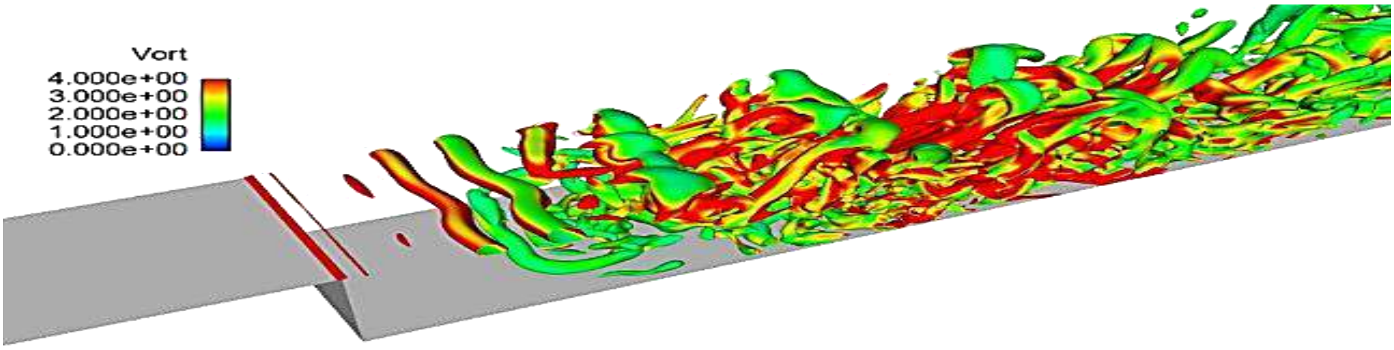
GARTEUR

ANNUAL REPORT 2018



GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE

Front cover image: Stock image and vortex behind the “backward facing step”, outcome of GoR AD - AG54.

Back cover image: Stock image

GARTEUR ANNUAL REPORT 2018

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1 INTRODUCTION

From its creation in 1981, GARTEUR has played a major role in coordination of research on basic technologies in Aeronautical Development in Europe, both for defence and civil applications.

Along the years, Aeronautics has changed, as well as Europe and the rest of the world did. New challenges in politics, economics and technology have raised. They have determined new societal challenges to be met for an ever growing population, with an ever increasing need of transport and communications, while keeping or improving existing levels of safety.

Defence Aviation, on its side, has also seen a major change, with new powers arising and changing the global scenario. Air forces have evolved from Air Superiority as the highest priority, towards a more flexible, deployable, multitask Air Power as it is seen today. New subjects of concern have taken its place and, today, they are menacing lives and lifestyle of Europeans. Safety and security have had to climb new steps of complexity and efficiency in design and operation of aviation elements.

GARTEUR, as a watchtower of technology needs in aeronautics arena and a tool to generate technical response for them, has also changed during the years, sometimes in a subtle way, sometimes more decidedly. Along the years, the work of the Action Groups, set up by the Groups of Responsables across the different specialties, have built up an impressive record of projects dealing with every aspect of the technologies needed for keeping European aeronautical industry at the lead.

However that, the need for GARTEUR to produce technical achievements in line with the demands from the society it has to serve, requires a constant update, or even reinvention, of the Technical Groups involved at different levels.

The GARTEUR Council, as the driving body of all that work, has to support the different technical levels with the authority it may represents. Ministeries, Defence Staffs, Research Institutes and all those involved here, have to be in the core of the impulse of technical activity. All participants are heartily encouraged to be as much active in GARTEUR as they can by providing resources or clearing out the way for the technical work to run smoothingly.

In this way, the new chairmanship proposed for consideration by the Council during the first meeting of the year 2018 to endorse the general feeling of a need for enhancing the running and performance of the organization. This had to be substantiated in several ways of action in identifying and reviewing technical mission and vision, positioning analysis as well as managerial update in the documents produce, website and social networks presence. All these to pave the way to establish a long term Strategic Plan and related Roadmap to fulfil it.

As a first step in that initiative, it was decided during the Spring´18 C64 meeting, to launch an exercise of SWOT analysis in order to have a clear position view of GARTEUR organization, establishing then actions to keep strengths, reduce weaknesses, exploit opportunities and cope with threats. It was expected with this exercise to plan and roadmap the actions required to respond to the rapid and evolving requirements in the Aeronautic arena with highly innovative solutions. We sincerely believe GARTEUR is of paramount importance to foster European countries partnership and collaboration to generate the first germ of the required innovative solutions which eventually will fill in the existing gap in the European programmes in regards of low-to-medium TRLs. The SWOT analysis was accomplished by the workshop held alongside the Autumn´18 C65 meeting in Stockholm.

As part of that Chairmanship and Council envision to the period, it was expected to empower the relationship with other organizations like EASA and EREA finding synergies and collaboration in mutual interests, not covered currently in present day European programmes (for example projects with low TRL R+D+i). In this way, the Chairman of EREA, Mr. Catalin Nae, kindly accepted to join one Council meeting (C65) to present current EREA vision and potential ways of collaboration with GARTEUR.

In the European Research Arena, a new EU Horizon Programme is now approaching and the competitiveness is more and more demanding, now including Defence Funds for collaborative efforts. Opportunities shall rise and they also disappear promptly if collaboration streams are not well prepared.

And, to finalise this brief on our GARTEUR Annual Report, it is needed to be expressed in the name of all GARTEUR community, our condolences to the family, to CIRA and to Italian Aeronautical R&T community, for the miss of Ludovico Vecchione, who was a very active member of this forum from the early moments of the Italian membership until the last time we all met in Rome 2018. His loss is very much heartfelt for all of us who had the opportunity to know him.

2 EXECUTIVE SUMMARY

The GARTEUR Annual Report 2018 provides a summary of the main managerial actions of the Council, and the scientific and technological progress made by the five Groups of Responsables (GoRs). The GoRs constitute the main bodies for establishing research priorities in the technology areas covered by GARTEUR: aerodynamics, structures and materials, helicopters, flight mechanics and systems integration, and security.

Chapter 3 of this report provides a summary of Council activities, including the changes in chairmanship and membership. Section 4 reports on the European aeronautical R&T environment by highlighting the importance of Horizon 2020, Flightpath 2050 and the Strategic Research and Innovation Agenda (SRIA) to civil aviation. Great steps have been taken to streamline aeronautical research in Europe and 2018 saw the mid-term review of H2020 which has aided in the preparatory talks for the H2020 successor programme FP9 to be entitled “Horizon Europe”.

Developments in military aeronautical strategy within Europe are also discussed with information provided on the European Defence Action Plan and Fund, the military perspective on the Single European Sky programme and the benefits that may be available to aeronautic development from EU funded defence research. The close involvement of GARTEUR members with ACARE is also described.

The GARTEUR scientific and technical activities are reported in Chapter 5, with each of the five GoRs presenting a summary of their work during 2018. This document is accompanied by the Annexes to the Annual Report 2018 in which the GoRs present a more detailed account of their activities. The Annexes can be downloaded in digital format via GARTEUR website. Information on the GARTEUR roadmaps can be found in section 6. A list of colleagues who received certificates in recognition of their services to GARTEUR is also included.

3 GARTEUR COUNCIL

3.1 Chairmanship and membership

On the 1st of January 2018, Spain succeeded the United Kingdom as chair of GARTEUR for a period of two years, ending on the 31st of December 2019.

During 2018 the Chairman of the Council was Bartolomé Marqués, INTA's Director for Aeronautical Systems, with Francisco Muñoz, head of INTA's Aeronautical Innovation and Systems Engineering Centre, as chairman of the Executive Committee. Jose Vicente García from ISDEFE served as GARTEUR secretary during 2018.

3.2 GARTEUR Council meetings

GARTEUR Council meetings occur twice a year, with the main Council meeting being preceded by a meeting of the Executive Committee (XC). During the XC the GoR Chairs and XC members meet to discuss the agenda for the Council meeting, reviewing and proposing outstanding actions, shaping the discussion topics in detail, and preparing proposals to the Council.

The Council meetings consist of representatives from the national delegations with the GoR chairs. These meetings provide a vital opportunity for the GoR chairs to inform the Council on the research being undertaken by their Action Groups and Exploratory Groups and to introduce potential new areas of interest.

The Council meetings also offer the member states an opportunity to provide updates and developments at national level in R&T activities and investments in civil and defence aeronautics. The multidisciplinary nature of the Council meetings provides excellent opportunities for dynamic collaboration and exchange of expertise and varied perspectives.

Meetings

- XC160 – 15th February 2018, ONERA, Palaiseau (France)
- C64 – 22nd and 23rd March 2018, Circolo Ufficiali dell'Esercito PIO IX, Rome (Italy)
- XC161 – 24th September 2018, CIRA, Capua (Italy)
- C65 – 8th and 9^{h} November 2018, FOI, Kista (Sweden)

3.2.1 XC160

The first XC meeting of 2018 was held in France, hosted by ONERA in its facilities at Palaiseau on the 15th February. The primary purpose of the meeting was to make an overall review of the status of GARTEUR considering both technical and administrative / organization matter.

During January 2018 was performed the handover for the Chairman from UK to Spain The handover was performed successfully, explaining main operational and administrative aspects (i.e how to deal with the website). The annual report was the only action still open to the UK delegation.

A first high-level objective to perform during Spanish Chairmanship was defined in regards of the GARTEUR role review taking into account:

- Mission and vision as it is currently defined in the basic documents.
- Try to identify the role of Garteur (position paper). It can evolve over the time, i.e 4-5 years.
- Check our position against similar organizations (either in rank, size, orientation), with a strength analysis.
- Develop a roadmap (enrich the current one) and control tools to have a clear track to follow.
- Review all existing assets.

3.2.2 C64

The first Council meeting of 2018, C64, was held in Rome, in the Circolo Ufficiali dell'Esercito PIO IX, on the 22nd and 23th March. In that meeting Francisco Muñoz explained Chairmanship approach to the period 2018-19 with the following lines of action:

1. Consolidate initiatives from previous periods
    a. Setting up a GoR on Aviation Security
    b. Identification of main tracks of research. Roadmap.
2. New impulse
    a. Review of all GoRs. Identification of main needs/obstacles. Support.
    b. Positioning. Survey on and relationship with other Aero research frameworks. EC, NATO STO, EREA, EDA.
    c. Roadmapping effort
3. Organizational issues
    d. Meetings. Structure. Frequency. Confluence at different levels (XC, GoR, AGs, Interdisciplinary)

   e. Reporting and dissemination. Reach. Annual Report.
   f. Website. Social Networks.
   g. Archive and custody.
4. Specific initiatives

It was considered to perform an SWOT analysis for GATEUR, because the world surround GARTEUR in changing dynamically.

Olivier Vasseur presented the influence/impact of scientific GARTEUR publications. As conclusions:

- Continue to foster the identification of GARTEUR works/results in the publications.
- Chinese/Singapore teams cite GARTEUR works/results regularly.
- The publications of GARTEUR are cited by many publications from China and USA.
- The evolution of the studied concepts is pointed out.
- Does the observation of the prominent concepts highlighted in citing articles give us orientations for future works? (GoR Chairs)

Francisco Muñoz also made an analysis of the current status of the 5 GoRs identifying the way ahead.

3.2.3 XC161

The XC161 meeting in Capua, in the CIRA facilities on 24th September 2018. This was the first XC GARTEUR meeting after Ludovico Vecchione, Head of the Italian delegation, regretfully had passed away. Francisco Muñoz read a condolence message draft which was used in the C65 meeting. The topics for discussion of XC161 were focused on three aspects:

- GARTEUR positioning study.
- GoR status review.
- Preparation of the Workshop in Sweden.

In regards to the positioning study, its scope is to try to identify the position (existing and desired) of GARTEUR within other fora /collaborative schemes in Europe and where possible.

This study was presented with the following planned phases:

1. Listing other existing schemes for developing collaborative research studies and low-to-medium TRL projects in Europe (FP, NATO/STO, EDF/PESCO, EREA,…) Identify their characteristics.

2. Inputs/Requirements from big Stakeholders in the Intl Aeronautical environment (ACARE, ICAO, EASA, National Programmes, EDF, …)
3. GARTEUR SWOT Study.
   - Bottom up. GoRs SWOTs
   - Consolidated GARTEUR SWOT
4. Industry Role
5. Matching with Roadmap
6. Conclusions /Recommendations

It was agreed the immediate start of the SWOT analysis.

In regards to the GoR status review, and after the analysis presented during C64, a few actions were derived, individualized for each GoR:

- AD GoR. To encourage them as to endorse initiative for a multidisciplinary AG on highly flexible Aircraft.
- AS GoR. Support for starting their 1st AG on “Cybersecurity for preventing malevolent use of RPAS”.
- FM GoR. Try to convince on setting up new EG/AG including Systems integration of powerplant Electric A/C.
- HC GoR. International workshop on “Forces on obstacles in rotor wake”. Hybrid powerplants for new vertical lift concepts.
- SM GoR. Standardization of Ice Accretion Characterization. Interest in an International working group.

The preparation of the workshop that was performed in Sweden, FOI facilities in Kista, on 7th November 2018 was planned with the following outline:

1. Reviewing initiatives
2. New AGs
3. Interdisciplinary projects
4. Addressing the preparation of SWOT Analysis
5. Reviewing the Roadmap effort
6. Reviewing procedures

3.2.4 C65

The C65 meeting was held in FOI, Kista (Stockholm), Sweden on 8th and 9th November 2018. The meeting was opened with Bartolome Marques's (GARTEUR Chairman) condolences to the family, to CIRA and to Italian Aeronautical R&T community, for the miss of Ludovico Vecchione who was a very active member of this forum from the early moments of the Italian membership until the last time we all met in Rome.

As part of the Chairmanship envision to the period, it is expected to empower the relationship with other organizations like EASA and EREA finding synergies and collaboration in mutual interests, not covered currently in present day European programmes (for example projects with low TRL R+D+i). In this way, the Chairman of EREA, Mr. Catalin Nae, kindly accepted to join us for this meeting to present current EREA vision and potential ways of collaboration with GARTEUR.

Francisco Muñoz presented the results of the workshop performed during the specific session, prior the C65 meeting.

3.3 GARTEUR website

The GARTEUR website is accessible at www.garteur.org and provides information on the mission, principles and background of GARTEUR, along with access to information and reports from the five GoRs. Contact details and information on how to be involved in GARTEUR research are also provided, along with links to the national strategic documents of the GARTEUR countries.

For the use of the GoRs, the site is also used as a repository for minutes and other documents. During 2018 the website was regularly updated by the secretary.

Moreover, during 2018, it has been started a redesign and more features that will give the website a more modern look, performance and security boost and legal compliance by means of:

- Use of a Content Management System (Wordpress) which allows to update the content easier than with the current website.
- Use cookie consent widget and legal pages in order to be fully GDPR compliant.
- Use 2FA (two-factor authentication) in order to ensure security of the website.
- Use SSL encryption to ensure the communication with the website is fully encrypted.
- Use proper SEO (Search Engine Optimization) to increase GARTEUR awareness on web search engines.

The new website is expected to be deployed in production (live website) during Q4 2019 – Q1 2020.

3.4 GARTEUR certificates

In 2018 GARTEUR certificates were awarded to past members of the Council, GoR chairs, industrial points of contact (IPoC) and secretaries, in recognition and appreciation of services rendered to GARTEUR.

France		
Hervé Consigny	Member of the Council	ONERA
Patrice Desvallees	Member of the Council	DGAC
Germany		
Harald Konrad	Member of the Council	Ministry of Defence: BMVg
Friedrich König	Member of the Council	DLR
Thomas Berens	GoR AD Member	Airbus Defence & Space
Italy		
Daniele Cucchi	Member of the Council	Segretariato Generale della Difesa
Sweden		
John Stjernfalk	Member of the Council	FMV - Swedish Defence Materiel Administration
Ebba Lindegren	Member of the Council	VINNOVA

Table 1. Awardees of GARTEUR Certificates.

4 THE EUROPEAN AERONAUTICS RTD ENVIRONMENT

This section provides a brief overview of the European aeronautics RTD environment in both civil aeronautics and military aeronautics.

4.1 Civil aeronautics

Civil aeronautics research and technology development (RTD) in Europe is centred around collaborative research calls performed within the Framework Programmes for Research and Innovation. The current Framework Programme, Horizon 2020, is the biggest research and innovation programme in Europe and offers almost €80 billion in grants, loans and incentives over seven years (2013-2020) for researchers, engineers and entrepreneurs in addition to private investments the programme attracts.

Horizon 2020 is funding a considerable number of initiatives that will have a positive impact on Europe by unlocking innovation, providing the funds necessary to encourage and enable scientific and technological breakthroughs. Seen as a key driver of economic growth and job creation, Horizon 2020 has the political backing of Europe's leaders and the Members of the European Parliament

Aeronautical RTD is funded through a specific Aviation programme within the Transport theme as a Societal Challenge and sets out to tackle some of the main environmental challenges attributed to the aeronautical industry including designing and producing cleaner and quieter aircraft, minimising the impact of transport on the environment. Another key focus of Horizon 2020 is aimed at creating better mobility, less congestion and more safety and security.

Within Horizon 2020, Clean Sky 2 is Europe's dedicated aeronautics research programme with a €4bn budget. Clean Sky 2 represents a Joint Technology Initiative (JTI), a Public-Private Partnership (PPP) that brings together industry (including SMEs), academia and research institutions with the European Commission. Its aim is to develop and demonstrate break-through technologies for the civil aircraft market to cut aircraft emissions and noise whilst securing the future competitiveness of Europe's aeronautics industry.

4.1.1 Strategic direction of European R&I

The European Commission's Flightpath 2050 document outlines long-term goals associated with meeting society's needs for more efficient and environmentally friendly air transport, as well as maintaining global leadership for the European aerospace industry. It is therefore a crucial reference document for organisations in Europe and serves as the basis for the research calls within Horizon 2020 and the research projects that GARTEUR chooses to undertake.

Along with the Flightpath 2050 reference document, the Advisory Council for Aviation Research and Innovation in Europe (ACARE) advises the European Commission on all aspects of aviation research and innovation in Europe and in its role as a European Technology Platform (ETP), it has a specific function to develop an industry-focused Strategic Research and Innovation Agenda (SRIA) for action at EU and national levels.

4.1.2 Strategic Research and Innovation Agenda (SRIA)

The SRIA provides a road map for aviation research, development and innovation in Europe and sets out areas of long-term research that support the Flightpath 2050 goals.

Comprised of two volumes, Volume 1 of the SRIA builds on Flightpath 2050, providing additional detail and explanation around the five central research themes;

- Meeting market and societal needs;
- Maintaining and extending industrial leadership;
- Protecting the environment and the energy supply;
- Ensuring safety and security; and
- Prioritising research, testing capabilities and education.

To tackle these challenges, several goals have been fixed (e.g. for Challenge 1: 90% of the travellers within Europe are able to complete their journey door to door within 4 hours). These are described in Volume 1 of the SRIA[1].

The purpose of volume 2 of the SRIA goes beyond this and describes what needs to be done, turning the high-level goals in Flightpath 2050 and Volume 1 of the SRIA into a series of specific and time-bound research and innovation objectives to guide the work of research and innovation teams across Europe.

4.1.3 GARTEUR and ACARE

In addition to its responsibility for developing the SRIA, ACARE plays an integral role in advancing aviation innovation within Europe by developing policy positions on European aviation initiatives and working closely with European Commission officials to ensure that Horizon 2020 funding calls - as well

[1] ACARE - Strategic Research & Innovation Agenda – 2017 Update Volume 1

as calls associated with the Clean Sky 2 and SESAR Joint Undertakings - are closely aligned with the SRIA.

Members of the GARTEUR Council are also heavily involved with ACARE and this ensures that GARTEUR's research interests are strategically aligned with the SRIA, ensuring that GARTEUR remains focused and committed to the major challenges being addressed by pan-European aerospace research and innovation.

GARTEUR's representatives within ACARE have emphasised that the innovation life-cycle needs to have the right mix of projects at all levels; covering the early, critical part of the innovation pipeline as well as the 'market readiness' associated with high TRL projects.

4.1.4 GARTEUR and EREA

EREA is the Association of European Research Establishments in Aeronautics. The focus of EREA and its members is on TRL 2 to 6 and therefore play a vital role in maintaining and improving the competitiveness of our industry and dealing with societal concern.

EREA proposed a Joint Research Initiative, named Future Sky, in which development and integration of aviation technologies is taken to the European level. Future Sky is based on the alignment of national institutional research for aviation by setting up joint research programmes. Future Sky is structured in six themes: Safety, Quiet Air Transport, Energy, Urban Air Mobility, Security for Aviation and Circular Aviation.

During 2018, EREA created a new group focused on Technology and Research Infrastructures (TRIG, Technology and Research Infrastructures Group).

There are many members of the GARTEUR Council that also are members of EREA, and therefore it the synergies and complementarities are taken into account in a continuous basis.

Mr. Catalin Nae joined a Council meeting to present current EREA vision and potential ways of collaboration with GARTEUR.

4.2 Military aeronautics

The European defence industry represents a large collaborative effort from EU members, as well as non-member states, progressing defence technologies and solutions across a variety of industrial fields, such as aeronautics, land and naval systems and electronics. The defence sector is highly innovative and centred on high-end engineering and technologies, with important cross application that extends into the civil market.

4.2.1 European Defence Agency

The European Defence Agency (EDA) is an intergovernmental agency of the Council of the European Union, comprising all EU members with the exception of Denmark and also including from non-EU member states, Norway, Switzerland, the Republic of Serbia, and Ukraine, through special administrative arrangements. Through close cooperation the EDA seeks to improve European defence by supporting the development of capabilities, and nurturing technology and research to meet future defence requirements, and to promote defence interests in wider EU policies. The EDA operates at ministerial level and connects over 4000 nationally based experts collaborating on defence projects.

4.2.2 European Union-funded defence research

The European defence fund supports the cross-border cooperation between EU countries and between enterprises, research centres, national administrations, international organisations and universities. This applies to the research phase and in the development phase of defence products and technologies. It has 2 strands. Under the research strand, the EU budget will provide funding for collaborative defence research projects. Under the capability strand, the EU will create incentives for companies and EU countries to collaborate on the joint development of defence products and technologies through co-financing from the EU budget.

As a first step, the European defence fund supports collaborative defence research and development through 2 pilot programmes with limited duration and budget:

- The preparatory action on defence research (PADR). The preparatory action on defence research provides grants for collaborative defence research with a budget of €90 million for 2017-2019.
- The European defence industrial development programme (EDIDP). The European defence industrial development programme offers co-financing for collaborative defence development projects with a budget of €500 million for 2019-2020

5 SUMMARY OF GARTEUR TECHNICAL ACTIVITIES

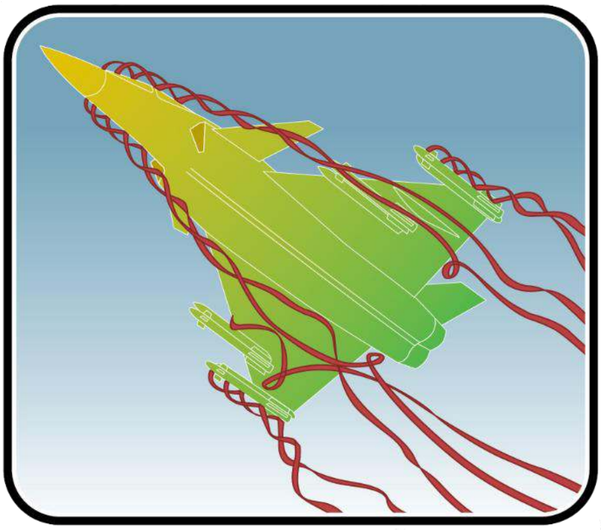
During 2018 the five GARTEUR Groups of Responsables (GoRs) continued to facilitate and deliver vital research in the field of aeronautics. The GoRs are responsible for monitoring and encouraging the progress of Action Groups (AGs) and Exploratory Groups (EGs). These groups are collaborations of researchers from national aerospace institutes, universities and industry. Although GARTEUR is not a source of funding, the GoRs constitute a powerful network and provide a unique forum for aeronautical research in Europe. The GoRs aid potential research consortia by critically reviewing their proposed research objectives and methodologies.

Without the constraints of financial accountability, the GoRs guide early stage research projects consistent with the GARTEUR road-map, which in turn is in line with European aeronautical strategy, while also allowing scope for innovative research and the development of low TRL disruptive technologies. The GoR chairs also encourage multidisciplinary research across the GoRs, with the biannual Council meetings providing excellent opportunities for the exchange of ideas and identification of dynamic partnerships.

The primary task of the GoR is to monitor Action Groups, encourage Exploratory Groups and instigate new ideas. The secondary task of each GoR is interaction with the other GoRs to promote interdisciplinary topics.

New ideas for research may be formulated by GoR members or arise within GARTEUR organisations. As GARTEUR does not offer funding, it is essential that the research is supported by the organisations themselves. Therefore, the GoR critically reviews the research objectives and methodology, but does not select particular topics over others.

Aerodynamics



5.1 Group of Responsables – Aerodynamics (AD)

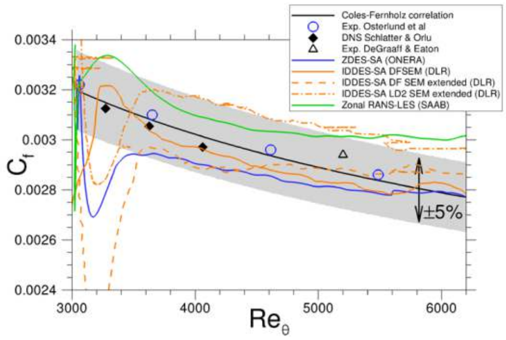
5.1.1 Overview

The GoR AD initiates and organises basic and applied research in aerodynamics. Whilst in general terms aerodynamics makes up the majority of the research done within the GoR, some of its work is multi-disciplinary. This trend is driven by industrial interests, and the importance of multi-disciplinary work is likely to increase in the future.

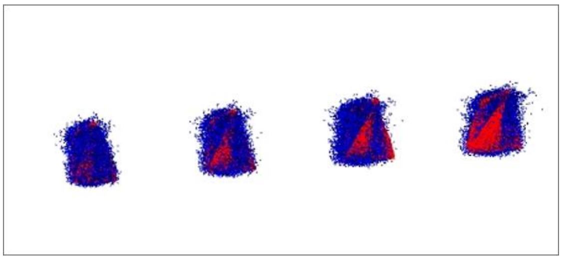
The current scope of the aerodynamic activities in the GoR covers the following:

- Aerodynamics,
- Aero-thermodynamics,
- Aero-acoustics,
- Aero-(servo-)elasticity,
- Aerodynamic shape optimization,
- Aerodynamic systems integration.

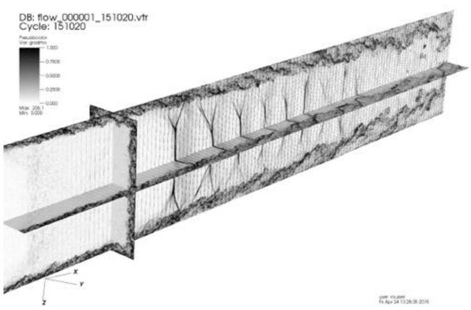
In all fields a synergy between experiments and simulations is aimed for.



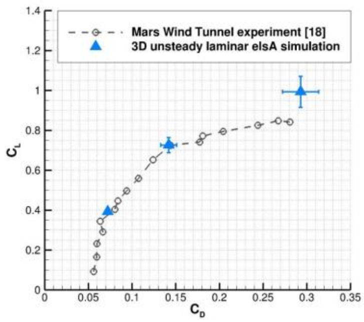
Validation of synthetic turbulence approach for a turbulent boundary layer(AG-54)



Code-to-code comparison of chaff blooming (AG-55)



Supersonic air intakes (EG-75)



Laminar separation bubbles (EG-76)

Figure 1. Illustrations of the Group of Responsables: Aerodynamics.

5.1.2 GoR-AD Activities

In 2017, GoR/AD monitored the following action groups:

AD/AG-51 *Laminar-turbulent transition in hypersonic flows*.
To understand and predict the triggering mechanisms for the transition to turbulence in hypersonic flows. For better predictions of hypersonic flows.

AD/AG-53 *Receptivity and Transition Prediction: Effects of surface irregularity and inflow perturbations*.
To understand the effects of surface irregularities and inflow perturbations for the transition to turbulence over laminar wings. For the improvement and maintenance of natural laminar wings.

AD/AG-54 *RANS-LES Interfacing for Hybrid and Embedded LES approaches*.
To improve the turbulence resolving methods near boundary layers. For better simulations of aerodynamic performance in off-design conditions.

AD/AG-55 *Countermeasure Aerodynamics.*
To understand the aerodynamics of chaff and flares. For improvement of the effectiveness of the countermeasures.

The following Exploratory Groups were active:

AD/EG-72 *Coupled fluid dynamics and flight mechanics simulation of very flexible aircraft configurations*.
To develop and compare aero-servo-elastic models of very flexible aircraft. For the multidisciplinary design and analysis of lightweight aircraft.

AD/EG-73 *Secondary Inlets and Outlets for Ventilation*.
To redesign secondary inlets and outlets. For the reduction of parasitic drag and improved ventilation performance.

AD/EG-74 *Integration of Innovative Nozzle Concepts with Thrust Vectoring for Subsonic Aircraft*.
To investigate the benefits of thrust vectoring for civil and military aircraft. For possible new tail layouts due to increased control authority.

AD/EG-75 *Supersonic air intakes.*

To understand and control the air flow in supersonic air intakes. For better aerodynamic performance of supersonic aircraft.

AD/EG-76 *Laminar separation bubbles*.

To assess RANS turbulence models for laminar separation bubbles. For better simulation for small aircraft or in a Martian environment.

5.1.3 GoR-AD Membership

The membership of GoR-AD in 2018 is presented in the table below.

Chairman		
Harmen van der Ven	NLR	The Netherlands
Vice-Chairman		
Fernando Monge	INTA	Spain
Members		
Eric Coustols	ONERA	France
Giuseppe Mingione	CIRA	Italy
Heribert Bieler	Airbus Operations GmbH	Germany
Bruno Stefes	Airbus Operations GmbH	Germany
Frank Theurich	Airbus Operations GmbH	Germany
Per Weinerfelt	SAAB	Sweden
Magnus Tormalm	FOI	Sweden
Kai Richter	DLR	Germany
Industrial Points of Contact		
Thomas Berens	Airbus Defence & Space	Germany
Nicola Ceresola	Leonardo Company	Italy
Michel Mallet	Dassault	France
Didier Pagan	MBDA	France
Luis P. Ruiz-Calavera	Airbus Defence & Space	Spain

Table 2. GoR-AD Membership 2018.

GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
FRANCE GERMANY ITALY THE NETHERLANDS SPAIN SWEDEN UNITED KINGDOM

AD/AG-53: Receptivity and Transition Prediction: Effects of surface irregularity and inflow perturbations

Action Group Chairman: Ardeshir Hanifi, KTH
Group of Responsables: Aerodynamics

Background

The transition process of boundary layers is mainly characterised by three stages. These are generation, growth and breakdown of disturbances. The process of birth of disturbances inside a boundary layer is called receptivity. Disturbances can be generated by surface roughness or other sources of forcing like free-stream turbulence or the acoustic field. Understanding the receptivity process and ability to accurately model/compute it belong to key issues for a reliable transition prediction. It is noteworthy that commonly used transition prediction methods lack any information about the receptivity.

Programme

Objectives of AD/AG-53

Main objective of the proposed activities is to understand the effects of surface irregularities and perturbations in incoming flow on transition in three-dimensional flows and efficiency of transition control methods. The activities cover both experimental and numerical investigations.

Approach

The activities are grouped under three topics:
• Acoustic receptivity in 3D boundary-layer flows
• Receptivity to free-stream perturbations
• Effects of steps and gaps on boundary-layer perturbations

Experiments on effects of free-stream perturbations using the ONERA D profile. Experimental and numerical work concentrated on effects of steps and gaps. The intention is to use a similar configuration as that used in Bippes' experiments. Numerical investigations of acoustic receptivity in 3D boundary layers. Comparison of direct numerical simulations with simpler methods like linearized Navier-Stokes computations and adjoint methods.

Partners: KTH, FOI, CIRA, ONERA, DLR, Imperial College, Airbus, Airbus Group Innovations
Project duration: September 2013 – December 2016

The Outcomes

Results/benefits

Understanding of capability of existing prediction methods through comparison with experimental and DNS data, and improvement of these computations.

Main achievements

Detailed wind tunnel tests have been performed at ONERA to investigate the effects of freestream turbulence on laminar-turbulent transition on a wing. A change in the instability characteristics is observed when freestream turbulence is increased.

IC has developed a number of numerical tools for receptivity analysis of three-dimensional flows. A number of different flow cases has been investigated, including instability of the flow behind bumps and gaps (ring-wing experiment case).

The ring wing experiments (ALFET project) has been conducted by AGI. A range of gaps with realistic filler depths has been studied and the effect of laminar-turbulent transition was assessed. The results shows, somewhat contrary to expectations, that for a filled gap on a natural laminar flow wing at cruise conditions, there is a marked forward movement in transition for gaps as shallow as D/L=0.02.

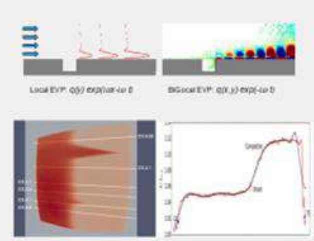
KTH have completed highly accurate simulations of the leading-edge acoustic receptivity, showing pervious results overestimating the receptivity coefficient. KTH has also performed direct numerical simulations of the interaction of acoustic waves with roughness-induced crossflow vortices, corresponding to the experiments performed within the RODTRAC project.

DLR has improved its in-house numerical tools (NoLoT code) for linear stability analysis of boundary-layer flows past forward- and backward-facing steps. Further, in order to experimentally investigate the stability of three-dimensional flows, DLR has designed and performed a set of wind tunnel experiments.

CIRA has further developed its acoustic receptivity tools based on the adjoint methods and investigated an empirical transition prediction method, which is based on the solution of a transport equation for some local flow parameters.

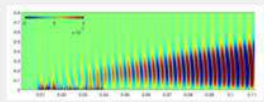
Gap Analysis

BiGlobal Stability Analysis a new approach to solve the spatial modes associated with the flow modifications generated by the step-gap region.

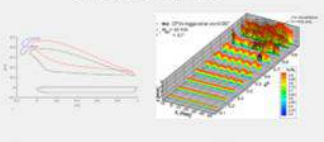


Left: TSP data from the ring wing (ALFET) experiment. Right: The use of TSP intensity ratio to determine transition.

Receptivity model development

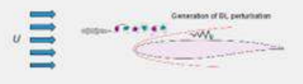


Perturbations generated by randomly distributed surfaces roughness of 5 microns.

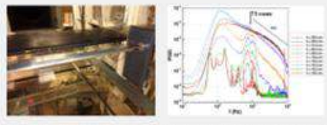


Different designs of the displacement bodies for DLR experiments (left). Visualization of the measured perturbation field (right).

Receptivity & transition experiment

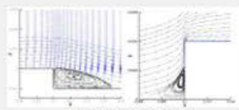


Aim: determine the onset of by-pass transition on a 2D wing due to upstream turbulence increase

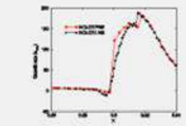


Left: Free stream turbulence was introduced through the turbulent wake of a small wing placed upstream the main wing. Right: Effect of distance from wake on generation and growth of perturbations inside the boundary layer over the ONERA D wing. h is distance between the two wings.

Backward/Forward-facing step



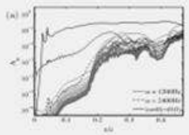
Mean-flow field from CFD.



Disturbance growth rate from PSE and LNS for a flow past a backward-facing step (step at x=0.3)

Leading-edge acoustic receptivity

Direct numerical simulations of flat plate with modified super elliptic leading edge.



Amplitude evolution of the steady and unsteady disturbances for interaction of acoustic waves with surface roughness in the boundary layer over a swept wing.

AIRBUS GROUP · CIRA · DLR · FOI · Imperial College London · KTH · ONERA THE FRENCH AEROSPACE LAB

GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
FRANCE GERMANY ITALY THE NETHERLANDS SPAIN SWEDEN UNITED KINGDOM

AD/AG-54: RaLESin

RANS-LES Coupling in Hybrid RANS-LES and Embedded LES

Action Group Chairman: Professor Shia-Hui Peng (FOI)

Background

Hybrid RANS-LES modelling aims at turbulence-resolving simulations, in particular, for unsteady aerodynamic problems with massive flow separation and extensive vortex motions, benefitting from the computational efficiency of RANS (Reynolds-Averaged Navier-Stokes) and the computational accuracy of LES (Large Eddy Simulation). Its development has been greatly facilitated by industrial needs in aeronautic applications.

Over nearly two decades since the earliest DES (detached Eddy Simulation) model by Spalart and co-workers, a number of alternative hybrid RANS-LES modelling approaches have been developed in previous work**,** being validated in and applied to a wide range of turbulent flows. In the EU framework program, a series of noticeable collaborative work has been dedicated to improved hybrid RANS-LES methods, as well as to applications of hybrid RANS-LES models in numerical analysis of numerous flow problems in relation to, typically, unsteady aerodynamics, flow& load control and aero-acoustics. While hybrid RANS-LES modelling has been proved a powerful methodology in these and other previous work, its weakness and drawback has also been revealed for further improvement

AG54 has been established after EG69 and the work has been set up on the basis of AG49, which has explored the capabilities of a number of existing models in resolving underlying physics of typical aerodynamic flows. AG54 focuses further on effective RANS-LES coupling methods towards novel and improved hybrid modelling and embedded LES modelling.

Partners: Airbus-F, Airbus-Innovations (formerly EADS-IW), CIRA, DLR, FOI (AG Chair), INTA, NLR,ONERA (AG vice-Chair), Saab, TUM, UniMan, ZHAW

Programme/Objectives

Main objectives: By means of comprehensive and trans-national collaborative effort, to explore and further to develop RANS-LES coupling methods in the context of embedded LES (ELES) and hybrid RANS-LES modelling and, consequently, to address the "grey-area" problem in association with the RANS and LES modes and their interaction so as to improve ELES and hybrid RANS-LES modelling for industrial applications.

Work program: The work in AG54 is divided into three tasks. Task 1 and Task 2 deal with non-zonal and zonal hybrid RANS-LES methods, respectively, and an overall assessment of the developed methods is conducted in Task 3.

Task 1: Non-zonal modelling methods

(Task Leader: **NLR**)
For models with the location of RANS-LES interface regulated by modelling (not prescribed), typically, for DES-type and other seamless hybrid methods. Two TCs are defined.

TC M1 Spatially developing mixing layer
Initiated from two BLs of U_1 = 41.54 and U_2 = 22.40 m/s, respectively, with Re_θ = 2900 and 1200. Focus on modelling/resolving initial instabilities of the mixing layer.

TC O1 Backward-facing step flow
Incoming BL with U = 50m/s and Re_h = 40000. Focus on modelling/resolving the free shear layer detached from the step (h = step height).

Task 2: Zonal modelling methods

(Task Leader: **UniMan**)
For models with the location of RANS-LES interface prescribed, Including embedded LES. Two TCs are defined.

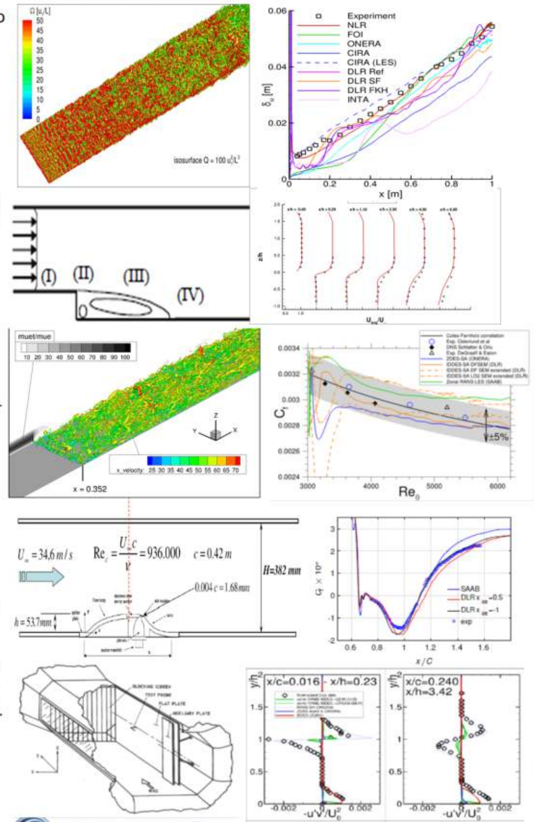
TC M2 Spatially developing boundary layer
Inflow defined with U = 70m/s and Re_θ = 3040. Focus on turbulence-resolving capabilities on the attached BL after the RANS-LES interface.

TC O2 NASA hump flow
Incoming BL has U = 34.6m/s, Re_c = 936000 (c = hump length). Focus on the turbulence-resolving capabilities on the flow separation over the hump.

Task 3: Modelling assessment

(Task Leader: **ONERA**)
Evaluation and assessment of the methods developed in Tasks 1 and 2 with one TC.

TC M3 Co-flow of BL and wake
Re = 2.4×10^6/meter and M = 0.2. Examination of modelling capabilities for a complex flow case.



Results

- **F**urther calibration and evaluation of hybrid RANS-LES methods of zonal and non-zonal modelling in computations of all test cases.
- **I**mproved modelling formulation to enhance turbulence-resolving capabilities with special focus on "grey-area" mitigation.
- **A**ssessment and verification of improved modelling in computations of different test cases by means of cross comparisons.

Summary:
The project kick-off took place in 2014. Since then, AG54 has had four progress meetings with the following results reported by AG members.

- Evaluation of existing baseline hybrid RANS-LES models in TC computations, including SST- & SA-IDDES, HYB0, HYB1, X-LES, ZDES, 2-eq. based hybrid zonal model, 2-velocity method, WMLES, LES, RSM-based hybrid model and other variants.
- For non-zonal hybrid RANS-LES modelling, improvement has been made on, among others, stochastic backscatter model plus temporal and spatial correlation, velocity-gradient-based energy backscatter, vorticity-based length scale and other verified hybrid length scale, commutation terms etc..
- For ELES and zonal hybrid RANS-LES modelling, methods of generating synthetic turbulence has been examined, among others, the synthetic eddy method (SEM) and its improved variant (e.g., DFSEM).
- All test cases have been well defined and experimental data have been used for modelling validation and verification.
- Progress of AG work has been made in line with the plan. Computations of TCs have been progressed well with relevant results reported and in cross plotting of partners results.
- Progress meetings were held in Oct. 2014, Oct. 2015, Nov. 2016 & Nov. 2017, respectively.

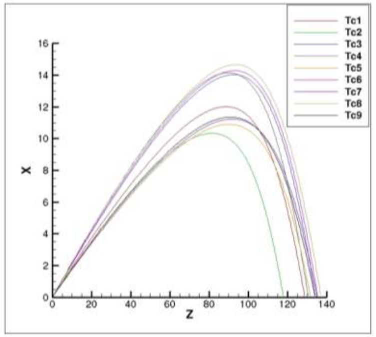
GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
FRANCE GERMANY ITALY THE NETHERLANDS SPAIN SWEDEN UNITED KINGDOM

AD/AG-55: Countermeasure Aerodynamics

Action Group Chairman: Torsten Berglind, FOI (torsten.berglind@foi.se)

The Background

Countermeasures are used to decoy enemy tracking systems. Two commonly used countermeasures are chaff and flares, which are the main focuses of this action group.
Chaff is a radar countermeasure consisting of small pieces or threads of metal or metalized glass fibre. Flares are used against IR-seeking missiles. They are a few decimetres in length and can have built in propulsions systems. In the test cases of this action group, counter-measures are ejected from generic aerial platforms. Their trajectories are significantly affected by the surrounding air.



Experimental flare tracks

The Programme

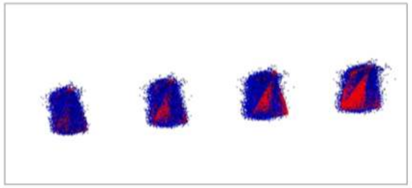
Objectives of AD/AG-55
The main objective is to evaluate computational methods to predict movement of countermeasures. The purpose of predicting chaff clouds is to be able to support development of tactics for usage of chaff. The trajectory of flares are important to predict accurately since the flare might damage the aircraft.

Approach
There are two main methods to simulate chaff dispersion, an Eulerian approach in which the chaff concentration is represented as a scalar field, and a Lagrangian approach in which individual chaff are tracked. Both methods are applied in a separate post processing step, assuming that the countermeasures do not affect main flow field properties.

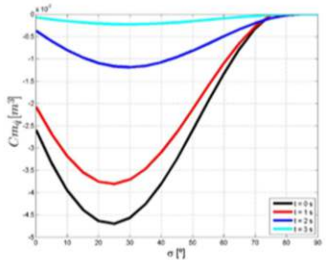
The ejection of a flare involves complicated physics. The cold flare model includes changes in shape, mass, moments of inertia in addition to 6 DoF movement. The hot flare model consists of the same features and in addition includes high boundary temperature flow and exhaust gases. The objective is to determine an appropriate level of modelling the flare that gives sufficiently accurate flare trajectories.

Partners: Airbus Defence & Space, Etienne Lacroix, FOI, MBDA, NLR

Project duration: January 2015 – June 2018



Lagrangian simulation of spherical chaff dispensed from a generic helicopter, FOI's results in blue and NLR's in red. The temporal increment between the chaff clouds is 0.1 sec.



Pitch damping coefficent

The Outcomes

Expected results/benefits
The action group is expected to yield increased understanding of simulation of chaff dispersion and flare trajectory modelling. A natural outcome is also that the partners obtain improved simulation tools

Management issues
One physical meeting, where all member organisations except LaCroix participated, was held at NLR in Amsterdam April 18th and 19th. In addition, four tele-conference meetings where hold on January 31st, June 20th, September 12th and November 8th.
This Action Group has applied for a 6 month extension since some additional computations and the major part of writing the final report remain.
The next tele-conference meeting is planned on February 7th. Eventually, there will be an additional physical meeting in Madrid during spring 2018.

Main achievements
A thorough investigation of deviations between FOI's and NLR's results has led to good agreement of the computational results. Evaluation has started comparing the movement of mass centre and standard deviation of chaff particle clouds.
Aerodynamic databases have been created for both the cold flare and hot flare models. Airbus D&S and MBDA have delivered a model for the aerodynamic damping of the flare.

FOI AIRBUS DEFENCE & SPACE LACROIX Protection Superiority MBDA MISSILE SYSTEMS nlr

Aviation Security

5.2 Group of Responsables – Aviation Security (AS)

5.2.1 GoR-AS Overview

The GoR AS focusses on basic and applied research in Aviation Security, exchanging ideas and experiences matured in different contexts. This topic is quite new in the scenario and expertise and results are spread over different activities. Most of work has a significant amount of multi-disciplinary content especially in domain different from aviation, so a lot of efforts have been dedicated to analyse external sources of information and assess current initiatives on aviation security with the aim to get awareness on the state of the art and build within Garteur a coherent harmonised approach with the external initiatives. This trend is driven by industrial interests, which have been properly analysed and the importance of multi-disciplinary work is likely to increase in the future. Two thesis have been finalised to build a common knowledge on topics of interest in the AS area.

The current scope of the security activities in the GoR covers the following:

- Cybersecurity for aviation critical assets
- Drone as threats and solutions

5.2.2 GoR-AS Activities

In 2018, GoR/AS monitored the external initiatives and some members actively participated in them to support an aviation informed and harmonised approach and related community.

The following Exploratory Group was active:

- AS/EG Malevolent use of drones in aviation asset

The exploratory groups, EG-1 has been endorsed by the GoR/AS and the Council, and started its activities in 2018.

The idea to launch an action group has been matured, it will try to build expertise about the chosen topic to start applying for collaboration opportunities.

The GoR has been working also on the extension of the group to involve UK and Germany.

5.2.3 GoR-AS Membership

Chairman		
Angela Vozella	CIRA	Italy
Vice-Chairman		
Francisco Munoz Sanz	INTA	Spain

Members		
Pierre Bieber	ONERA	France
Rene Wiegers	NLR	Netherlands

Table 3. GoR-AS Membership 2018.

Flight Mechanics, Systems and Integration

5.3 Group of Responsables – Flight Mechanics, Systems and Integration (FM)

5.3.1 GoR-FM Overview

The Group of Responsables for Flight Mechanics, Systems and Integration is active in the field of flight systems technology in general.

The GoR-FM is responsible for all research and development subjects concerning a chain starting from the air vehicles and their flight mechanics, concerning embedded sensors, actuators, systems and information technology, cockpits, ground control and human integration issues, with reference to automation for both inhabited and uninhabited aircraft, including, but not limited to:

Aircraft multidisciplinary design aspects;

- Flight performance, stability, control and guidance;
- Aircraft navigation and mission management;
- Air traffic management and control;
- Integration of remotely piloted systems in the air spaces;
- Safety critical avionics functions and embedded systems;
- Scientific and technical expertise for air systems certification and regulatory aspects.

Noticeably, GoR-FM is not active in the rotary wing domain, where the GARTEUR Helicopter GoR leads.

5.3.2 GoR-FM Activities

The activities in 2018 have been limited to keep exploring new opportunities for joint approach.

The new Exploratory Groups identified in the past are still pending to be activated despite several efforts to staff the groups.

New topics discussed in 2016 were turned into pilot papers during 2017 but no Exploratory Group was established as the FM GoR meeting had to be postponed to 2019. New EGs are expected in 2019 and work has begun to ensure these are commissioned.

At present, topics under consideration are around the following research subjects described in 5.3.3.

5.3.3 GoR-FM Rolling plans

FM GoR Research Objectives	Subjects	CAT	2014	2015	2016	2017	2018	2019
C	Portable avionics	PP						
A	Electric RPAS	PP						
B	Smart RPAS swarms	PP						
A	Upset condition detection, prevention and mitigation	PP						
A	Verifiable adaptive robust control.	PP						
A	RPAS as validation flight test platform	PP						
B	RPAS autoflight	PP						
A	A Non-linear control benchmark EG28	PP/EG			No EGs started, possible restart 2019			
A	A Trajectory V&V Methods EG29	PP/EG						

AG		EG		Pilot Paper	
	Existing		Existing		Existing
	Planned		Planned		Planned

FM GoR Research Objectives - Legend	
A	Development and benefit assessment of advanced methods for analysis and synthesis of flight control systems for aircraft with both conventional and non-conventional aero structural configurations.
B	Development of advanced methods for UAV mission automation
C	Development and benefit assessment of advanced aircraft capabilities into ATM/ATC related applications

5.3.4 GoR-FM membership

Chairperson		
Mr. Martin Hagström	FOI	Sweden
Members		
Mr. Leopoldo Verde	CIRA	Italy
Mr. Philippe Mouyon	ONERA	France
Mr. Bernd Korn	DLR	Germany
Mr. Wilfred Rouwhorst	NLR	The Netherlands
Mr. Jaime Cabezas Carrasco	INTA	Spain
Industrial Pints of Contact		
Mr. Laurent Goerig	Dassault	France
Mr. Philippe Goupil	Airbus	France
Mr. Hans Kling	Saab	Sweden
Mr. Martin Hanel	Airbus Defence and Space	Germany

Table 4. GoR-FM Membership 2018.

Helicopters

5.4 Group of Responsables – Helicopters (HC)

5.4.1 GoR-HC Overview

The GoR-HC 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 GoR-HC initiates, organises and monitors basic and applied, computational and experimental multidisciplinary research in the following areas and in the context of application to rotorcraft vehicles (helicopters and VTOL aircraft, such as tilt rotors, compounds and multicopters) and systems technology.

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 (improve speed, range, payload, all weather capability, highly efficient engines, more electric rotorcraft ...)
- Increase security, safety
    - Security studies, UAVs, advanced technologies for surveillance, rescue and recovery,
    - Flight mechanics, flight procedures, human factors, new commands and control technologies,
    - Increase crashworthiness, ballistic protection, …
- Integrate rotorcraft better into the traffic (ATM, external noise, flight procedures, requirements/regulations)
- Tackle environmental issues:
    - Greening, pollution
    - Noise (external, internal)
- Progress in pioneering: breakthrough capabilities

Technical disciplines include, but are not limited to, aerodynamics, aeroelasticity including stability, structural dynamics and vibration, flight mechanics, control and handling qualities, vehicle design synthesis and optimisation, crew station and human factors, internal and external acoustics and environmental impact, flight testing, and simulation techniques and facilities for ground-based testing and simulation specific to rotorcraft.

A characteristic of helicopter, tilt rotor, compound and multicopter matters 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.

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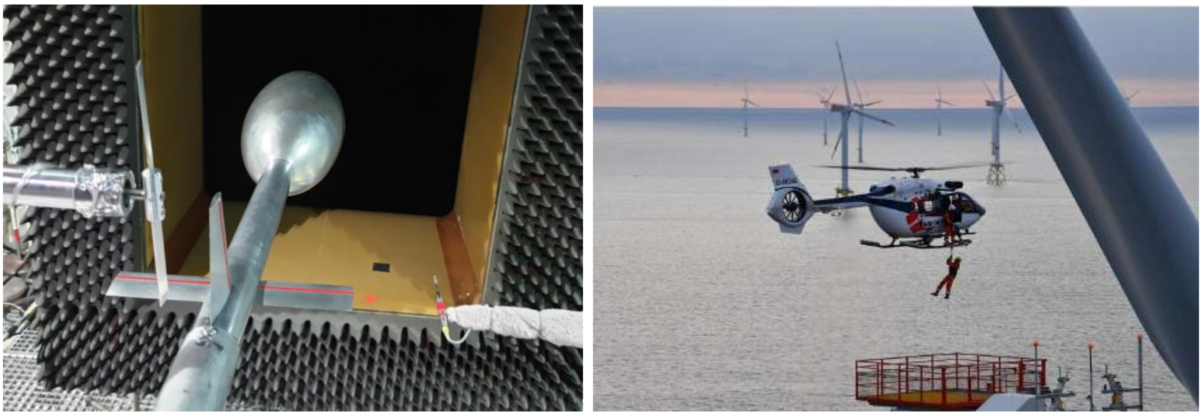


Scattering Test with rotor model(HC/AG-24)

Helicopter in offshore wind turbine mission (www.airbus.com) (HC/AG-23)

Figure 2. Illustrations of the Group of Responsables Helicopters.

5.4.2 GoR-HC Activities

In 2018, GoR/HC monitored the following action groups:

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

Main goal of the project is the development of new simulation assessment criteria for both open-loop predictive fidelity and closed-loop perceived fidelity. Final simulation trials were done in 2016 and analysed in 2017. All technical activities are closed. The final report is expected to be issued 2019.

HC/AG-22 *Forces on Obstacles in Rotor Wake*

The objective is to investigate, both numerically and experimentally, the interactional process between a helicopter rotor wake and the surrounding obstacles and the evaluation of the forces acting on these obstacles. All experimental activities were

	completed in 2017 and the numerical simulations have been finished. The final report was issued in March 2018.
HC/AG-23	*Wind turbine wake and helicopter operations* The objectives are the analysis of the behaviour of helicopters in a wind turbine wake, the identification of the safety hazards and the definition of measures to mitigate identified safety issues. Partners have updated their computational flow and flight mechanics tools. Turbulent unsteady wind turbine wake fields have been computed and have been used to assess handling qualities of helicopter – Wind Turbine wake encounters. Piloted simulations have been performed. The final report is expected in the first quarter 2019.
HC/AG-24	*Helicopter Fuselage Scattering Effects for Exterior/Interior Noise Reduction* The main objective is to examine 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 influence of a fuselage (2016-17 activities) and also include main/tail rotor interactions (on-going). The last test campaign initially planned for September/October 2017 was postponed to I/2019.

5.4.3 List of Exploratory Groups

The following Exploratory Groups were active:

HC/EG-36	*Rotor-Rotor Wake Interactions* To investigate, both numerically and experimentally the effect of rotor / rotor and rotor / propeller wakes interactions on high speed rotorcraft operating in low speed conditions with the aim to establish low order models to be used in pre-design phases of advanced rotorcraft vehicles or in comprehensive codes.
HC/EG-37	*Noise Annoyance Generated by Helicopters* To study the annoyance of helicopter noise on populations. The group considered how to perform listening tests and estimate annoyance through lab tests, using measured and/or predicted helicopter noise data. After several meetings it turned

	out that due to limited resources only a subcritical volume of activities could be achieved and the group was closed without producing the ToR for an AG.
HC/EG-38	*Verification & Validation: Metrics for the Qualification of Simulation Quality* To define metrics for the qualification of the quality of rotorcraft simulations, as a contribution to the Verification and Validation (V&V) process of numerical codes.
HC/EG-39	*Testing and modelling procedures for Turbulent Boundary layer noise* To identify ways how to reduce the flow induced noise in rotorcraft

5.4.4 List of New Topics

New topics which are under consideration are:

Acoustics of drone / e-VTOLs (noise sources) To understand, predict and reduce the noise of drones / eVTOLS.
Modelling of electric systems for e-VTOLS (pre-design) To provide simple relations for considering the electric system of eVTOLS in predesign.
Drone impact on Helicopters (rotating parts) To gain insight in the severity level of drone rotor blade interactions.
Ice accretion and performance prediction on rotary wings To improve the assessment of performance degradation when flying with rotorcraft in icing conditions.
Human Factors issues and Training methods for complex automation in cockpit To improve the overall performance of the pilot / rotorcraft system in accomplishing misisons
PSP/TSP for rotors/propellers (drone,e-VTOLS...) To assess the potential and the limitations of pressure and temperature sensitive paint in rotorcraft wind tunnel tests.

5.4.5 GoR-HC Membership

The membership of GoR-HC in 2018 is presented in the table below:

Chairperson		
Philippe Beaumier	ONERA	France
Vice-Chairman		
Klausdieter Pahlke	DLR	Germany
Members		
Mark White	University of Liverpool	United Kingdom
Joost Hakkaart	NLR	The Netherlands
Lorenzo Notarnicola	CIRA	Italy
François Xavier Filias	Airbus Helicopters	France
Rainer Heger	Airbus Helicopters	Germany
Antonio Antifora	Leonardo	Italy
Observer		
Richard Markiewicz	DSTL	United Kingdom

Table 5. GoR-HC Membership 2018.

GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
FRANCE GERMANY ITALY THE NETHERLANDS SPAIN SWEDEN UNITED KINGDOM

HC/AG-22: Forces on Obstacles in Rotor Wake

Action Group Chairman: Antonio Visingardi (a.visingardi@cira.it)

Background

Helicopters are routinely employed in missions within "confined areas", regions where the flight of the helicopter is limited in some direction by terrain or by the presence of obstructions, natural or manmade. Rescue operations, emergency medical services, ship-based rotorcraft operations are some examples of near-ground and near-obstacle operations.

The wind conditions, the distance of the helicopter from the obstacles, and the height of the helicopter from the ground are the main factors due to which the wake generated by the obstacle in the vicinity of the ground may result in: high compensatory workload for the pilot; degradation of the handling qualities and performance of the aircraft; unsteady forces on the structure of the surrounding obstacles. These forces are of aerodynamic nature and arise from the interaction between the wake induced by the rotor and the airflow around the obstacles.

A helicopter sling load is another, however particular, case of obstacle subject to forces produced by its interaction with the rotor wake. Once airborne a sling load comes under the influence of aerodynamic forces and moments associated with its size, shape, mass, and transport speed. The instabilities that can arise from these forces affect the rotorcraft and/or the load itself and their avoidance is therefore crucial not only for safety reasons, but also when a controlled attitude of the load is required.

Several publications address the problem of the helicopter ground effect in confined areas, the majority of them concerning investigations of the helicopter-ship interactional problem. Nevertheless, references of the evaluation of forces acting on obstacles in rotor wake are scarce. Likewise, there are few experimental databases for the validation of numerical methodologies, their accessibility is uncertain, and do not provide force measurements on obstacle surfaces.

Programme/Objectives

The principal objective of HC-AG22 was then to promote activities which could contribute to fill these gaps. This was accomplished by investigating, both numerically and experimentally:

- the effects of the confined area geometry on a hovering helicopter rotor from the standpoints of both the phenomenological understanding of the interactional process and the evaluation of the forces acting on surrounding obstacles;
- the downwash and its influence on the forces acting on a load, loose or sling, at low to high separation distances from the rotor disc.

The project, started in November 2014, had a duration of three years during which the following activities were carried out:

- application and possible improvement of computational tools for the study of helicopter rotor wake interactions with obstacles;
- set-up and performance of cost-effective wind tunnel test campaigns aimed at producing a valuable experimental database for the validation of the numerical methodologies applied;
- final validation of the numerical methodologies.

The work programme was structured in four work packages:

- WP0 – Management & Dissemination;
- WP1 – Preliminary Computations & Code Enhancements;
- WP2 – Experimental Test Campaigns:
  1. HOGE/HIGE rotor with a loose/sling load (at CIRA);
  2. HIGE rotor in proximity to a square-shaped obstacle (at ONERA);
  3. HIGE rotor in proximity to an obstacle in wind-on conditions (at PoliMi);
  4. HIGE rotor in proximity to an obstacle in wind-off conditions (at Univ. Glasgow).
- WP3 – Final Validation of Codes.

Results

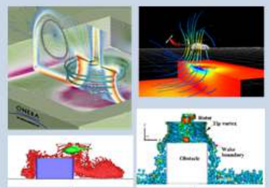
An extremely fruitful cooperation was set among all AG-22 partners. Each partner produced itself in an effort well beyond what was proposed at the beginning of the project.

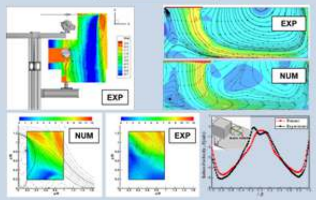
Four valuable databases were produced by investing a relatively low amount of their own internal funding, and using their own laboratory/wind tunnel facilities

A complete set of measurements was employed to quantify the changes in performance of a helicopter rotor together with the pressure distributions - and then the forces - acting on an obstacle during the flight in mutual close proximity. PIV and LDA measurements were made in order to quantify and visualize the interactional process between the rotor wake and the obstacle. This gave the partners the opportunity to: 1) deepen the knowledge of this complex interactional phenomenology; 2) enable the validation of the computational tools employed for the numerical simulations.

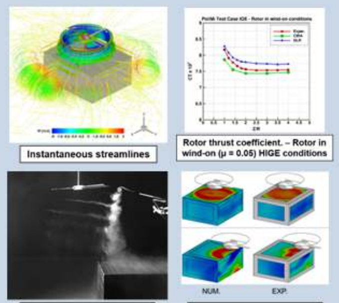
All partners applied and, when necessary, upgraded their own computational tools to numerically simulate these flight conditions of a helicopter rotor.

The full range of methodologies was investigated: from the simpler and faster flight mechanics-based solvers to the sophisticated but significantly more computational demanding Navier-Stokes solvers, with the additional purpose to set the limits of applicability of the various methodologies.





All methodologies proved to be able to evaluate the rotor thrust in almost all the flight conditions investigated. The URANS Navier-Stokes solvers were also fully able to accurately evaluate the pressure distributions induced by the rotor wake on the obstacle and the flow field structure downstream of the obstacle. Instead, the inherent inability of the panel methods and flight mechanics-based solvers to take account of the viscosity and compressibility effects was clearly highlighted. Nevertheless, possible solutions were proposed despite not all implemented during the project: the use of 2D look-up tables could overcome the problem of evaluating the torque of the rotor; the explicit modelling of the wake generated at the obstacle's edges for viscous reasons could be a reasonably effective means to improve the evaluation of the pressure distributions on the side faces of an obstacle and of the flow structure downstream of the obstacle.



Finally, AG22 also represented an occasion for training young researchers who provided their lively contribution to the project activities. In particular, two master thesis and a doctoral thesis, were specifically dedicated to the experimental investigations of this topic.

Members of the HC/AG-22 group:

A. Visingardi, F. De Gregorio	CIRA
T. Schwarz	DLR
R. Bakker	NLR
S. Voutsinas	NTUA
Q. Gallas, R. Boisard	ONERA
G. Gibertini	Politecnico di Milano
G. Barakos, R. Green	University of Glasgow

GARTEUR Responsable:

K. Pahlke	DLR

GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
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HC/AG-23: Wind Turbine Wakes and Helicopter Operations

Action Group Chairman: Richard Bakker (richard.bakker@nlr.nl)

Interest of the research

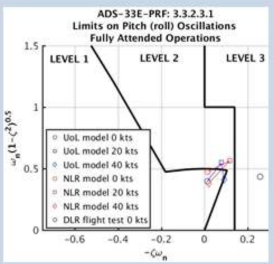
AG-23 investigates the impact of large wind turbine wakes on the flight safety of rotorcrafts.

Background

The amount of energy produced by wind turbines is still on the rise and seems to continue to do so in the near future. In addition the rotor size of wind turbines increases, with current rotor diameters that may range up to 126m.

At the same time we see the development that helicopters operate more and more in non-regulated airspace with the advent of medical air services, police surveillance and fire fighting helicopters etc., where they may encounter the air wakes from wind turbines.
More and more wind farms consisting of a large number of wind turbines are spreading across the North Sea. Also the military with their low level flying exercises are more likely to come upon the wind turbine wakes at some moment in time. Ultimately the likelihood of air traffic encounters with wind turbine wakes is increasing, showing the need for a detailed study on the interactions of rotorcraft and the wind turbine wake.

An extensive study of the wind turbine wake and its effect on helicopter flight with regard to stability, handling quality and safety has not yet been performed. The Action Group under the Garteur Group of Responsables Helicopters (GoR-HC) will aim to investigate the issue. This will be done by performing a survey on the wind turbine wake characteristics and using this data for the identification of relevant flow phenomena for the study of its effects on rotary flight.



Programme/Objectives

Objectives

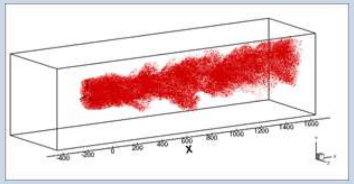
Despite the amount of literature on both wind turbine wakes and helicopter – fixed wing tip vortex encounters, not much research has been done on the interactions of wind turbine wakes and helicopter flight.
The aim of the Action Group is to set up a team of researchers from universities and research institutes to cooperate and perform the following activities:
•Perform a survey of available experimental and analytical wake data for typical wind turbines. Collect and assemble the data to produce a database of wind turbine wake properties. Identify appropriate wake characteristics with regard to the effect it has on the helicopter flight characteristics
•Define representative test cases for a wind turbine and helicopter combination. Several combinations of small/large helicopter and wind turbines, depending on available experimental data, available helicopter models, pilot-in-the-loop facilities etc. should be considered
•Perform computations and piloted simulator experiments and analyse the effects of wind turbine wake on the stability, handling qualities and safety aspects of a helicopter
•Validate the results of the computational tools and simulator trials with available experimental data.
•The group should provide recommendations for legislation and disseminate the findings to the appropriate authorities and parties concerned.

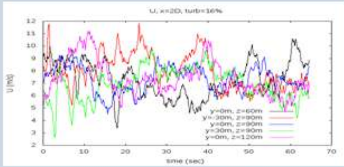
Programme

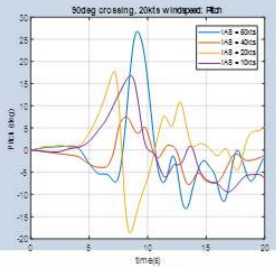
The programme consists of 5 work packages

0. Project Management and Dissemination
1. Wind turbine wake identification
2. Wind turbine wake experiments and computations
3. Helicopter - Wind turbine off-line simulations
4. Helicopter - Wind turbine wake piloted simulations.

The kick-off of the Action Group HC-AG23 took place 6 November 2014







Results

- Partners have updated their computational tools and have computed (turbulent) unsteady wind turbine wake fields
- Experimental data and calculated wind turbine wake velocity fields were shared, and have been used to harmonize the off-line simulation activities with a common wake velocity field
- Handling qualities of the UoL/DLR/NLR BO105 reference helicopter, have been compared w.r.t. stability, bandwidth, response, coupling etc. to use as a common helicopter reference model
- Piloted simulations have been performed or are being prepared
- WTN 250 Offline (Virtual Airdyn) and Piloted simulations show serious degradation of handling qualities levels. Considerable pilot effort at lower helicopter speeds with 30 knot wake
- NREL 5MW piloted simulations show rating 3 and higher for WT wake crossing (work on-going)

Members of the HC/AG-23 group are:

G. Barakos	University of Glasgow
M. Pavel	Technical University Delft
A. Visingardi	CIRA
P. M. Basset	ONERA
F. Campagnolo	Technical University Munich
M. White	University of Liverpool
S. Voutsinas	NTUA
B. Van der Wall	DLR
R. Bakker	NLR

GARTEUR Responsable:
J. Hakkaart NLR

UNIVERSITY OF LIVERPOOL · TU Delft · TECHNISCHE UNIVERSITÄT MÜNCHEN · NLR · ONERA THE FRENCH AEROSPACE LAB · CIRA · DLR

GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
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HC/AG-24: Helicopter Fuselage Scattering Effects for Exterior/Interior Noise Reduction

Action Group Chairman: Jianping Yin (Jianping.yin@dlr.de)

Background

A negative undesirable by-product of the helicopter during its operation is noise generation. Both the main and the tail rotors (including Fenestron) of a helicopter are major sources of noise and contribute significantly to its ground noise footprint. With rising concern for environmental issues and increasingly stringent noise regulation, helicopter noise has gained importance in comparing with performance, safety and reliability.

The main research effort in the past was concentrated on the helicopter rotor noise generation and the reduction of the noise. Extensive work, both theoretical and experimental helped to deepen the understanding of the noise generating mechanisms. Even though the scattering of noise generated by helicopter rotors has been recognized as a significant influence on the noise spectra and directivity, the research effort towards the scattering of noise, especially the scattering of tail rotor noise has not been studied extensively.

To accurately predict the effective helicopter external noise under the influence of the fuselage, advanced analysis tools that overcome the so-called free-field limitation of classical acoustic analogy methods are required. For this purpose, validations of the tools with the experiment data need to be conducted. Until now little activities for generating such database for validation are conducted. Moreover, the evaluation of the scattered acoustic field is of interest for the prediction of the internal noise in the fuselage and its vibrations that, in turn, are a source of interior noise. In addition, the possibility to develop and install acoustically treated panels (liners) on some parts of the fuselage and thus estimate the effect of a wall impedance on the external noise levels, require a particular care in the choice of the wave model. Concerning the helicopter interior noise, vibro-acoustic numerical analyses of different physical sophistication levels require the accurate knowledge of the acoustic pressure distribution on the external skin of the fuselage, and this can be only predicted through an accurate external noise computation.

Programme/Objectives

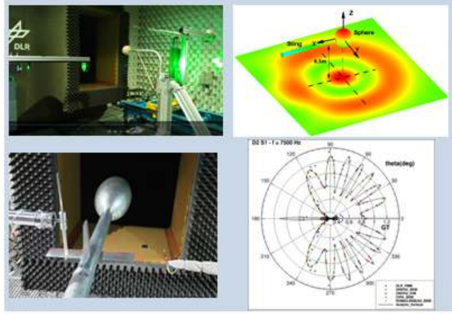
Objectives

The present research work will address noise propagation in presence of the fuselage. The principal objective of HC-AG24 is then to promote activities to:

- establish unique quality database - for unsteady scattered acoustic pressure on the fuselage and in the far field as well as flow field, including flow refraction and convection effect;
- validated prediction design tools for main and tail rotor noise under influence of fuselage - including main/tail rotor interactions;
- proof of rotor noise reduction through adding acoustic absorbing liner on the part of fuselage.

The timescale for the project is three years during which the following topics are to be addressed:

- Investigate the capability and reliability of tools capable of predicting the effects of noise scattering problems;
- Perform computations of numerical benchmark cases and incorporation of the convective flow effects;
- Study the possibility to account for a surface impedance;
- Define representative test cases for generating a data base with a generic configuration, including sound pressure and flow field data



The work programme is structured in three work packages:

➢ WP 1: Simulation on the acoustic scattering effect

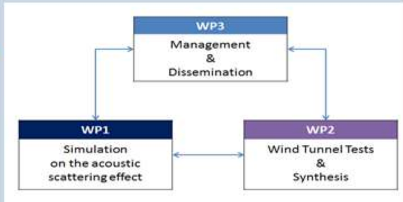
- Code adaptation & prediction
- Code validation & improvement of prediction tools
- Evaluation of noise scattering of various components using validated codes

➢ WP 2: Wind Tunnel Tests & Synthesis

- Model preparation
- Test preparation
- Model setup and installation
- Test matrix & instrumentation
- Test conduct
- Test data compilation & distribution
- Test data analysis

➢ WP 3: Management & Dissemination

- Action group Management
- Exploitation & Info dissemination
- Technology Implementation Plan (TIP)



Results

The action group started the activities in 1st of January 2015.

Six technical review meetings were conducted since the beginning of the action group. The following results were achieved during this period:

1. Description of available analytical, experiment test cases including database completed and distributed;
2. The common simulations for the sphere and NACA0012 wing scattering defined and the results comparied with the test. In addition the comparison results published in ERF 2016, 2017;
3. The Sphere scattering tests composed of 3 spheres, two support systems, and two noise sources were conducted and the results published in ERF 2016; Model tail rotor were manufactured, tested and published in ERF 2018;
4. Specifications on the test for the GARTEUR helicopter scattering defined. The generic helicopter were manufactured; tests for generic helicopter with three different sources has been conducted in 2019 at DLR Acoustic Wind Tunnel Braunschweig (AWB);
5. GARTEUR activities on acoustical methods and experiments is published in 2018 CEAS Aeronautical Journal;
6. 9 publications and 8 reports related to group were produced

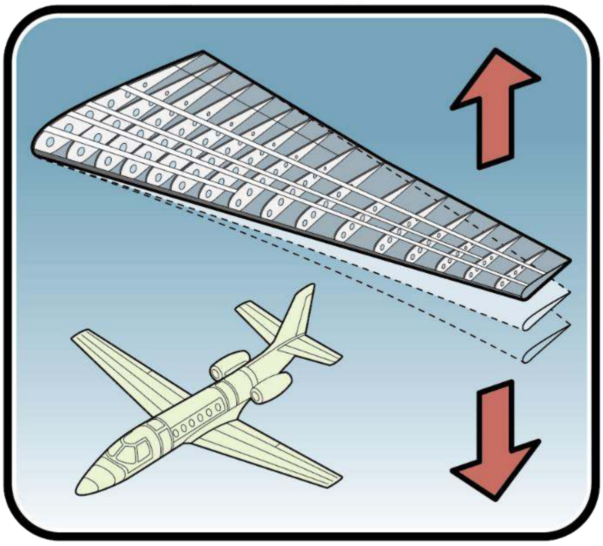
Members of the HC/AG-24 group are:
(only contact persons are listed here)

M. Barbarino	CIRA (Vice Chairman)
C. Testa	CNR-INSEAN
J. Yin	DLR (Chairman)
H. Brouwer	NLR
G. Reboul	ONERA
L. Vigevano	Politecnico di Milano
G. Bernardini	Roma TRE University

GARTEUR Responsable:
K. Pahlke DLR

CIRA Centro Italiano Ricerche Aerospaziali · Marine Technology Research Institute INSEAN · DLR · NLR · ONERA THE FRENCH AEROSPACE LAB · POLITECNICO MILANO · ROMA TRE UNIVERSITÀ DEGLI STUDI

Structures and Materials



5.5 Group of Responsables – Structures and Materials (SM)

5.5.1 GoR-SM Overview

The GoR SM is active in initiating and organising aeronautics oriented research on structures, structural dynamics, acoustics and materials in general. Materials oriented research is related to material systems primarily for the airframe but also for the landing gear and the engines; it includes specific aspects of polymers, metals and various composite systems. Especially the integration of new functionalities is a key to further enhance the performance of materials. Structural research is devoted to computational mechanics, loads and design methodology. Research on structural dynamics involves vibrations, response to shock and impact loading, aeroelasticity, acoustic response and adaptive vibration suppression.

The group is active in theoretical and experimental fields of structures and materials to strengthen development and improvement of methods and procedures. Of great importance is the mutual stimulation of the diverse scientific approaches. Experiments give new insights into the mechanisms of structural behaviour that can be included in improved theoretical models. Finally, the theoretical results must be verified and validated by comparison with results from suitable experiments or trials.

The activities within the Action Groups cover several aspects of new technologies, new structural concepts and new design and verification criteria. Recent and current work is devoted to:

- Fatigue and damage tolerance assessment of hybrid structures;
- Damage repair in composite and metal structures;
- Bonded and bolted joints;
- Additive layer manufacturing.

5.5.2 GoR-SM Activities

In 2018, GoR/AD monitored the following action groups:

SM/AG-34	*Damage repair with composites* This AG started in the second half of 2012 and originated from SM/EG-40.
SM/AG-35	*Fatigue and Damage Tolerance Assessment of Hybrid Structures* This AG started in March 2012 and is a result from SM/EG-38.

The following Exploratory Groups were active:

SM/EG-43	*Development of additive layer manufacturing for aerospace applications* This EG was formally started at the GoR Fall 2014 meeting and the first EG-43 meeting was held on 10th April 2015. An AG proposal is under preparation.
SM/EG-42	*Bonded and bolted joints* This EG was initiated by FOI and was formally started at the GoR fall meeting 2013. Due to recent reorganisations, FOI won't be able to manage or even participate in the AG. Based on the member feedback it was decides to stop this EG.
SM/EG 39	*Design for high velocity impact on realistic structures* This EG has been stopped since there haven't been any activities for a long time and there is currently no interest among the members to proceed with this activity.

New topics which are under consideration are:

Multi-functional Materials with a focus on improving the electrical conductivity and structural health monitoring (SHM)
Multi-scale dynamics of joints: modeling and testing
New Methodologies for thermal-mechanical design of Supersonic and hypersonic vehicles
Composite Fire Behaviour
Structural Uncertainties
Aeroelasticity and aero-servo-elasticity
Thin ply laminates
Standardization of ice adhesion characterization

5.5.3 GoR-SM Membership

Chairperson		
Peter Wierach	DLR	Germany
Members		
Domenico Tescione	CIRA	Italy
Aniello Riccio	SUN	Italy
Javier San Millan	INTA	Spain
Tomas Ireman	SAAB	Sweden
Anne Denquin	ONERA	France
Bert Thuis	NLR	The Netherlands
Industrial Points of Contact		
Andrew Foreman	QinetiQ	United Kingdom
Roland Land	Airbus Defence and Space	Germany
Mathias Jessrang	Airbus	Germany
Angel Barrio	Airbus Defence and Space	Spain
Hans Ansell	SAAB	Sweden
Robin Olsson	SWEREA Sicomp	Sweden
Caroline Petitot	Airbus	France
Luc Hootsmann	Fokker	The Netherlands

Table 6. GoR-SM Membership 2018.

6 INTERNAL ANALYSIS AND GARTEUR ROADMAPS

6.1 Internal Analysis

During 2018, and aligned with established lines of action for the Spanish Chairmanship period, specifically the development of a Strategic Plan, the following activities were performed:

- Identification of Strengths, Weaknesses, Opportunities and Threads (SWOT).
- Prioritization of the SWOT items.
- GARTEUR self-assessment and positioning exercise.
- Main research streams.

The outcomes of the aforementioned activities will be used as the framework to define an action plan and the Strategic Plan in 2019.

6.2 GARTEUR Roadmaps

For an organization like GARTEUR is of a paramount importance to not only know what we have done, and doing but also what we will do during the upcoming years. The portfolio of EGs and AGs materializes the GARTEUR mission.

Over the 45 years of its existence, GARTEUR has developed an extensive research and technology portfolio delivering a wealth of leading edge projects. Research has traditionally focused on early stage, low TRL (Technology Readiness Level) technologies, guided by the wider European priority research areas as set out in section 4 and specifically the ACARE SRIA targets.

The civil aeronautical roadmaps are guided by the Strategic Research and Innovation Agenda (SRIA) developed by ACARE, providing a technology pathway to achieve the goals set out by Flightpath 2050. Defence drivers, out of scope for the SRIA, have been defined and driven by the respective Governments of the GARTEUR member states. Consultation through GARTEUR and its members, alongside the European Defence Agency (EDA), has allowed a coherent focus for defence goals. The roadmaps review past and current GARTEUR research activities providing a strategic pathway for technology development, ensuring future GARTEUR research activities align with the wider European strategic programmes.

The complete assessment of GARTEUR research activities across the five GoRs has focused on research undertaken through the Exploratory and Action Groups maximising impact. The chairs and members of the GoRs systematically review the relevance of the work being investigated in the Action Groups, Exploratory Groups or EU collaborations to the wider GARTEUR strategy, in addition to identifying links and interdependency between projects. The roadmaps also enable identification of collaboration opportunities both within and across the GoRs, providing a mechanism to measure impact against ACARE and defence targets. Further to streamlining research areas, the roadmaps also highlight where gaps may exist, from which an assessment can then be made as to whether these need to be acted upon or considered out of scope.

The established roadmaps in 2017 are under revision, and therefore the information in the following figures has not been updated. The main streams identified in the internal analysis will feed the future versions.

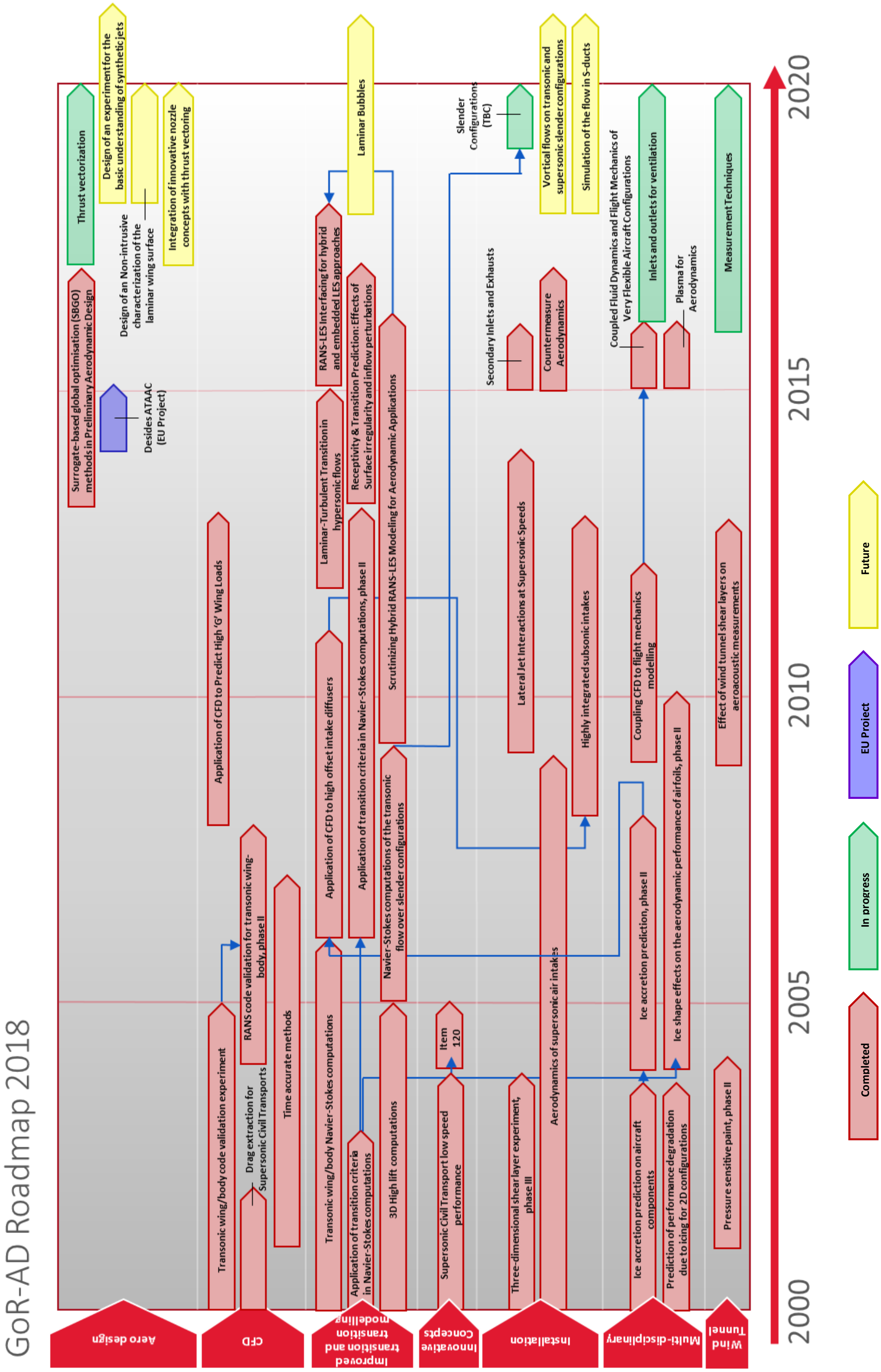


Figure 3. Roadmap for GoR Aerodynamics.

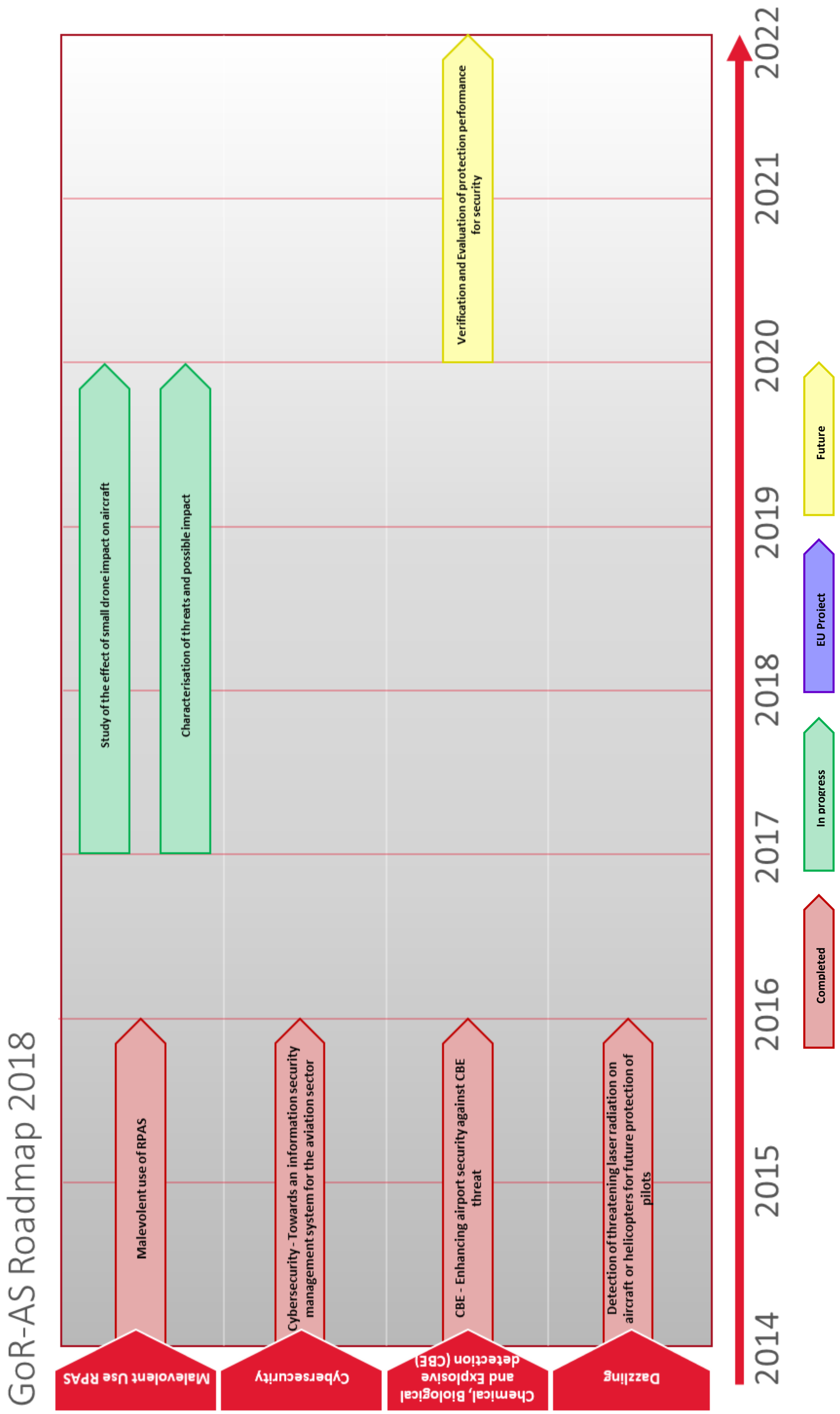


Figure 4. Roadmap for GoR Aviation Security.

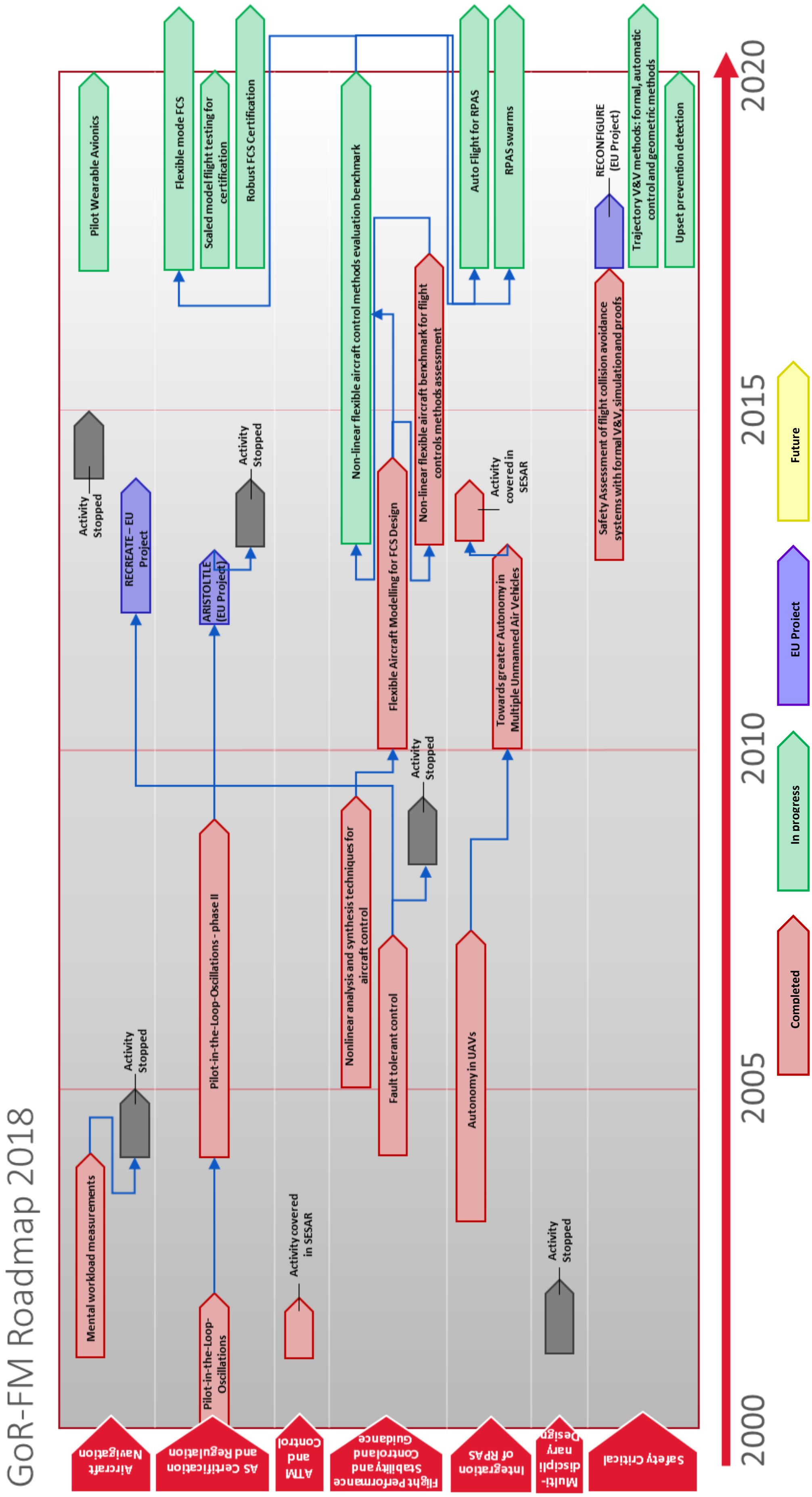


Figure 5. Roadmap for GoR Flight Mechanics and Systems Integration.

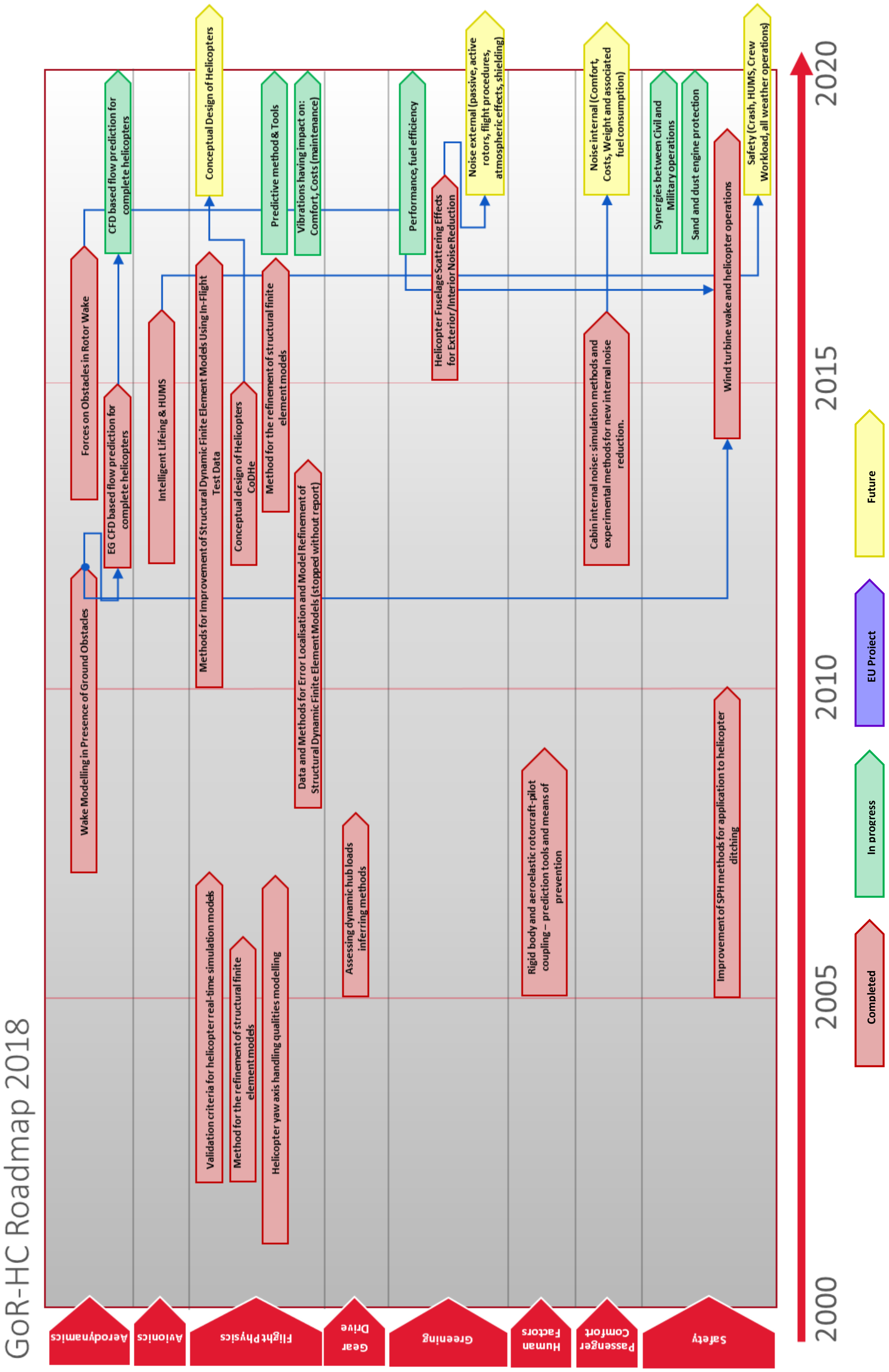


Figure 6. Roadmap for GoR Helicopters.

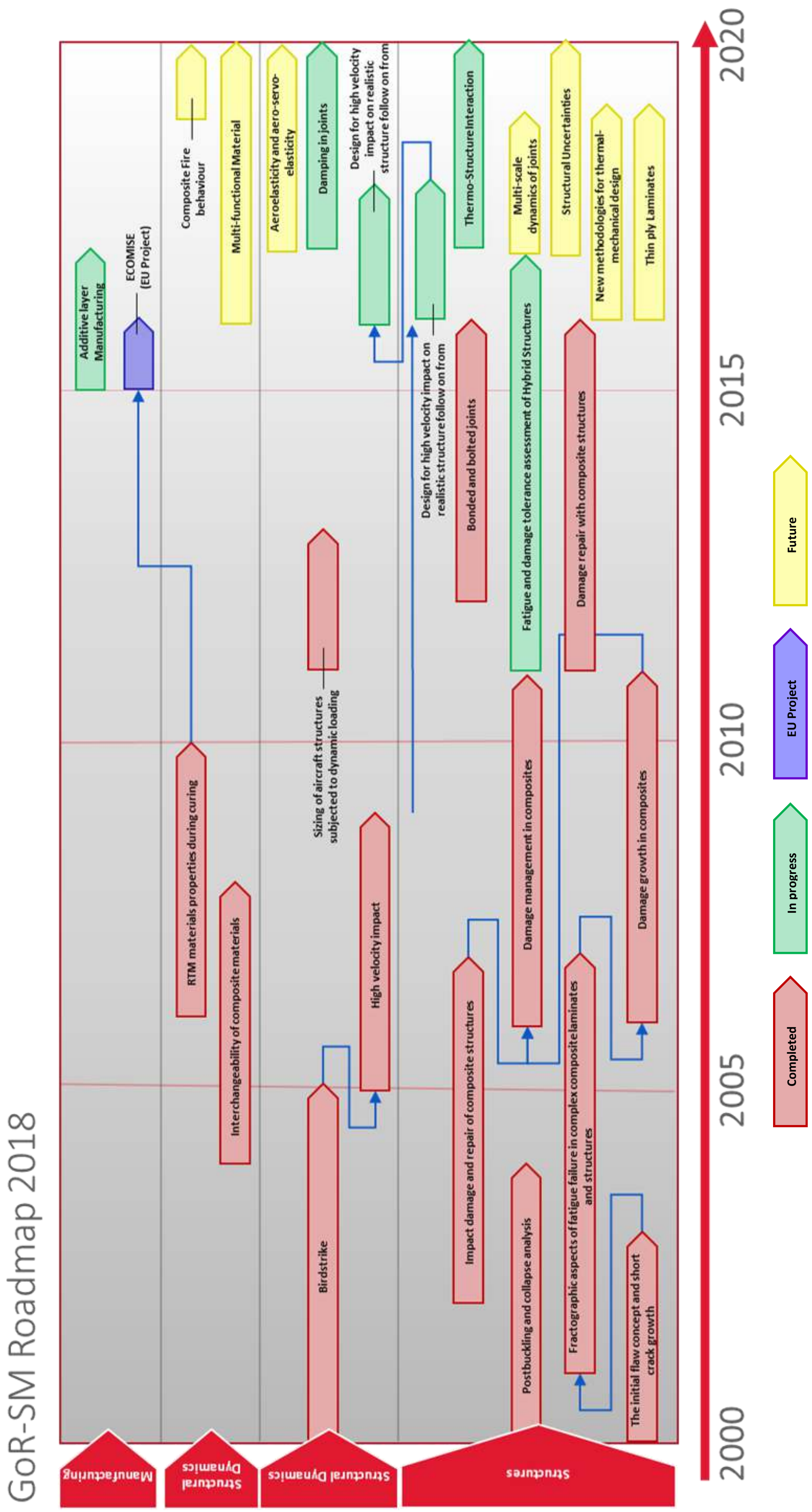


Figure 7. Roadmap for GoR Structures and Materials.

7 LIST OF TABLES AND FIGURES

7.1 List of Tables

7.2 List of Figures

8 LIST OF ABBREVIATIONS

ACARE: Advisory Council for Aviation Research and Innovation in Europe

AG: Action Group

AIRC: Aircraft Integration and Research Centre

ATI: Aerospace Technology Institute (UK)

BEIS: Department of Business, Energy and Industrial Strategy (UK)

CIRA: Italian Aerospace Research Centre

DGA: Direction Générale de l'Armement (France)

DLR: German Aerospace Centre

DNS: Direct Numerical Simulation

DSTL: Defence and Science Technology Laboratory (UK)

EDA: European Defence Agency

EDAP: European Defence Action Plan

EDRP: European Defence Research Programme

EG: Exploratory Group

ESMAB: European Defence Agency Single European Sky Military Aviation Board

ETP: European Technology Platform

EU: European Union

FOI: Swedish Defence Research Agency

FP: Framework Programme

GARTEUR: Group for Aeronautical Research and Technology in Europe

GoR: Group of Responsables

- AD: Aerodynamics
- AS: Aviation Security
- FM: Flight Mechanics, Systems & Integration
- HC: Helicopters
- SM: Structures & Materials

IAT: Ice Accretion Test

IPoC: Industrial Points of Contact

INTA: National Institute of Aerospace Technology (Spain)

ISDEFE: Ingeniería de Sistemas para la Defensa de España (Spain)

JTI: Joint Technology Initiative

LES: Large Eddy Simulation

MALE RPAS: Medium-Altitude Long Endurance Remotely Piloted Aircraft System

MFF: Multiannual Financial Framework

NLR: Netherlands Aerospace Centre

ONERA: Office National d'Etudes et Recherches Aérospatiales (France)

PADR: Preparatory Action on Defence Research

PPP: Public-Private Partnership

RANS: Reynolds-Average Navier-Stokes

RPAS: Remotely Piloted Aircraft System

R&T: Research & Technology

RTD: Research & Technology Development

SEO: Search Engine Optimization

SES: Single European Sky

SESAR: Single European Sky Air Traffic Management Research

SME: Small and Medium-sized Enterprise

SRIA: Strategic Research & Innovation Agenda

TRL: Technology Readiness Level

UTM: Unmanned Traffic Management

XC: Executive Committee

GARTEUR

GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE

FRANCE GERMANY ITALY THE NETHERLANDS SPAIN SWEDEN UNITED KINGDOM

GARTEUR Organisation 2018

GARTEUR Chair Country 2018-2019: Spain
Council Chair: Mr Bartolome Marques, Spain

XC Chair: Mr. Francisco Muñoz, Spain
Secretary: Mr. Jose Garcia, Spain

GARTEUR COUNCIL							
Function	**France**	**Germany**	**Italy**	**Netherlands**	**Spain**	**Sweden**	**United Kingdom**
Head of Delegation	J. L'Ebraly	J. Bode	-	C. Mekes	B. Marques	A. Blom	P. Griffiths
XC Member	O. Vasseur	F. König	L. Paparone	K. Wijnberg	F. Muñoz Sanz	E. Bernhardsdotter	S. Gates
Other Members of Delegation	P. Beaumier	H. Hemmer M. Fischer	-	C. Beers	J.F. Reyes-Sánchez	R. Stridh N. Tooloutalaie	S. Weeks S. Pendry M. Scott

GROUPS OF RESPONSABLES									
Aerodynamics (AD)		**Aviation Security (AS)**		**Flight Mechanics, Systems & Integration (FM)**		**Helicopters (HC)**		**Structures & Materials (SM)**	
GoR AD members		**GoR AS members**		**GoR FM members**		**GoR HC members**		**GoR SM members**	
F. Monge Gómez	ES chair 2018-19	**A. Vozella**	IT chair 2017-18	**M. Hagström**	SE chair 2017	**P. Beaumier**	FR chair 2017-18	**P. Wierach**	DE chair 2016-18
K. Richter	DE vice-chair 2018-19	V. Wiels	FR	W. Rouwhorst	NL	M. White	UK	T. Ireman	SE
H. van der Ven	NL	I. Ehrenpfordt	DE	B. Korn	DE	L. Notarnicola	IT	D. Tescione	IT
E. Coustols	FR	B. Eberle	DE	L. Verde	IT	J. Hakkaart	NL	J. Sanmilan	ES
G. Mingione	IT	F. Muñoz Sanz	ES	P. Mouyon	FR	A. Antifora	IT	J. Schön	SE
P. Weinerfelt	SE	A. Eriksson	SE	TBC	SP	R. Heger	DE	A. Riccio	IT (Associated member)
M. Tormalm	SE	R. Wiegers	NL			F. X. Filias	FR	B. Thuis	NL
						R.-H. Markiewicz	UK	F. Roudolff	FR
						K. Pahlke	DE		
Industrial Points of Contacts		**Industrial Points of Contacts**		**Industrial Points of Contacts**		**Industrial Points of Contacts**		**Industrial Points of Contacts**	
T. Berens	DE			E. Cortet	FR			H. Ansell	SE
N. Ceresola	IT	AS IPoCs will be included very soon		L. Goerig	FR	HC IPoCs included above		A. Barrio Cardaba	ES
M. Mallet	FR			M. Hanel	DE			L. Hootsmans	NL
D. Pagan	FR			TBC	SE			R. Lang	DE
L. P. Ruiz-Calavera	ES							C. Petiot	FR
B. Stefes	DE							A. Foreman	UK
								M. Jessrang	DE
								R. Olsson	SE
								M. Riccio	IT

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secretariat@garteur.org or go to **www.garteur.org**