

Retrospectives: Civil Rotorcraft

50 years of Civil Rotorcraft Research in the context of
GARTEUR: Some spotlights.

Dr.-Ing. Klausdieter Pahlke, DLR, Institute of Flight Systems

Historical Background of Rotorcraft Technology



Aérospatiale SA 360,
Prototype first fl.: 1972 Mod. 1973

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EH 101,
first fl. 1987

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BA 609

first fl. 2003, not certified

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H160

first fl. 2015

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Bell 525

first fl. 2015, not certified

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H 145

Certification 2021

Photo: Airbus Helicopters

Research Results produced, shared & published

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HC GoR Action Groups w

- HC/AG-01 "Comparison with Prediction Methods for a Helicopter"
- HC/AG-02 "Analysis of the for advanced rotorcraft" Report
- HC/AG-03 "Mathematical qualities and performance" Report
- HC/AG-04 "Helicopter interaction"
- HC/AG-05 "Advance rotorcraft of tilt-rotor aircraft and comparison"
- HC/AG-06 "Tilt rotor advance"
- HC/AG-07 "Helicopter Performance Verification of the Baseline Configuration" Report 1996
- HC/AG-08 "Helicopter vibration" Report 1995

GoR RC Presentation
Pozzuoli, 5 Oct. 2023

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HC GoR Action Groups

- HC/AG-09 "Mathematical Flying Qualities" Report
- HC/AG-10 "The Prediction Report 1998"
- HC/AG-11 "Helicopter interaction"
- HC/AG-12 "Validation Simulation Models" Report
- HC/AG-13 "Validation techniques"
- HC/AG-14 "Methods for Element Models"
- HC/AG-15 "Improvement helicopter ditching"
- HC/AG-16 "Rigid Body"
- HC/AG-17 "Wake Model"

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Running HC GoR Action Groups 2014+



- HC/AG-18 "Data and Methods for Error Localisation and Model Refinement of Structural Dynamic Finite Element Models"
- HC/AG-19 "Methods for improvement of structural dynamics FE methods using in-flight test data"
- HC/AG-20 "Simulation and experimental methods for new solutions for internal noise reduction"
- HC/AG-21 "Rotorcraft Simulation Fidelity Assessment: Predicted and Perceived Measures of Fidelity"
- HC/AG-22 "Forces on Obstacles in Rotor Wake" Report 2018
- HC/AG-23 "Wind Turbine Wakes and Helicopter Operations"
- HC/AG-24 "Helicopter Fuselage Scattering Effects for Exterior/Interior Noise Reduction"
- HC/AG-25 "Rotor-Rotor-Interaction"
- RC/AG-26: Noise Radiation and Propagation for Multirotor System Configurations

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Aerodynamics Performance

- From 80-ties to today several HC/AGs on the topic of performance and interactional aero (blue) and tiltrotor technology (green).
- Many very successful EU-Projects initiated



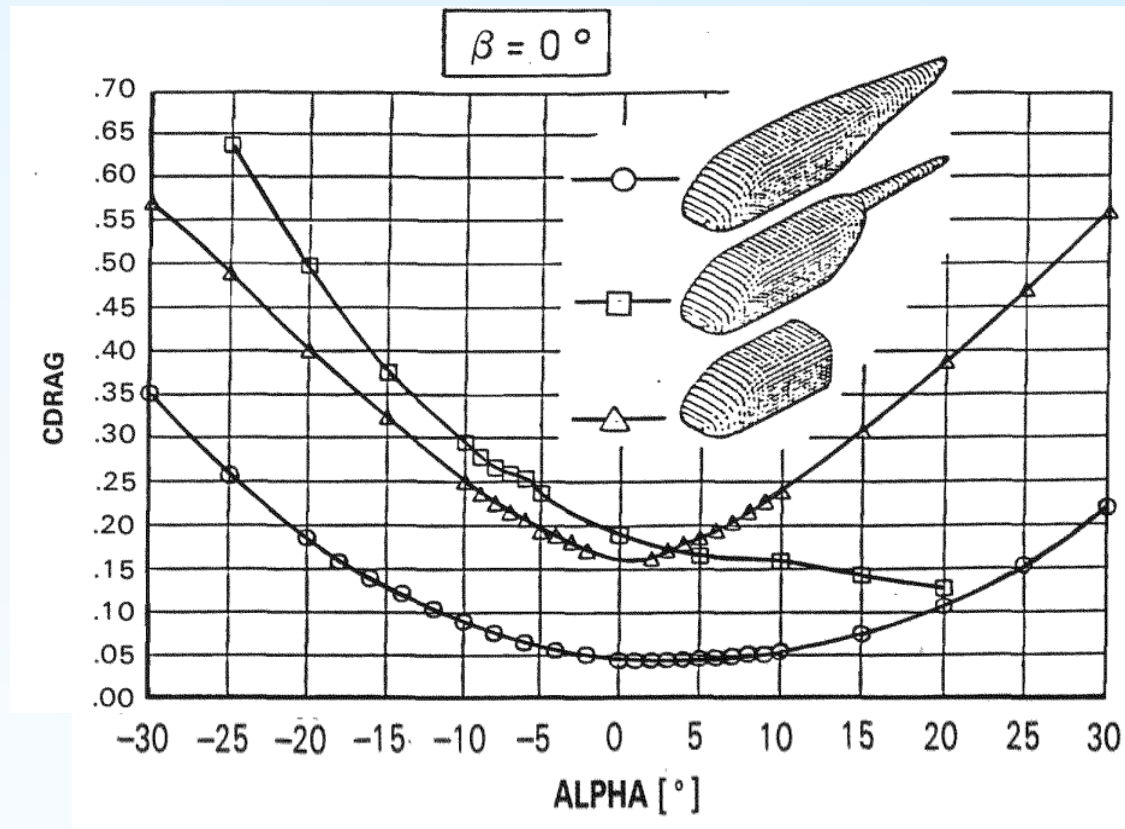
HC GoR Action Groups with end date within 1980-1995

- HC/AG-01 "Comparison with Experiment of Three Pressure Prediction Methods for a Helicopter Fuselage" Report 1986
- HC/AG-02 "Analysis of the operational requirements and missions for advanced rotorcraft" Report 1985
- HC/AG-03 "Mathematical modelling of helicopters for handling qualities and performance" Report 1988
- HC/AG-04 "Helicopter interactional aerodynamics" Report 1989
- HC/AG-05 "Advance rotorcraft evaluation: preliminary design study of tilt-rotor aircraft and compound helicopter." Report 1987
- HC/AG-06 "Tilt rotor advanced technology" Report 1989
- HC/AG-07 "Helicopter Performance Modelling, Development and Verification of the Baseline CSM and Proposals for Improvements" Report 1996
- HC/AG-08 "Helicopter vibration prediction and methodology" Report 1995

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Aerodynamic Performance



HC/AG-04: Helicopter Interactional Aerodynamics
1/7 model in DFVLR Göttingen wind tunnel with inter-changeable rear-ends. $V=60$ m/s.

Classical GARTEUR style activity:

- Producing exp. data together (e.g. DFVLR, MBB, Westland, Aerospatiale) allowing a basic understanding of the physics
- Making code to code and code to exp. data comparisons together in common formats paving the way for solid code validation and enhancement.

➔ EU Project GOAHEAD (Generation of Advanced Helicopter Experimental Aerodynamic Database for CFD code validation, 2005-2009)


➔ one of the milestones providing the ground for today's CFD codes

(old day: CFD= color for directors)

today: CFD = every day tool in the project departments)

Handling Qualities

- 6 AGs in HQ context
- Rotorcraft HQ are by definition directly connected to the mission
- Key outcome of HC/AG-09: which model features are a must to provide meaningful HQ assessments, i.e. model behavior that is sufficiently close to the behavior of the real hc for the same mission task element (ADS 33).



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HC GoR Action Groups with end date within 1996-2013

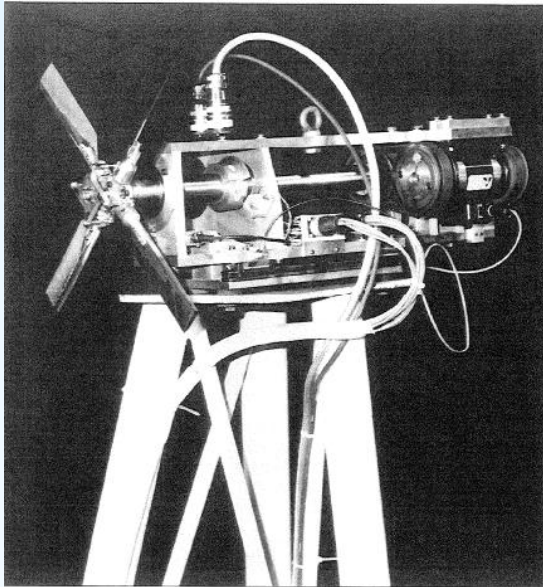
- HC/AG-09 "Mathematical Modeling for the Prediction of Helicopter Flying Qualities" Report Nov. 1999
- HC/AG-10 "The Prediction of Dynamic Stall and Blade Torsion" Report 1998
- HC/AG-11 "Helicopter yaw axis handling qualities modelling"
- HC/AG-12 "Validation Criteria for Helicopters Real-Time Simulation Models" Report 2006
- HC/AG-13 "Validation of rotor blade / hub load synthesis techniques"
- HC/AG-14 "Methods for Refinement of Structural Dynamic Finite Element Models"
- HC/AG-15 "Improvement of SPH methods for application to helicopter ditching"
- HC/AG-16 "Rigid Body and Aeroelastic Rotorcraft-Pilot Coupling".
- HC/AG-17 "Wake Modelling in the presence of Ground Obstacles" Report 2012

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Handling Qualities

HC/AG-11: Helicopter yaw axis handling qualities modelling



GKN_WHL tail rotor model for DERA
wind tunnel (HeloFlow EU-Project)



Fenestron of Dolphin SA 365N

Combination of tests provided by several partners (WTT, Flight Tests (Bo105, Dauphin)) provided the basis for model improvements and understanding of key physical phenomena to be included.

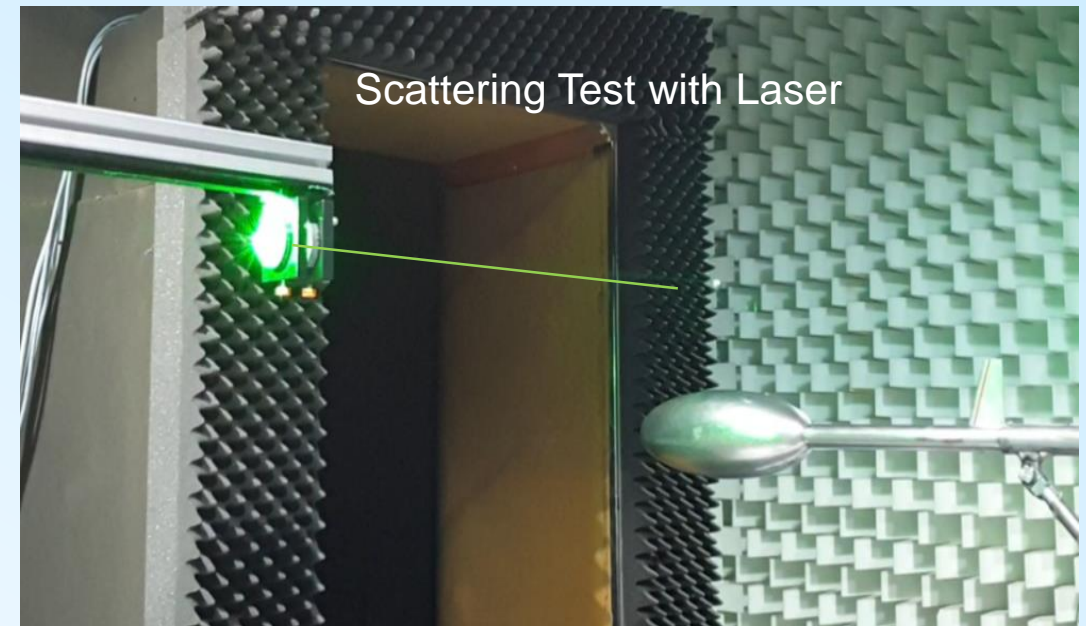
Noise

- 3 AGs on Noise (internal and external)



HC/AG-20: Simulation methods and experimental methods for new solutions for internal noise reduction.

➔ define benchmarks for tools (exp. / num.) for complex designs



HC/AG-24: Helicopter Fuselage Scattering Effects for Exterior Noise Reduction

➔ Provide validation data and validated num. tools for noise scattering

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RC-Pilot Coupling and Sim. Fidelity



HC/AG-21: Rotorcraft Simulation Fidelity Assessment. Predicted and Perceived Measures of Fidelity

Objectives:

- To gain a better understanding of the various components that contribute to the definition and perception of rotorcraft simulation fidelity.
- To develop new criteria for fidelity assessment

Based on several desktop analyses and real-time piloted simulations

HC/AG-16: RIGID BODY AND AEROELASTIC ROTORCRAFT-PILOT-COUPPLING (RPC)

Unexpected oscill. of the pilot-rotorcraft system have become a critical issue for augmented helicopters with modern flight control systems.

→ physical understanding of both rigid body and aero elastic RPC

→ Guidelines and criteria have been defined to prevent or suppress critical RPC

Conclusion and Outlook

- Only very few spotlights presented.
- Retrospective view:
 - In the 70-ties > 2 industrial partners very active in exp. / numerical tasks. Today industrial partners act quite often as observers.
 - EU-projects: today EU-projects target high TRL (e.g. flight demonstration) or greening
- HC/RC-GoR always tried to tackle the hot topics which are on the international rotorcraft research agenda. But: not all ideas → AG.
- Although limited to low TRL, HC/RC GoR supported cooperation and created by this the critical mass to progress relevant topics (AG or EU projects).
→ pushing basic physical understanding and numerical simulation tools to the next higher level.
- Future: Many relevant topics are suited for GARTEUR GoR RC/AGs.