Future needs for experimental verification. The next 20 years. HELICOPTERS

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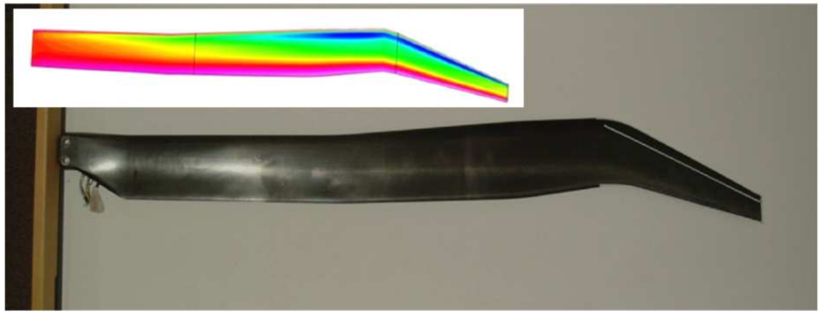
THE FRENCH AEROSPACE LAB

return on innovation

BlueEdge: the H160 example at a glance

Certification
2019?



ERATO: Tools and Simulations ➔ New Shape ***1992***

1st flight of H160
13th June ***2015***
Airbus Helicopters

Flight Tests (Eurocopter ***2008****)*

ONERA-DLR Wind Tunnel tests ***1998***

- Facts & lessons learnt:
  - A long story: 25+ years!
  - Wind-Tunnel tests of the main rotor in large facilities (S1MA, DNW-LLF)
  - No WT tests of the fixed components, nor of the complete HC (but: industrial tests of fuselage)
  - Flight tests were necessary to identify and solve problems: vibrations, stability

Extract from ONERA-DLR mid-term program

- A pre-requisite for validated codes and for progress in modeling is the **access** of ONERA and DLR **to test facilities ranging from lab tests to wind tunnel tests in large scale tunnels** like DNW LLF and S1MA to highly instrumented flight test aircraft. But this type of validation is now very **expensive** and not affordable for research studies any more.

- For flight mechanics studies, **flight simulators** are very useful tools.

- In addition both Research Centers operate **UAS** (RESSAC or ARTIS) to develop and demonstrate autonomous flight systems or functionalities. This part of activity is constantly growing year by year.

Objective of the presentation

- Focus on **Helicopter** WT testing in research & pre-industrial facilities
  - Aerodynamics and related disciplines: dynamics, acoustics, aerothermics

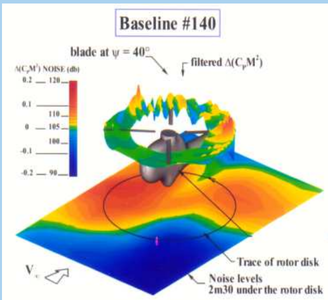
- I will NOT talk about testing through simulators

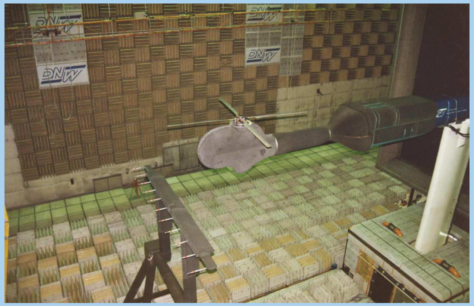
- Try to address the following questions:
  - Will more research tests allow industrial programs to go faster?
  - Contrary to fixed wings, design is frozen AFTER the flight tests on rotorcraft: will this change thanks to WT testing?
  - Why less tests on rotorcraft than on fixed wings industrial programs?
  - How will / should research facilities evolve within the next 20 years?
  - Can digitalization kill WT testing?

Wind-Tunnel testing: what for?

- Understand the physics
  - Physics is universal but some aspects are more pregnant in Helicopters:
    - Unsteadiness (rotating parts) → airloads

    - Separation → performance, stability
    - Vortical structures → performance, vibrations, noise





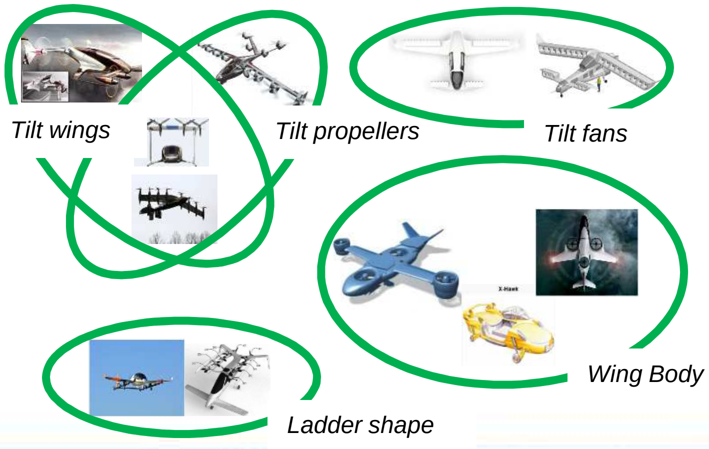
  - Turbulence modeling remains a major issue and will still be in 20 years
    - DNS of a transport aircraft may be achievable in 2045 ($N_{xyz} > 10^{16}$, Spalart et al)

Wind-Tunnel testing: what for?

- Support the design
  - Conventional Helicopters
  - Rotorcraft with increased speed: tiltrotor, compound
  - On-Demand Mobility: multi-rotors

→ **validation of new concept/technologies for proof-of-concept and risk mitigation**



My vision of important topics requiring testing

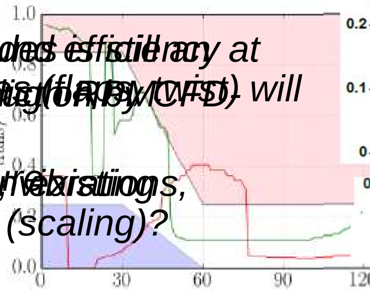
- Main rotor
  - Laminar-Turbulent Transition in forward flight
  - Main rotor at high advance ratio
  - Dynamic stall?
  - Active rotors
- Multi-Rotor interactions
- Complete rotorcraft:
  - **Dynamics**
  - Drag reduction
  - Engine integration
- New concepts of VTOL vehicles (UAV and ODM)

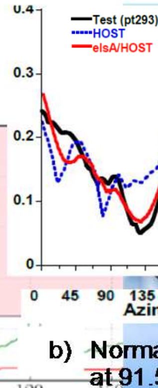
My vision of important topics requiring testing (1)

- Main rotor
  - Laminar-Turbulent Transition **in forward flight** (< 5 years)
  - Main rotor at high advance ratio (< 10 years)
  - Dynamic stall?
  - Active rotors (< 15 years)

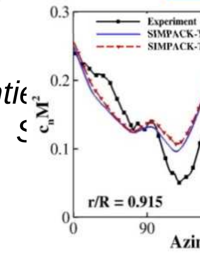
Databases in hover exist (even on full-scale blades)

- *Dynamic stall of rotating blades is still an issue, although airloads prediction by CFD seem quite accurate!*
- *Still some impact on airloads, vibrations, stability, control…*
- *Developing active rotor blades (flaps, twist) will require a lot of testing*
- *Technology not yet fully mature*
- *Representativity of WT tests (scaling)?*



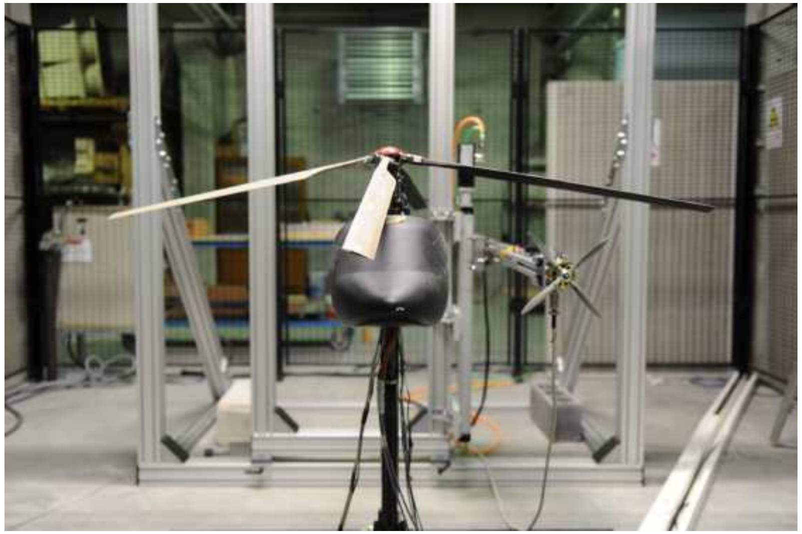


Large uncertaintie



My vision of important topics requiring testing (2)

- Multi-Rotor interactions (< 5 years)
  - Performance
  - **Acoustics**
  - Vibrations



My vision of important topics requiring testing (3)

- Complete rotorcraft:
  - **Dynamics: could be the top priority for the next 5 to 10 years**
    - Vibrations on the blades: OK
    - Vibration transmission to fuselage through pitch-links ...: no data
    - Vibrations induced by the hub vortices on tail surfaces + fuselage structural response (tail-shake): no data
  - Drag reduction: test of technologies to reduce parasite drag (compound)
  - Engine integration: no detailed data, a lot to be gained for the manufacturers
  - e-VTOLs: certainly an opportunity for wind-tunnel testing (small scale, reduced costs)

Necessary evolutions of testing

- Advanced metrology:
  - Model (elastic) deformation: combination of advanced optical techniques and traditional ones based on strain gauges should bring more confidence in measurements
  - Smarter use of instrumentation: Kullites for pressure & transition assessment
  - 3D & TR-PIV + BOS3D: application to a model rotor
  - PSP on rotating blades or for unsteady phenomena (separation)
  - Non intrusive techniques for transition: IR thermography

- Increased accuracy?
  - As good as for fixed wings: maybe not possible because of rotorcraft specificities
  - But: systematic accuracy / uncertainty assessment

- **Data assimilation** = smart combination of numerical predictions and experimental measurements (a brick to certification?)
  - A test campaign should be specified in such a way that its combination with numerical predictions will:
    - Allow reducing the test matrix, the instrumentation
    - And simultaneously increase the value of the resulting data

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Conclusion: some personal answers to questions raised in the introduction

- Why less tests on rotorcraft programmes than on fixed wings industrial programmes?

  Complexity (unsteadiness) → costs

  Scale-1 WT testing not accessible in Europe

- Will digitalization kill WT testing?

  No! Data assimilation must become more mature

- Contrary to fixed wings, design is frozen AFTER the flight tests on rotorcraft: will this change thanks to WT testing?

  It could, if we master Dynamics…

- Will more research tests allow industrial programs to go faster?

  It could, if we master Dynamics…

- How will / should research facilities evolve within the next 20 years?

  Advanced measurement techniques in (pre)-industrial tests