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THE GROUP OF RESPONSABLES "ROTORCRAFT (RC-GOR)": AN OVERVIEW OF ACTIVITIES AND SUCCESS STORIES

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by

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- Why a GoR dedicated to rotorcraft ?
- Structure and management of the Rotorcraft GoR (RC-GoR)
- Main objectives of the RC-GoR
- A brief history of the RC-GoR
- What the future holds
- Conclusions

About GARTEUR

- **Member Countries**:
  - France 1973
  - Germany 1973
  - United Kingdom 1973
  - The Netherlands 1977
  - Sweden 1991
  - Spain 1996
  - Italy 2000

MoU 1981

1 - Objectives

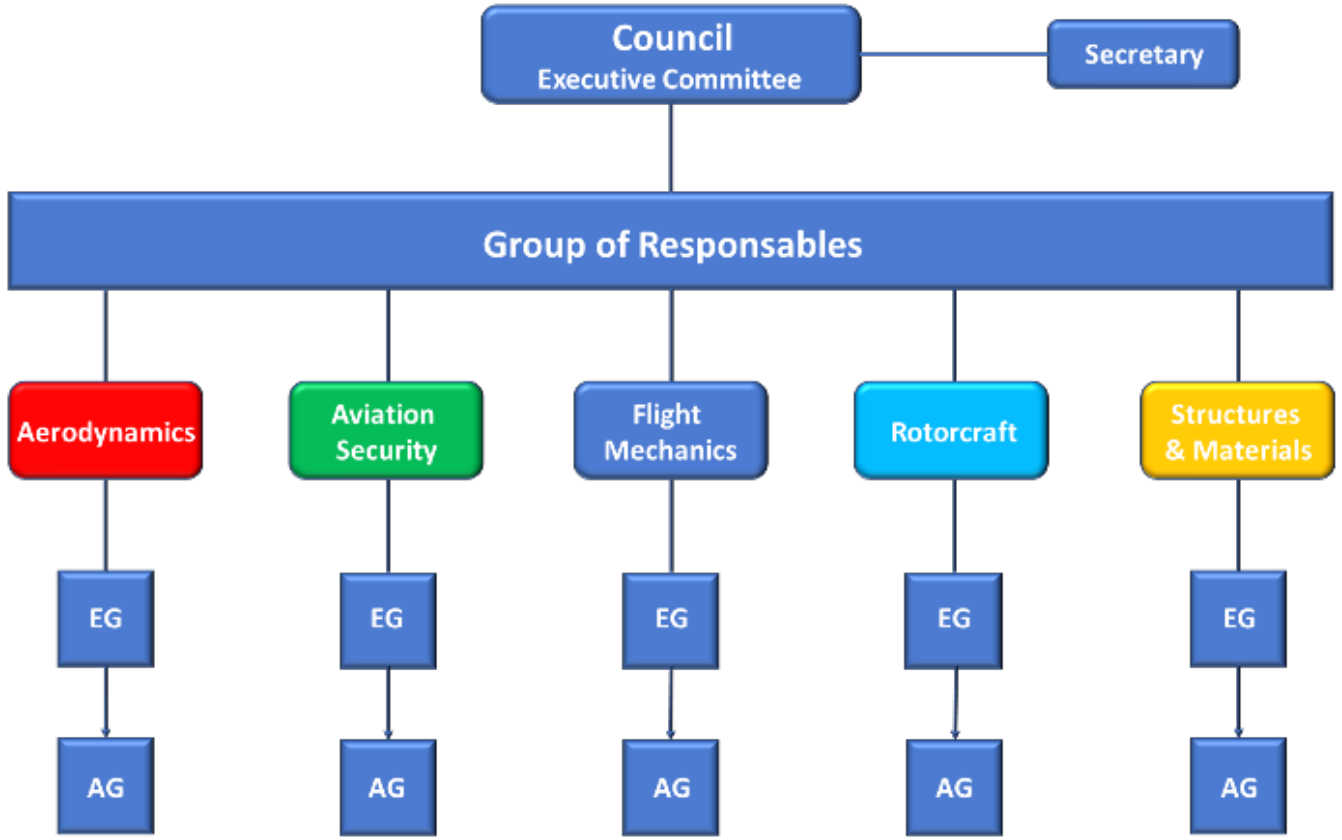
- to strengthen collaboration between European nations with major aeronautic capabilities and industry, for **both civil and military applications.**
- to increase competitiveness of European industry
- to extract the best long-term innovative R&T from upstream research and pull it through for applications in industry.
- to provide a platform and network for scientists to pool technology and knowledge to develop ideas and concepts in various aeronautics areas.
- based on this, to initiate proofs of concept and demonstrations through GARTEUR and other fora such as Framework programmes of the EU for final application by industry

2 - Organization

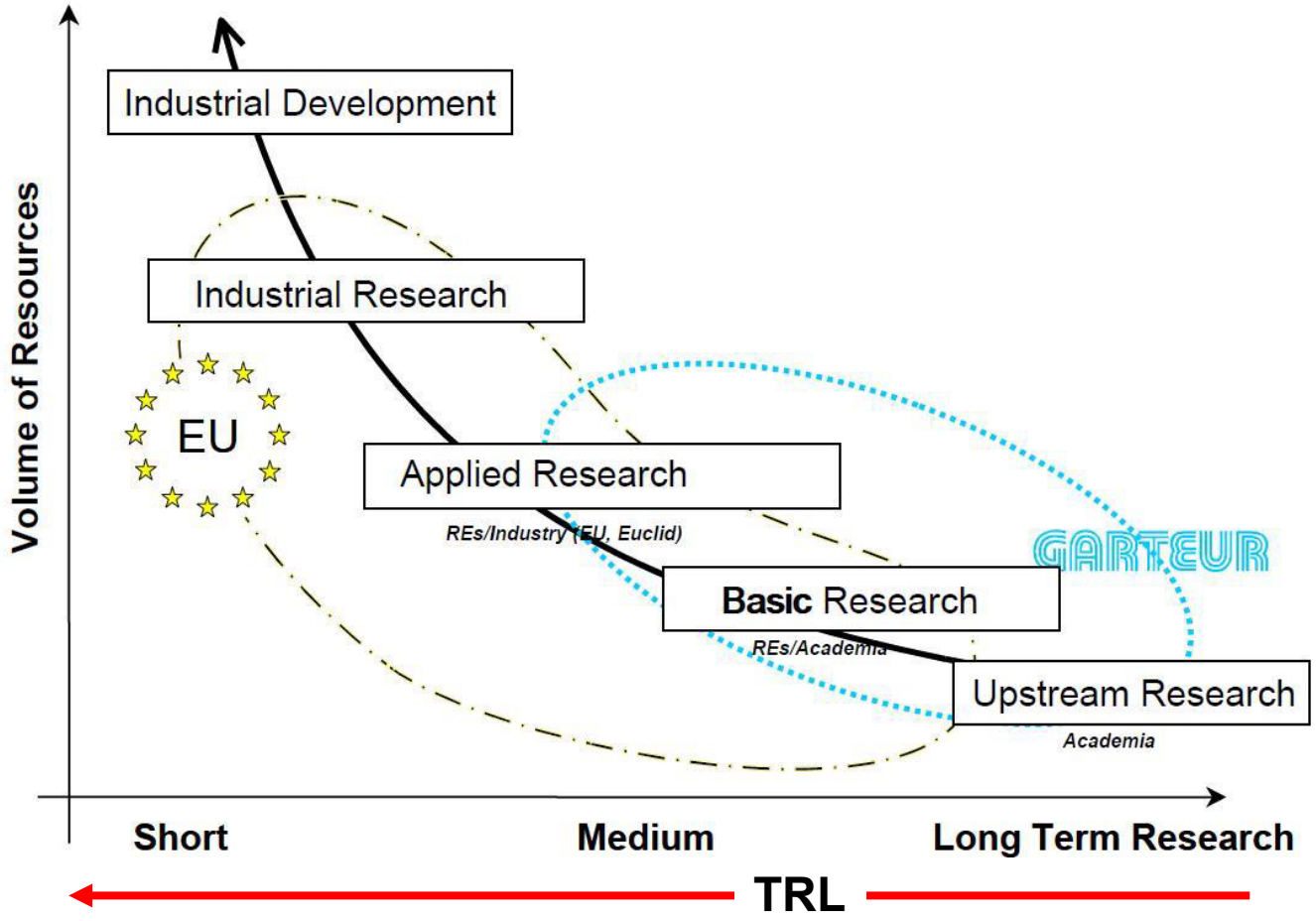
Level 1

Level 2

Level 3



3 - Role

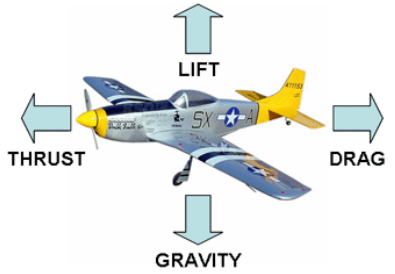

Industrial Development
Industrial Research
EU
Applied Research
REs/Industry (EU, Euclid)
GARTEUR
Basic Research
REs/Academia
Upstream Research
Academia
Volume of Resources
Short
Medium
Long Term Research
TRL

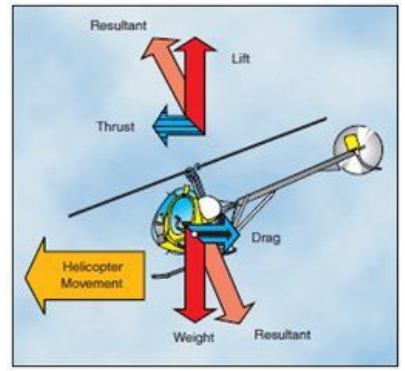
4 - GARTEUR projects peculiarities

- No funding. Each partner provides its own funding for its own tasks.
- Projects open to partners of the 7 member countries…
- … but partners of non member countries can participate upon prior approval of the Council
- Exploratory Groups (EG) have a maximum duration of one year (two meetings).
- EGs are converted to Action Groups (AG) if the project ToR is approved by the Council
- A GARTEUR AG needs participation from at least three GARTEUR countries
- Typical duration of an AG project is 3 years

Why a GoR dedicated to rotorcraft?

- Unlike all the other GoRs, which concentrate their investigations to monodisciplinary topics, the RC-GoR promotes multidisciplinary research activities that are platform-based: rotorcraft
- The reason for it lies in the need to tackle with technological, operational and certification problems of this category of aircraft which require specific competences in the rotary-wing field for their investigation
- A rotorcraft is an aircraft that generates the lifting, propulsive and control forces by the rotation of a set of aerodynamics surfaces, named blades, around a shaft
- Thanks to this peculiarity, a rotorcraft, unlike the fixed-wing aircraft, does not need a translational velocity to fly and is capable of many flight operations that are almost precluded to or inefficiently performed by fixed-wing aircraft, such as pure vertical take-off and landing, hovering flight, and, more generally, to operate in confined areas, in the proximity to the ground and obstacles man-made or natural

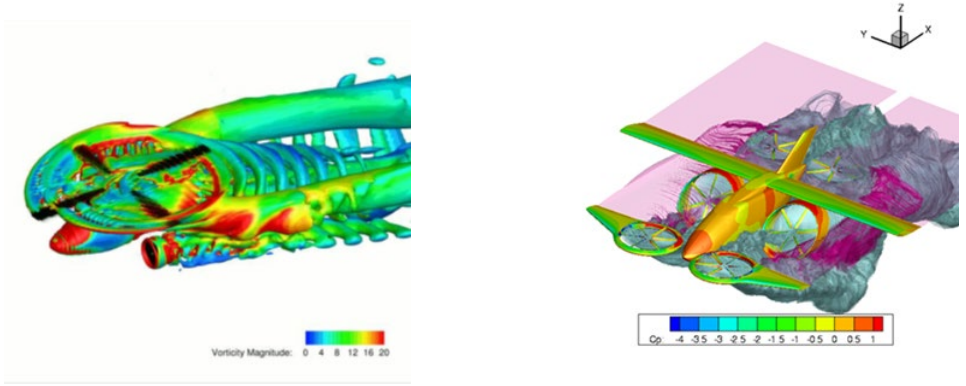




- These unique capabilities allow the helicopters to be employed in several operations and missions for civil and military applications such as: emergency medical services, rescue operations, patrolling, firefighting, law enforcement operations, commuting flight toward oil & gas platforms, ship landings, large wind turbine maintenance operation, VIP and governmental authorities transportation. In addition, with recent transportation trends - specifically, entrusted to multirotor configurations - air taxis and package/parcel services in urban and/or rural areas

Figure 1 – Example of helicopter missions in confined areas

- However, all these peculiarities do not come without a cost.
- Actually, just because of these outstanding capabilities, the rotorcraft is an extremely complex machine:
  - it is hard to study, theoretically and experimentally;
  - it is hard to manufacture and to pilot;
  - it is noisy and relatively slow;
  - it is expensive;
  - it poses serious safety aspects to be carefully addressed, and certification issues, especially when referring to the new eVTOL configurations.
- A characteristic of rotorcraft design is the need for a multidisciplinary approach due to the high level of interaction between the various technical disciplines for tackling the various issues for rotorcraft improvement.



The complex wake systems generated by a compound helicopter (left - Univ. Glasgow) and by a multirotor configuration (right – CIRA). Numerical simulations

Figure 1 – The complex, densely instrumented tilt-rotor model manufactured by NLR (left); its installation in the ONERA S1MA wind tunnel (right). NICETRIP project.

- The main characteristics of rotorcraft are such that this category of vehicles cannot be employed for very-long range flights nor for volume of passengers typical of the airplane commercial flights. For this reason, the rotorcraft market is much smaller than that of the fixed-wing one (in 2021, the global helicopter market was USD 45.21 billion worth vs the USD 128.31 billion of the global commercial aircraft market).
- As a matter of fact, the rotorcraft R&D community, especially the European one, is rather small with lower resources with respect to the fixed-wing world.

1- GoR Rotorcraft Specifics

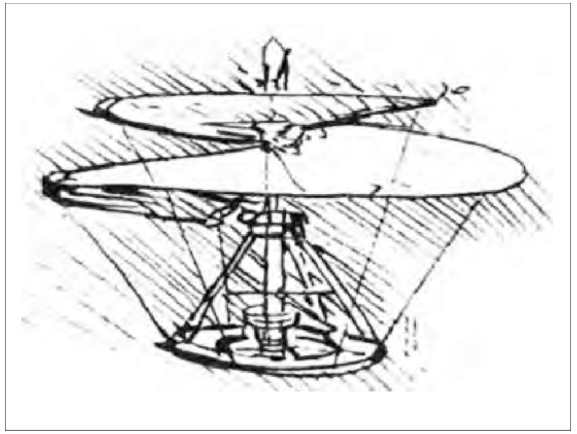
- Participation of the major national research centres and helicopter manufacturers* in the EU with many contributions of universities in the EGs/AGs for both civil and military research
- Think tank for new ideas and their assessment (➔ GARTEUR EG/AG, ➔ other programmes)
- RC-GoR is a forum for “soft” coordination of other collaborative initiatives in Europe e.g. EU Technology Programmes on rotorcraft.
- The RC-GoR is a kernel for ideas for new research projects and supports the preparation of several EU proposals
- Most AGs have multidisciplinary character

UNIVERSITIES

* **Airbus + Leonardo > 60% of the worldwide delivery of civil helicopters**

2 - GoR Rotorcraft members

- ***Antonio Visingardi, Chair – I (7/21 – 6/23)***
- ***Mark White, Vice Chair - UK***
- Klausdieter Pahlke – D
- Arnaud Le Pape - F
- Rainer Heger (representing both D & F)
- Richard H. Markiewicz – UK
- Barbara Ohlenforst – NL
- Presently vacant – I & UK
- Alicia Verónica Barrios Alfonso – SP – New Entry!



Main objectives

1 - RC-GoR overview

- The RC-GoR supports the advancement of civil and defence-related rotorcraft technology in European research establishments, universities and industries through collaborative research activities, and through identification of future projects for collaborative research.
- The RC-GoR initiates, organizes and monitors basic and applied, computational and experimental multidisciplinary research.
- The field for exploration, analysis and defining requirements is wide. It covers knowledge of basic phenomena of the whole rotorcraft platform in order to:
  - Decrease costs (development and operation) through Virtual Engineering using numerical tools based on low-order (analytical, BEM) to high-order (CFD) methods, validated with relevant tests campaigns;
  - Increase operational efficiency;
  - Increase security and safety;
  - Better integrate rotorcraft into the traffic;
  - Tackle environmental issues: Noise and pollution
  - Progress in pioneering: breakthrough capabilities.

2 - Technical disciplines

- Aerodynamics
- Aeroelastics including stability, structural dynamics and vibration
- Flight mechanics
- Control and handling qualities
- Vehicle design synthesis and optimisation
- Human factors
- Internal and external acoustics
- environmental impact and public acceptance
- Flight testing
- Simulation techniques and facilities for ground-based testing
- Simulation specific to rotorcraft
- Icing
- Extension of flight envelope
- Operational Efficiency
- Safety, Survivability, Security
- Passenger comfort
- Cost, Affordability, Time-to-market
- Pioneering
- Etc.

A brief history of the RC-GoR

- The birth of a Group of Responsables dedicated to rotorcraft has a very precise date and place: February 11th 1980 at Farnborough (UK).
- That day, a first meeting to justify a GARTEUR AG concerning helicopter's fuselage drag was held. However, the kick-off meeting of the first AG was held on December 4th, 1981 in Paris.
- Members of this first AG were: Mr. G. Polz (MBB – now Airbus Helicopters), chairman; Mr. J. Amtsberg (DFVLR, now DLR - D); Dr. E.C. Maskell (RAE- now DSTL – UK); Mr. J.J. Philippe (ONERA – F); Mr. A. Vuillet (Aerospatiale Helicopters – now Airbus Helicopters – F), and Mr. F. Wilson (Westland Helicopters – now Leonardo Helicopters – UK).
- The reason for such an AG was motivated by the awareness that the fuselage drag prediction poses serious simulations issues due to the massive and complex flow separation produced by the bluff shape of the fuselage afterbody.
- The numerical simulations were carried out by using potential methodologies coupled, when possible, to semi-empirical models to account for the parasitic drag, being the methodologies Euler-based or the Navier-Stokes solvers in an earlier stage of development and hence not suitable at the moment of the AG activities.
- At the end of the project, in 1985, the final document specifically reads that it was prepared "under the auspices of Responsables for Aerodynamics of GARTEUR" because the activity was still considered as concern of the Aerodynamic GoR.

- The full autonomy was reached starting from the AG-02 launched in 1982, and the new-born GoR was named the **Helicopter Group of Responsables (HC-GoR)**.
- The first AG launched by the HC-GoR, AG-02, was related to a sort of opinion poll, based upon questionnaire replies from organisations representing a significant proportion of the major civil helicopter users, but including only a limited input from military users, to acquire opinions about alternative configurations to helicopters (named advanced rotorcraft, today known as fast rotorcraft) to overcome the operational limits of this aircraft: speed and altitude
- Advanced rotorcraft such as tilt-rotors and compound helicopters were investigated in the AG-05. The main conclusions drawn in the final document, dated 1987, indicated that the tilt-rotor owned the most favourable efficiency and potential compared to the compound helicopter.
- It is also thanks to the outcomes of these two action groups that a long series of European-funded reserach projects related to the tilt-rotor was launched several years later, starting from the end of the 90s with the projects ACT-TILT, ADYN, DART, RHILP, TILTAERO, TRISYD, and NICETRIP, and which still continue today in the framework of the CleanSky 2.

- From the end of the first decade of the new millennium, the research activities of the HC-GoR were also addressed to aspects not directly linked to the aircraft but rather to its interaction with the surrounding environment during specific flight missions.
- The exclusive capabilities of a rotorcraft to operate in hover or to fly in confined areas make this aircraft able to operate in the proximity to the ground and obstacles.
- This peculiarity triggered the interest of the HC-GoR members towards the investigation of a helicopter in ground effect, AG-17 from 2008 to 2012; of the forces generated on the rotorcraft and on the surrounding obstacles as well, AG-22 from the end of 2014 to 2017; of the flight of a helicopter inside a large wind turbine wake system, AG-23 from the end of 2015 to 2018.

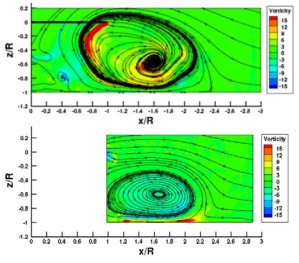


Figure 1 – Helicopter in IGE forward flight. Flow field vorticity. CIRA simulations (top) vs Univ. Glasgow experimental results (bottom)

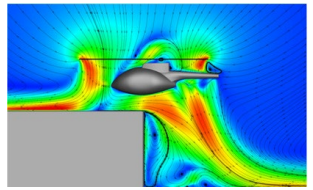


Figure 1 – Politecnico di Milano RANS simulations of a hovering helicopter in the proximity to an obstacle

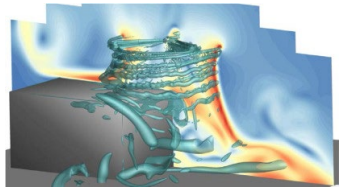


Figure 2 – ONERA RANS simulations of a hovering helicopter in the proximity to an obstacle

Figure 1 – Wind turbine scenario in the DLR helicopter simulations facility

Figure 2 – NLR Helicopter Pilot Station and NREL5 wind turbine wake

Figure 3 – Wind turbine scenario in the Univ. Liverpool simulator

- All these projects benefitted from a strong cooperation among the members who put at disposal several numerical tools for the simulations, ranging from flight mechanics tools to panel methods to the sophisticated Navier-Stokes solvers, and numerous low-budget wind tunnel test campaigns aimed at generating the necessary database for the numerical validation.
- AG-22 turned out to be particularly prolific in publications, more than 30, which continue to grow, Master and PhD theses.
- The paper produced by the AG-22 consortium to show the main outcomes of the project was awarded in 2018 the European Rotorcraft Forum Chairman's award for having the best paper with a focus on international Cooperation at the 43rd European Rotorcraft Forum.

- The first AG that investigated the internal acoustics of a fuselage was the AG-20 in the period 2012-2016. The AG investigated numerically and experimentally the adoption of passive acoustic solutions, such as the trim panels, to control the acoustics of a helicopter cabin.
- Regarding the external acoustics, the AG-24 examined, in the period 2015-half 2019, the main rotor noise propagation in the presence of a fuselage. The activity established an experimental acoustic database and prediction design tools for main and tail rotor noise in the presence of a fuselage, and also included the main/tail rotor interactions.

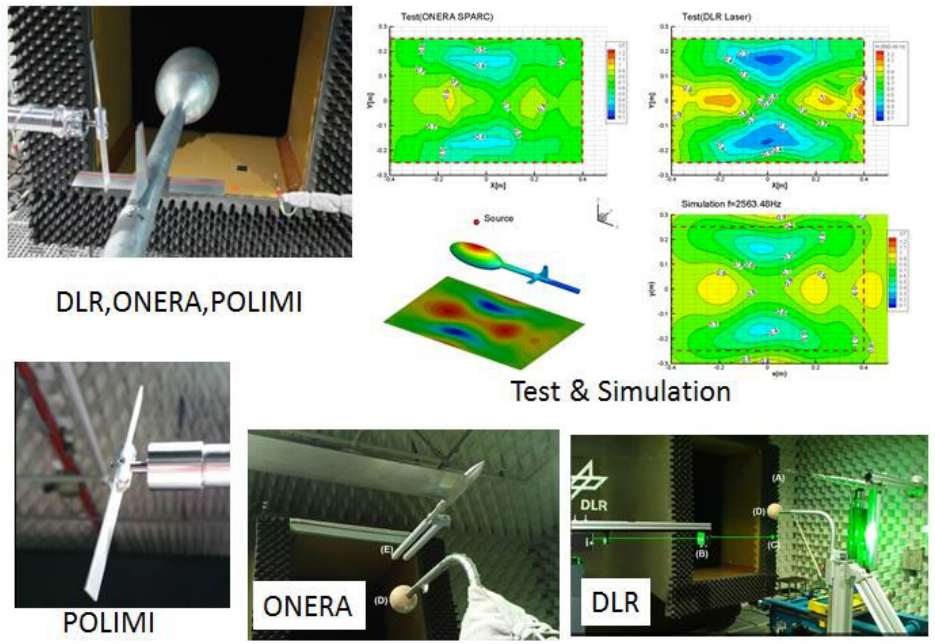


Figure 1 – Numerical and experimental activities in AG-24

- AG-25, started in September 2019, aims at investigating both numerically/experimentally the aerodynamics of rotor/rotor wakes interactions. These kind of interactions occur on fast rotorcraft, but could also appear in UAVs or eVTOL concepts.
- Recently, there is a significant interest and research activities concerning multirotor VTOLs, which differ substantially from the typical main rotor-tail rotor one of a helicopter.
- For this reason, the HC-GoR members deemed more appropriate to change the name of the GoR to **Rotorcraft Group of Responsables (RC-GoR)**. This new denomination was approved by the Council and replaced the old one starting from January 1st 2021.
- AG-26, is the first action group approved by the RC-GoR and is the latest one activated. Its aim is the investigation of the aeroacoustics of multirotor configurations.

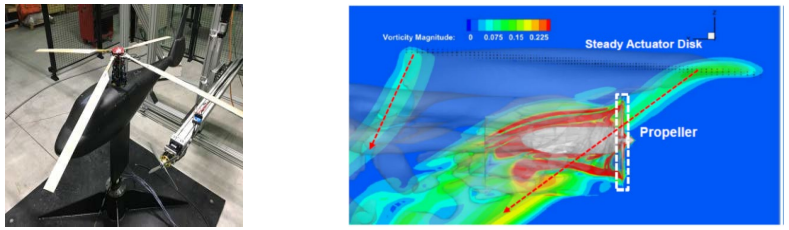


Figure 1 – AG-25: ONERA wind tunnel test set-up (left); Univ. Glasgow CFD simulation (right)

Figure 1 – AG-26: Test rigs for experimental activities. DLR (top left); CIRA-UniCusano (top right); PoliMi (bottom)

- From the first AG project to date, 26 AGs have been launched dealing with the many disciplinary aspects of the rotorcraft, from helicopters, to fast rotorcraft to the recent multirotor VTOLs.

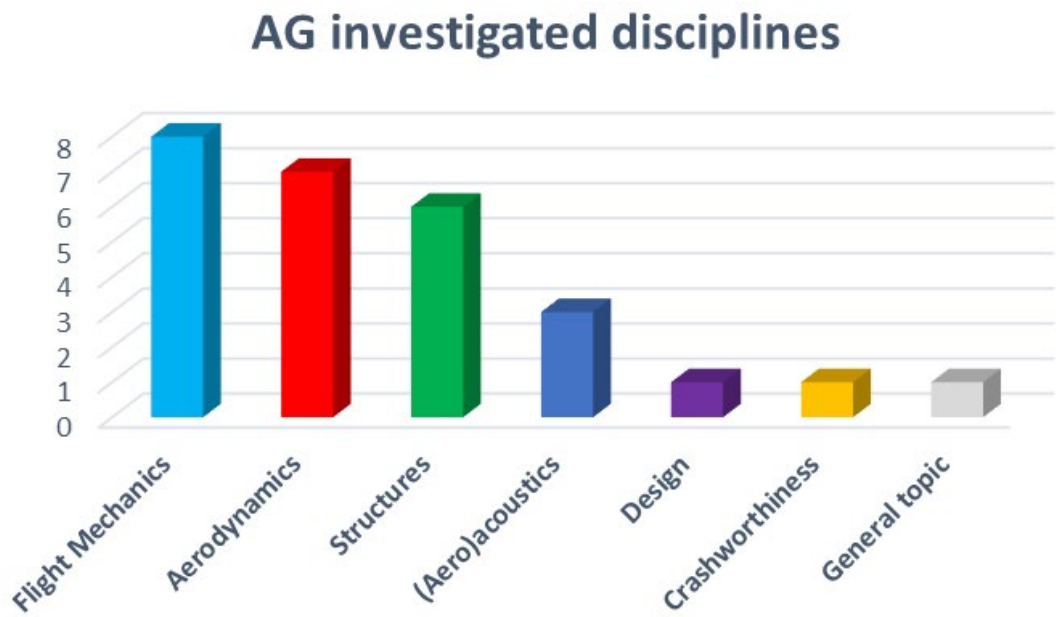
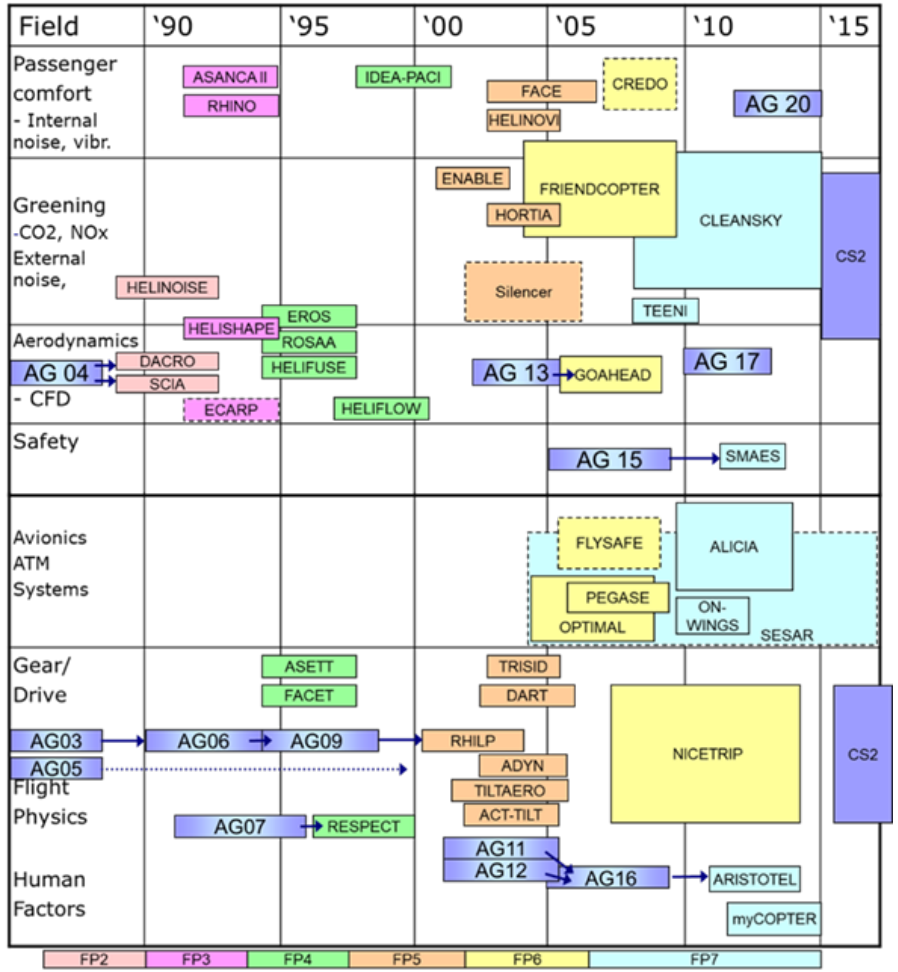


Figure 1 – The disciplines investigated in the Rotorcraft AGs

RC-GoR / EU projects

- Relation between many of the AGs promoted by the HC-GoR and the European funded research projects in 25 years starting from the '90s



EU program overview by Eric Lecomte EC)

What the future holds

The future of the RC-GoR activities is intimately linked to the technological advancements in the rotorcraft field. Three main areas of investigations can be identified:

- **Classical helicopter configurations**:
  - To reduce CO2 and NOX emissions, noise and operating costs;
  - To increase performance, safety and reliability, integration in the air traffic system
- **Fast rotorcraft (tilt-rotors, compound helicopters and coaxial rotors helicopters)**:
  - To mitigate the main technological limits of the conventional helicopter such as low flight speed, range and operating altitude:
- **eVTOLs**:
  - a disruptive electric and multi-rotor technology for Urban Air Mobility.

1 - Industry Needs for the Future (Airbus vision)

- Early noise prediction for:
  - new concepts / new configurations (incl. Air taxis in early architecture phase).
  - Rotor-rotor interaction
  - Rotor installation noise; Ducted rotor / rotor-wing interaction / shading effects
  - Noise propagation / perception
- Gust resilience
- Sense and avoid; sensors and their reliability
- Vertipads; landing on top of skyscrapers

2 – Running Exploratory Groups

- RC/EG-40: Gust Resilience of VTOL Aircraft;
- RC/EG-42: Analysis and Decomposition of the Aerodynamic Force Acting on Rotary Wings

3 - New Ideas for EGs

- Drone impact on Helicopters (rotating parts)
- Human Factor issues and Training methods for complex automation in cockpit
- Installation effect of propeller noise (wing, ducts) in early architecture phase
- PSP/TSP for rotors/propellers (drones, e-VTOLs...)
- Helicopter Icing & De-Icing
- Perception and public acceptance of UAM
- Noise propagation in urban environment (high RPM with high frequency noise)

Conclusions

- The RC-GoR is the expression of the European rotorcraft community, a small yet united one, and aims at supporting the advancement of civil and defence-related rotorcraft technology in European research establishments, universities and industries through collaborative research activities, and through identification of future projects for collaborative research.
- The areas of concern to rotorcraft are such that their investigations require a multidisciplinary approach, which is carried out by a team of experts specifically skilled on rotorcraft topics.
- Born in 1981, and during more than forty years of activity, the RC-GoR has promoted numerous Exploratory Groups forming 26 Action Groups in which the various disciplines of a rotorcraft have been theoretically and experimentally investigated.
- Historical requirements defined the majority of activities devoted to conventional helicopters. However, in recent years there is a growing interest toward fast rotorcraft, and even more toward multirotor configurations that will likely focus the attention of the rotorcraft community in the forthcoming years, especially if UAM is demonstrated to be a viable and successful new concept of air transport.

1- RC-GoR successes

- The RC-GoR, despite its small size, has proven over the years to be a successful group which has had, and is having, the capabilities to promote activities in which the cooperation, despite the lack of funding, has been very successful producing many experimental databases employed to validate the numerical tools applied and improved during the life cycle of the AGs.
- In many occasions, the expertise matured in GARTEUR has been profitably put at disposal of follow-on funded research projects.
- RC-GoR has produced a large number of publications, Master and Doctoral theses, which have enabled students and young researchers to train on the job and to acquire the necessary expertise that will allow them to successfully contribute to the rotorcraft research of the future.
- Modelling capabilities have been developed and validated. They have underpinned improvements across the field of rotorcraft performance, enhancing both military and civil market competitiveness, as well as safety for all users.
- The availability of high quality, well-validated modelling tools is essential to the effective design and development of competitive rotorcraft and it may fairly be claimed that in supporting the creation of such tools over many years, GARTEUR has significantly contributed to place the European industry in the favourable position that it holds in the world market-place today.

2 - RC-GoR concerns

- The industrial contribution should be improved
- The number of helicopter dedicated projects within H2020 has significantly been reduced compared to previous framework programmes
- Rotorcraft topics are not included in the working program for Clean Aviation and that opportunities of a European project dedicated to rotorcraft in Horizon Europe are limited

Acknowledgments

- The Rotorcraft Group of Responsables is grateful to GARTEUR. Thanks to this European initiative a strong collaboration within the small European rotorcraft community can be established to promote research activities able to increase the competitiveness of the European rotorcraft industry.

Thank You

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