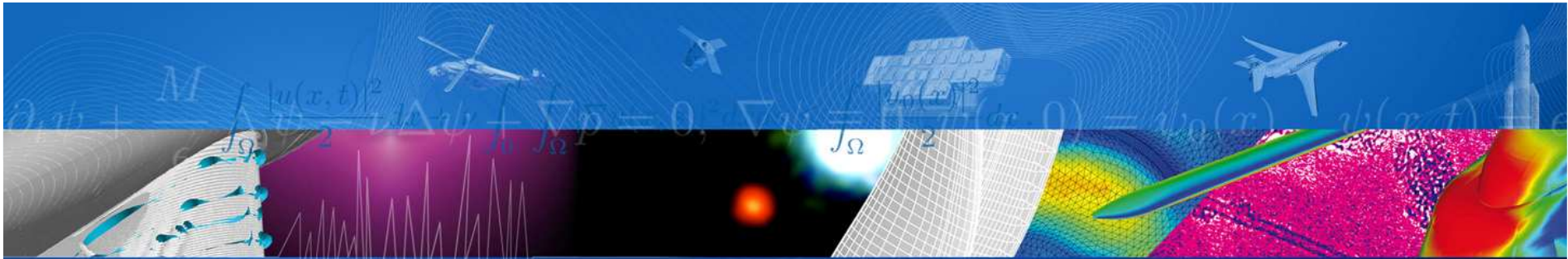


ONERA

THE FRENCH AEROSPACE LAB

r e t u r n o n i n n o v a t i o n

www.onera.fr



Studies on Rotorcraft Platform and its Operational Capabilities

Dominique TRISTRANT
Systems Control and Flight Dynamics Department

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return on innovation

Outlook

- ONERA's Identity and Missions
- How ONERA is working for Rotorcraft benefit ?
- Examples of Results
- Open Technical Challenges and Perspectives

ONERA : the French Aerospace Lab

Innovation, Expertise and long-term Vision
For Industry, French government and Europe

- A public entity created in 1946
- Reporting to the ministry of defense
- 2,131 employees, 1500 Engineers
- 259 doctoral students and post-docs
- 244 million euro budget
- 125 M€ contract awarded 17% international (collaboration, export)
- Largest fleet of Wind Tunnels in Europe
- "Carnot label" from Ministry of Higher Education and Research

Science driving innovation in aerospace and defense

A balanced business portfolio:

- 1/3 civil
- 1/3 defense
- 1/3 dual-use

Funding origin:

- Governmental grants and Contracts
- Industry contracts
- European initiatives

Return on innovation

Expanding knowledge
to meet Society's challenges

Advanced technology and industrial success

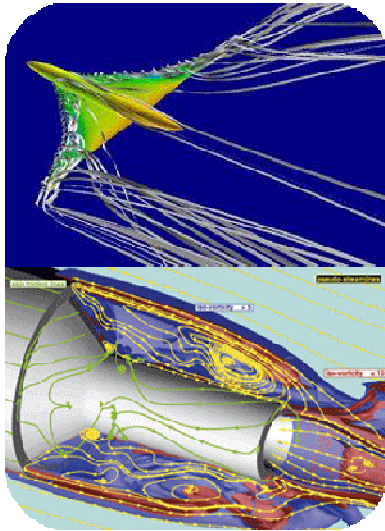
Examples :

- All Airbus jetliners including the upcoming A350
- Falcon 7X
- Ariane 5
- Propulsion
- Helicopters
- Space missions

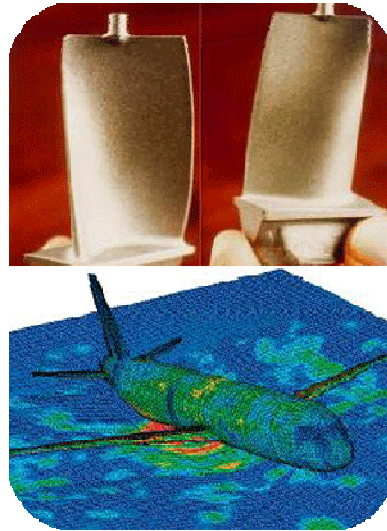
Environmental protection :

- Reduce aircraft noise
- Reduce emissions
- Alternative fuels

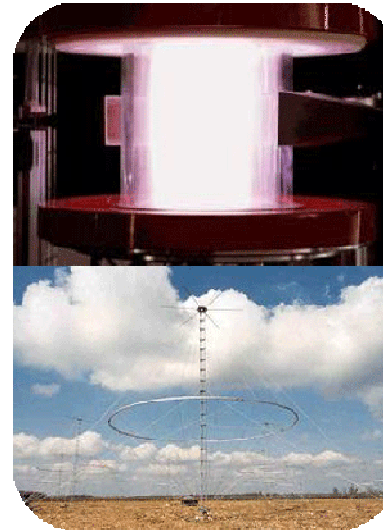
ONERA Organisation



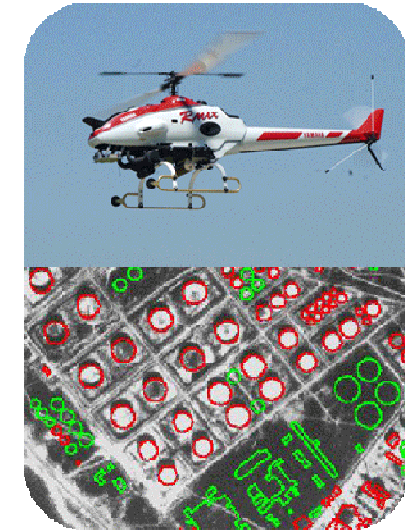
Fluid Mechanics
and Energetics



Materials
and Structures



Physics



Information Processing
and Systems

In each Branch, fundamental and applied activity



Test facilities



Outlook

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DLR - ONERA Cooperation: Rationale



Since 1998 DLR and ONERA are cooperating on Rotorcraft research. The first integrated common research programme was formalized in 2000.

The volume is ~24M€ / year, about 65 personnel-year for each.

The common programme includes studies performed by common teams or partner teams, partly within common projects, or activities performed only by one partner.

How it works:

- Development and use of common computer codes
- Common use of facilities: Research helicopters, Wind tunnels, test rigs, Ground based simulators.
- Common reporting and activities reviews to the management.

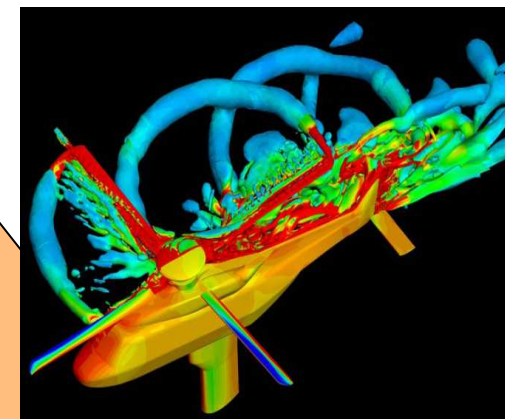
From Idea to Innovative Technologies: From TRL1 to TRL6



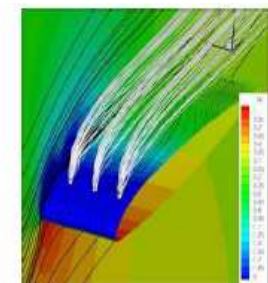
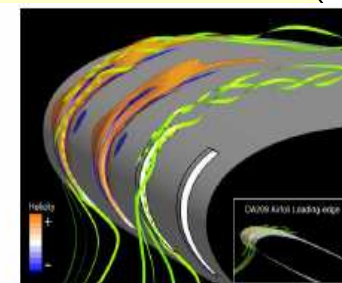
Innovation

Validation:
Wind tunnel
Flight Test

New Blade Shapes
Optimisation
Noise, Vibration, Perf



Idea + numerical simulation, CFD codes
elsA, Dynamics, Acoustics,
Interactional Phenomena



URANS simulation of DVGs (left) and air jets (right)

ONERA and DLR: International Research Cooperations

In Europe:

Contribution to EU initiatives

R&D Framework Programmes:

GOAHEAD, NICETRIP, ...

Clean Sky (Green and environmental issues) to develop breakthrough technologies to significantly increase the environmental performances of aircraft and air transport, SESAR (Single European Sky ATM Research) technological and operational dimension of the Single European Sky (SES) initiative to meet future capacity and air safety needs.

Members of EREA, the association of European Research Establishments in Aeronautics



ONERA and DLR: International Research Cooperations

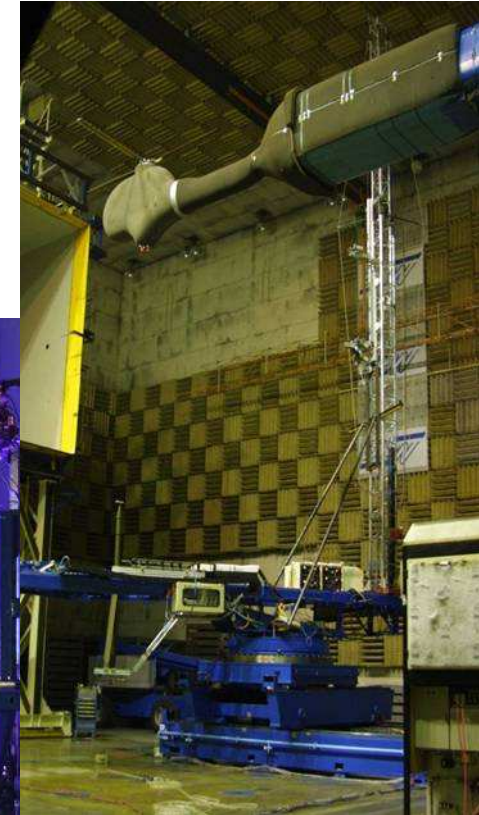
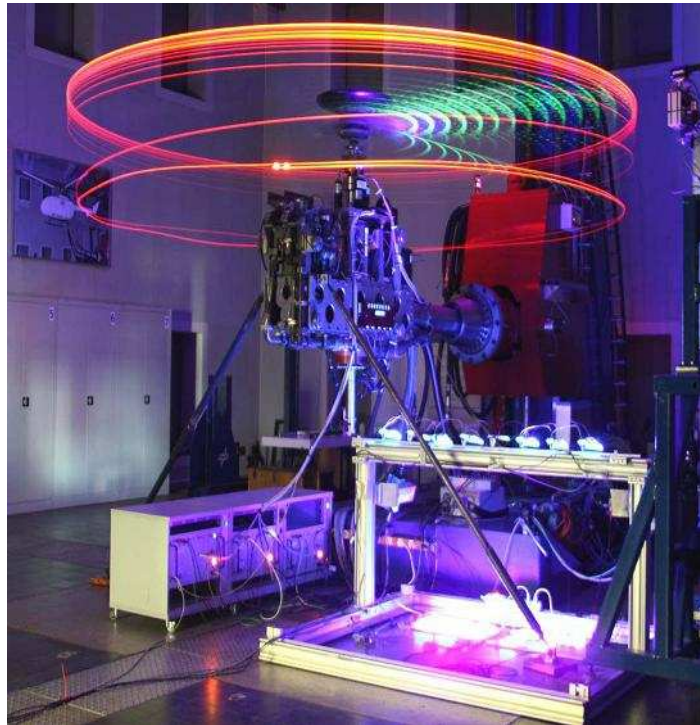
Outside Europe:

USA:
NASA, bilateral agreements

**US Army: bilateral agreements
and HART I and II**

**Asia : JAXA (Japan)
Korea, China ...**

**and STAR (multinational
cooperative program)**



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Common DLR-ONERA Programme



Testing:

WT tests: highly equipped models, access to WT of various sizes

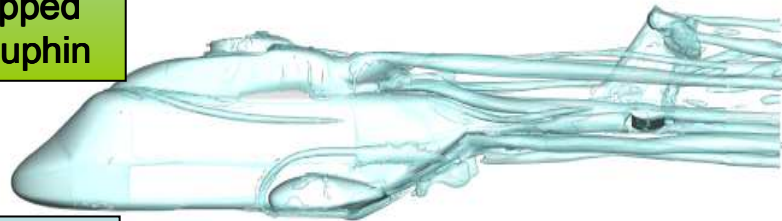
Flight tests: well equipped test aircraft: FHS, Dauphin

Aerodynamics: Complete helicopter CFD tool chain including fluid-structure-coupling

CFD-based optimization

Aeroacoustic calculation chain

low noise flight procedures
internal noise control



New concepts (high speed, spec missions, ...)

Active rotor control:

Active blades (flap or twist) to reduce noise, vibration and to improve performance

Flow Control (passive and active)

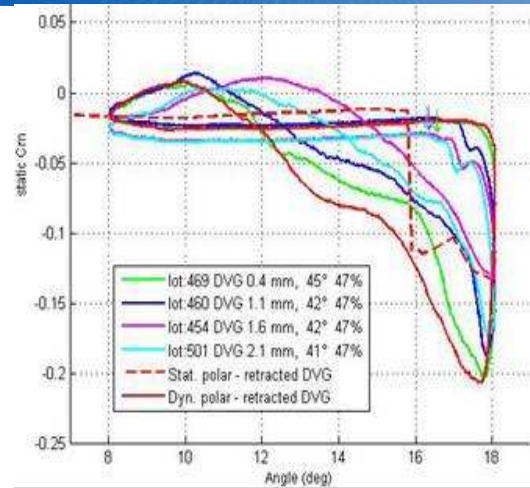
Flight mechanics tool (HOST) improvements by modeling, flight safety controls, pilot assistance, sensors, autonomous flight, UAV

Safety: crash modeling tools, composite behavior, new composites

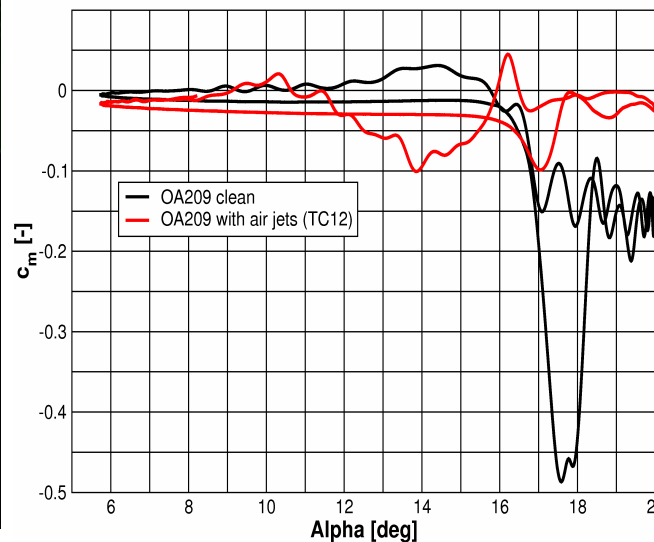
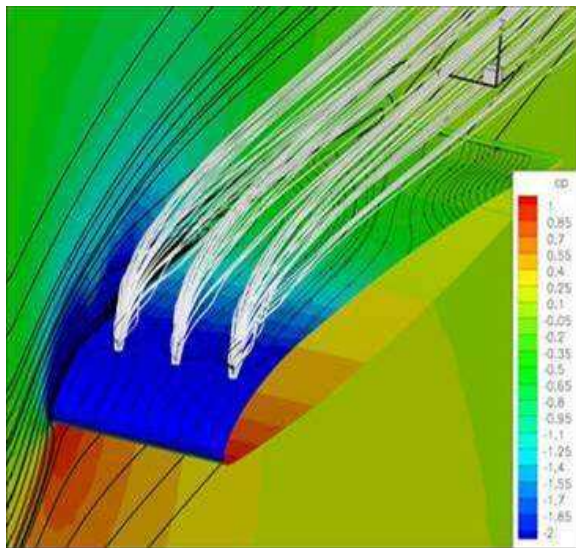
efficient production techno for composites

All weather limitations improvement:
icing, lightning

Active Flow Control



Influence of Deployable Vortex Generators on Pitching Moment Evolution (F2WT) of an airfoil in Dynamic Stall conditions

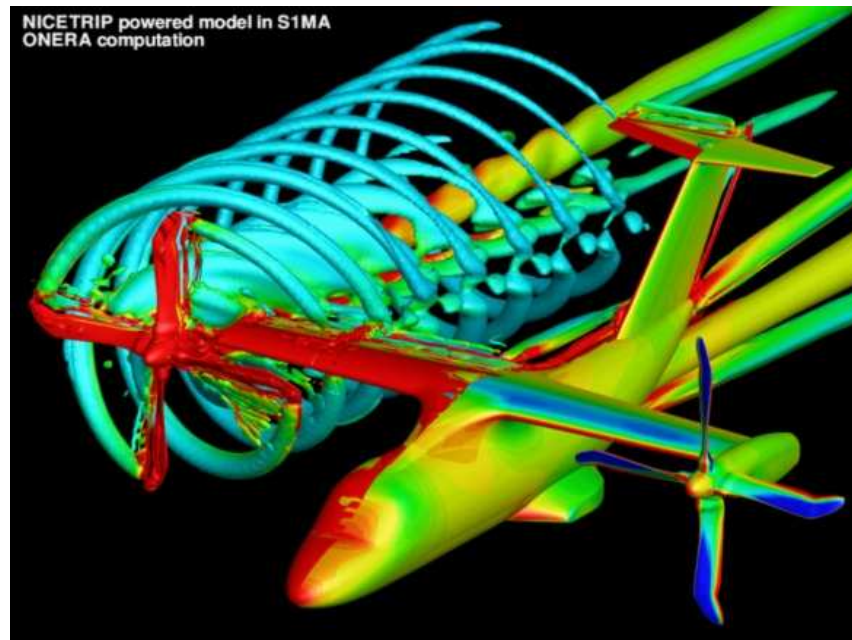
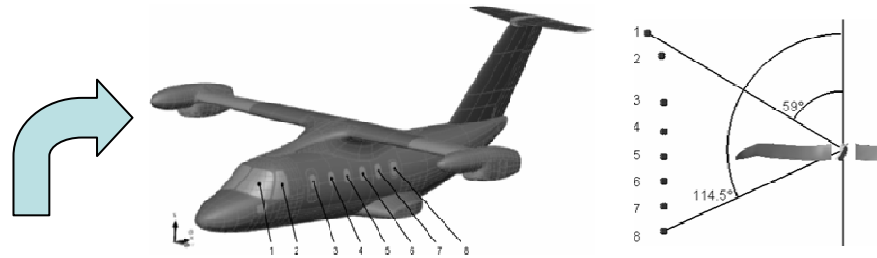


Investigation of Fluidic control devices 3D TAU simulations on pitching airfoil

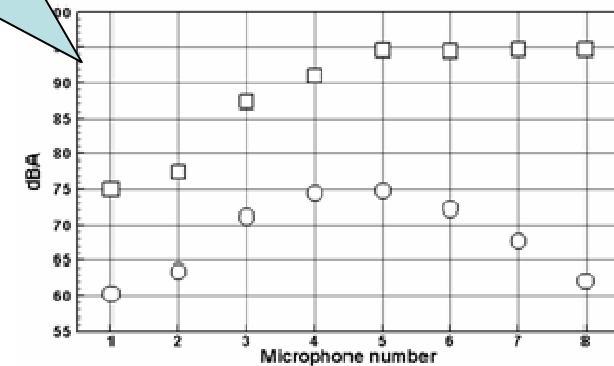
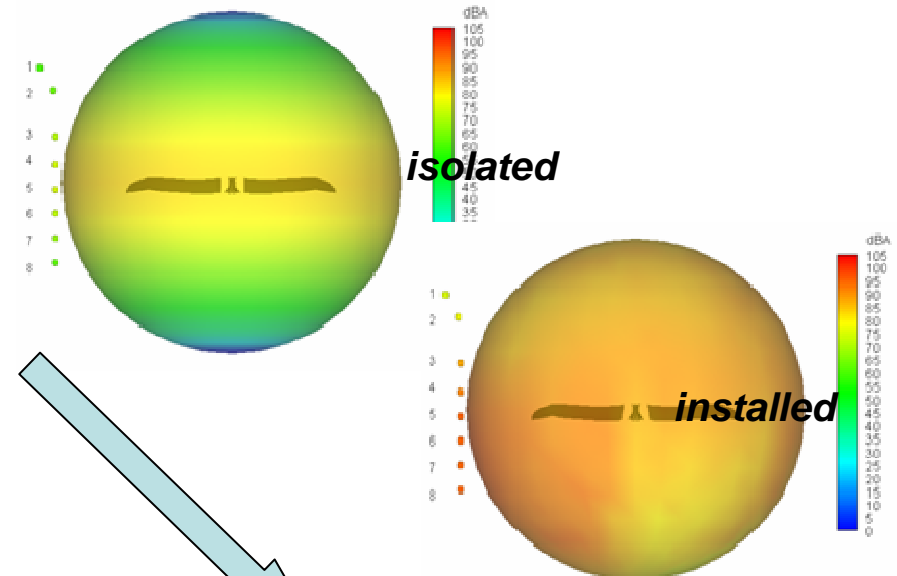
From Le Pape, Costes, Joubert, Richter Gardner (ERF and AHS 2010, 2011, 2012)

NICETRIP: Novel Innovative Competitive Effective Tilt Rotor Integrated Project

CFD-CAA (FWH) coupling for cabin noise evaluation
ONERA, *elsA*-KIM approach



URANS calculation of ERICA in cruise (*elsA*)



Perceived noise increase
between 15 and 30 dBa
(depending on microphone)

Advanced systems or functions for flight management

Objectives:

- To study and propose new **Concepts** of on-board **systems** or **functions** for :
Pilot assistance and/or Protection of the flight envelope

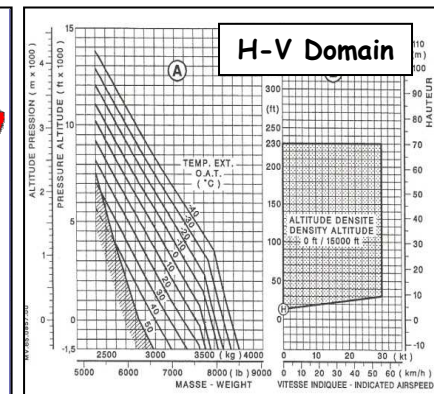
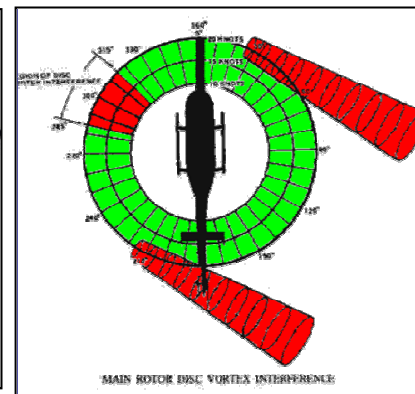
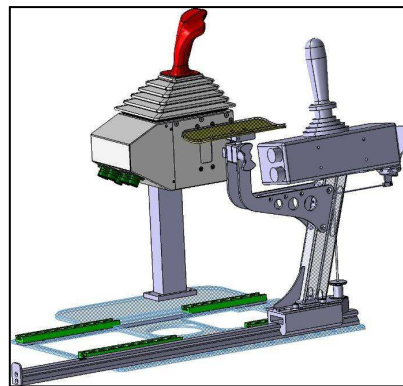
Examples:

- Assistance / monitoring flight procedure
- Dynamic definition of flight procedures (Take-off...)
- Dynamic position of helicopter w.r. to H-V domain
- Prediction of flight limitations approach
- Predictive function of VRS onset
- Predictive function of Lateral Loss of Control
- Flight Surveillance while piloting with assistance
- Use of active inceptors

DLR

ONERA

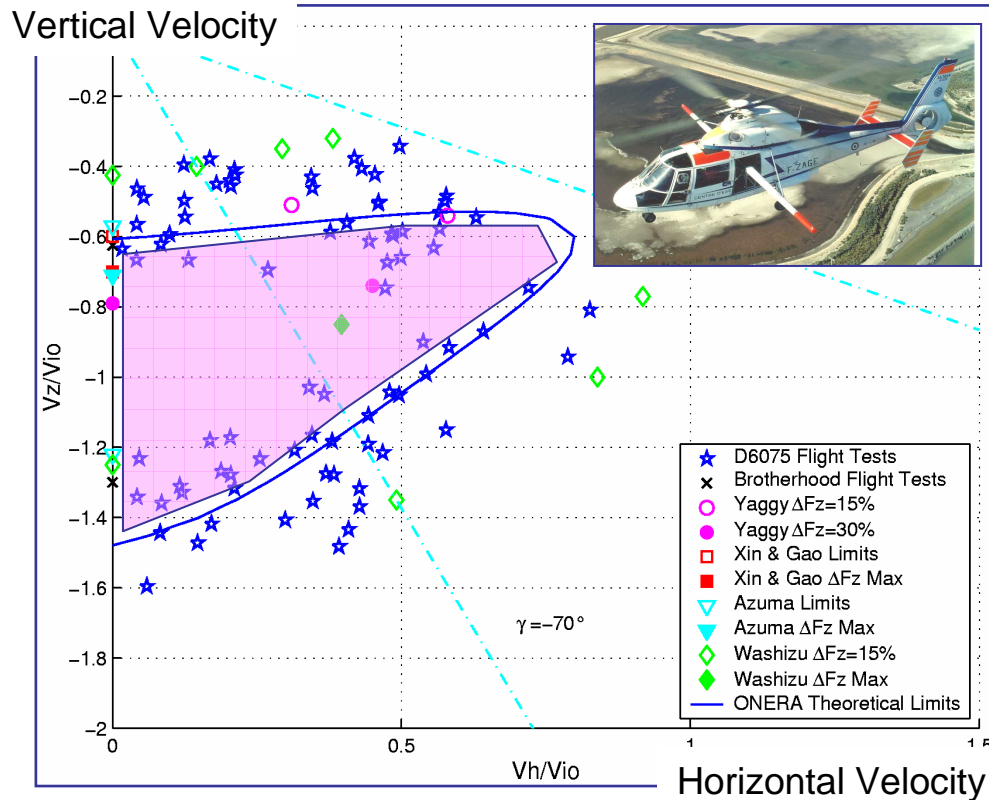
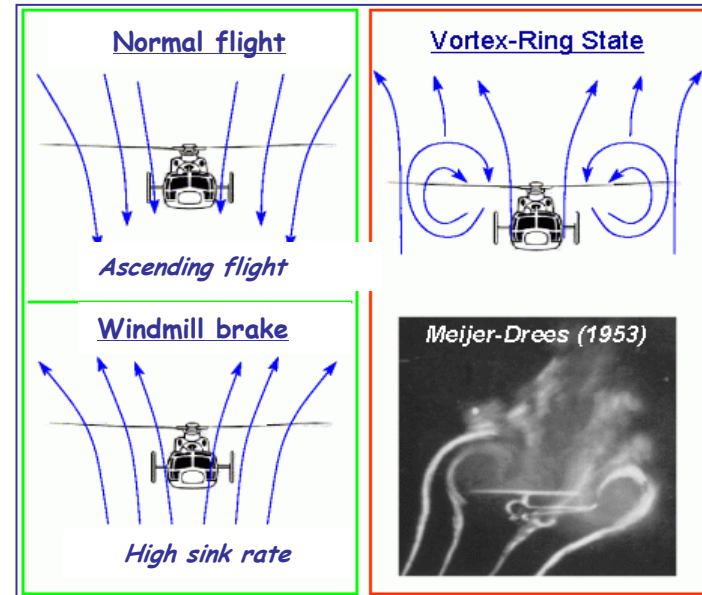
DLR



Flight envelope limit, e.g : VRS Onsets

Objectives :

- Flight envelope prediction : reliability & accuracy
- Improve safety & extend Flight Envelope
 - ⇒ Understand "Vortex Ring State" phenomenon
 - ⇒ Predictive model / Flight tests data



Dauphin 6075 of the CEV

e.g : VRS Tactile Cueing

ONERA has defined VRS avoidance function
Haptic feedback on the stick as RW approaches VRS domain
DLR integrated it in the flight control system
Both partners tested it on DLR ground and flight simulation

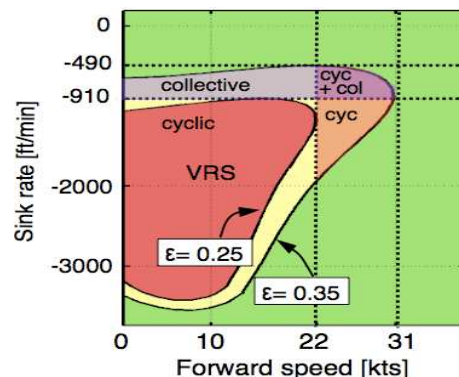
VRS warning
function

Tactile
cueing

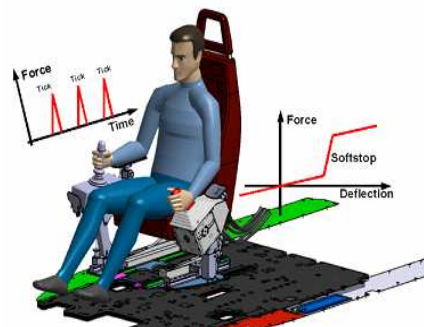
Tests in
simulator

Preparing
flight tests

ONERA



DLR



DLR + ONERA



DLR + ONERA

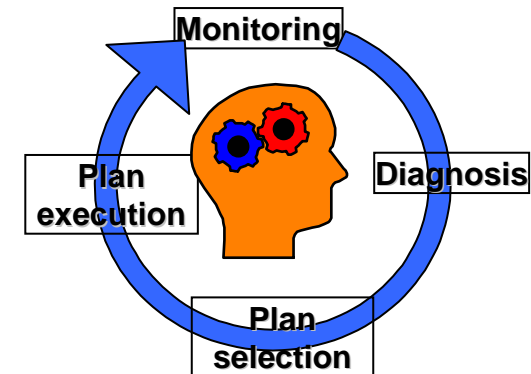


→ Technological and Human Factor aspects must be considered together

Human Factor is also a key issue to the future RW technologies

Motivation :

- o Increasing complexity of cockpits : numerous systems to monitor or to control
- o Automatic, semi-automatic and manual systems
- o Missions more and more complex (coordination and environmental requirements)
- o Increasing Workload in operation
- o New technologies more difficult to master (technology gaps, high rate of change)
- o Stress in risky situations (combat, hazards, various obstacles, heavy air traffic...)



Challenges :

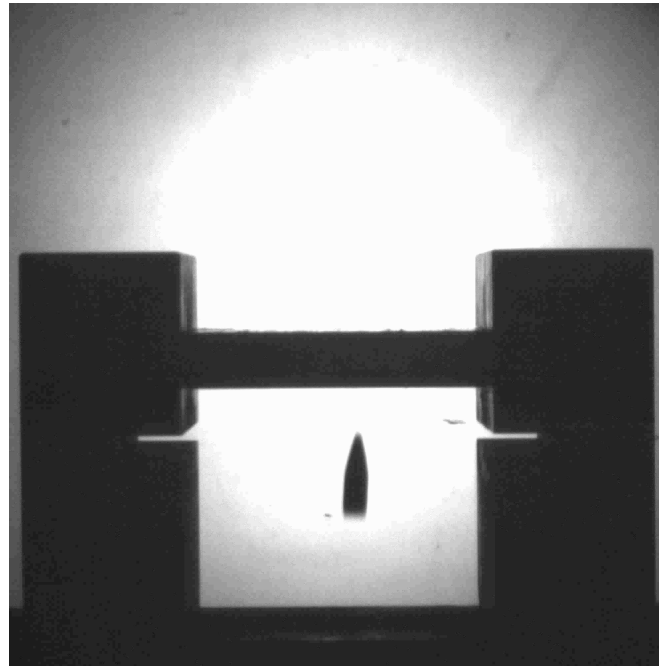
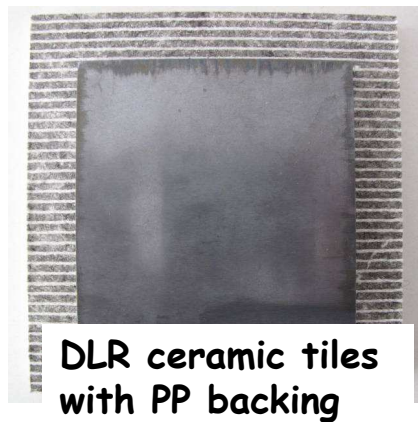
- ➔ Take into account **H.F** at an early phase of conception in order to:
 - o Adapt systems and **interfaces** to the **cognitive limits** of human operators
 - o Avoid a too high **workload** in any flight situation
 - o Improve crew **awareness** and operational efficiency
 - o Provide assistance and **decision aids** in critical situations
 - o Develop and integrate new **visual** or **haptic aids** in adverse flight conditions

Helicopter vulnerability :

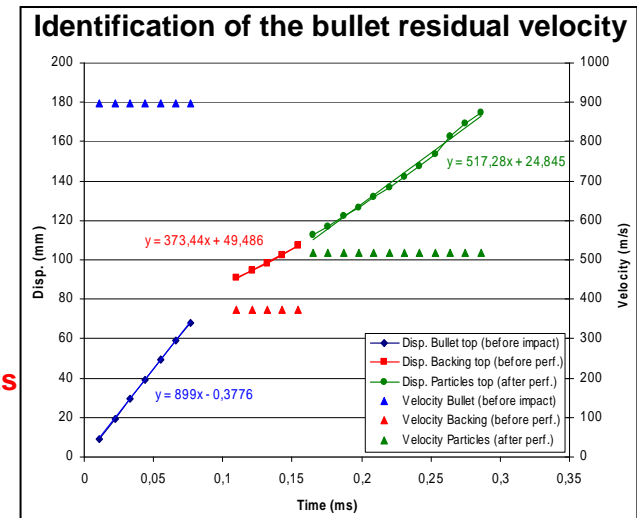
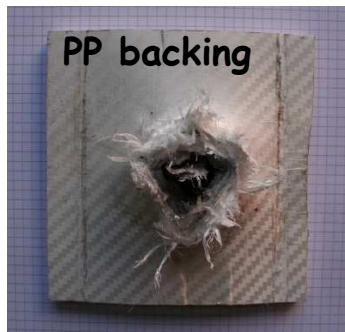
Ballistic performance evaluation of lightweight armour tiles

ONERA-DLR Cooperation

Specimens
manufactured at
DLR



Ballistic test at ONERA



Concept Design Tools

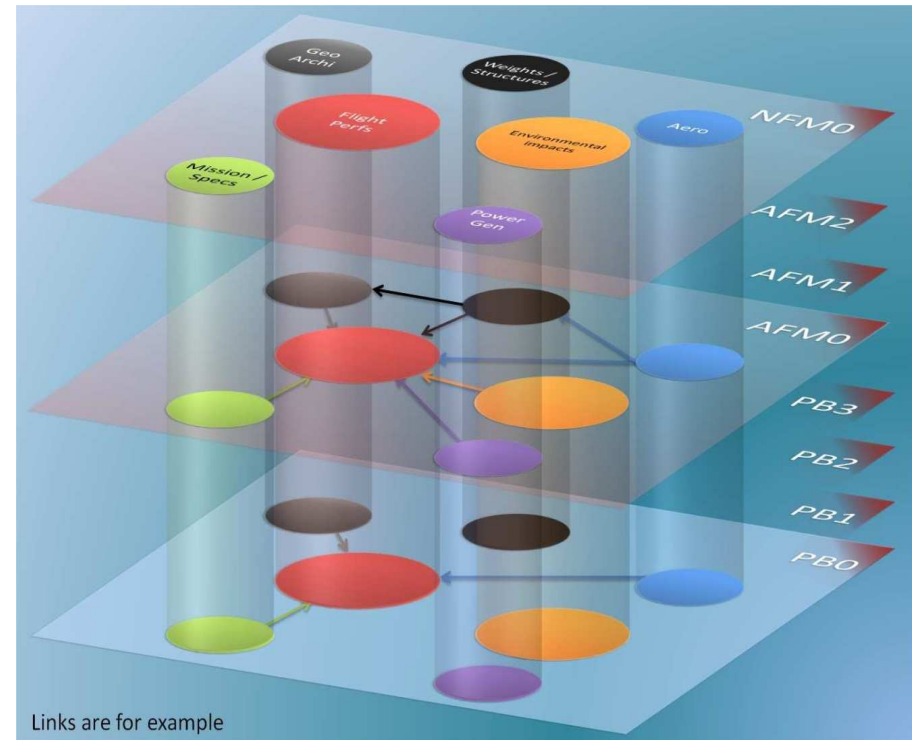
Development of Numerical Platforms based on multi-disciplinary, and multi-levels tool for **Preliminary Design and Evaluation** of VTOL configurations

RIDE (DLR) : Rotorcraft Integrated Design and Evaluation,

CREATION (ONERA) : Concepts of Rotorcraft Enhanced Assessment Through Integrated Optimization Network

ONERA and DLR will run common tests cases (classical HC, ...)

The final objective is to analyze and evaluate **alternative** and/or **innovative** concepts designed on **mission** or **environmental requirements**.



CREATION :
Level 0: Power Balance and RSM
Level 1: Analytical Models
Level 2: Numerical Models

From Basset AHS Spe. Meeting, 2012

Outlook

- ❑ Onera's Identity and Missions
- ❑ How Onera is working for Rotorcraft benefit
- ❑ Examples of Results
- ❑ Open Technical Challenges and Perspectives

Open Technical Challenges

The main key issues for future rotary wing configurations are :

- o Increase capability of **All Weather Operations** for safety in rescue or offshore operations (DVE, sensors, pilot assistance)
 - o Prepare the future with "**Greening**" : reducing emission, decreasing noise, vibration, respect environmental regulations for materials...
 - o Increase **Safety** : Crash demonstration, passenger protection, flight domain protection Systems, Improving crew **awareness**
 - o Extend the **Flight Envelope** (speed, range)
 - o Increase **Operational efficiency** : integration of **new technologies, new systems and HMI** taking into account **Human Factors**
 - o **New concepts** :
 - On "classical" helicopters (e.g : primary control w/o swashplate),
 - Other RW formulas : Tilt-rotor, Compound, Contrarotative
- ➔ **Breakthrough Technologies are needed for increasing safety, expanding the flight domain in adverse conditions, improving efficiency in operation, and addressing environmental requirements**

Mid and Long-Term Perspectives

Highly accurate calculation and simulation tools (all disciplines) :

- o **Numerical Prediction** of Complete HC in maneuver flight (including flight mech. and fluid-structure coupl.)
- o Design of **optimized flight procedures** (Noise, Safety, Emissions)
- o **Flow control** (design of actuators)

Multidisciplinary Optimization for more efficient rotorcraft :
requires variable fidelity approaches with controlled accuracy for each discipline

Dedicated experiments for generation of validation data, e.g:

- o **Unsteady transition**, dynamic stall
- o **Vibration** : Structural model from actuator, swashplate, pitchlink to blade structure
- o **Low noise** flight procedures

→ **Providing validated tools based on deep physical and multidisciplinary knowledge**

Mid and Long-Term Perspectives

Crew assistance:

- o Sensor integration and sensor data fusion → Interfaces
- o Advanced control and automation
- o Pilot assistance (system degradation, flight safety...)
- o Efficiency of Simulator training
- o Ship deck landing
- o Optionally manned rotorcraft (OPV) concept
- o Manned-unmanned teaming

**Pilot workload,
Human factors,
Autonomous
flight phases,
Increasing
safety**

Reducing Helicopter Vulnerability:

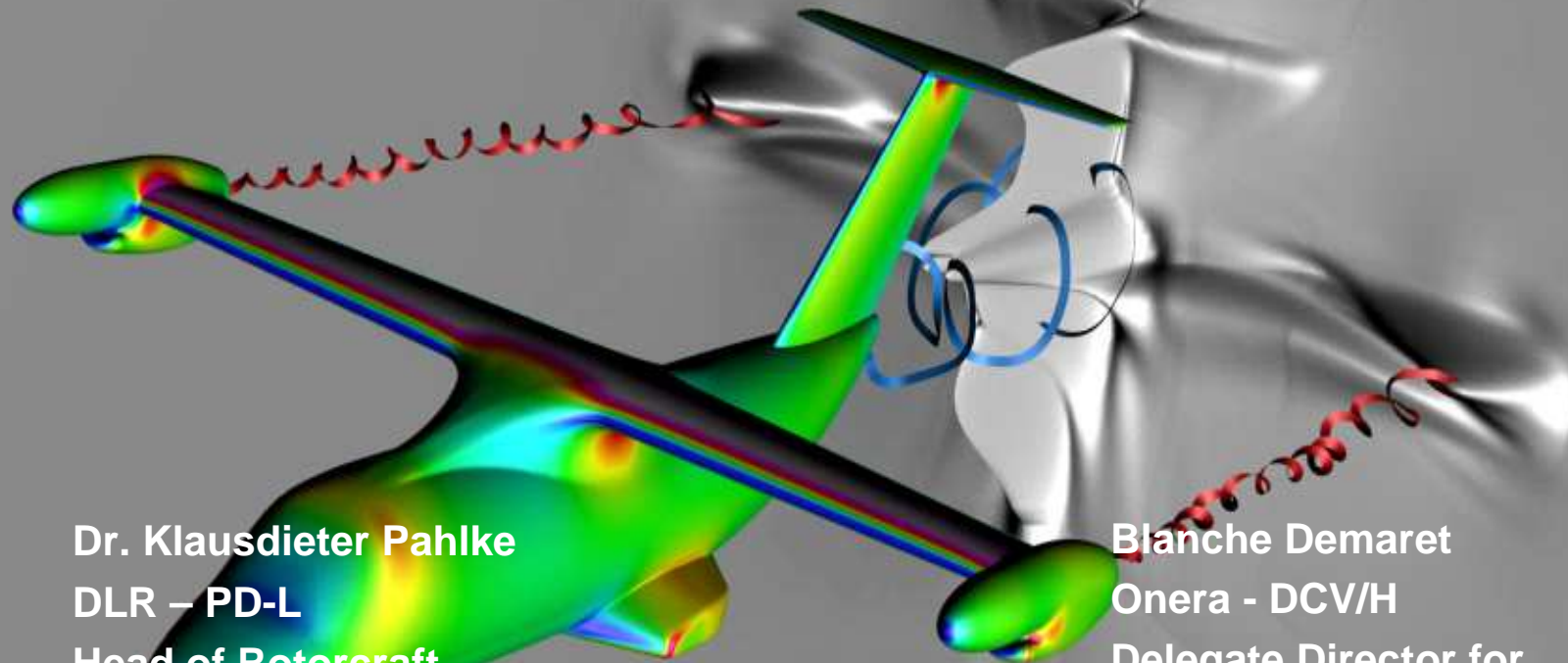
- o Improved crash performance (solid / soft soil / water)
- o FOD (Flying Objects and Debris), Icing, etc.

Environmentally friendly Manufacturing:

- o Innovative production technologies and materials
- o More efficient production of composites

→ By teaming, ONERA and DLR are addressing rotary wing challenges with multidisciplinary and bi-national teams

Contacts



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Thank you for your attention

QUESTIONS ?