AERO-ACOUSTIC OF INTEGRATED PROPULSION & LANDING GEAR SYSTEM : TECHNOLOGIES MATURATION THROUGH EXPERIMENTAL DEVICES

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Outline

1. **Introduction**
   - Acoustic regulation context & challenge
   - Aircraft noise level prediction with experimental data base
   - Leap acoustic experimental program tests overview
2. **Exemples of IPPS aeroacoustics tests at DNW LLF**
   - UPS Fan rig (GE 90)
   - Unducted Fan (Counter Rotative Open Rotor)
3. **Next generation UHBR engines and future architecture experimental expectations**
4. **Landing gear vision**
5. **Conclusions on experimental data/device expectations**

1

INTRODUCTION

Context and challenge

Aircrafts must meet ICAO regulations in terms of noise emissions

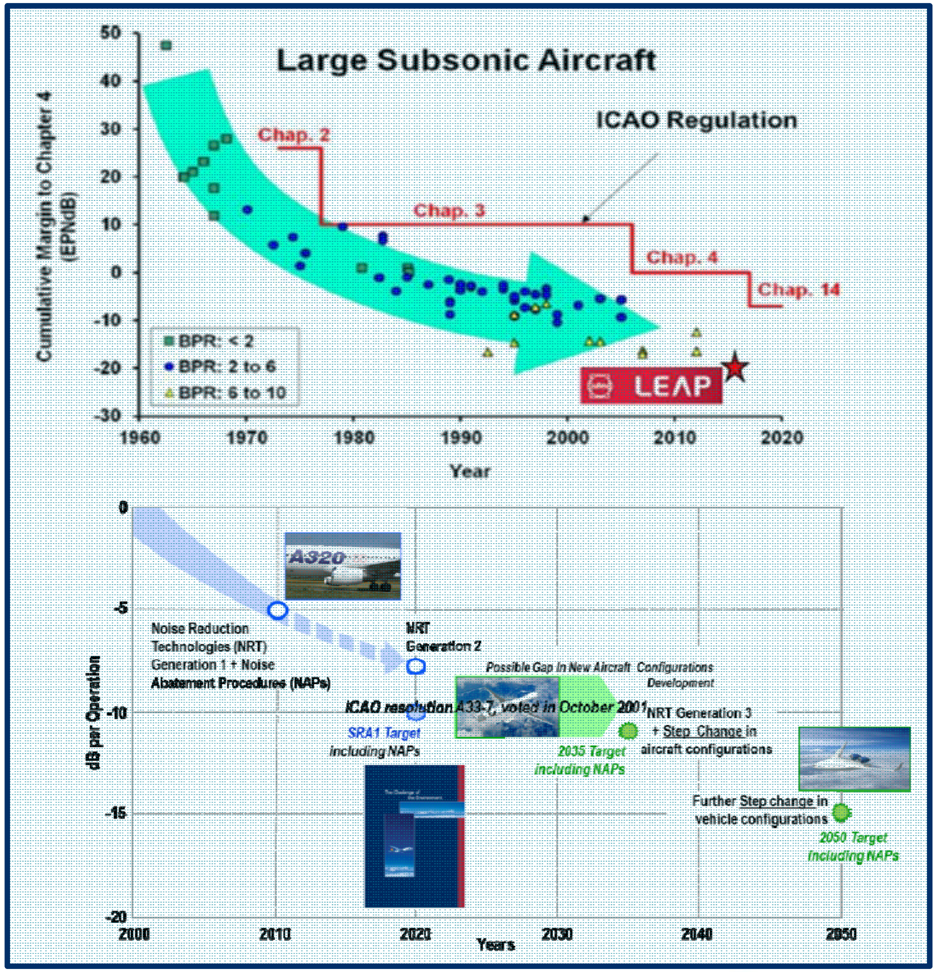
- Over the past 40 years, significant progress have been made by airframe/engine manufacturers to develop quieter aircrafts.

Manufacturers must maintain their efforts to design low noise products

- Acoustics : Entry into force of the Chap. 14 (Annex 16, Vol I)
- Keeping in mind that other requirements (fuel burn, NOx emissions,…) will be revised upwards.

Manufacturers have to think their way of working to ensure that next generation products meet these high expectations

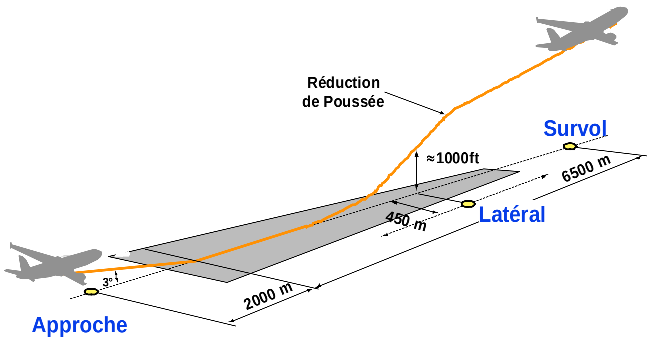
- Towards multidisciplinary optimizations
- Closer collaboration between engines & airframes manufacturers



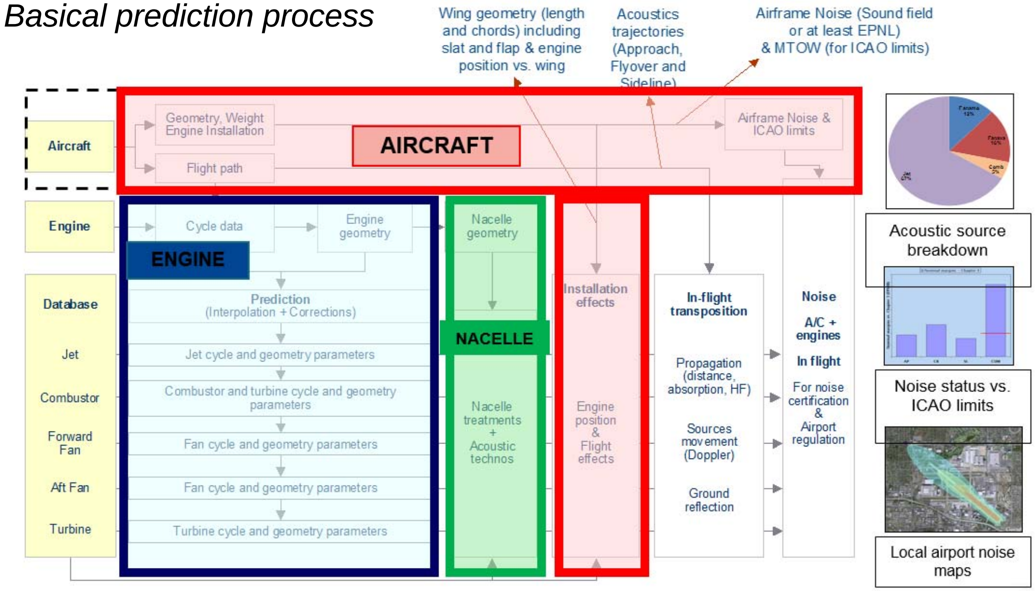
Aircraft noise prediction

Acoustic IPPS design actually driven by EPNL compliance (and also Cabin noise) vs. requirements

Acoustic noise certification



Basical prediction process



Experimental datas bases (direct and/or adapted) are still widely used to ensure accurate noise level prediction at aircraft level

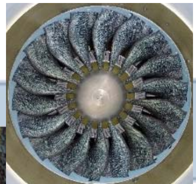
Leap acoustic experimental program tests overview

During aircraft program development, Noise level margin policy applied on noise prediction is linked to the data base TRL level

Aeroacoustics experimental characterization (from mock up to full scale / static and in-flight) are deployed to validate component performance and reduce program risks

2008-2011

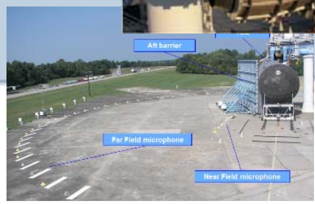
DTP FAA/EPSL



Static mock up test @ race test bench

2009-2011

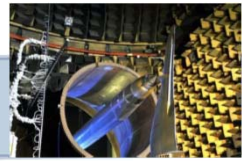
DTP MASCOT/EPSL



Static full scale engine tests bench @ Peebles (Aft modal ring detection)

2012

Mock up / instal.



Jet noise measurement @ Cepra19

2012-2016

NDST & NCST

Static full scale engine test bench @ Peebles (Modal ring/jet noise array)

2015-2016

NCFT

Flight tests @ Moron

Maturation & demonstration phase

Development & certification phase

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2

EXAMPLES OF IPPS AEROACOUSTIC TESTS AT DNW LLF

UPS aeroacoutic test campaign (DNW 1995)

Several test campaigns done to assess aerodynamic, acoustic, and cross wind performances (L=9)

Acoustic expectations regarding fan and nacelle design control

Parameters effects (L/D, blade /OGV grid design, ,,,) and mechanism understanding

Improvement and calibration of semi empirical tools/ validate aeroacoustics simulations

Acoustic Instrumentation

In flow nose cone and far field out of flow microphones

In duct sensors

Lessons learned

Data range exploitability (Instrumentation, background noise,…)

Scaling/transposition uncertainties (liner performance, forward/aft separation,..)

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Open Rotor aeroacoustics test campaigns (DNW 2012)

Several tests campaign performed to assess aerodynamic and acoustic CROR blades performances

Blades design and architectures concept characterized in isolated and intalled configurations

- Isolated configuration
- Hera 3 with Airbus pylon (pusher configuration)
- Z08-HERA3 with aft wing to evaluate puller installation
- Z08-HERA3 A30X full Aircraft pusher (2 engines simulator)

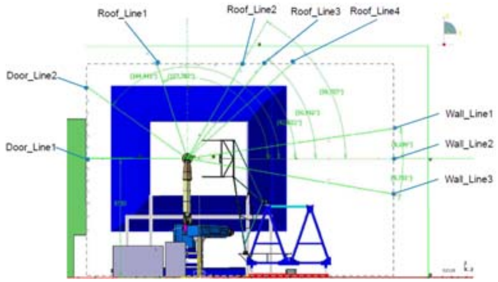


These tests contributed to the sucess of the full scale engine test at Istres Q4 2017

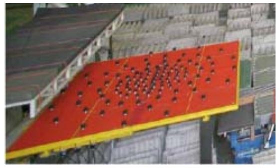
Open Rotor aeroacoustic test campaigns (DNW 2013)

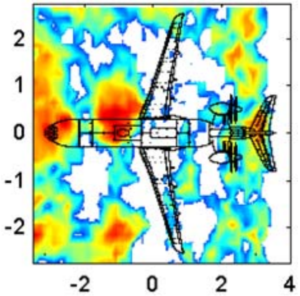
Conventional and advance aeroacoustics measurements devices

- Microphones antenna in flow/out of flow

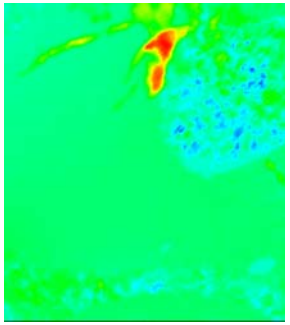


- Beamforming





- PIV



3

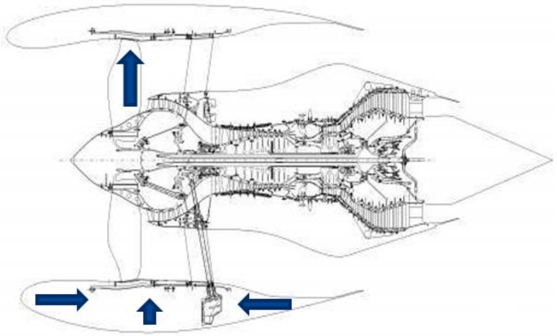
NEXT GEN UHBR ENGINES AND FUTURE ARCHITECTURES

Next generation UHBR engines

UHBR engine challenges

High Fan diameter with reduced blade number
→ Reduced rotating speed, low freq. signature

Objective : low fuel consumption
Constraint : Weight controlling



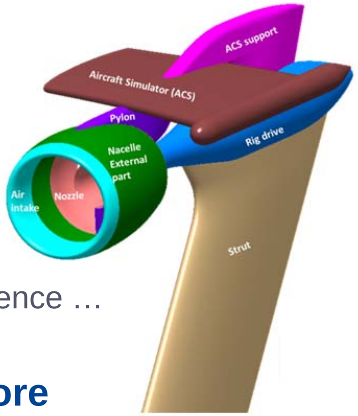
High Nacelle diameter with reduced aerodynamic drag
→ Slim and short Inlet, Liner integration difficulties

Noise source balance evolution needs to be anticipated to evaluate best UHBR architectures and improved their abilities to reach noise regulation target objective

Aeroacoustics Experimental devices expectations linked with technologies maturation and risks reduction plans :

- Fan module noise signature evolution
- Integration (short inlet, liner performance,…) and installation effects on dominant sources
- Other potential emergent components : fan/booster, turbine, core noise, …
- Noise reduction technologies demonstration

Next generation UHBR engines : SAAFIR project overview



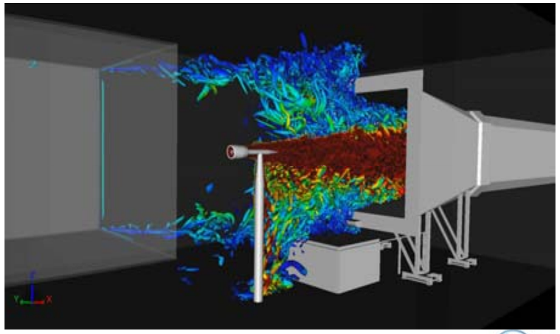
Novel IPPS rig developed in collaboration with Airbus airframer

- Aerodynamic/acoustic/mechanical design validation purposes
- Ambitious expected end results : UHBR BPR range, isolated/installed, L&H speed, AoA/incidence …

Aeroacoustics considerations for experimental devices development and more robust data exploitations

- Additional quasi-static test configuration to capture data for transposition process improvement
- Calibration with a Fan reference configuration (understand and minimize scaling effects)
- Acoustic barrier for fan noise decomposition and liners performance characterization

Advance LBM simulations performed to anticipate rig integration and verify flow characteristics for different DWN LLF flow conditions



Instrumentation and data treatments expectations

Data accuracy, range exploitability extension and physics understanding are some Key drivers to push forward aeroacoustics measurements techniques developments

Some interesting measurements technics to apply/develop to increase expected end results:

→ **all means allowing to reduce uncertainty on noise level and transposition process**

- In flow and out of flow noise data corrections improvements
- Wind tunnel background noise reduction faisability ? And/or denoising techniques
- Improved measurements devices (sensors, wiremesh,…)
- Sources separations techniques (data cleaning, forward/aft separation,…)
- Dereverberation technics ?

→ **Inverse measurements technics (modal detection, beamforming, in duct to far field technics,…) to understand sound field (source generation and propagation)**

→ **Advance understanding regarding aeroacoustics design, simulation, scaling effects,… (PIV, instationnary pressure signals, boundary layer transition detection ,…)**

A stronger and efficient data exploitation process targeted to ensure test reactivities and reduce analysis operating time

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Future architectures

Fixed-wing architecture

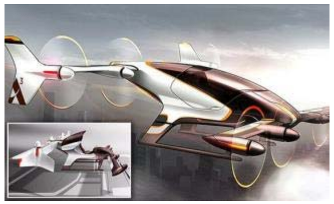
BLI driven by electric motors

Hybrid distributed propulsion

Experimental needs are also oriented by noise assesment of most promising architecture concept (see. CROR)

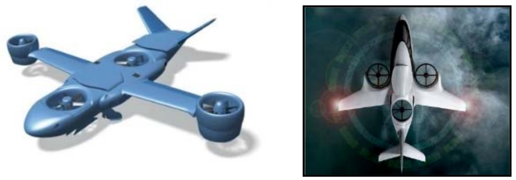
- Installation effects (Distortion,…), BLI, … on noise source generation
- Shielding effects, Distributed propulsion on noise sound field propagation
- …

VTOL architectures



A3 Vahana: Tilt-wing

Joby aviation S2: Tilt hélices / rotors



Boeing Phantom Swift_Cormoran_Trifan
Wing Body - Ducted-propeller

4

LANDING GEAR

Landing Gear Noise at Safran Landing Systems

Landing Gear Noise Status

- *Lack of specification / requirements in terms of acoustics from customers on Landing gears*
- *Increasing solicitations on landing gear noise on new bids or within « retrofit » modifications*

In service Success technology

Looking for a successful noise reduction technology on LG, in service

- *Looking for noise reduction device to the limited validations achieved in Flight Tests only (acoustic and integration still of high complexity)*
- *Increase TRL levels on low noise devices*
  - *Impact of weight*
  - *Acoustic efficiency*

Transition of aero-acoustic activities to "normal" Engineering

- *Suitable acoustic modelling methods*
- *Acoustic Design Practices*
- *Suitable tools integrated*

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Acoustic needs within Safran Landing Systems

Objectives : Increase noise sources phenomenon and support technological studies

Numerical Methods

- Benchmark recent numerical methods vs. PowerFlow
- In-depth analyze and modelling of LG flow
  - Porous / Solide FWH formulations
  - Scaling effects (size / velocity) on aeroacoustic sources
  - Dipolar / quadripolar sources breakdown with respect to velocity, size, definition/complexity of small components
- 1D modelling methods

Technological

- Benchmark wind tunnel capabilities vs. S2A (Saint Cyr, France)
  - Installation effects
  - Beamforming and comparison with numerical beamforming

Acoustic Landing Gear Improvement Approach in Safran

Preliminary Design Phase

Semi - empirical Models
(Smith model)

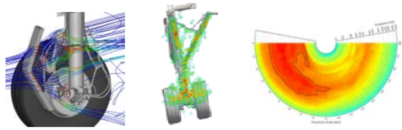
- Based on analytical solution of cylinder noise
- Correction coefficient to account for the different shapes of the components, orientation and dressings

Development

- **Model that will be based on**
  - **Semi-empirical models**
  - **Unsteady CFD results**
  - **Wind Tunnel Tests**
  - **Low noise design guide based on existing programs and research activities**

Incremental Innovation

Computational Fluid Dynamics (CFD) and AeroAcoustics



- **Commercial Solution from EXA (Lattice Boltzmann Method)**
- Unsteady 3D
- Solid integration (and/or porous surfaces) for far-field propagation
- Strong capabilities in terms of post processing and analysis

Simulation tools developed to improve existing airplanes and future platforms

5

CONCLUSION

Conclusion

Integrated propulsion system maturation plan includes several experimental TRL steps / assessments from components to full aircraft

- Many challenges for engine manufacturer to develop next generation engines propulsion system
- TRL depends on the demonstration representativeness (environment, scaling effects,….)
- All challenges not fully covered in this short presentation (such as Jet noise installation effects,….)

Stronger mock-up experimental expectations (wind tunnel test facilities, rig, instrumentation, …) to increase noise level representativeness and ensure full scale transposition (certification as a target)

- Safran AE strongly pushing for LLF improvements

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