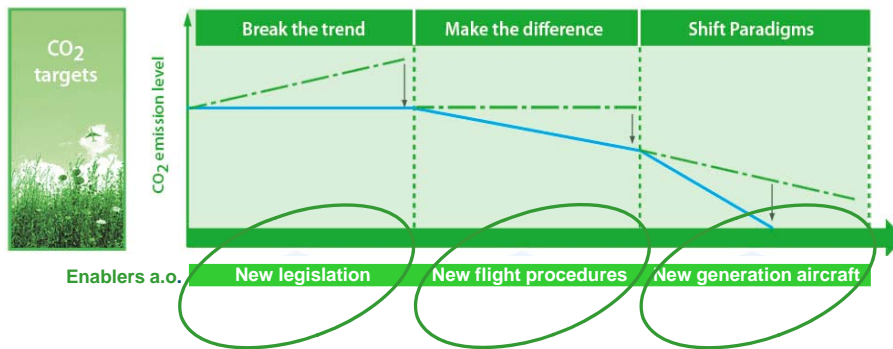
- Engine: 15-20%



- ATM: 5-10%



CO2 reduction Necessary to break the trend



Ways to make aviation (more) sustainable

Reduction of environmental impact (noise and emissions) can be achieved by:

- Regulation
- Reduction by the source
- Flight procedures

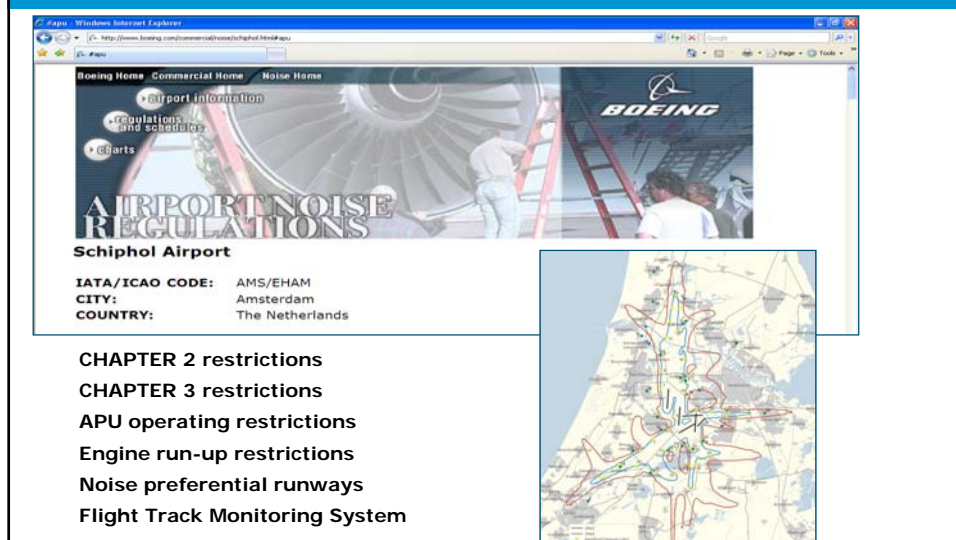


Airports with Noise and Emissions regulations



AIRPORT IATA	CODE	COUNTRY	City	APU CHOPW					NOISE				Emissions Class	Quotas Prof	Ramp High	C22	Restr	
				L	R	W	U	S	LA	LA	LA	LA						LA
Aalborg Airport	AAL	Denmark	Aalborg															
Aarhus Airport	AAR	Denmark	Aarhus															
Aberdeen Airport	ABZ	Scotland	Aberdeen															
Abruzzo Leonardo Capital	SPR	US	Springfield															
Adelaide International	ADL	Australia	Adelaide															
Aleppo Airport	ALG	Algeria	Aleppo															
Aeroporto Internazionale de Belém	BEL	Brazil	Belém															
Aeropuerto de Ezeiza (Ezeiza Aires)	EZE	Argentina	Ezeiza Aires															
Agnon La Couronne Airport	AGF	France	La Couronne															
Athens International	ATH	Greece	Athens															
Auckland Airport	AKL	New Zealand	Auckland															
Alexandria International	AEX	Egypt	Alexandria															
Amman Al-Sayidat	AMM	Jordan	Amman															
Amman Queen Alia	AMM	Jordan	Amman															
Amman Zarqa	AMM	Jordan	Amman															
Amman Zarqa East	AMM	Jordan	Amman															
Amman Zarqa West	AMM	Jordan	Amman															
Amman Zarqa North	AMM	Jordan	Amman															
Amman Zarqa South	AMM	Jordan	Amman															
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Amman Zarqa South	AMM	Jordan	Amman															

Example: Schiphol



IATA/ICAO CODE: AMS/EHAM
CITY: Amsterdam
COUNTRY: The Netherlands

CHAPTER 2 restrictions
CHAPTER 3 restrictions
APU operating restrictions
Engine run-up restrictions
Noise preferential runways
Flight Track Monitoring System
Noise level limits

Spatial planning

- **Restricted area's for new houses**
- **Area's in which existing houses should be removed**
- **Noise insulation of existing houses**

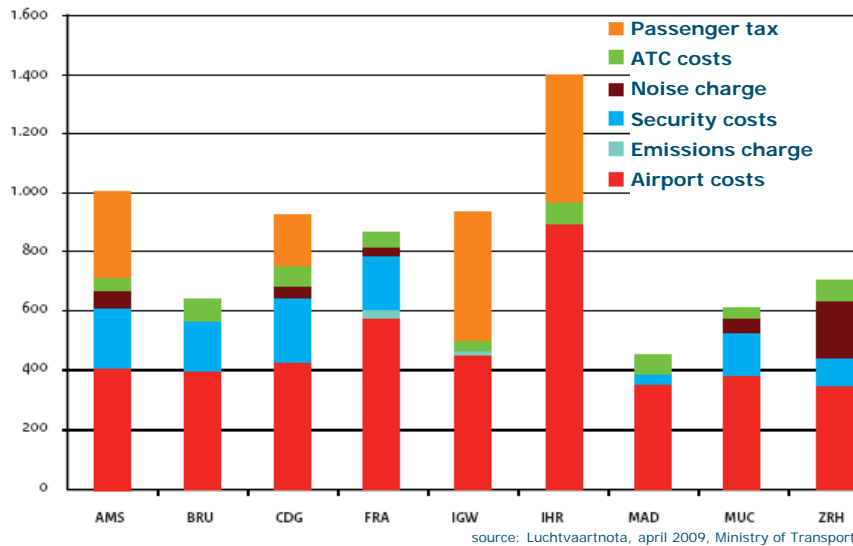


EU Emission Trading Scheme for Aviation

- **Objective**
 - End goal: reduction of 70% (2050) of the 1990 total emissions
 - Aviation ETS contributes to the compliance to the Kyoto protocol
- **Design**
 - Cap based on average 2004-2006 emissions. 2012: 3%, 2013: 5%, 2020: 30% reduction
 - At start 85% of the rights are given away for free (based on 2010 data) , 15% auctioned



Airport charges (benchmark 2008)



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Project examples NLR

Noise enforcement

- Limiting noise levels of individual aircraft based on principle of speed camera
- Noise measurements for monitoring:
 - Monitor: How and what?
 - Exceeders: Who and where?
 - Address: How and when?



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Project examples NLR

New noise legislation system

- Replace legislation system with fixed noise limits in 35 points



- New system: prescribed use of runways and routes due to
 1. Weather (safety,)
 2. Least noise impact

Ways to make aviation (more) sustainable

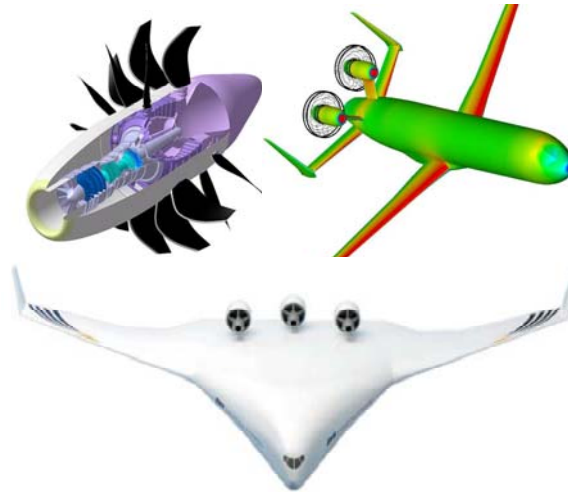
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- Regulation
- **Reduction by the source**
- Flight procedures

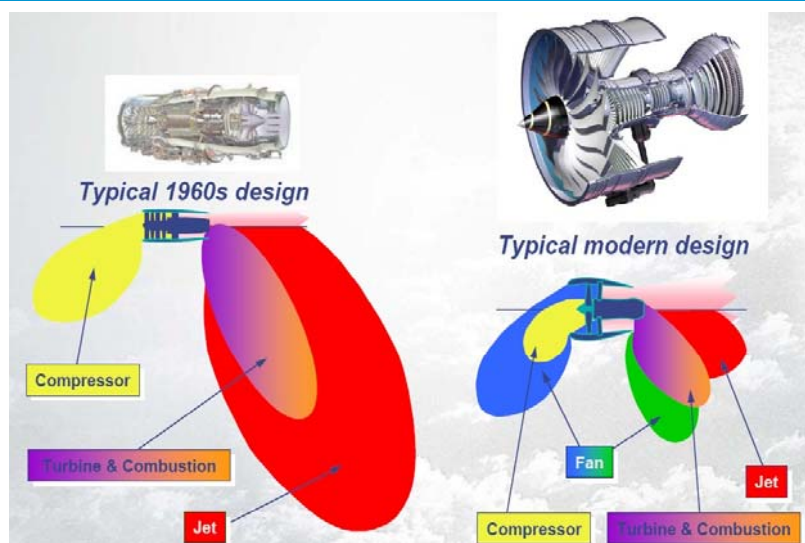


Reduction by the source

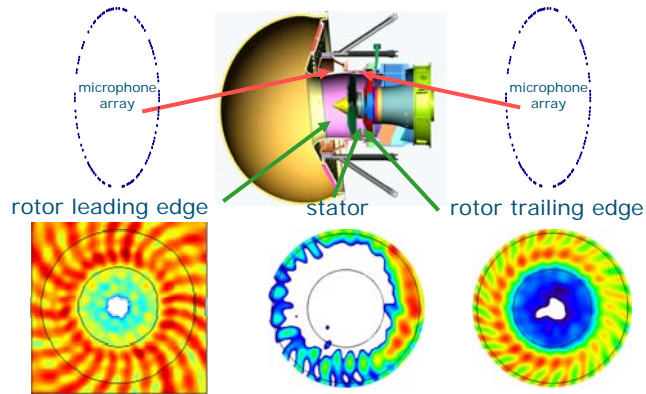
- Engine noise & emissions
- Airframe noise
- New aircraft architectures



Engine noise reduction



NLR contribution to EU Turnex & Proband projects



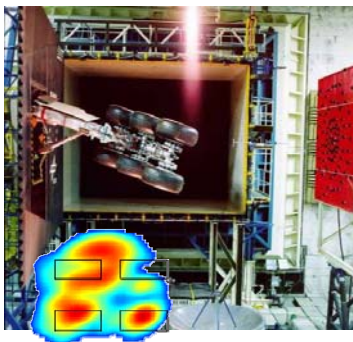
NLR microphone array to locate & quantify rotating broadband noise sources in turbofan engine on both rotor and stator (never been demonstrated before!)

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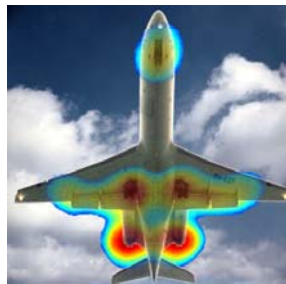
Examples of NLR projects with acoustic microphone array technology



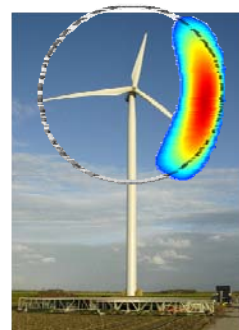
Landing gear in DNW



Fly-over Fo70



Wind turbine



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Engine noise reduction



chevron

Source: NASA

NLR participated in EU SILENCE(R) project

- Fan design
- Exhaust Nozzle
- Negatively Scarfed Inlet
- Up Liner
- Zero splice Inlet
- Low Freq. Liners
- High Freq. Liners
- Landing Gear Fairings



Emissions reduction – alternative fuels



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Engine emission reduction



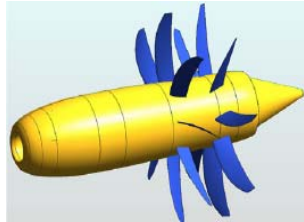
NASA/GE Unducted Fan Demonstrators

1986

1988

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NLR contribution to EU DREAM project (validation of Radical Engine Architecture systems)

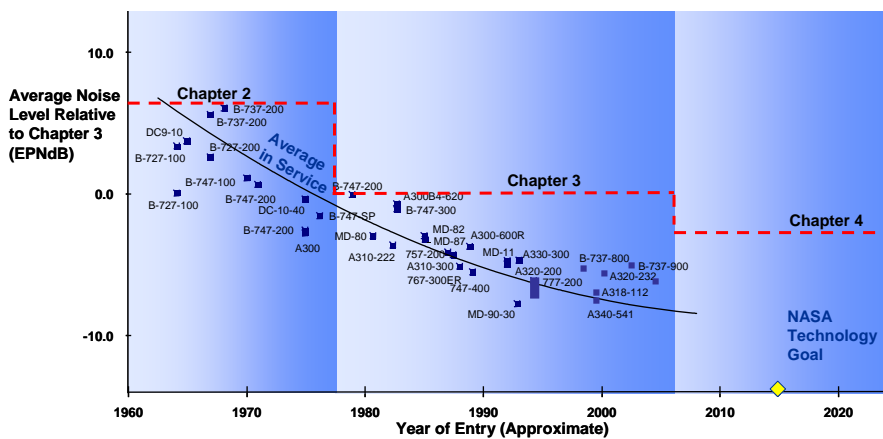


Open rotors are more fuel-efficient (by ~25%), but what about the noise?

For DREAM to answer, in 2011, by (acoustic) wind tunnel tests

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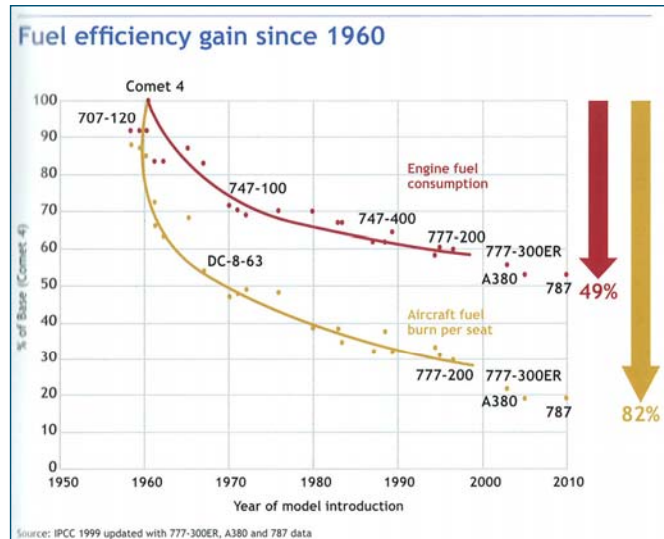
Aircraft noise reduction



Source: NASA

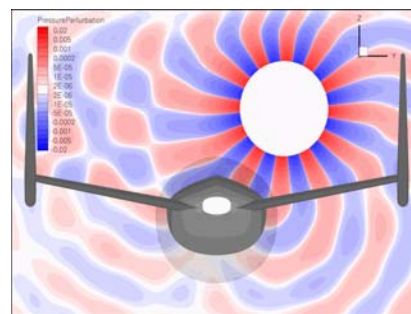
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Aircraft fuel/emissions reduction



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NLR contribution to EU NACRE project (New Aircraft Concepts REsearch)

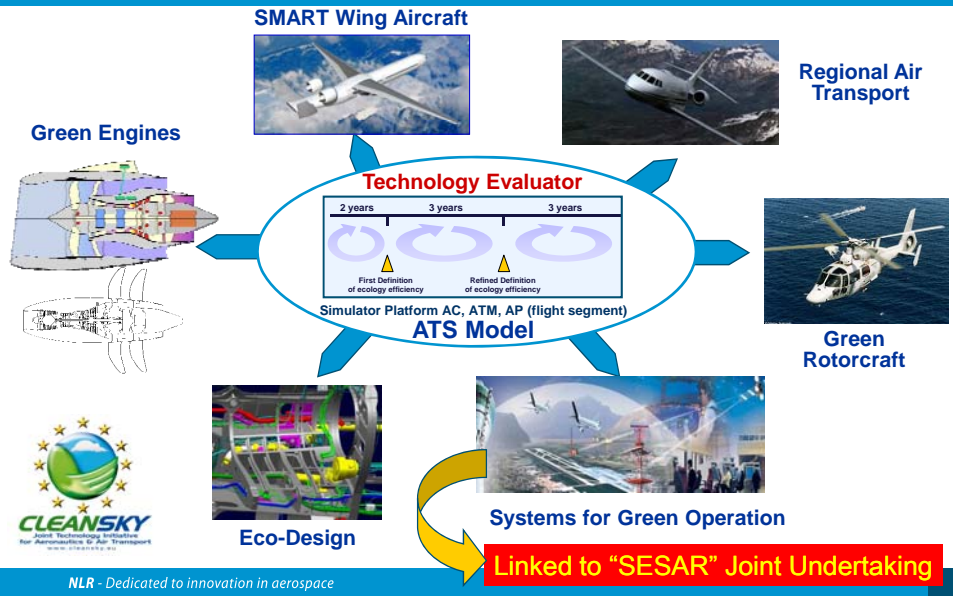


Shielding & reflection of noise
NLR computation



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NLR contribution to Clean Sky Joint Technology Initiative



Future aircraft architectures



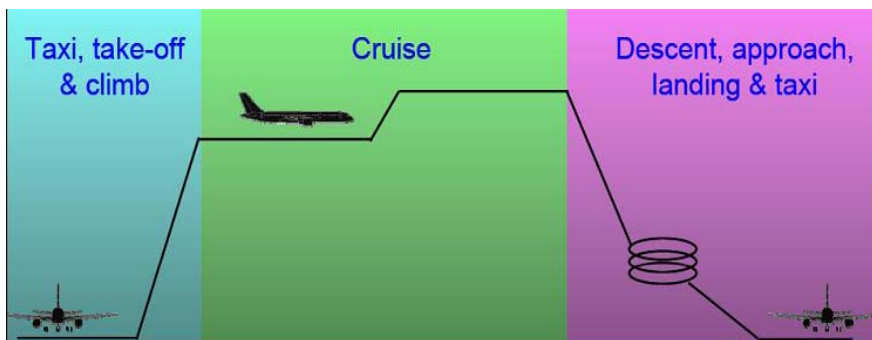
Ways to make aviation (more) sustainable

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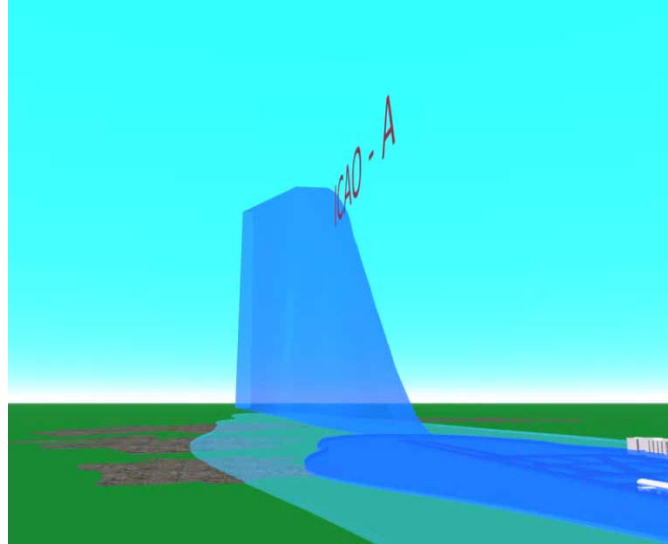
- Regulation
- Reduction by the source
- **Flight procedures**



Reduction by flight procedures



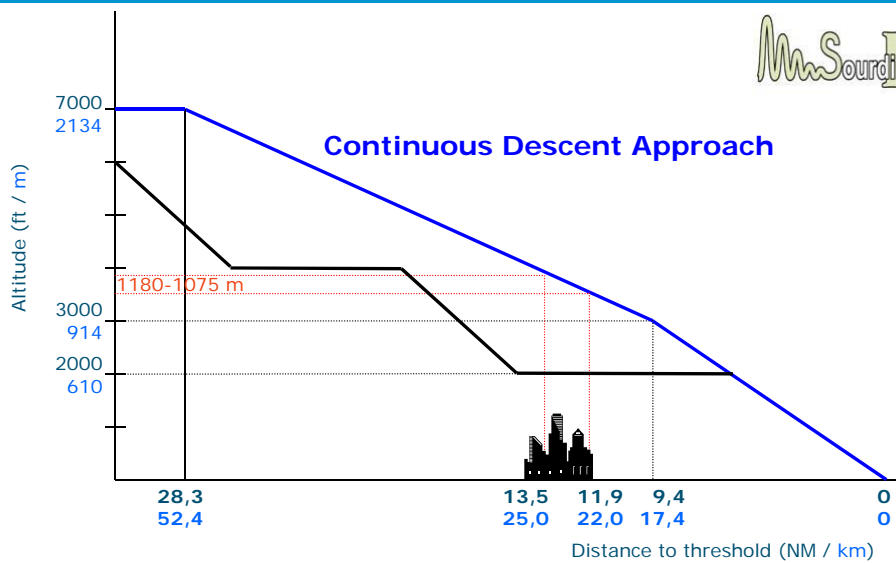
Departure procedures



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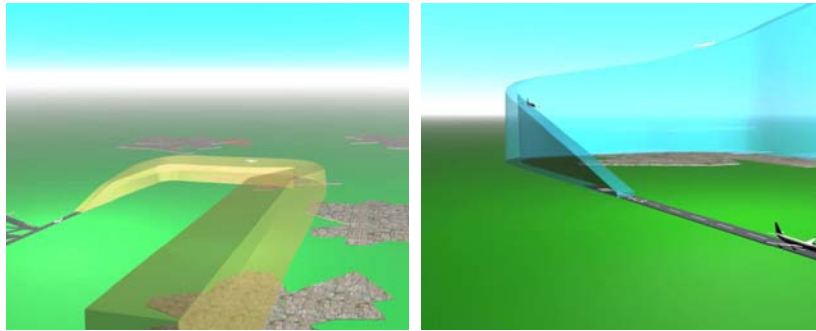
NLR contribution to EU Soudine projects

MrSoudine II

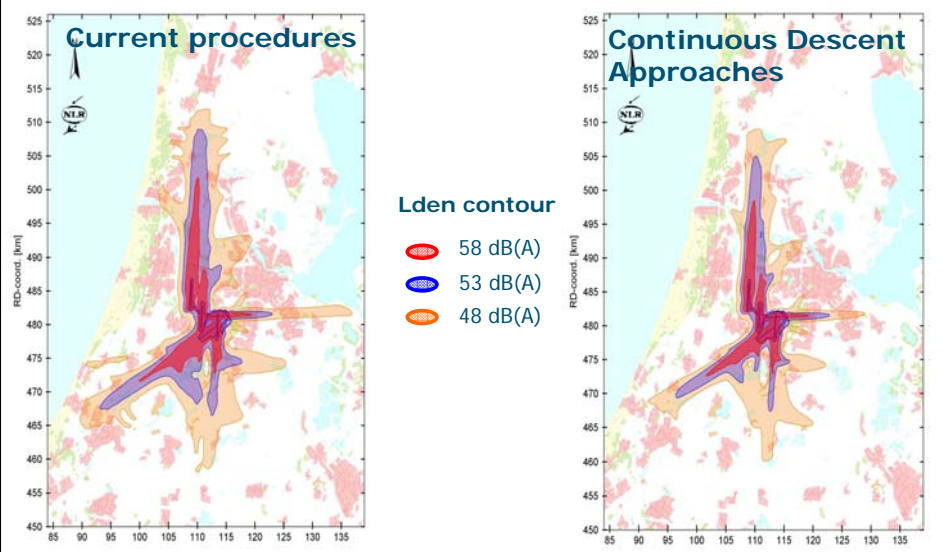


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Continuous Descent Approach

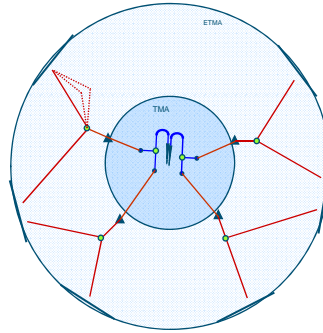


Continuous Descent Approach



NLR contribution to EU OPTIMAL project

Required working method to enable Continuous Descent Approaches



OPTIMAL Integration in European Airspace



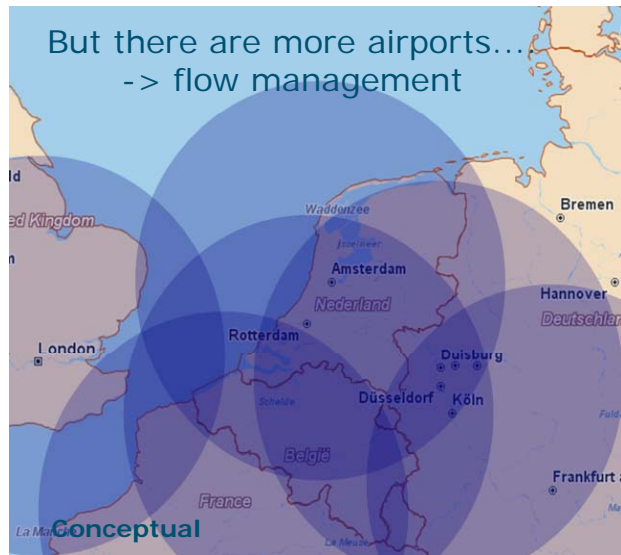
Current: 100-200 km
Required: ~220 km



OPTIMAL Integration in European Airspace



But there are more airports...
-> flow management



Conceptual

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SESAR: project aims



Capacity x3



Safety x 10



Environment
impact -10%



ATM cost/flight
-50%

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NLR contribution to SESAR



Capacity



Safety



Environment



• Not decided yet

- Airport Operations Centre
- Operations in Adverse Weather Conditions
- Integration of airport (airline/ground/atc) processes
- Advanced-Surface Movement Guidance and Control Systems

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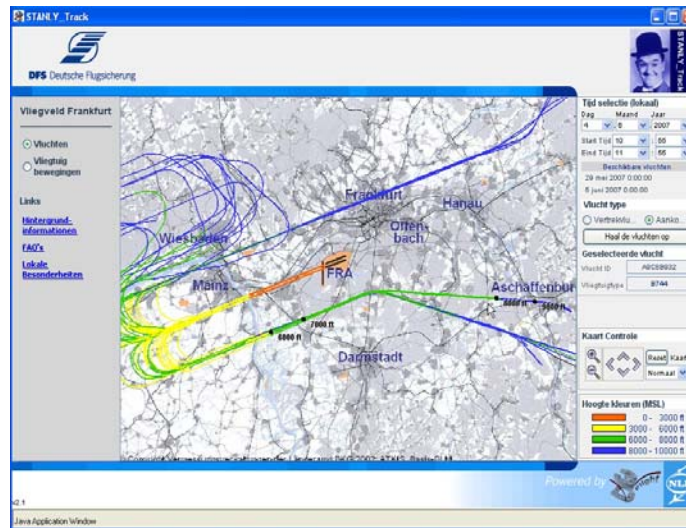
- Regulation
- Reduction by the source
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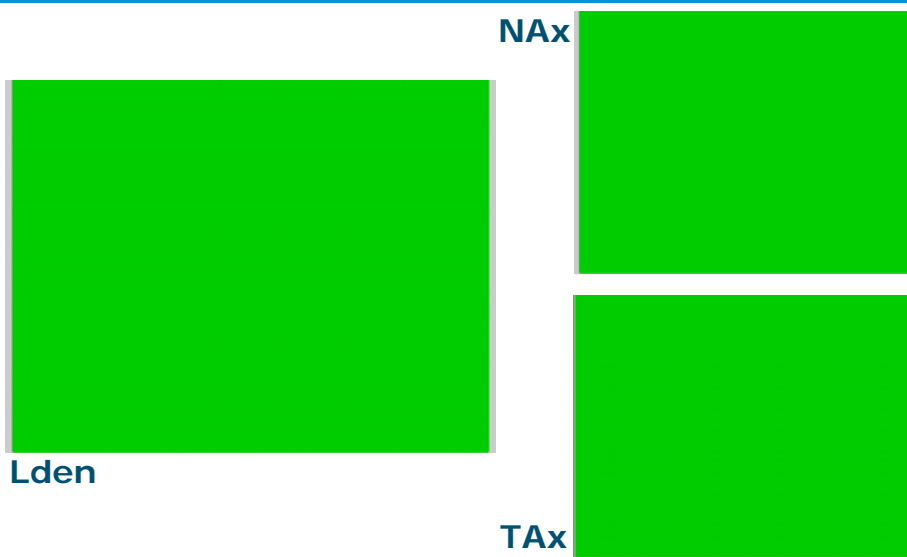
Information Management



Information Management



Lden, Nax and Tax



NASA

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Virtual Community Noise Simulator (VCNS)

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Ways to make aviation (more) sustainable

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Information Management

Conclusions

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Conclusions

- **EU Vision 2020 provides ambitious targets**
 - 50% reduction in CO₂ per passenger kilometer
 - 50% reduction in perceived noise per flight
 - 80% reduction in NO_x
- **Small up to large (EU) programs contribute to obtain these targets**
- **NLR and partners “Break the trend”**
 “Make the difference” and “Shift Paradigms”



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Future sustainable aviation.....



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DEFENSE & PEACEKEEPING MISSIONS



INNOVATION



JOB CREATION



WORKING TOGETHER



SAFETY



PH-



ENVIRONMENT



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