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
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

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

- Regulation
- Reduction by the source
- Flight procedures
Airports with Noise and Emissions regulations

Example: Schiphol

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)

- Passenger tax
- ATC costs
- Noise charge
- Security costs
- Emissions charge
- Airport costs

Source: Luchtvaarnota, April 2009, Ministry of Transport

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?
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

**Reduction of environmental impact (noise and emissions) can be achieved by:**
- Regulation
- **Reduction by the source**
- Flight procedures
Reduction by the source

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

Engine noise reduction

Typical 1960s design
Typical modern design

Compressor
Turbine & Combustion
Jet

Compressor
Turbine & Combustion
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!)

Examples of NLR projects with acoustic microphone array technology

Fly-over Fo70

Landing gear in DNW

Wind turbine
Engine noise reduction

NLR participated in EU SILENCE(R) project

- Fan design
- Exhaust Nozzle
- Negatively Scarfed Inlet
- Up Liner
- Zere splice Inlet
- Low Freq. Liners
- High Freq. Liners
- Landing Gear Fairings
Emissions reduction – alternative fuels

Engine emission reduction

NASA/GE Unducted Fan Demonstrators

1986 1988
NLR contribution to EU DREAM project (validDation 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

Aircraft noise reduction

Source: NASA
Aircraft fuel/emissions reduction

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

Shielding & reflection of noise
NLR computation
NLR contribution to Clean Sky Joint Technology Initiative

SMART Wing Aircraft
Regional Air Transport
Green Engines

Technology Evaluator
First Definition of ecology efficiency
Refined Definition of ecology efficiency

Simulator Platform AC, ATM, AP (flight segment)
ATS Model

Eco-Design
Systems for Green Operation

Green Rotorcraft

Future aircraft architectures

Linked to “SESAR” Joint Undertaking

NLR: Dedicated to innovation in aerospace
Reduction of environmental impact (noise and emissions) can be achieved by:

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

**Reduction by flight procedures**
Departure procedures

NLR contribution to EU Sourdine projects

Continuous Descent Approach
Continuous Descent Approach

Current procedures

Lden contour
- 58 dB(A)
- 53 dB(A)
- 48 dB(A)
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

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OPTIMAL
Integration in European Airspace

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

SESAR: project aims

Capacity x3  Safety x 10  Environment impact -10%  ATM cost/flight -50%
NLR contribution to SESAR

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

Not decided yet

Ways to make aviation (more) sustainable

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

- Regulation
- Reduction by the source
- Flight procedures

Information Management
Information Management

Lden, NAx and TAx

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Virtual Community Noise Simulator (VCNS)

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

- Regulation
- Reduction by the source
- Flight procedures

Ways to make aviation (more) sustainable

Information Management

Conclusions
Conclusions

- EU Vision 2020 provides ambitious targets
  - 50% reduction in CO2 per passenger kilometer
  - 50% reduction in perceived noise per flight
  - 80% reduction in NOx

- Small up to large (EU) programs contribute to obtain these targets

- NLR and partners “Break the trend”
  “Make the difference” and “Shift Paradigms”

Future .... sustainable aviation.....