GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE

FRANCE GERMANY ITALY THE NETHERLANDS SPAIN SWEDEN UNITED KINGDOM

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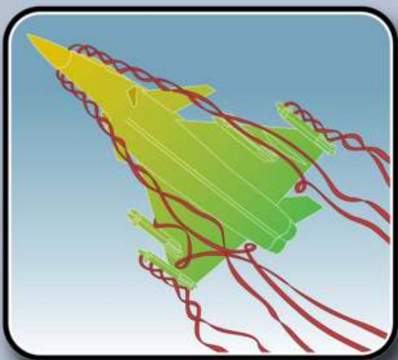
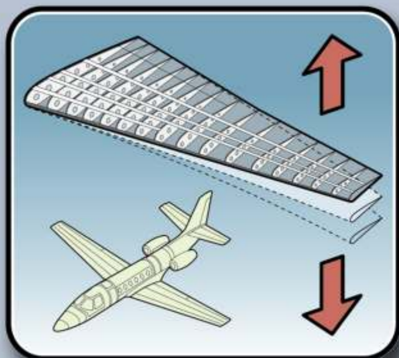
GARTEUR Annual Report 2014







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GARTEUR ANNUAL REPORT 2014

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1. EXECUTIVE SUMMARY

Air transport is an essential sector in the more and more globalized world meeting the needs of societies by giving means to connect markets and people. It has been continuously growing these last 45 years and according to recent market surveys it is expected to continue over the next 20 years.

The European aviation industry is currently world leading and contributes very positively to European economic welfare. To reinforce this position it is therefore vitally important to be ready to meet future major economical and societal challenges. Industrial competition is fierce and increasing, not only from established regions but also from new and strong challengers. Protecting the environment and ensuring safety and security are other key challenges. Hence, the entire sector must improve its performance in order to maintain its global leadership and meet the needs of citizens. Top level objectives of European aviation industry are addressed in the vision document “Flightpath 2050” presented in 2011. ACARE[1] stakeholders also come together to develop the “Strategic Research and Innovation Agenda” (SRIA) presented in 2012. Both these documents define the civil aviation policy in which the GARTEUR action is placed.

Research, technology and innovation are essential catalysts for a competitive and sustainable future and efforts have to be pursued to remain effective. Aviation operates on long timescales for exploitation of technology and innovation both because of the complexity of the systems involved and because of the necessary safety requirements and certification processes. This leads to the need for a long term research plan to initiate research on new promising technologies in time.

Likewise, the European Military Aircraft Industrial base has been and is very strong, and several Air Power Systems are being taken into service as well as being upgraded. Many of the technologies developed for these programmes have also been the basis for the successful commercial aircraft industry and other industrial sectors. Conversely, technologies developed for civil aviation are more and more beneficial to military aviation.

The declining defence budgets mean that it is no longer economically viable to retain non-controlled redundant development capabilities in Europe. This necessitates a harmonised approach between Governments, their agencies, industry and research institutions, to enable European Governments to have access to affordable European Air Power solutions, meeting future defence and security requirements. Through various European collaboration projects and studies European countries are paving the way for the next generation of Future Air Systems (manned and unmanned).

More generally, the GARTEUR Council is a unique forum of R&T aeronautical experts from relevant government ministries and research establishments. The Groups of Responsables (GoR), the scientific management bodies and think-tank of GARTEUR, are composed of representatives from government departments, national research establishments and industry.

[1] ACARE: Advisory Council for Aviation Research and innovation in Europe

GARTEUR is the only framework for both civil and military R&T collaboration in Europe. It has been working successfully for numerous projects over the past decades and has continuously adapted to meet new challenges. This Annual Report includes a summary overview of GARTEUR projects (Action Groups) as well as new topics under consideration. The activities and projects of the Groups of Responsables are described in more detail in a separate report (GARTEUR X/D 50 - Annexes to the Annual Report 2014). These annexes, which can also be downloaded from the GARTEUR website, well demonstrate the added value of the cooperation to improve the technology base of the contributing actors.

Beyond that, GARTEUR can take advantage and stimulate R&T activities in the aeronautical framework programmes at both national and European levels. Several examples show that GARTEUR projects are often continued in more application-orientated EU-funded projects, complementing national R&T efforts.

Regarding the EU funded ERA-Net AirTN[2] project, for which GARTEUR was the initiator, the final workshop was held in Bonn in December 2013. The activities are now pursued in the AirTN NextGen project. The AirTN team has successfully established and maintained an extensive network of European aeronautics stakeholder groups that include ACARE and GARTEUR along with universities and research institutes.

The reports on national situations in aeronautics, in both civil and military domains, are presented at each GARTEUR Council meeting, reflect the changing situation and show that the Governments of the GARTEUR countries are closely following and adapting to the developments described above. Over the past years some of the GARTEUR countries have formulated new national strategy plans and R&T programmes. These are made available at the GARTEUR website.

Members of the GARTEUR Council are involved with several other European organizations so that GARTEUR Council meetings act as an effective forum for information exchange. Senior scientific or technical managers from large aerospace companies are invited to give specific presentations at each Council meeting to pursue contacts with the industry.

In the aeronautic community the development of autonomous vehicles and related technologies as well as the growth of cybersecurity technologies are becoming increasingly important topics. For this reason a GoR on Aviation Security was created in 2014. Tasks concerning Remotely Piloted Aircraft Systems and Cybersecurity are suggested among identified actions. Furthermore, a position paper of the GARTEUR community on this topic is expected in 2015.

France took over the GARTEUR chairmanship from Sweden at the beginning of 2013 and will remain in charge until the end of 2015.

Hervé Consigny
GARTEUR Council
Chairman
(2013-2015)

[2] AirTN: Air Transport Net

2. INTRODUCTION

The GARTEUR Annual Report 2014 has been prepared by the Executive Committee for the 58th Council meeting held in Stockholm March 19-20, 2015.

The Report provides a summary of all the ongoing activities at scientific and technical levels as well as at the management level, according to the Action Plan agreed by the Council in March 2014.

All matters directly connected to Council activities or decisions are addressed in the next chapter on GARTEUR Council.

Chapter 4 provides an overview of the European aeronautics RTD environment, within which GARTEUR nations continue to account for the vast majority of aeronautical activities.

The GARTEUR scientific and technical activities are summarised in Chapter 5, where ongoing activities are presented as one page posters. More details about the scientific and technical activities are presented in a separate report prepared by the Groups of Responsables (GARTEUR X/D 50 - Annexes to the Annual Report 2014). These annexes can also be downloaded from the GARTEUR website. Data and statistics for GARTEUR activities are provided in the Appendices to this report.

3. GARTEUR COUNCIL

3.1. Chairmanship and membership

Following the transfer of the GARTEUR Chairmanship from Sweden on 1 January 2013, France has started chairing GARTEUR for a 3-year period ending on 31 December 2015.

Since January 2013 Dr. Hervé Consigny has been the Chairman of the Council, Dr. Olivier Vasseur the Chairman of the Executive Committee (XC) and Mrs Anne-Laure Delot the GARTEUR Secretary, all of them being employed by ONERA, the French Aerospace Lab.

Several changes to the national delegations took place in 2014:

- in the French Delegation C. Griseri (from DGA) succeeded to O. Dugast as a French Member of Delegation;
- in the German Delegation J. Bode (from BMWi) replaced F.J. Mathy as the German Head of Delegation;
- in the Italian Delegation M. Amato (from CIRA) was appointed the Executive Committee representative for Italy;
- in the Dutch Delegation C. Beers (from NLR) succeeded to B. Oskam as a Dutch Member of Delegation due to his retirement;
- in the Spanish Delegation B. Marqués (from INTA) replaced Á.L. Moratilla Ramos as the Spanish Head of Delegation and F. Muñoz Sanz (also from INTA) was appointed the Executive Committee representative for Spain;
- in the Delegation of the United Kingdom R. Kingcombe (from BIS) retired in September 2014 and his successor has not been appointed yet.

The composition of the GARTEUR Council at the end of December 2014 is presented in Figure 10 in Appendix 1.

3.2. Meetings

3.2.1. General points

The GARTEUR Council met twice in 2014:

- C56 meeting in London, UK on 13-14 March 2014,
- C57 meeting in Venezia, Italy on 9-10 October 2014.

The Council meetings followed the usual meeting agenda with the main focus on recurring agenda topics i.e. the GoR chairpersons report about the activities in the Action/Exploratory Groups on their 3-5 years rolling plans and the XC Chairman reports about the status of ongoing and planned GARTEUR actions with respect to the GARTEUR Action Plan.

An important point on the Council meeting agendas is the reports on the national situations in aeronautics, on the civil and military sides. Furthermore members of the GARTEUR Council are involved with several other European organisations and hence the GARTEUR Council meetings also act as an effective forum for information exchange. Several member countries have published strategy documents on aeronautics. The public versions of these are included on the GARTEUR website.

Since March 2014 "open discussions" are proposed in the agendas of the Council meetings so that Council members informally exchange opinions about current programs and questions arising in Europe. In 2014 Council members shared ideas on topics such as H2020 perspectives or funding for Research Infrastructures. They also took time to think about how to further develop GARTEUR to be a good instrument for coordinated actions.

Since 2009 the GARTEUR Council has installed an award procedure with one award per Council Chair period. Regarding the French Chairmanship period the Council decided to deliver the GARTEUR Award of Excellence to AD/AG-46 "Highly Integrated Subsonic Air Intakes". The winning AG chairman, T. Berens (from AIRBUS Defence and Space, formerly EADS CASSIDIAN, Germany) was invited to receive the award at the Council meeting of October 2014 (see paragraph 3.4.1 for details).

The Executive Committee (XC) met twice in 2014:

- XC153 meeting in Roma, Italy on 12 February 2014,
- XC154 meeting in Amsterdam, The Netherlands on 4 September 2014.

In addition the Executive Committee held short meetings together with GoR chairpersons in the morning before the Council meetings.

The latest version of GARTEUR Basic documents is available on the GARTEUR website. The most recent alteration to the GARTEUR Basic documents was made at the Council meeting of October 2013 to comply with changes regarding the dissemination of GARTEUR recent results.

3.2.2. Creation of a new GoR on Aviation Security

Given a strong demand for progress in Aviation Safety and Security (cf. ACARE/SRIA/Challenge 4) a GARTEUR Ad-hoc Group on Aviation Security (AGAS) was initiated in 2013 to discuss European security topics and prepare a proposal of actions on specific GARTEUR activities concerning "Aviation Security" and "RPAS" challenges.

As the only framework in Europe for both civil and military Research and Technology for aeronautics GARTEUR is the appropriate organization to conduct research on Aviation Security. Considering the work performed by AGAS members to identify specific well-focused topics a new Group of Responsables on "Aviation Security" was created inside GARTEUR in March 2014 with the aim of extending GARTEUR R&T activities. Since March 2014 this new GoR has worked on further analysing the field of aviation security and has identified important fields of research activities such as Cybersecurity, Chemical, Biological and Explosive (CBE) detection, Dazzling and Malevolent use of RPAS.

3.2.3. Contacts with EREA

In order to discuss and coordinate common strategy issues between EREA and GARTEUR the EREA Chairman, J. Kaspar (from VZLU), was invited at the GARTEUR Council meeting in October 2014. During that meeting the EREA Chairman informed GARTEUR Council members on "Future Sky", an EREA proposal for a Joint Research Initiative (JRI) in Aviation. J. Kaspar pointed out that under "Future Sky" there were 4 "Joint Research Programmes", so called "Twentyfour-Seven Enablers" ("TSE"), which are the 4 major pillars of JRI that would be started one by one every two years:

- TSE 1: Safety (2015-2022),

- TSE 2: Quiet Air Transport (2017-2024),
- TSE 3: Air Transport Integration,
- TSE 4: Energy.

It is worth mentioning that one of the objectives of the newly-formed GARTEUR GoR on "Aviation Security" is to complete the task done by EREA in the Safety domain.

The GARTEUR Chair was also invited by EREA to the EREA Board Meeting to inform each other and to define joint strategies towards the EU.

3.2.4. Contacts with industry

In order to strengthen the links with industry, top level representatives from aeronautical industries and interest groups are regularly invited to attend the Council meetings to give presentations on their organisations and activities.

At the Council 56 meeting in London in March 2014, R. Chapman (Head of Aerodynamics at BAE Systems) was invited to give a presentation on "Future Capability, Research and Technology" at BAE Systems, Military Air & Information. During his presentation R. Chapman informed GARTEUR members about the ASTRAEA[3] programme, whose aim is to enable the routine use of Unmanned Aircraft Systems (UAS) in all classes of airspace without the need for restrictive or specialised conditions of operation. This will be achieved through the coordinated development and demonstration of key technologies and operating procedures required to open up the airspace to UAS.

At the Council 57 meeting in Venezia in October 2014, M. Arra (Head of External relations & Funding at AgustaWestland) was invited to inform GARTEUR on Research & Technology in AgustaWestland (AW). In particular he highlighted the necessity of continuing to invest in advanced tilt rotor technology and UAVs. Regarding the Next Generation Civil Tiltrotor (NextGenCTR) the AW representative informed GARTEUR members on skills that have to be developed to achieve objectives in environmental compatibility, competitiveness, mobility, jobs & skills for difference technical areas.

Additionally G. Gardini from Gemelli (the Italian leader for the design and supply of aircraft internal communication equipment and systems) was invited at the 57th Council meeting to give a presentation on "Integrated Helmet for Aeronautics Applications". In his presentation he gave details on a recent research project concerning an innovative pilot helmet with an improved noise protection and a better communication intelligibility.

Finally a visit of the AgustaWestland NH90 plant was arranged in Tessera (Venezia) at the end of the Council 57 meeting.

3.2.5. European Commission

The Strategic Research and Innovation Agenda (SRIA) - a roadmap for aviation research, development and innovation developed by ACARE - was published in 2012 (more in Chapter 4).

The budget line for "Aeronautics/Aviation" is contained under "Smart, green and integrated transport" within "Horizon 2020".

This agenda was very useful to launch the Aviation Security initiative and to determine the preliminary needs in this field.

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[3] ASTRAEA (Autonomous Systems Technology Related Airborne Evaluation & Assessment).

3.2.6. Strategy discussions

At the Council meetings the status for ongoing and planned GARTEUR actions with respect to the GARTEUR Action Plan are discussed. A specific time slot is systematically devoted to strategic discussions with the aim to strengthen the role of GARTEUR projects within the European R&T environment.

A key asset of GARTEUR is its unique collaboration mechanism which can be used for both civil and military, as well as for dual-use projects. Hence, this provides a straightforward mechanism to increase collaboration on dual use projects without introducing new procedures. Partners with either civil or military funding can therefore easily work together.

Within the framework of the GARTEUR Action Plan 2014 and given a strong demand for progress in Aviation Safety and Security (cf. ACARE/SRIA/Challenge 4) a new Group of Responsables on “Aviation Security” was created to promote the development of actual dual areas (i.e. that are well related to defence R&T). The research topics identified by the newly created Aviation Security GoR concern Cybersecurity for aviation, CBE detection in airports or airplanes and Dazzling of pilots, as well as the “Malevolent use of RPAS”.

The Groups of Responsables (GoRs) are the key bodies for GARTEUR success. The enthusiasm and competence of GoR members and GoR chairs are essential for the set up of new GARTEUR Action Groups. It is an important role for Council to facilitate and stimulate the process, which has been the focus of some of the 2014 GARTEUR activities.

There is an increased focus on dual use in light of growing budget pressures. In this context it is noted that GARTEUR projects are of different types:

1. Benchmarking of codes and methods;
2. Experimental data for validation of codes and criteria;
3. Initial studies of new technologies with potential for future applications in aeronautics. This type of projects implies a potential special role for GARTEUR since lower TRL projects have difficulties to fit within EU-FP projects as well as within applied military projects. Hence it could be a good role for GARTEUR to make sure that these needed projects are performed.

3.3. External communication

The contacts and relations to other European fora are followed up at all GARTEUR Council meetings:

- in the field of civil aeronautics: contacts with EU, ACARE, EREA, JTI, AirTN and AirTN NextGen,
- in the field of defence related organizations: contacts with EDA, ETAP and NATO/STO.

An overview of GARTEUR activities was presented at the AIAA SciTech forum in National Harbor, USA, in January 2014 (see paragraph 3.3.3 for details).

With regard to the ILA Berlin Airshow from 20th to 25th May 2014 the BMWi ministry proposed to present AirTN and GARTEUR at the BMWi booth.

3.3.1. GARTEUR Website and archive

Concerning the GARTEUR website (www.garteur.org) dedicated pages to the five Groups of Responsables present information on the technical programme of each GoR, current Action and Exploratory Groups and a list of all issued GARTEUR Technical Reports. These pages are regularly updated and the annual reports from the GoRs are also included.

"GARTEUR Open" Technical Reports are available on the website after 3 years if not otherwise specified by the Action Group.

Some national strategy documents on aeronautics are included or linked from the GARTEUR website.

Additional documents can be found on the GARTEUR website such as the GARTEUR brochure, GARTEUR presentations given during conferences or special events (ICAS 2004, Aerodays 2011, 2014 AIAA SciTech conference, etc) or links on specific websites dedicated to specific GARTEUR Actions Groups…

Old documents, meeting minutes and annual reports from the paper archive were scanned with the aim to have the entire archive in electronic form, which can be very convenient when the secretariat is transferred every second year from one country to another one.

3.3.2. AirTN and AirTN NextGen

The AirTN third phase started in December 2013 with the new EU project: AirTN NextGen.

The Air Transport Network, AirTN NextGen, a CSA (Coordination and Support Action) funded under FP7, creates a platform of networking and communication between regional, national and governmental organizations supporting research and innovation in the EU Member States and Associated Countries to the EU Framework Program in the field of Aviation.

The aim is to stimulate transnational cooperation in the aviation field for: RTD and innovation, research infrastructure related activities, education related activities.

During the first year, the following events were organized to stimulate exchanges and to strengthen the network:

- A seminar on clusters of simulation capabilities titled "Towards virtual certification: key challenges in the field of simulation capabilities for European research infrastructures", with the aim of exploiting the potential advantages and their associated constraints of clusters of simulations in the fields of virtual testing and virtual certification. It was held in Bonn on 25th September 2014.
- The first AirTN-Nextgen Network Meeting, organized in Brussels on the 27th of October 2014, gave an overview of the project goals and results achieved so far. Win-win situations, barriers and solutions for improved trans-national cooperation in research, technological developments and innovation have been discussed.
- The International Conference on Air Transport INAIR 2014 "Europe: How to Stay Connected?" was held in Prague on November 13 and 14. As the only conference of its kind in Central Europe it dealt mainly with the future direction of Europe and the need of strengthening the links between university education and industry.

To foster transnational cooperation in aviation research and technology a survey on national/regional funding programs, calls and strategies relevant for aviation is being performed with the support of ACARE Member States Group and EU projects. A study on research and innovation strategies for smart specialisation has been performed to identify regions that support aeronautic technologies and a map has been realized with detailed information about specific technologies and contacts. A deep study on synergies between H2020 and ESIF has been carried out as well.

Activities aiming at supporting transnational cooperation under H2020 and better understanding of the new ERA-NET instrument have been implemented. In this context, AirTN reports on the opportunities offered by the SME instrument and by the ERA-NET Cofund instrument, both under Horizon 2020, are available on http://www.airtn.eu/programmes--calls/programmes/index.html.

The Research Infrastructures Catalog, established under AirTN FP7, has been updated with new information (http://www.airtn.eu/catalogues/research-facilities/index.html).

3.3.3. GARTEUR Special sessions at the 2014 AIAA SciTech Conference

Two GARTEUR Special Sessions were organised during the 2014 AIAA Science and Technology Forum, each of these starting with a general presentation on GARTEUR by the Council Chair.

For each paper session the first presentation provided an overview of collaboration in aeronautics between European countries as stimulated in GARTEUR and highlighted the fields of scientific and technical activities covered by the different GoRs. The subsequent presentations were devoted to results obtained in the framework of GARTEUR AD/AG-43 and AD/AG-46 regarding the aerodynamics of air intakes.

3.4. GARTEUR Award and Certificates

3.4.1. GARTEUR Award of Excellence 2013/2014

Since 2009 one GARTEUR Award of Excellence has been delivered for each Council chair period. Regarding the French Chairmanship period the Council decided to deliver the GARTEUR Award of Excellence 2013/2014 to AD/AG-46 “Highly Integrated Subsonic Air Intakes”. The winning AG chairman, T. Berens (from AIRBUS Defence and Space, formerly EADS CASSIDIAN, Germany) was invited to give a presentation on AD/AG-46 and to receive the award at the Council meeting of October 2014. At the Council meeting in Venezia a trophy and a certificate for each AG member was handed over to T. Berens, who chaired the winning Action Group.

Partners in the international collaboration of AD/AG-46 were AIRBUS Defence and Space (formerly EADS CASSIDIAN, Germany, Chair), ONERA (France, Vice-Chair), FOI (Sweden), AIRBUS Defence and Space (formerly AIRBUS Military, Spain), SAAB (Sweden), DLR (Germany), Alenia Aermacchi (Italy), MBDA (France) and Dassault-Aviation (France).

The major objectives of AD/AG-46 were to investigate the capability of Detached Eddy Simulation (DES) methods for the analysis of unsteady flow phenomena of serpentine air intakes and the accuracy levels of the computations. CFD computations were carried out for the EIKON UAV configuration, which was designed and wind tunnel tested at FOI in Sweden. A wide variety of topics concerning highly integrated subsonic air intakes was also covered in the AG, such as the impact of not considering the wind tunnel walls in the CFD, the influence of intake cowl shaping on aerodynamic forces, a trade-off study between boundary layer diversion versus ingestion, the effects of passive and active flow control devices. Additionally a diverterless intake model was built and tested at DLR in Göttingen in the cryogenic blowdown wind tunnel DNW-KRG with the goal of contributing to a better understanding and correlation of installed performance predictions of highly integrated innovative intake designs.

Figure 1: GARTEUR Award trophy and certificate delivered by Council Chair to GARTEUR AD/AG-46 Chair in October 2014

3.4.2. GARTEUR certificates 2014

GARTEUR Certificates were in 2014 awarded to the following persons:

France		
ICA Olivier Dugast	Council member, leaving in August 2014	DGA
Mr. Daniel Cazy	FM-GoR Member, leaving 2014	Airbus Operations S.A.S.
Germany		
Mr. Franz-Josef Mathy	Council member, leaving 2013	BMWi
Dr. Thomas M. Berens	AD/AG46 Chairman	Airbus Defence & Space
The Netherlands		
Dr. Bas Oskam	Council member from 1977 to February 2013	NLR
Mr. Koen de Cock	AD-GoR Member, leaving 2014	NLR
Spain		
Mr. Ángel L. Moratilla Ramos	Council member, leaving July 2014	INTA
Sweden		
Mr. Torsten Berglind	AD-GoR Chair, leaving 2014	FOI
Dr. Tomas Ireman	SM-GoR Chair, leaving 2014	SAAB AB
Mr. Ernst Totland	AD-GoR Member, leaving 2014	SAAB AB
Prof. Shia-Hui Peng	AD/AG50 Chairman	FOI
UK		
Dr. Ray Kingcombe	Council member, leaving September 2012	Department for Business, Innovation & Skills

Table 1: GARTEUR Certificates 2014

4. THE EUROPEAN AERONAUTICS RTD ENVIRONMENT

A short overview of the total European aeronautics RTD environment is presented in two sections below, Civil Aeronautics and Military Aeronautics, respectively.

4.1. Civil aeronautics

For the past two decades civil aeronautics research and technology development (RTD) in Europe has been increasingly focused around the research performed within the European Framework Programmes jointly financed via EC. This has given a strong momentum to European collaboration and excellence in civil aeronautics RTD.

The Vision 2020 document[4] from 2001 and the follow on Strategic Research Agendas[5,6] (2002 and 2004) have been the foundation stones to direct and focus European RTD and collaboration for civil aeronautics. Furthermore, in the past years national agendas and platforms aligned to the ACARE SRA have been developed in several member states, and European aeronautics has made great progress in working together to reach the common goals.

A new vision "Flightpath 2050 - Europe's Vision for Aviation" was presented[7] at Aerodays 2011 in Madrid. During 2012 the follow up new Strategic Research and Innovation Agenda (SRIA) was published[8]. The next European Framework Programme "Horizon 2020" was being prepared in 2013.

4.1.1. Flightpath 2050 - Europe's Vision for Aviation

The Flightpath 2050 vision addresses two parallel objectives: firstly to serve society's needs for safe, more efficient and environmentally friendly air transport; and secondly, to maintain global leadership for Europe in this sector with a competitive supply chain including large companies and small and medium size enterprises.

The vision set out in this document stresses the need for an innovation friendly environment relying on strong, sustainable and coherent investment in research and innovation and enhanced governance, funding and financing structures. Research, technology and innovation are essential catalysts for a competitive and sustainable future and Europe needs to start quickly in order to reach the goals for 2050.

This document setting out a European vision for the future of aviation emphasizes where those working in aviation see the priorities for the relevant policy, research and innovation instruments. It is a high-level vision of Europe leadership with a competitive aviation industry that is clean, competitive, safe and secure.

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[4] European Commission (2001) European Aeronautics: A Vision for 2020. Meeting society's needs and inning global leadership. Report of the Group of Personalities.
[5] ACARE (2002) Strategic Research Agenda 1. Volume 1 and Volume 2.
[6] ACARE (2004) Strategic Research Agenda 2. Volume 1 and Volume 2.
[7] European Commission (March 2011) "Flightpath 2050 - Europe's Vision for Aviation". Report of the High Level Group on Aviation Research.
[8] ACARE (2012) Strategic Research & Innovation Agenda (SRIA).

To meet the ambitious goals set by Flightpath 2050, the Advisory Council for Aviation Research and Innovation in Europe (ACARE) has developed a new Strategic Research and Innovation Agenda (SRIA).

The SRIA document is focused around five key challenges. For each of these challenges the targets by 2050 and the key action areas are described. The renewed ACARE does look into the entire aviation sector i.e. aeronautics and air transport and includes Innovation in addition to research and the work to prepare the SRIA involved all stakeholders.

4.1.2. Strategic Research and Innovation Agenda (SRIA)

The document will serve as the guideline for civil RTD in Europe for years to come. Below is copied the SRIA recommendations and the five challenges with Targets by 2050 and the Key action areas.

SRIA RECOMMENDATIONS

To achieve the Flightpath 2050 goals for European Aviation, Europe must:

- **Lead the development of an integrated resilient European air transport system** that will meet the mobility needs of European citizens as well as the market needs.
- **Maintain global leadership** for a sector that is highly advanced and anticipated to grow.
- **Establish efficient and effective policy and regulatory frameworks**, which ensure a global level playing field and allow European industry to prosper and compete fairly under market conditions in order to **stimulate research, technology and innovation**.
- Put in place incentives, which are accompanied by **long-term programmes with continuity across R&T efforts over many years**. This requires developing mechanisms that provide public sector investment both at European and national level, complemented by public/private partnerships.
- **Champion sustainable growth** so that noise and greenhouse gas emissions can be further reduced and innovative, affordable, alternative energy sources can be developed.
- **Maintain the sector's safety track record** and enable solutions to increasing security risks to be 'built-in' to future designs.
- **Provide long term thinking** to develop state of the art infrastructure, integrated platforms for full-scale demonstration and meet the critical need for a qualified and skilled workforce for today and the future.

4.1.2.1. Challenge 1: Meeting societal and market needs

Targets by 2050

- European citizens are able to make informed mobility choices.
- 90% of travellers within Europe are able to complete their journey, door-to-door within 4 hours.
- A coherent ground infrastructure is developed.
- Flights land within 1 minute of the planned arrival time.
- An air traffic management system is in place that provides a range of services to handle at least 25 million flights a year of all types of vehicles.

Key action areas

The following enablers are needed to achieve the goals:

1. Design of a customer-centric intermodal transportation system: including, for example, knowing future customer profiles and expectations as well as market and societal opportunities and acceptance factors, identifying the benefits and implementation issues of new mobility system concepts, design of the total transport system architecture, mobility performance assessment and forecast as well as innovative infrastructure planning methodologies.
2. Travel process management: to provide the customer a single ticket for the entire journey as well as travel information capable of delivering robust, relevant, complete and unbiased travel choice before and during a journey. This will also involve enhancing crisis management to mitigate the impacts of serious disruption by providing customers with a robust management and recovery mechanism as well as protecting their rights and interests.
3. Integrated air transport: offering customers a vastly improved seamless travel experience, integrating the points of arrival and departure of all types of air vehicles with other modes of transport, mitigating their impact on their neighbours, strategic and tactical air traffic management and supporting information, communication, navigation and surveillance infrastructure, and delivering system intelligence and autonomy.

4.1.2.2. Challenge 2: Maintaining and extending industrial leadership

Targets by 2050

- The whole European aviation industry is strongly competitive, delivers the best products and services worldwide and has a share of more than 40% of its global market.
- Europe has retained leading edge design, manufacturing and system integration capability and jobs supported by high profile, strategic, flagship projects and programmes which cover the whole innovation process from basic research to full-scale demonstrators.
- Streamlined systems of engineering, design, manufacturing, certification and upgrade processes have addressed complexity and significantly decreased development costs (including a 50% reduction in the cost of certification). A leading new generation of standards is created.

Key action areas

The following enablers are needed to achieve the goals:

1. Continuous development of new technologies, new vehicles and their demonstration and flight test.
2. Efficient development and manufacturing process featuring seamless integration of design and manufacturing capabilities.
3. Continued and focused investment in Research and Innovation to be at the forefront of new technologies.
4. A fair and balanced set of global regulations and standards to create a global level playing field.
5. Innovative business models, regulations and incentives to accelerate innovation.
6. Efficient certification of aviation products.

4.1.2.3. Challenge 3: Protecting the environment and the energy supply

Targets by 2050

- CO_2 emissions per passenger kilometer have been reduced by 75%, NO_x emissions by 90% and perceived noise by 65%, all relative to the year 2000.
- Aircraft movements are emission-free when taxiing.
- Air vehicles are designed and manufactured to be recyclable.
- Europe is established as a centre of excellence on sustainable alternative fuels, including those for aviation, based on a strong European energy policy.
- Europe is at the forefront of atmospheric research and takes the lead in formulating a prioritised environmental action plan and establishes global environmental standards.

Key action areas

The following enablers are needed to achieve the goals:

1. Dynamic allocation of targets between stakeholders, permanent survey of research results and regularly updated research priorities.
2. Extraordinary technological effort to define the air vehicles of the future.
3. Improved air operations and traffic management, achieved initially through the deployment phase of SESAR, allowing for short/medium-term traffic growth in Europe.
4. Improved airport environment (including heliports) which, being at the heart of the intermodal transport system, must deliver a service that meets the needs of passengers while mitigating its environmental impact.
5. Availability of affordable, sustainable, alternative energy sources for commercial aviation which will depend on liquid hydrocarbons for at least several decades.
6. Mastering aviation's climate impact to allow low impact operations planning, deeper analysis of the formation/dissipation of contrails and induced cirrus clouds and their contribution to global warming to evaluate the actual environmental impact of a given flight and to optimise flight operations according to atmospheric conditions.
7. Incentives and regulations that create the right framework to promote environmentally friendly behavior as a part of business-as usual throughout all lifecycle phases from new aircraft design and development, over the whole operational period, up to aircraft end-of-life.

4.1.2.4. Challenge 4: Ensuring safety and security

Targets by 2050

- Overall, the European Air Transport System has less than one accident per ten million commercial aircraft flights.
- Weather and other environmental hazards are precisely evaluated and risks are properly mitigated.
- Air Transport operates seamlessly through interoperable and networked systems allowing manned and unmanned air vehicles to safely operate in the same airspace.
- Efficient boarding and security measures allow seamless security for global travel. Passengers and cargo pass through security controls without intrusion.
- Air vehicles are resilient by design to current and predicted on-board and on-the-ground security threat evolution, internally and externally to the aircraft.
- The Air Transport System has a fully secured global high bandwidth data network, hardened and resilient by design to cyber-attacks.

Key action areas

Enablers covering the following aspects are detailed to achieve the goals:

1. Expectations by society for levels of safety and security, the associated burdens and the need to provide privacy and dignity.
2. Air vehicle operations and traffic management particularly relating to cyber threats and the integration of autonomous vehicles into airspace.
3. Design, manufacturing and certification to include safety and security at all stages.
4. Human factors accounting for re-alignment of responsibility and the balance of decision making between the human and the machine.

4.1.2.5. Challenge 5: Prioritising research, testing capabilities and education

Targets by 2050

- European research and innovation strategies are jointly defined by all stakeholders, public and private, and implemented in a coordinated way with individual responsibility. This involves the complete innovation chain from blue sky research up to technology demonstration.
- A network of multi-disciplinary technology clusters has been created based on collaboration between industry, universities and research institutes.
- Strategic European aerospace test, simulation and development facilities are identified, maintained and further developed. The ground and airborne validation and certification processes are integrated where appropriate.
- Students are attracted to careers in aviation. Courses offered by European Universities closely match the needs of the Aviation Industry, its research establishments and administrations and evolve continuously as those needs develop. Lifelong and continuous education in aviation is the norm.

Key action areas

The following enablers are needed to achieve the goals:

1. Optimisation of the research and innovation lifecycle: encompassing the full European aviation sector, defining research roadmaps which cover all the successive steps of the innovation cycle.
2. Modern infrastructure: high quality R&D infrastructure as a fundamental pillar of efficient high-technology research, ranging from wind tunnels to experimental aircraft, all organized in a network for use by all stakeholders.
3. A skilled workforce: possessing the quality, skills and motivation to meet the challenges of the future; and being supported by a harmonised and balanced approach covering the entire scope: from attracting talent over primary and secondary education to apprenticeship, academia and life-long professional development.

4.1.3. Horizon 2020

The next EU Framework Programme for Research and Innovation has been named Horizon 2020.

It will be running from 2014 to 2020 with a total budget of around €80 billion. It has three major objectives for research and innovation:

- Excellence in the science base – The aim here will be to strengthen the EU's world-class excellence in science by developing talent within Europe and attracting leading researchers to Europe.
- Creating industrial leadership and competitive frameworks to support and promote business research and innovation in key enabling technologies; services and emerging sectors with a strong focus on leveraging private sector investment in R&D; and, to address SME-specific problems.
- The third block "Tackling societal challenges" will respond directly to the challenges identified in EU's growth strategy Europe 2020. It will support activities across the entire spectrum from research to market.

As key new features of Horizon 2020 it is stated that for the first time EU funding for research and for innovation is put together into a truly integrated programme. The aim is to get more impact from every euro spent, and to radically simplify the complex landscape of funding programmes that currently exist. Implementation will be simplified and standardized, with simplification covering both funding schemes and rules. Key aspects will include: a rationalized set of funding schemes, a single set of rules, earlier project start and major externalization. In Horizon 2020 Aeronautics and Aviation are found under Transport under a general heading "Smart, green and integrated transport".

4.2. Military aeronautics

The European Military Aircraft Industrial base has been and is very strong, and several Air Power Systems are being taken into service as well as being upgraded. Many of the technologies developed for these programmes have also been the basis for the successful Commercial Aircraft industry and other industrial sectors.

Through various European collaboration projects and studies European countries have been paving the way for the next generation of Future Air Systems (manned and unmanned). But the sector is fragmented and the situation can be described as that five major European aerospace companies are currently engaged in three competing combat aircraft programmes and the same will be true for drones if no European strategy is put in place.

It can be noted that there are a number of 5th generation fighter programmes underway in different parts of the world (US: F22, F35/JSF; Russia: T50 PAK-FA; China: J-20, J-31), while in Europe a joint planning for the next generation is lacking. This and new operational requirements imply new challenges for defence related aeronautical R&T in Europe.

The declining defence budgets and a change in military priorities mean that it is no longer economically viable to retain a redundant development capability in Europe. This necessitates a harmonised approach between Governments, their agencies, industry and research institutions, to enable European Governments to have access to affordable European Air Power solutions, meeting future defence and security demands.

Over the past decades a number of initiatives for enhanced collaboration have been taken on the government side like the six-nation initiative of 1998, the European Technology Acquisition Programme (ETAP) and the European Defence Agency (EDA).

4.2.1. Six-nation initiative (LOI)

A first example on the governmental side was the six-nation initiative of 1998 between France, Germany, Italy, Spain, Sweden and the United Kingdom with a Letter of Intent (LOI) aiming at "Establish a co-operative framework to facilitate the restructuring of European defence industry". This initiative involves all GARTEUR member nations except The Netherlands. It should be noted that this initiative was between nations with strong capabilities in military aeronautics, which implies a joint potential to take initiatives regarding military aeronautics.

4.2.2. European Technology Acquisition Programme (ETAP)

A resulting initiative out of the LOI-agreement was the European Technology Acquisition Programme (ETAP) established as an initiative to support the cooperative development of Future Combat Air Systems (FCAS). Encompassing both Technology Development Programmes and Technology Demonstration Vehicles, the agreement started in November 2001 when the Ministers of Defence of the six nations signed a Memorandum of Understanding underlining the importance of preparing for future fighter systems.

4.2.3. European Defence Agency (EDA)

The European Defence Agency (EDA) was established under a Joint Action of the Council of Ministers on 12 July 2004, to support the Member States and the Council in their effort to improve European defence capabilities in the field of crisis management and to sustain the European Security and Defence Policy (ESDP). EDA is composed of 26 participating Member States (all EU Member States, except Denmark).

4.2.4. Examples of projects funded by the EDA

4.2.4.1. JIP RPAS

The Joint Investment Programme on Remotely Piloted Aircraft Systems (JIP-RPAS) addresses the challenges of RPAS traffic insertion in the general airspace. EDA works in close coordination with ESA and the EC to achieve initial safe integration of RPAS in the European air space by 2016.

Launched in June 2012, JIP-RPAS aims at addressing the interlinked challenges of technology and regulation needed to ensure this integration, focusing on the enhancement of military capabilities. The work is strongly coordinated with the integrated roadmaps of the EC, namely the Regulatory Roadmap led by EASA, the R&D roadmap led by the SESAR-JU and the legal and societal roadmap led by the EC.

JIP-RPAS, an umbrella program of the EDA, has now been signed by ten member states; all GARTEUR nations except The Netherlands are involved. The German initiative, Autarkia, now renamed ERA, will be contracted in 2015. Germany is lead, and with participation from Italy, France, Poland and Sweden. Budget is estimated to be €35-40 million. The project will focus on automatic take-off and landing and on-route emergency recovery.

4.2.4.2. MIDCAS: the European Detect & Avoid (D&A) project

The MIDCAS project is laying the groundwork for future developments in the field of RPAS air traffic integration. The project has gathered European industries within the field of D&A with the purpose to achieve jointly agreed results with European and global standardisation stakeholders. The MIDCAS project was launched in 2009 by five contributing Member States (France, Germany, Italy and Spain under the lead of Sweden) under the framework of the European Defence Agency, with a total budget of €50 million.

MIDCAS has been carried out by an industrial consortium composed of 11 partners: SAAB (project leader) from Sweden, Sagem and Thales from France, Airbus Defense & Space, Diehl BGT Defence, DLR and ESG from Germany, Alenia Aermacchi, Selex ES, CIRA from Italy and Indra from Spain. Throughout the project, external stakeholders such as EASA, EUROCONTROL, EUROCAE or JARUS, were involved in the process.

MIDCAS ensures a continuous dialog with all players of the aviation community and organisms in charge of aerial safety in order to favor the acceptance of the proposed solution by this community.

The MIDCAS program (2011-2015) is planned for flight tests in the Italian UAS Sky-Y during the first half of 2015. Discussions have started on a follow-on program covering take-off and landing, a wider range of altitudes and small UAVs less than 150 kg.

5. SUMMARY OF GARTEUR TECHNICAL ACTIVITIES

The total volume of technical activities in the Action Groups was reduced in 2014 compared to 2013 due to the termination of several AGs.

GoR-AD monitored 7 Action Groups during 2014. The final reports of two of them were completed in January and November 2014 and another one was completed early 2015. The activities of this GoR were slightly reduced in 2014 compared to 2013. One more Action Group is expected to start in 2015.

Since its creation in March 2014, the newly created AS-GoR has worked on further analysing the field of Aviation Security and has identified important R&T domains such as Cybersecurity, CBE detection, Dazzling and Malevolent use of RPAS. In 2014 the AS-GoR activity mainly focused on the redaction of the white paper to describe GARTEUR position on Aviation Security. The next step would be to launch Exploratory Groups and Actions Groups as in the other GoRs.

GoR-FM didn’t monitor any Action Group during 2014 but promising subjects are under discussion.

GoR-HC monitored 5 Action Groups during 2014, two of them starting up their activities in 2014. The activities of this GoR were at a higher level compared with 2013. One Action Group is expected to start beginning 2015.

GoR-SM monitored 2 Action Groups during 2014. The activities of this GoR were at the same level than in 2013. One Action Group may start in 2015.

Some statistics for the activities are included in the Appendixes as follows:

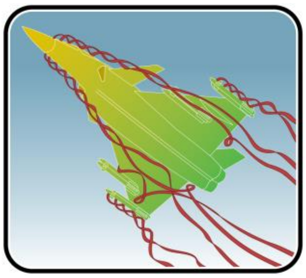
- Appendix 2 shows an overview of GARTEUR Technical activities 2011-2016;
- Appendix 3 shows the participation in the Action Groups by nations/organizations in 2014;
- Appendix 4 shows the resources deployed within Action Groups;
- Appendix 5 lists the Technical Reports that were finalised in 2014. Furthermore a number of conference presentations were made by some of the Action Groups.

The following pages present the technical highlights from the four GoRs mainly as one page posters for Action Groups active during 2014. The situation regarding Exploratory Groups and potential new topics is also described.

Detailed reports of the GoR activities 2014 are included in a separate document (X/D 50 - Annexes to the Annual report 2014). These annexes are also available on the GARTEUR website.

In chapter 6 examples of GARTEUR success stories are included as well as a section illustrating the links between GARTEUR and EU-projects.

5.1. Group of Responsables - Aerodynamics (AD)

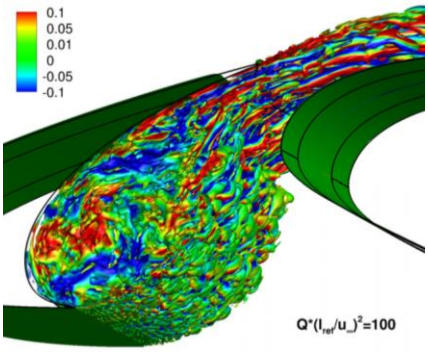


The GoR AD initiates and organises basic and applied research in aerodynamics. Whilst in general term aerodynamics makes up the majority of the research done within the GoR, some of work has a significant amount of multi-disciplinary content. This trend is driven by industrial interests, and is likely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

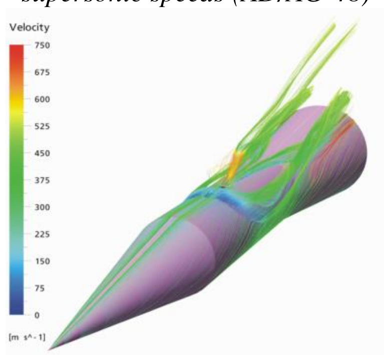
The current scope of the aerodynamic activities in the GoR covers the following:

- Aerodynamics,
- Aero-thermodynamics,
- Aero-acoustics,
- Aero-elasticity,
- Aerodynamic Shape optimum,
- Aerodynamics coupled to Flight Mechanics,
- Aerodynamic Systems Integration.

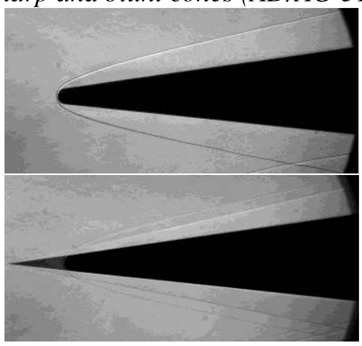
a) ZDES computation of a 3-element aerofoil (AD/AG-49)



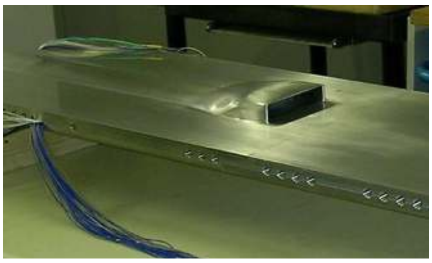
b) Lateral jets interactions at supersonic speeds (AD/AG-48)



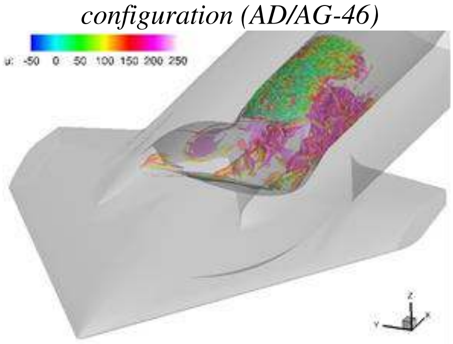
c) Transition in hypersonic flows for sharp and blunt cones (AD/AG-51)



d) Experimental parametric study of intake design (AD/AG-46)



e) CFD computations for a UAV configuration (AD/AG-46)



f) Counter-measures aerodynamics (AD/AG-55)

Figure 2: Illustrations of the Group of Responsables "Aerodynamics"

During 2014 GoR-AD monitored the following Action Groups:

- AD/AG-46 "Highly Integrated Subsonic Air Intakes" (final report delivered in January 2014);
- AD/AG-48 "Lateral Jet Interactions at Supersonic Speeds" (final report delivered early 2015);
- AD/AG-49 "Scrutinizing Hybrid RANS-LES Methods for Aerodynamic Applications" (final report delivered in November 2014);
- AD/AG-51 "Effect of laminar-turbulent transition in hypersonic flows";
- AD/AG-52 "Surrogate-Based Global Optimization methods in aerodynamic design";
- AD/AG-53 "Receptivity and Transition Prediction";
- AD/AG-54 "RANS-LES Interfacing Hybrid for Hybrid RANS-LES and embedded LES".

For the Action Groups 46, 48 to 55 a one page summary poster is included on the following pages.

The situation regarding Exploratory Groups and New Topics under review was as follows at the end of 2014:

- GoR-AD Exploratory Groups:
  Three Exploratory Groups have been running throughout 2014. As several AD/AGs are close to finish it is important that the new Exploratory Groups develop into Action Groups.
  - AD/EG-70 "Plasma for Aerodynamics";
  - AD/EG-71 "Countermeasure Aerodynamics";
  - AD/EG-72 "Coupled fluid dynamics and flight mechanics simulation of very flexible aircraft configurations".
- New Topics
  The following topics are considered for Exploratory Groups in 2014:
  - Thrust vectorization (active in 2014);
  - Inlets and outlets for ventilation (to be pursued as an EG in 2015);
  - Measurement techniques (to be reconsidered in 2015).

The membership of GoR-AD in 2014 is presented in the table below.

Chairman		
Frank Ogilvie	ATI	United Kingdom
Vice-Chairman		
Vacant		
Members		
Norman Wood	Airbus Operations Ltd	United Kingdom
Bimo Prenata	NLR	The Netherlands
Eric Coustols	ONERA	France
Giuseppe Mingione	CIRA	Italy
Fernando Monge	INTA	Spain
Henning Rosemann	DLR - Airbus Operations	Germany
Geza Schrauf	Airbus Operations GmbH	Germany
Per Weinerfelt	SAAB	Sweden
Torsten Berglind	FOI	Sweden
Industrial Points of Contact		
Thomas Berens	Airbus Defence & Space	Germany
Nicola Ceresola	Alenia	Italy
Michel Mallet	Dassault	France
Didier Pagan	MBDA	France
Luis P. Ruiz-Calavera	Airbus Defence & Space	Spain
Vacant	QinetiQ	United Kingdom

Table 2: Membership GoR-AD in 2014

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

AD/AG-46:
Highly Integrated Subsonic Air Intakes

Action Group Chairman: Dr Thomas Berens, CASSIDIAN (Thomas.Berens@cassidian.com)

Background

Unsteady internal aerodynamics for UAVs: Dynamic performance of highly integrated sub-sonic air intakes, low-observable diffuser design

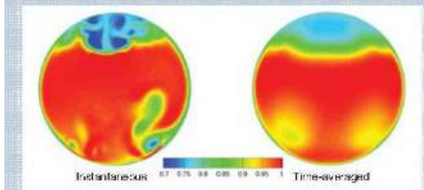
Application of modern hybrid CFD methods: Detached Eddy Simulation (DES) of internal flow field with separation, code validation

Challenge: Time-accurate prediction of dynamic intake performance parameters for enhanced assessment of engine/intake compatibility

Previous activity: Investigations in AD/AG-43 on the application of CFD to high offset intake diffusers

State of the art: CFD methods for steady and unsteady simulation of subsonic internal flow

Critical flow region: Separation at intake cowls and in high offset intake diffuser due to low-observable UAV design features



DES S-A Computation: Total Pressure Ratio Distribution in the AIP Case 3 Sharp Intake Cowl, M_∞ = 0.60, MF = 3.97 kg/s

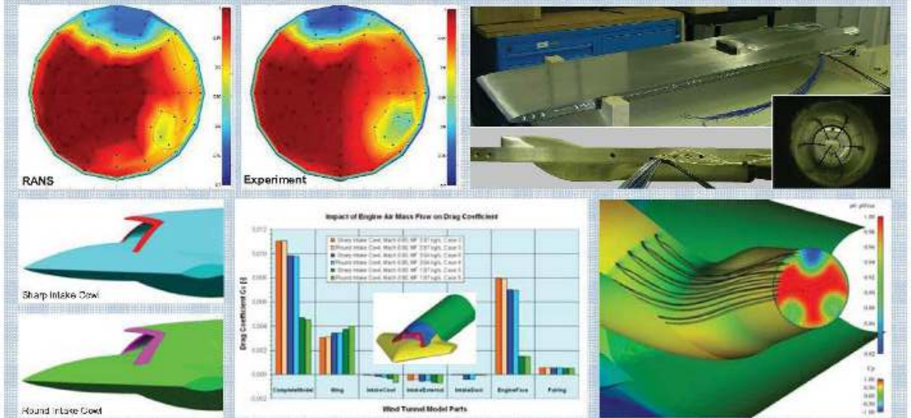
Programme/Objectives

Main objectives of AD/AG-46: (1) to investigate the capability of modern CFD methods (Detached Eddy Simulation DES) to analyze unsteady flow phenomena of highly integrated subsonic air intakes, (2) to support innovative design for advanced subsonic aerial vehicles, and (3) to assess the flow behavior at the intake cowls due to complex multi-disciplinary lip shaping addressing intake performance and drag.

Focus: Numerical simulations of unsteady internal flow in a subsonic air intake highly integrated into the airframe of a UAV applying different standard CFD methods and DES, comparison with experimental data. Parametric studies of innovative intake design features accompanied by basic wind tunnel investigations addressing low-observable intake design issues for UAVs and contributing to a better understanding and correlation of installed performance predictions of highly integrated intake configurations.

Partners: CASSIDIAN, ONERA, FOI, AIRBUS Military, DLR, SAAB, MBDA, Alenia, Dassault-Aviation

Activity: Numerical simulations for the EIKON UAV intake wind tunnel model with a variety of CFD methods and validation with T1500 wind tunnel test data; experimental investigations with a generic intake wind tunnel model in the cryogenic WT DNW-KRG at DLR Göttingen for parametric studies.



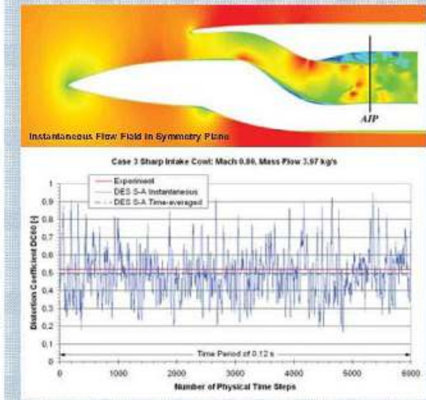
- Assessment of dynamic distortion coefficients at aerodynamic interface plane and comparison with test data
- Simulations for internal flow control by employing numerical models for vortex generators and micro-jets
- Computational investigation on intake lip shaping impacting intake performance and aerodynamic drag

CASSIDIAN AN EADS COMPANY · FOI · DLR · SAAB · ONERA THE FRENCH AEROSPACE LAB · AIRBUS MILITARY · MBDA MISSILE SYSTEMS · AleniaAeronautica A Finmeccanica Company · DASSAULT AVIATION

Results

Investigation of the capability of modern CFD methods (DES) to analyze unsteady internal flow phenomena and dynamic intake distortion

- The basis for time-accurate predictions of intake performance parameters such as dynamic intake distortion will be enhanced in order to prepare the groundwork for engine/intake compatibility prediction with improved accuracy levels.
- To accompany the design process of highly integrated subsonic air intakes, efficient hybrid CFD methods are a vital means for improving performance prediction capabilities as well as for reducing system development time and cost. Expenses for wind tunnel experiments could be minimized by increasing numerical support.



Assessment of the flow behavior of diverterless intake designs due to multi-disciplinary shaping

- Fundamental experimental studies of decisive intake design parameters will advance the knowledge innovative configurations of compact air induction systems require.
- Numerical investigations on intake cowl shaping will provide interesting insight into the impact of this important design parameter on internal flow, intake performance, and aerodynamic drag.

GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
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AD/AG-48: Lateral Jet Interactions at Supersonic Speeds

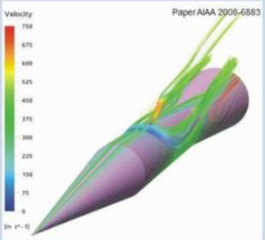
Action Group Chairman: Dr Patrick Gnemmi, ISL (patrick.gnemmi@isl.eu)

Background

Guidance of a supersonic missile: low-velocity or high-altitude missiles, fast response time of hot-gas jets, reproduction in wind tunnels of real hot-gas jet effects by the use of cold-gas jets

Application of RANS CFD methods: multi-species RANS numerical simulations, validation of different codes

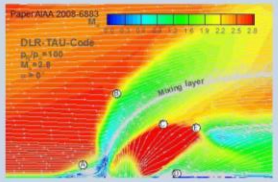
Challenge: defining the most appropriate similarity parameters for wind-tunnel tests using a cold-gas jet



Previous activity: basic experiments and wind-tunnel tests on generic missiles conducted at DLR, ISL and ONERA allowed a better understanding of the phenomenological aspects of the jet interference; effects of Reynolds number and jet pressure ratio studied, not the jet nature

State of the art: reliable steady-state CFD of cold-gas jets interacting with a supersonic flow

Critical flow region: multi-species real-gas flow interacting with the missile cross-flow



P. Gnemmi, R. Adeli, J. Longo, "Computational Comparisons of the Interaction of a Lateral Jet on a Supersonic Generic Missile", Paper AIAA 2008-6883

Programme/Objectives

Main objectives of AD/AG48: (1) to accurately predict by CFD the steady-state aerodynamics of the interaction of a hot multi-species gas jet with the cross-flow of a supersonic missile at acceptable computational costs; (2) to deeply analyze the effect of the hot-gas jet from numerical simulations; (3) to define the most appropriate similarity parameters for wind-tunnel tests using a cold-gas jet

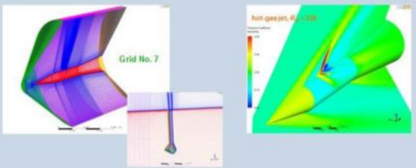
Focus: (1) numerical simulation validations of the interaction of cold-air and hot-gas jets with the cross-flow of supersonic missiles using different Reynolds-Averaged Navier-Stokes (RANS) codes and experimental data from DLR Cologne and ONERA/MBDA-France; (2) numerical simulations for the replacement of the hot-gas jet by a cold-gas jet able to reproduce the effects of the hot-gas jet

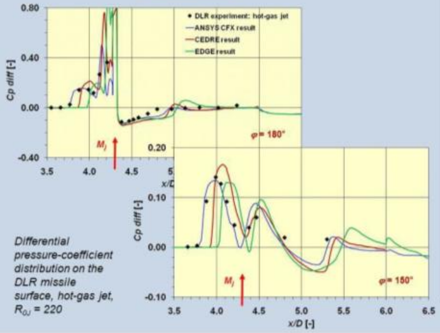
Partners: DLR Cologne, FOI, ISL, MBDA-France, MBDA-LFK, ONERA

Activity: numerical simulations with different RANS codes and validations using high-quality wind-tunnel data

DLR Cologne configurations:

- supersonic flow at Mach 3.00, $\alpha = 0°$
- cold-air and hot-gas jets
- ejection pressure ratio of 130 and 220

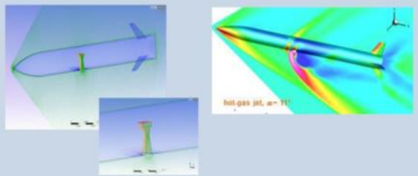


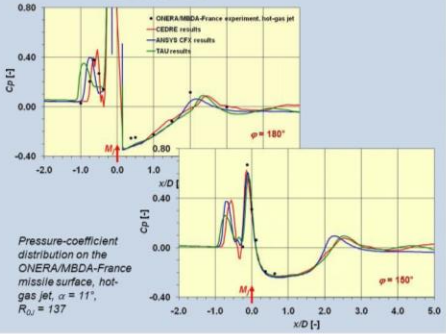


Differential pressure-coefficient distribution on the DLR missile surface, hot-gas jet, R_{0J} = 220

ONERA/MBDA-France configurations:

- supersonic flow Mach 2.01, $\alpha = 0°$ and 11°
- cold-air and hot-gas jets
- ejection pressure ratio of 81 and 137





Pressure-coefficient distribution on the ONERA/MBDA-France missile surface, hot-gas jet, α = 11°, R_{0J} = 137

DLR FOI ISL MBDA ONERA THE FRENCH AEROSPACE LAB

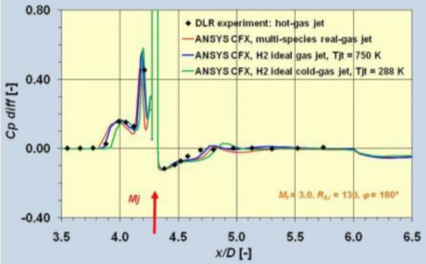
Results

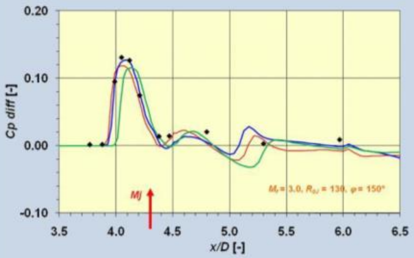
Prediction of cold-gas and hot-gas lateral jet interaction with missile cross-flow

- steady-state numerical simulations able to accurately predict the aerodynamics of cold-gas and hot-gas jets interacting with the missile cross-flow
- less accurate for hot-gas jets with some codes in case of sonic jet flow

Most appropriate similarity parameters for wind-tunnel tests using cold-gas jets

- steady-state numerical simulations used to try to reproduce the effects of a hot-gas jet by the use of a cold-gas jet
- numerous numerical simulations in progress which must be analyzed





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

AD/AG-49: Hybrid RANS-LES Methods for Aerodynamic Applications

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

Background

Hybrid RANS-LES modelling (including DES – Detached Eddy Simulation) combines RANS (Reynolds-Averaged Navier-Stokes) and LES (Large Eddy Simulation) modelling approaches. Its development has been greatly facilitated by industrial needs in aeronautic applications, particularly in CFD analysis of unsteady aerodynamic flows characterized by massive separation and vortex motions. Computations using a hybrid RANS-LES model are able to provide turbulence-resolving simulations.

A number of hybrid RANS-LES modelling approaches have been developed in **Previous work,** being validated in and applied to a wide variety of turbulent flows.

The work in AG49 has focused on an exploration of modelling capabilities in resolving some underlying flow physics in typical aerodynamic applications, e.g., free shear layer, confluence of BLs and wakes, flow separation, recirculation and reattachment. Several selected hybrid RANS-LES methods are scrutinized and evaluated. Some further modelling improvements are also reported.

Fundamental aspects: Examination of hybrid RANS.LES models, modelling evaluation and improvement, modelling-related numerical issues.

Aerodynamic applications: high-lift flows with boundary-layer separation, vortex bursting and shedding, and unsteady flow phenomena associated potentially to flow control and aero-acoustic noise generation.

Partners: Research and academic organizations : CIRA, DLR, FOI, INTA, NLR,ONERA and TUM.

Programme/Objectives

Main objectives: To evaluate and to assess selected hybrid RANS-LES methods with a focus on the simulation and modelling capabilities of handling B.L. separation, shear-layer instabilities and vortex motions and, further, to bridge the gap between "academic" modelling and industrial application.

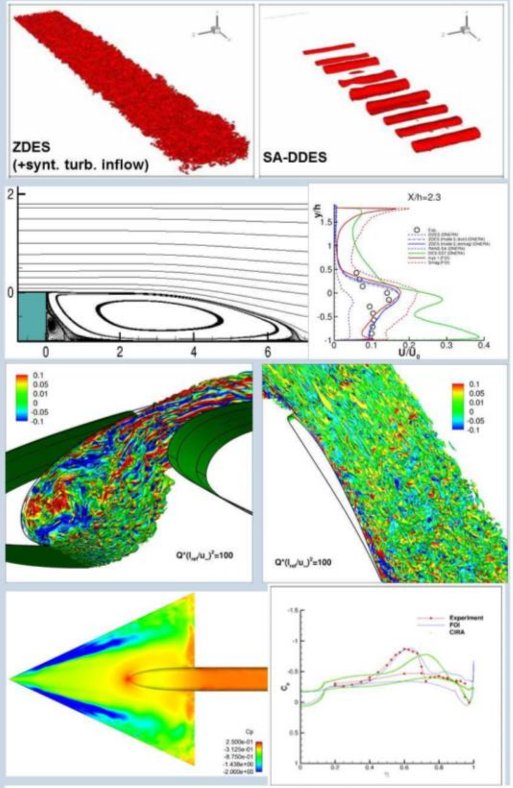
Work plan: The work in AG49 is divided into three tasks. Task 1 and Task 2 are test-case based and each contains two different test cases. "Best-practice guidelines" are addressed in Task 3. AG49 was completed in April 2013.

TC 1.1 Spatially developing mixing layer
Participants: NLR, FOI, INTA, ONERA & TUM
Flow conditions: U_1 = 41.54 m/s, U_2 = 22.40 m/s, with BL. θ =1.00/0.73 mm, Re_θ = 2900/1200
Focus: shear-layer instabilities (in association to grey-area problem), effect of upstream inflow condition, LES mode accounting for downstream vortex motions.

TC 1.2 ONERA backward-facing step flow
Participants: ONERA, FOI, NLR, CIRA & TUM
Flow Conditions: U = 50m/s, Re_h = 40000
Focus: shear-layer instabilities (in association to "grey-area" problem), effect of inflow condition, flow recirculation and reattachment, downstream flow recovery.

TC 2.1 F5 high-lift configuration
Participants: DLR, FOI, ONERA & TUM
Flow conditions: M = 0.15, Re = 2.094 M
AoA = 7.05 deg. (WT), 6.0 deg. (CFD-corrected)
Local transition specified
Focus: BL and wakes confluence, shear-layer interaction, BL separation and subsequent vortex motions, effect of local transition.

TC 2.2 VFE-2 delta wing
Participants: TUM, CIRA, FOI & NLR
Flow Conditions: M = 0.07/0.14
Re =1.0 M, AoA = 23 deg, round leading edge
Focus: formation of primary and secondary vortices, vortex breakdown and shedding.



Results

- Exploration and further improvment of modelling and turbulence-resolving capabilities based on a number of test-case computations using different hybrid RANS-LES models
- Assessment of hybrid RANS-LES methods in terms of their respective advantages and disadvantages, by means of cross comparisons of partners' computations.

Summary:

- Asessment made for a number of hybrid RANS-LES models through test-case computations, and further improvement on XLES with stochastic forcing and/or based on EARSM; HYB0 with energy backscatter in the LES mode, improved ZDES with vorticity-based length scale in the LES mode.
- All AG members have computed the test cases planned and contributed to the cross plotting of the results for computed TCs.
- Partners have used the following hybrid models: *SA-DES / DDES and IDDES, SST-DES / DDES, zonal SA-DDES, zonal RANS-LES/DNS, HYB1, HYB0, X-LES, ZDES and their variants.*
- Cross plots have been conducted for all TCs in comparison with available experimental data, and reported in the final summary report.
- Comparative studies have been conducted for modelling evaluation.
- The impacts of other significant factors have been explored, typically, incoming BL, numericla dissipation, grid resolution and domain size etc..
- Experience gained and lessons learned from the work conducted are summarized
- A new EG (EG69) has been set up in 2013 by the AG49 members, plus several new EG members. A new AG is planned to launch in 2014 to address RANS-LES couplng for zonal and embedd LES methods.

GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
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AD/AG-50: Effect of open jet shear layers on aeroacoustic wind tunnel measurements

Action Group Chairman: Dr Pieter Sijtsma, NLR (Pieter.Sijtsma@nlr.nl)

The Background

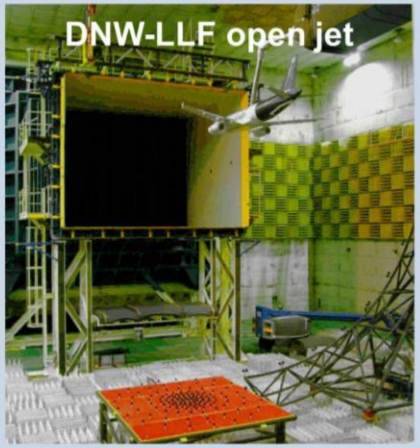
Aeroacoustic wind tunnel tests are typically conducted in open jets
Sound propagates through shear layer

Shear layer causes refraction, spectral broadening and coherence loss
These effects complicate interpretation of test results (e.g. identification of open rotor tones)

Shear layer effects depend on frequency, wind speed, and source position

Currently most groups only correct for shear layer refraction, using ray-acoustics approximation

Challenge
Understand shear layer effects and develop correction methods or reduction concepts



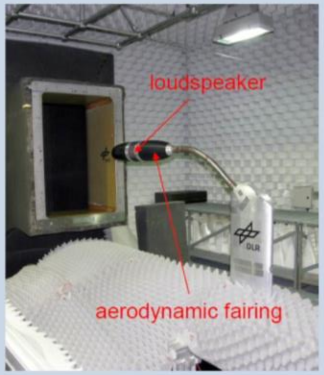
The Programme

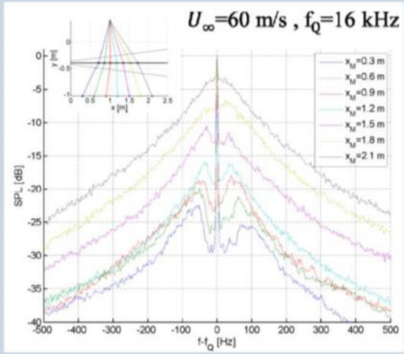
Objectives of AD/AG-50
- To improve the understanding of shear layer effects;
- To quantify the magnitude of shear layer effects, including the dependence on different parameters;
- To develop procedures to correct for shear layer effects;
- To investigate the possibilities to reduce shear layer effects.

Approach
- Experiments with calibration sources in different wind tunnels
- Benchmark computations using existing correction methods
- Advanced computations to improve understanding

Partners
Airbus, CIRA, DLR, NLR, ONERA, University of Southampton

Project duration: 1 January 2010 – 30 April 2013



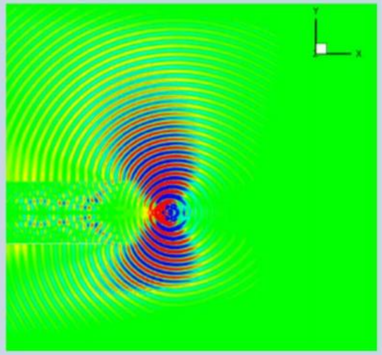


The Outcomes

Wind tunnel experiments
- Quantification of spectral broadening as a function of wind speed, frequency and source position
- Better understanding of mechanisms through turbulence measurements
- Methods to retrieve correct acoustic energy of tones measured outside shear layer

Computations
- Existing analytical correction methods were benchmarked
- Advanced numerical methods were developed and compared to benchmark cases
- CAA calculations including spectral broadening
- Comparison to experiments

AD/AG-50 improved the quality of aeroacoustic wind tunnel testing



AIRBUS CIRA DLR NLR ONERA University of Southampton Institute of Sound and Vibration Research

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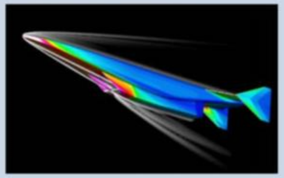
AD-AG51 : Effect of laminar/turbulent transition in hypersonic flows

Action Group Chairman: Jean Perraud (ONERA)
Vice Chairman: Antoine Durant (MBDA-F)

The Background

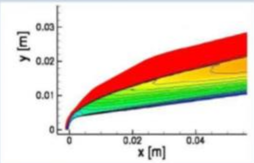
Transition laminar/turbulent:
Thrust-drag balance and air intake adaptation (air breathing hypersonic vehicles)
Heat fluxes (re-entry vehicles)



Different experimental data sources in Europe

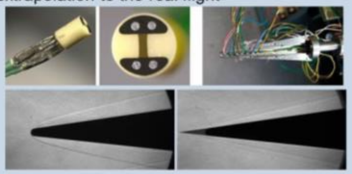
Increasing capability of CFD :
Need of tools/methods to predict laminar/turbulent transition in hypersonic using RANS code

Challenges:
Cross studies between configurations and tools (RANS, LST, wind tunnel)

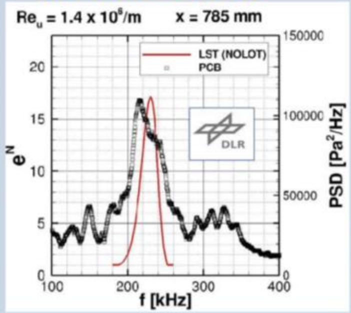


State of the art:
Linear stability theory, Wind tunnel experiments

Critical aspect:
Measurement techniques, wind tunnel noise, extrapolation to the real flight

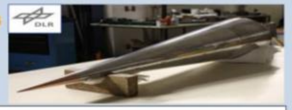


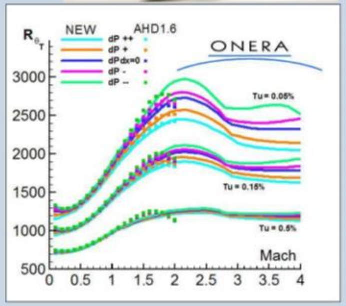
Activities 2013



WP1 :
Experimental data described in a draft report, to be completed.
Part of the data bank available at ONERA ftp site.
Figure :
Linear stability calculation compared to experimental wall pressure spectra measured using miniature PCB pressure sensor.

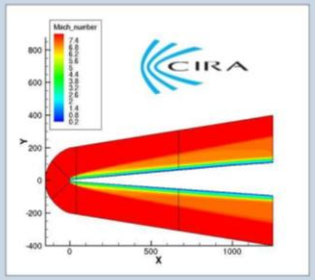
Sharp and blunt cones
Natural transition
Mach=7
Re=3.7 10^6/m





WP2 :
Transition prediction model has been extended to non zero pressure gradients, for adiabatic wall.
The model has been introduced into codes 3C3D (boundary layer) and elsA (RANS) in replacement of AHD transition criteria.
Figure : validation in 3C3D (5 pressure gradients using velocity ramps, 3 turbulence levels)
Validation underway in elsA

WP3 :
First computations on the LEA forebody done at CIRA



Mach=[4-8]
Re=[1.4 – 14] 10^6/m

Hypersonic forebody
Natural and triggered transition
▪ Schlieren, Pitot pressure, Oil flow, TSP

Programme

Objectives of the Action Group AD-AG51:

- Cross studies between different wind tunnel tests (blow-down and hot shot)

- Comparisons to numerical approaches
  - Extension of transition criteria to hypersonics
  - Implementation into elsA solver validation based on above test cases
  - Impact of wind tunnel on transition extrapolation to real flight
  - Study of the design of triggering devices

- Navier-Stokes solver with extended criteria (AHD)
- Linear stability codes

Partners: industries and research establishments : CIRA, DLR, ISL, MBDA-F, ONERA, VKI, UniBwM

Current status :

- **Submission to GARTEUR council: June 2011**
- **Project approval : September 2011**
- **Kick-off meeting: 1st Feb 2012**
- **Meeting 1 at VKI: 22nd Nov 2012**
- **Meeting 2 at MBDA : February 2014**

Next Steps :

- **Validation and application of the extended AHD criterion to LEA forebody**
- **Work plan for tasks 3.3 / 3.4**
  - **Navier-stokes computations on ISL cones**
  - **Laminar BL extraction and comparison**
  - **LST codes benchmark for natural transition**
- **Next meeting : Feb 2014, MBDA**

CIRA DLR ISL INSTITUT FRANCO MBDA ONERA THE FRENCH AEROSPACE LAB Universität der Bundeswehr München VON KARMAN INSTITUTE

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AD/AG-52: SBGO methods for aerodynamic design

Action Group Chairpersons: Dr. E. Andrés (INTA) and Dr. E. Iuliano (CIRA)

Background

Surrogate-based global optimization methods (SBGO) can meet the requirement of performing a broad exploration of the design space, as they have the ability to work with noisy objective functions without assumptions on continuity and with a high potential to find the optimum of complex problems. However, global optimization methods involve a vast number of evaluations even for a small number of design variables. As each evaluation requires a CFD complete analysis, this would make the method unfeasible, in terms of computational cost. Therefore, there has been a **raising interest in surrogate modeling** which promises to provide sufficiently accurate solution of complex problems with reduced computational efforts.

Current work in AG52 focuses on the assessment of different surrogate modeling techniques for fast computation of the fitness function and the evaluation of surrogate-based global optimization strategies for the shape design of the selected configurations.

Specific challenges: Deal with the "curse of dimensionality", off-line and on-line model validation strategies, proper error metrics for comparison, efficient DoE techniques for optimal selection of training points towards validation error mitigation, reduction of the design space, improvement of surrogate accuracy at fixed computational budget, and variable fidelity models.

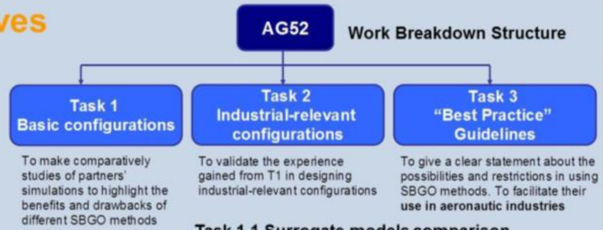
Aerodynamic applications: Aerodynamic shape optimization problems in an early stage. "Best practice" guidelines for the industrial use of SBGO methods

Partners: Research, academic organizations and industries: INTA, CIRA, AIRBUS-Military, Brno University of Technology, FOI, ONERA, SAAB, University of Alcala and University of Surrey.

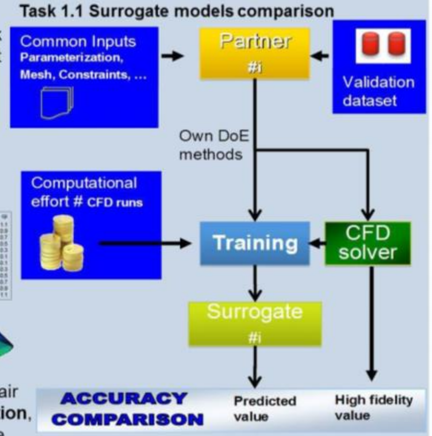
Programme/Objectives

Main objectives: To analyze the feasibility and possible contributions of SBGO methods in an early phase of the aerodynamic design, where the design space will be broadly analyzed to get the optimum solution

Project duration: 3 years (2013-2015)

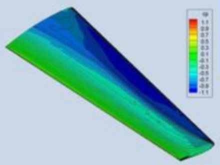


Work plan: The work in AG52 is divided into three tasks. Task 1 and 2 are test-case based and each contains two different test cases. "Best-practice guidelines" are addressed in Task 3.

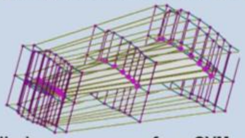


Two test cases are defined in Task 1:
TC 1.1 RAE2822 airfoil
Design points: DP1 M=0.734, Re=6.5x106, AoA=2.65°.
DP2 M=0.754, Re=6.2x10^6, AoA=2.65°
Objetive: maximize C_L/C_D

TC 1.2 DPW-W1 wing
Design points: DP1: M=0.76, C_L=0.5, Re=5x10^6, DP2: M=0.78, C_L=0.5, Re=5x10^6, DP3: M=0.20 and C_L^{max} (optima) >= C_L^{max} (original). Objetive: Minimize C_D with constant C_L

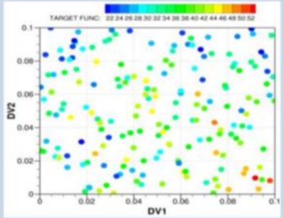


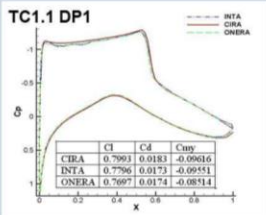
In order to minimize the sources of discrepancies and allow a fair comparison between surrogates, the **geometry parameterization**, the **computational grids** (unstructured and structured) and the **surface deformation algorithm** are **shared** between all partners.



Shared parameterization of the DPW-W1 wing

A CFD cross-analysis of the initial configurations has been performed to quantify differences of using different solvers..





Preliminary measures for a SVM surrogate

Cd		Cl	
MAE	MSE	MAE	MSE
1.4001e-04	3.7997e-08	5.8423e-04	6.2314e-07
1.3642e-03	3.3071e-06	4.8181e-03	4.1851e-05
1.2694e-03	2.7198e-06	4.1788e-03	3.0904e-05

Results

- Assessment of SBGO methods investigated by AG members in terms of their respective advantages and disadvantages for the application to the aerodynamic shape design, by means of cross comparisons of solutions.

Partial reports delivered:
- **PR01**: RAE2822 definition and common geometry parameterization (May 13)
- **PR02**: DPW-W1 definition and common geometry parameterization (March 13)
- **PR03**: Strategy for surrogate models validation in aerodynamic shape optimization (Dec.13)

Current Status:
- **Common data** (parameterization, grids and surface mesh deformation) for all TCs of Task1 are **available** for surrogate model validation and optimization comparison.
- A website has been created for dissemination: www.ag52.blogspot.com
- Participation and organization of Special Sessions at **EUROGEN 2013** and **ECCOMAS CFD 2014**.
- A **CFD cross-analysis** to identify the error sources of using different CFD solvers has been performed.
- Preliminary results on surrogate validation (task 1.1) have been shown by some of the partners

Next steps:
- All AG members have started the integration of the common tools into their optimization frameworks and are **currently extracting the surrogate validation data**.
- **Comparative studies will be conducted** for surrogate models evaluation, and proper error measurement, **following the PR03 document**.
- Results on surrogate models comparison will be shown in next meeting.

Next meeting: February 2014, INTA

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

Action Group Chairman: Dr Ardeshir Hanifi, FOI (ardeshir.hanifi@foi.se)

The Background

Environmental issues
Future demands on huge reduction of CO_2 and NO_X have caused an increased interest for laminar aircraft. Design of such devices and specifications of the manufacturing tolerances require a reliable and accurate prediction of transition.

Receptivity process
In the last fifty years the initial linear amplification and the nonlinear stage of growth of these perturbations can now be accurately estimated. However, accurate initial conditions for the amplified waves need to be provided in order to correctly predict the onset of transition.

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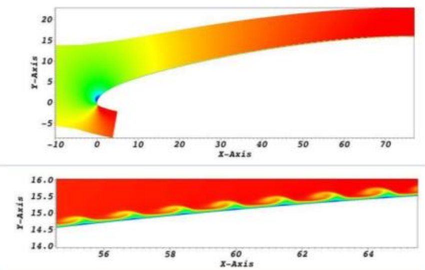


Direct numerical simulation around NLF (2)-0415. Lower figure is a close up of CF vortices in side the boundary layer caused by DRE.

The Programme

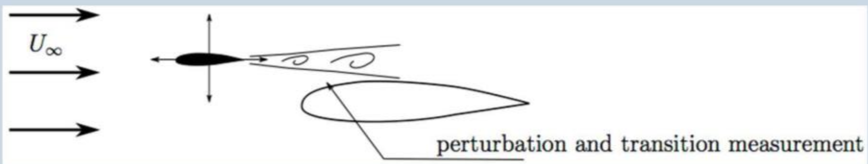
Objectives of AD/AG-53
Main objective of the proposed activities is to understand the effects of surface irregularities and perturbations in incoming flow on transition in three-dimensional flows and efficiency of transition control methods. The activities cover both experimental and numerical investigations.

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. The work includes investigations of 2D and 3D flows. The free-stream perturbation will be generated by wake of a moveable body placed upstream of the wing.
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
FOI, KTH, CIRA, DLR, Imperial College, Airbus

Project duration: September 2013 – September 2016

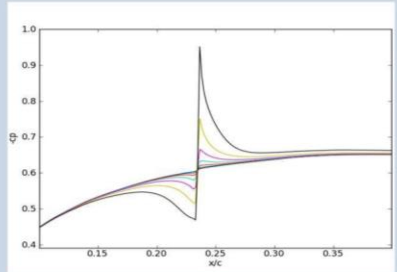


Schematic view of the experimental set-up in the ONERA Juju wind tunnel.

The Outcomes

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

Main achievements
So far the activities are in starting phase or planning stage. IC & EADS have performed flow computations have for a range of step gap deformations at 23% chord on an underlying 2d symmetric aerofoil configuration (M2355).
FOI & KTH have implemented a projection method for extraction of amplitude of boundary-layer instability waves (TS and CF) from the unsteady flow filed. This is a necessary step for computation of acoustic receptivity coefficient from the DNS data.



Pressure and maximum N factor for increasing step height (cubic filler profile).

FOI KTH ROYAL INSTITUTE OF TECHNOLOGY CIRA DLR Imperial College London AIRBUS AN EADS COMPANY

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AD/AG-54:
RANS-LES Coupling in Hybrid RANS-LES and Embedded LES

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

Background

Hybrid RANS-LES modelling aims at turbulence-resolving simulations, in particular, for unsteady flows 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 variety 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 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.

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 some underlying physics of typical aerodynamic flows. AG54 focuses on effective RANS-LES coupling towards novel and improved hybrid modelling and embedded LES methods.

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

Programme/Objectives

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

Work plan: 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.

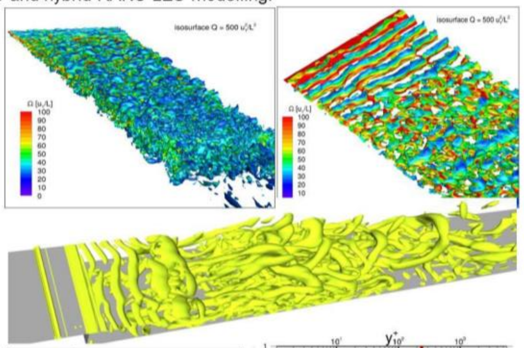
TC M2 Spatially developing boundary layer
Inflow defined with U = 70m/s and Re_θ = 3040. Focus on turbulence-resolving capabilities on the attached BL after the RANS-LES interface.

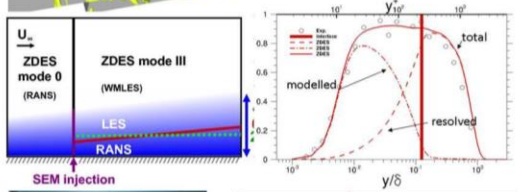
TC O2 NASA hump flow
Incoming BL has U = 34.6m/s, Re_c = 936000 (c = hump length). Focus on the turbulence-resolving capabilities on the flow separation over the hump.

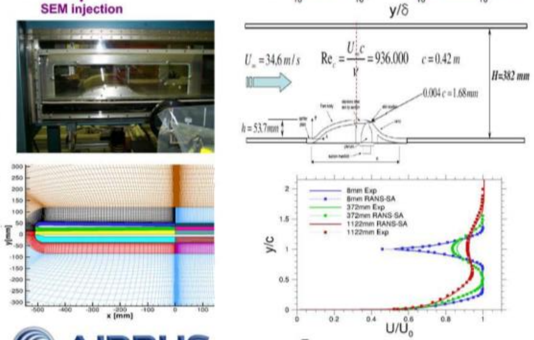
Task 3: Modelling assessment

(Task Leader: **Airbus-Innovations** (EADS-IW))
Evaluation and assessment of the methods developed in Tasks 1 and 2 with one TC.

TC M3 Co-flow of BL and wake
Re = 2.4x10[6]/meter and M = 0.2. Examination of modelling capabilities for a complex flow case.







Results

- **E**valuation of existing hybrid RANS-LES methods of zonal and non-zonal modelling in computations of test cases.
- **I**mproved modelling formulation to enhance turbulence-resolving capabilities with special focus on the so-called "grey-area" problem.
- **D**efinition of all the test cases, and a number of preliminary computations conducted for different test cases.

Summary:
The project kick-off took place in April 2014. Since then, AG54 has made the following progress.

- In the evaluation, the following baseline hybrid RANS-LES models have been planned/used in test-case computations, *SST-IDDES, HYB0, HYB1, X-LES, ZDES, 2-eq. based DES, 2-velocity method, WMLES, RSM-based hybrid model, SAS and other variants.*
- For non-zonal hybrid RANS-LES modelling, improvement has been progressing on, among others, X-LES with stochastic backscatter model; HYB0 and HYB1 with energy backscatter, improved ZDES with vorticity-based length scale; SST-IDDES model with well-defined hybrid length scale.
- For zonal hybrid RANS-LES modelling, including ELES, synthetic turbulence has been further examined with ZDES formulation. Noticeably, the synthetic eddy method, DFSEM, has been further improved for ELES.
- All the test cases have been defined with formulated test-case description, including the mandatory test cases M1, M2 and M3, as well as the optional test cases O1 and O2.
- Most of AG members have actively started computations of test cases according to the plan, and some preliminary results have been presented
- AG54 had its 1st progress meeting in October 2014, hosted by UniMan.

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AD/AG-55: Countermeasure Aerodynamics

Action Group Chairman: Dr Olof Grundestam, FOI
(olof.grundestam@foi.se)

The Background

In order to increase the defensive capability of aircraft, countermeasures are used to decoy enemy tracking system. Two commonly used countermeasures are chaff and flares.
Chaff is a radar countermeasure consisting of small pieces (or threads) of metal or metalized glass fibre. The chaff interacts with the electromagnetic radar wave and can thereby decoy or distract enemy radar. Chaff are dispensed in very large numbers from specific dispenser devices, typically located on the fuselage or under the wing of an aircraft. Chaff can also be applied in naval warfare against anti-ship missiles.
Flares are used against IR-seeking missiles. They are much larger in size (typically a few decimetres in length) and are considered individual entities even though several flares are often fired in series. Flares can have built in propulsions systems.
The aerodynamic behaviours of these two countermeasures differ significantly. Chaff dispensed from an aircraft propagate through the wake of the aircraft with the motion induced by trailing vortices. When simulating chaff dispersion it is hence of major importance to obtain an accurate description of the flow in the wake. Flares, on the other hand, are solid bodies and from this point of view, more conventional methods can be used to evaluate the aerodynamic properties.

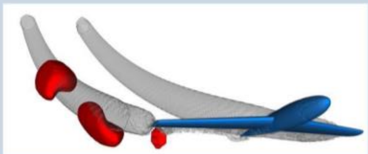
The Programme

Objectives of AD/AG-55
The main objectives of the proposed activities are to obtain increased understanding and improved modelling tools for chaff dispersion and flare trajectiory simulation. The project consists of two work packages: WP1 for chaff and WP2 for flares.The main focus of WP1 is to include directional information of the chaff. For this purpose chaff will assumed to have the shape of finite cylinders (or fibres). For WP2, the primary concern is how the burning of the flare IR payload affects the aerodynamic properties.

Approach
The proposed work is divided into chaff and flare parts. For chaff dispersion, two methods (Eulerian and Lagrangian) will be considered. The principle behind the Eularian method is that chaff is traced as a concentration instead of individual specimen (Lagrangian). The aim is include directional information for both approaches. In addition to this, parametric studies (chaff dispenser position, concentration and distribution) will be performed.
For flares, the primary focus is the aerodynamic properties and how they are affected by the burning of the IR payload. Numerical studies will include inert and reacting flares. For the latter case, a special boundary condition will be developed in order to model the release of heat and exhaust gases from flare. The final goal is to be able to incorporate all essential physical aspects of the process, hopefully also the 2-way fluid-flare coupling.

Partners
Airbus Military, Etienne Lacroix, FOI, MBDA, NLR

Project duration: Oktober 2014 – December 2017



The Outcomes

Expected results/benefits
The project is expected to yield increased understanding of how chaff dispersion and flare trajectory modelling can/should be performed. A natural outcome is also that the concerned partners obtain improved simulation tools, as the work packages are finalized.

Main achievements
AD/AG-55 was approved by the GARTEUR board at the beginning of October 2014. and since several partners have not yet commenced their activities, no goals have been achieved so far.

FOI · AIRBUS MILITARY · LACROIX Protection Superiority · MBDA MISSILE SYSTEMS · NLR

5.2. Group of Responsables - Aviation Security (AS)

[9]

The Group of Responsables on Aviation Security was created during the GARTEUR Council meeting in March 2014. The GoR AS pursues to do research in the Aviation Security field dealing with both military and civil R&T.

Four major R&T domains have been identified inside this GoR:

- **Cybersecurity**:

Airspace operators (both commercial and military) wish to make use of new communications capabilities to support their missions, develop new cost efficient operations and maintenance procedures, and offer new revenue producing services. These intentions can only be realised by moving more information on and off the aircraft on a regular basis. The latest aircraft therefore rely on interconnected systems which extend off the aircraft to ground-based systems run by airlines, airports and Aviation Service providers of various types. With the continual and rapid integration of new technologies, the aviation industry keeps expanding, changing, and becoming increasingly connected.

The introduction of new technologies and interconnection of systems also introduce new vulnerabilities. Without the appropriate cyber-security measures in place, the air transport system may be at risk. More attention is therefore due to this complex problem.

- **CBE (Chemical, Biological and Explosive detection):**

Both, the criminal and the accidental release of chemical, biological and explosive (CBE) substances represent a threat to civil security, especially at public places like airports. Laser based standoff methods offer promising possibilities for early detection and identification of hazardous CBE substances at a distance. People and luggage can be screened nearly instantaneously in a harmless way without any further disturbance of the passengers and by maintaining their integrity. In case of crisis management discrete and reliable detection methods allow for an immediate initiating of counter measures and thereby reduce the threat for people in general and first responders in particular.

- **Dazzling**:

Recent events have shown that laser can be used to dazzle persons or optronic systems. In order to protect pilots from such attacks, laser radiation present on an aircraft has to be detected and to be reported to the pilots to make them aware of the threat and to prepare protection measures.

- **Malevolent use of RPAS**:

Remotely Piloted Aircraft Systems and/or Unmanned Aerial Systems (RPAS/UAS) are expected to become a reality in the airspace within the coming years thanks to their (imminent) integration into non segregated airspace (thanks, among others, to EU roadmap). This will open the airspace not only to security applications but also to a wide number of particular, private, leisure and commercial ones.

[9] It is worth mentioning that the logo for the Aviation Security GoR is made from royalty-free images. On the other hand GARTEUR has the property rights for the logos of the other GoRs (AD, FM, HC and SM).

Many small and low cost systems (some hundred Euros) such as autonomous model aircraft or micro/mini RPAS/UAS are currently being flown in cities and/or in open environments and will exponentially thrive within this context. Recent events have shown malevolent use of RPAS. So, more effort in prevention has to be done to ensure the protection of aviation activities regarding this threat.

The membership of GoR-AS in 2014 is presented in the table below.

Chairman		
Virginie Wiels	ONERA	France
Vice-Chairman		
Ingmar Ehrenpfordt	DLR	Germany
Members and Industrial Points of Contact		
Bernd Eberle	Fraunhofer	Germany
Anders Eriksson	FOI	Sweden
Francisco Munoz Sanz	INTA	Spain
René Wiegers	NLR	The Netherlands

Table 3: Membership GoR-AS in 2014

It is worth reminding that the GoR on Aviation Security was created in March 2014. The current work of this newly created GoR is to define Exploratory Groups for each of the R&T domains and subsequently to come up with proposals for Action Groups, as usually done in the other GoRs.

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

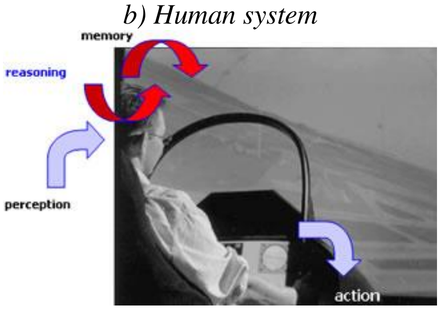
GoR-FM is active in the field of flight systems technology in general.

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:

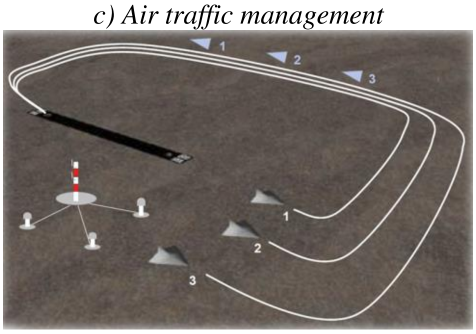
- Aircraft multidisciplinary design aspects;
- Flight performance, stability, control and guidance;
- Aircraft navigation and mission management;
- Air traffic management and control;
- Integration of remotely piloted systems in the air spaces;
- Safety critical avionics functions and embedded systems;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

a) Flight desk

b) Human system



c) Air traffic management



d) ONERA SV4 vertical wind tunnel and associated dynamic simulation test benches

e) Flexible Aircraft Modeling Methodologies (FM/AG-19)

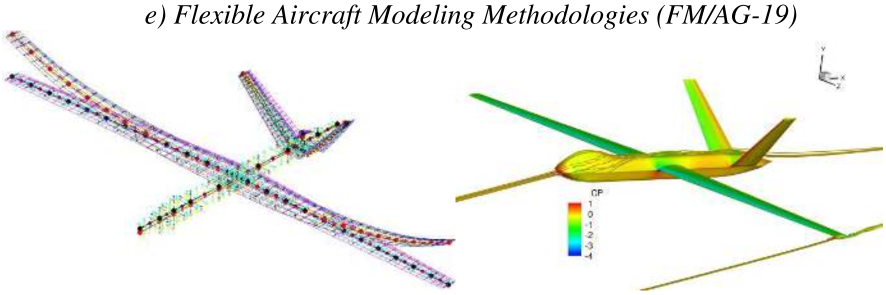


Figure 3: Illustrations of the Group of Responsables "Flight Mechanics, Systems and Integration"

The FM GoR faced a few changes in membership in 2014. Several members are facing significant budget reductions, preventing new ideas to grow and Exploratory Groups to transition to Action Groups. GoR management has been active. Despite, existing EGs did not transition into AGs, and new ideas did not transition into EGs.

Several discussions were held at FM GoR meetings to discuss new topics. FM GoR agreed to review FlightPath2050 reports and Horizon 2020 rejected proposals for topics to start in FM GoR as EGs. It was agreed to prepare a pilot paper on Pilot Wearable Avionics.

In 2014, there were no Action Groups active. A one page summary poster of Action Group FM/AG-18 ("Towards Greater Autonomy in Multiple Unmanned Air Vehicles"), whose group presented a series of publications during a special session at the international Bristol UAV Conference in May 2013, is included on the following page.

The situation regarding Exploratory Groups and New Topics under Review was as follows at the end of 2014:

- GoR-FM Exploratory Groups:
  Two Exploratory Groups have been alive in 2014:
  - FM/EG-28 "Non-linear flexible civil aircraft control methods evaluation benchmark";
  - FM/EG-29 "Trajectory V&V Methods: formal, automatic control and geometric methods".

- Topic under consideration:
  - Pitot Wearable Avionics.

The membership of GoR-FM in 2014 is presented in the table below.

Chairman		
Francisco Muñoz Sanz	INTA	Spain
Vice-Chairman		
Rob Ruigrok	NLR	The Netherlands
Members		
Antonio Vitale	CIRA	Italy
Daniel Cazy (until mid 2014)	Airbus	France
Emmanuel Cortet (from mid 2014)	Airbus	France
Martin Hagström	FOI	Sweden
Bernd Korn	DLR	Germany
Philippe Mouyon	ONERA	France
Industrial Points of Contact		
Francisco Asensio	Airbus Military	Spain
Laurent Goerig	Dassault	France
Fredrik Karlsson	SAAB	Sweden
Martin Hanel	CASSIDIAN	Germany

Table 4: Membership GoR-FM in 2014

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

FM/AG-18: Towards greater Autonomy in Multiple Unmanned Air Vehicles

Action Group Chairman: Dr Jon Platts (jtplatts@QinetiQ.com)

Background

The wider use of UAVs for Military, Civil and Commercial applications is dependent on obtaining the optimum partnership between the human supervisor and the system. Communications between the supervisor and the system should be reduced as far as possible and be at high levels of abstraction with the majority of activity carried out with a minimum of human intervention. Given adequate autonomy, communications between the human supervisor and the vehicle can be minimised being necessary only where critical decisions are required. Moreover, it is clear that the more challenging applications with only a small number of human supervisors available to operate more than one UAV will create a distributed control problem.

Work carried out by the GARTEUR nations has led to the conclusion that unprecedented autonomy levels will be required and world-wide research in the area is very active examining a range of methods for achieving autonomy. It is very difficult to judge the effectiveness of innovative methods for achieving UAV autonomy due to:

- Scarcity of adequate models and simulation environments.
- Dispersion of techniques (not well-known or unknown)
- Lack of common benchmark for comparison
- Lack of awareness about autonomy gap and its implications.

Consequently, it is difficult to identify where investment is needed to rapidly mature the most promising contenders. This action group is designed to aid this process and the aim of the work is the:

Collection, implementation and systematic categorisation of machine based reasoning and artificial cognition approaches applicable to facilitate co-operation between UAVs and other assets with reduced human intervention. Those other assets will include other UAVs, manned assets and human operators performing supervisory control. The environment is highly uncertain, the goals may change and the problem may have no unique solution.

Programme/Objectives

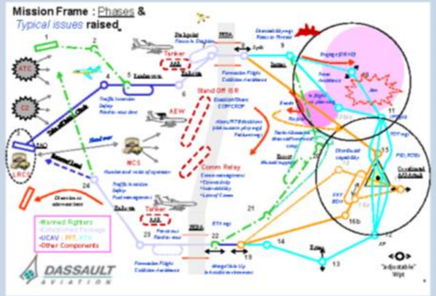
Within the aviation industry human supervisory control of complex systems has long been a requirement driven by the need to reduce air vehicle crew levels and workload, compensate for human frailty and latterly, the demands of UAVs deployed in many diverse tasks. The development of autonomous planning and decision making techniques will increase vehicle autonomy potentially enabling a reduction in the number of operators required, a reduction in operator workload, as well as compensating for human frailty and thus preserving system effectiveness in a more cost-effective manner.

The objectives of the FM/AG-18 are:

- The definition and selection of a suitable overarching framework comprising relevant aspects of anticipated future autonomous UAV missions.
- The application of various methods within the framework.
- A better understanding of autonomous systems and levels of autonomy.
- An indication of spin-off applications and critical technology research areas for the future.
- To inform the generation of a toolset and metrics to support the work.
- Better understanding of human operator requirements for different levels of autonomy.
- To acquaint the wider UAV community of the current state of the art and to inform the development of a technology roadmap to greater autonomous capability.

It is expected that the machine reasoning and artificial cognition methods to be developed in this AG will have broader application in a wider range of domains than FM/AG-14 given the greater coverage of the work framework.

A three-year project is in progress (having commenced in Sep 2009) and composed of a number of Work Packages (WP). Problem areas are derived (WP2) from an overarching framework (WP1) and then appropriate methods (WP3) are mapped to these areas. Applicable methods are applied to the problem areas in WP4 and the experimental approach and gathering of results is contained within WP5. WP6 looks after exploitation of the knowledge gained within the study.



Typical mission framework showing mission phases

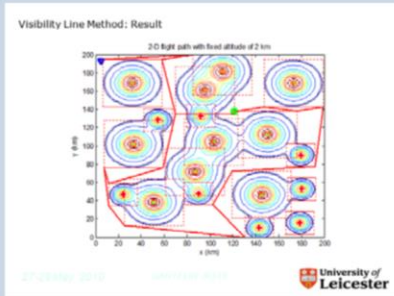
WP1 has concluded, producing an operational framework into which all of the methods addressed will be contextualised. An example framework is shown above. WP2 has developed a matrix methodology that allocates the framework functions to six broad categories of technology. These are: Automated Flight; Vehicle Health Management; Data Management; Reasoning/Planning/Decision-making; Communication and Collaboration. These categories, in the broadest terms, reflect the nature of the technology being addressed in WP4 of the AG. Within each of these broad categories are further sub-categories of problem which are cross referred to the original framework function. Using this matrix it has been possible to map the chosen technological approaches investigated within the AG to be assessed as to their fitness to solve a range of problems within the context of the over-arching framework. WP3 is carrying out an ongoing assessment via questionnaire of each of the candidate technologies being investigated across the AG. The questionnaire will elicit a general description of all methods, their maturity, applicability as well as implementation considerations.

Results

Organisations taking part in the FM/AG-18 are: Cassidian, CIRA, Dassault Aviation, DLR, INTA, NLR, ONERA, QinetiQ, Selex-Galileo, Thales NL, and the Universities of Complutense, German Armed Forces, Leicester and Loughborough. This impressive team aspires to gather evidence as to where particular technologies can be applied across the entire UAS design space, the relative strengths and weaknesses of each approach in solving these problems, and finally, where particular approaches have not been addressed within FM/AG-18 but which might offer some value. Such evidence will help to identify where investment is needed to rapidly mature the most promising technological approaches. The AG is confident that the exploitation of the results can improve the understanding of research and industrial bodies of the key domain issues, helping to further develop strategies and methodologies for increasing Autonomy in UAVs.

The candidate methods are being further applied to the problem to produce the results, on the basis of which indications will be given of spin-off applications and critical technology research areas for the future. How the candidate approaches can be applied to both military and civil systems with few or minor modifications will be articulated.

The AG hopes to exploit its results by a dedicated session in the Bristol UAV conference in May 2013. Therefore, the AG has been extended to the end of June 2013



Screenshot of Path Planning work

5.4. Group of Responsables - Helicopters (HC)

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 (helicopters and tilt rotor aircraft) vehicles 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 CFD and comprehensive calculation tools, validated with relevant tests campaigns;
- Increase operational efficiency (improve speed, range, payload, all weather capability, highly efficient engines, ...);
- 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, aeroelastics 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 and tilt rotor 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.

(copyright: Patrick PENNA)

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Figure 4: Illustrations of the Group of Responsables "Helicopters"

During 2014 GoR-HC monitored the following Action Groups:

- HC/AG-19 "Methods for Improvement of Structural Dynamic Finite Element Models using In-Flight Test Data";
- HC/AG-20 "Cabin internal noise: simulation methods and experimental methods for new solutions for internal noise reduction";
- HC/AG-21 "Rotorcraft Simulation Fidelity Assessment. Predicted and Perceived Measures of Fidelity";
- HC/AG-22 "Forces on Obstacles in Rotor Wake" (stating up in November 2014);
- HC/AG-23 "Wind turbine wake and helicopter operations" (stating up in November 2014).

For the Action Groups HC/AG-19, HC/AG-20, HC/AG-21, HC/AG-22 and HC/AG-23 a one page summary poster is included on the following pages.

The situation regarding Exploratory Groups and New Topics under review was as follows at the end of 2014:

- GoR-HC Exploratory Groups:
  Six Exploratory Groups were running in 2014:
  - HC/EG-29 "Health & Usage Monitoring Systems - HUMS";
  - HC/EG-31 "PreFCS - Conceptual Design of Helicopters" (PreFCS: Pre-flight Checks);
  - HC/EG-32 "Forces on Obstacles in Rotor Wake" resulted in the Action Group HC/AG-22;
  - HC/EG-33 "Wind turbine wakes and the effect on helicopters" resulted in the Action Group HC/AG-23;
  - HC/EG-34 "CFD based flow prediction for complete helicopters";
  - HC/EG-35 "Helicopter Fuselage Scattering (installation) Effects for Exterior/Interior Noise Reduction" expected to result in an Action Group beginning 2015;
- New Topics
  The following topics are being considered for future Exploratory Groups:
  - Conceptual Design of Helicopters;
  - CFD based flow prediction for complete helicopters;
  - Performance, fuel efficiency;
  - Safety (Crash, Hums, Crew Workload, all weather operations);
  - Noise external (passive, active rotors, flight procedures, atmospheric effects, shielding);
  - Noise internal (Comfort, Costs, Weight → fuel consumption);
  - Vibrations having impact on: Comfort, Costs (maintenance);
  - Predictive method & Tools;
  - Synergies between Civil and Military operations;
  - Sand/dust engine protection.

The membership of GoR-HC in 2014 is presented in the table below.

Chairman		
Lorenzo Notarnicola	CIRA	Italy
Vice-Chairman		
Mark White	Uni of Liverpool	United Kingdom
Members and Industrial Points of Contact		
Blanche Demaret	ONERA	France
Klausdieter Pahlke	DLR	Germany
Antonio Antifora	AgustaWestland	Italy
Philipp Krämer	ECD	Germany
Elio Zoppitelli	Eurocopter	France
Joost Hakkaart	NLR	The Netherlands
Observer		
Richard Markiewicz	DSTL	United Kingdom

Table 5: Membership GoR-HC in 2014

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

HC/AG-19: Improvement of Structural Dynamic FEM using In-flight Test Data

Action Group Chairman: Hans van Tongeren (Hans.van.Tongeren@nlr.nl)

Background

The issue of vibration in helicopters is of major concern to operators in terms of the maintenance burden and the impact on whole life costs. Operators are demanding smooth ride vehicles as a discriminator of vehicle quality, which requires close attention to the vehicle dynamics.

Good mathematical models are the starting point for low vibration vehicles. The ability to faithfully simulate and optimize vehicle response, structural modifications, vehicle updates, the addition of stores and equipment is the key to producing a low vibration helicopter. However, there are many issues affecting the creation of an accurate model and it is clear that much research is needed to further that understanding.

A recent GARTEUR Action Group, HC/AG-14, concluded that helicopter dynamic models are still deficient in their capability to predict airframe vibration. The AG looked at the methods for improving the model correlation with modal test data along with the suitability of existing shake test methods.

Among others, the following recommendations were made for continued research:

• Study effects of configuration changes in the structure. How significant are these effects? How can uncertainties be handled in the context of an FE model. What is the influence of flight loads.

• The helicopter structure tested in HC/AG-14 was suspended in the laboratory. However, this is not the operational environment where there are very significant mass, inertia and gyroscopic effects from the rotor systems. Could in-flight measurements be made? What are the benefits?

Other recommendations with respect to ground vibration testing are considered in the closely related GARTEUR Action Group HC/AG-18.

Programme/Objectives

Objectives

The main purpose of this AG is to explore methods and procedures for improving finite element models through the use of in-flight dynamic data. For the foreseeable future it is expected that validated finite element models will be the major tool for improving the dynamic characteristics of the helicopter structural design. It is therefore of great importance to all participants that the procedure of validating and updating helicopter finite element models with such in-flight data is robust, rigorous and effective in delivering the best finite element model.

The members will present further developments of methods used to update the finite element model whether automated, manual or both. Advantages and disadvantages of the approaches should be given and possible future developments of the procedures for localizing the areas of the models causing the discrepancies and for improving the updating process presented. The members will present developments of methods for the prediction of the effect of configuration changes on FRF behaviour. These can be based on a finite element model. Advantages and disadvantages of the approaches should be given and possible future developments of the procedures presented.

Finally the group shall assess the methodology with respect to evaluating vibration measurements from flight tests where effects of aerodynamic and rotating machinery affect the vehicle response. The objective is to extract modal parameters from in-flight measured data. Advantages and disadvantages of the approaches should be given and possible future developments of the procedures presented.

Traditional analysis versus OMA analysis

Available flight test data

Three sources of flight test data are available to the action group:

A flight test programme on an attack helicopter resulted in vibration response measurements on the stub wings for a wide range of manoeuvres and store configurations. A Full Aircraft GVT on RNLAF attack helicopter was conducted by AgustaWestland Ltd (with NLR assistance) on 5-7 March 2012.

The department of mechanical and aerospace engineering of "La Sapienza" University has a model helicopter at it disposal. Flight tests have been conducted with this helicopter. A finite element model is available. Ground vibration tests have been conducted. The advantage of this helicopter is that it is available for additional ground vibration and flight tests.

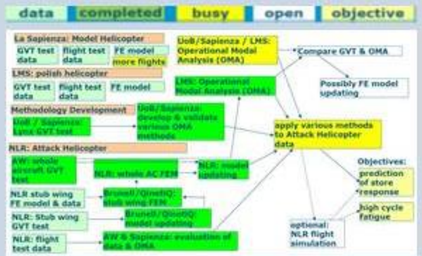
The third data set will be based on a discontinued commercial helicopter model from AW.

University of Liverpool, Brunel University West London, LMS Engineering Innovation, University of Bristol, NLR, Sapienza Università di Roma, AgustaWestland, University Technology Centre

Results

The project should result in a review of various methods to process acceleration (or other) time signals. Sine inputs from rotating components in the flying helicopter dominate the response signals and obscure the structural responses related to structural vibration modes. The methods should separate the rotating component contributions from the structural vibration content. The updated finite element models will be used to predict in flight vibration responses of existing and new store configurations. This may reduce the amount of flight testing required to validate new store configurations. This is beneficial to both operators and manufacturers. This could involve coupling the structure model to simulation models that predict the main and tail rotor hub excitation levels.

So far, available experimental flight test data for validation purposes has been analyzed to update their FE modes. For the attack helicopter, model mass and construction of the complete helicopter model is finished. The GVT on a Dutch Attack helicopter will be used to update the complete helicopter model. The flight test data will be used to further improve this model.



Members of the HC/AG-19 group are:

Giuliano Cappotelli	Sapienza University Rome
Johnathan Cooper	Bristol University
David Ewins	Bristol University
Cristinel Mares	Brunell University
Simone Manzato	LMS
Hans van Tongeren	NLR
Trevor Walton	Agusta Westland Ltd

GARTEUR Responsable:
Joost Hakkaart NLR

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

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

Action Group Chairman: Frank Simon (frank.simon@onera.fr)

Background

Since several years, aeronautical industries have wished to improve internal acoustic comfort. It is particularly true within the cabin of a helicopter where the passenger is in very close proximity to disturbing sources that contribute to interior noise: main and tail rotors, engines, main gearbox (tonal noise) and aerodynamic turbulence (broadband noise).

Nevertheless, to reduce global mass, the trim panels in cabin are generally provided with a core in Nomex honeycomb and external layers in composite fibres. This light assembly is not subjected to high static force and must just assure a sufficient stiffness not to be damaged during the helicopter life. Each material satisfies specific tests to be certified: behavior in high temperature, with humidity... To use these components can worsen the internal acoustic comfort because their behaviour is essentially due to mass effect.

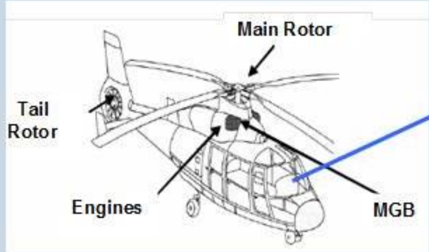
It appears that conventional passive systems (trim panels, passive anti-resonance isolation systems as well as classical vibration absorbers and pendulum absorbers) are still the main way to control the acoustic of the cabin whereas active systems (active vibration and noise control) are not completely reliable or applicable (problems of robustness or time convergence of algorithms – often reduction in some area but increase outside – high added mass and electrical power – difficult identification of optimal locations for actuators and sensors).

Programme/Objectives

Objectives

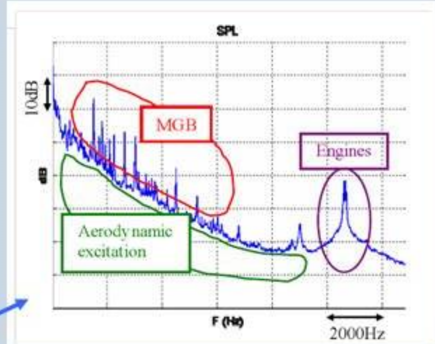
HC/EG-28, about internal noise and associated passive acoustic solutions (soundproofing, e.g. 1cm-thick trim panels designed for optimizing the absorption or the transmission loss), development of a vibro-acoustic model of the cabin (SEA coupled with FEM), human factors (subjective annoyance, speech intelligibility)" brought to launch the HC/AG20.
The HC/EG-28 conclusions listed the following needs:

1) to improve quality of absorption of materials with absorbing fillings or foam material tuned to control specific frequency bands
2) to design composite trim panels with industrial requirements and simulate acoustic performances of treatments after integration in cabin
3) to develop reliable vibro-acoustic "methodologies" to reproduce the interior noise levels in large frequency range by combined numerical models/ experimental data
4) to estimate mechanical power sources and contribution of vibration panels radiating in cabin (Structure-borne transmission of energy from gearbox and engines through helicopter frame to the trim panels)
5) to take into account "subjective or human annoyance" in specific frequencies
6) to study influence of noise on the communication between pilot and crews (problem of speech intelligibility)



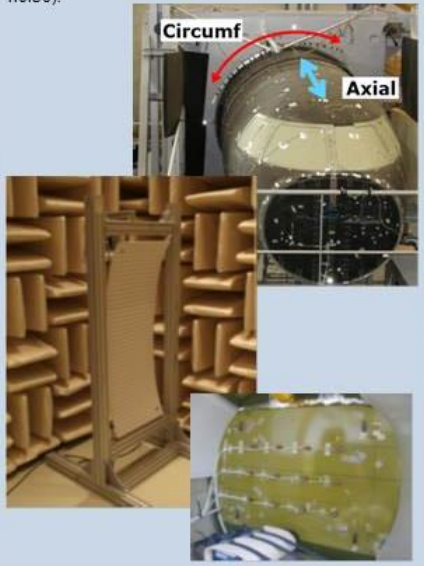
The activities in the new HC/AG-20 constitute the conclusion of HC/EG-28 and explore the points 2 to 4:

- applying different types of simulation methods to design and optimize composite trim panels according to common acoustic cost functions, and to validate numerical approaches by tests in laboratory
- applying different types of experimental techniques to characterize composite trim panel acoustic radiating in both a standardized test set –up and a generic helicopter cabin.
- experimental methods to separate correlated and uncorrelated acoustic sources in cabin. This identification is essential to reproduce internal noise from experimental database and also to apply sound source localization methods as beamforming or holography.



Results

The AG should result in a benchmark of the appropriateness of tools for complex configurations (multiple anisotropic layers with various mechanical characteristics, effect of confined medium on internal noise).



Members of the HC/AG-20 group are:

F. Simon	ONERA
A. Grosso	MICROFLOWN
T. Haasse	DLR
R. Wijntjes	NLR
P. Vitiello	CIRA
Gian Luca Ghiringhelli	Politecnico di Milano

GARTEUR Responsable:
B. Demaret ONERA

Microflown Technologies — Charting sound fields
NLR
ONERA — THE FRENCH AEROSPACE LAB
CIRA
DLR
POLITECNICO MILANO

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

HC/AG-21: Rotorcraft Simulation Fidelity Assessment: Predicted And Perceived Measures Of Fidelity

Action Group Chairman: Mark White (mdw@liv.ac.uk)

Background

The qualification of rotorcraft flight simulators is undertaken using the new framework detailed in "Certification Specifications for Helicopter Flight Simulation Training Devices CS-FSTD(H). This document contains a number of component fidelity requirements, flight loop data matching tolerances (i.e. Qualification Test Guide) and some brief guidance material on the requirements for the final subjective assessment of a simulator in order for it to be qualified to a certain Level.

The work from a previous GARTEUR activity, HC/AG-12, "Validation Criteria for helicopter real-time simulation models", indicated that there were a number of shortcomings in the current civil simulator standards, namely the tolerances contained within JAR-FSTD H (predecessor to CS-FSTD(H)) have no supporting evidence for their definition and there is not a systematic approach identified for overall fidelity assessment.

HC/EG-30, (Simulation Fidelity) examined the state of play of current research and industrial practice and recommended a focussed activity for a future Action Group to examine critical aspects of simulator fidelity and fitness for purpose, e.g. the flight model tuning process, metrics and tolerances, integrating predicted and perceived fidelity. The GARTEUR work highlighted the need for the evaluation of overall fidelity of the integrated system of pilot and machine and is driver for the new GARTEUR activity in this area.

Programme/Objectives

Objectives

Helicopter simulation training device qualification is a complex activity, requiring a large number of resources. In order to effectively address some of the key challenges identified previously a work programme has been developed in order to enhance current simulator qualification standards.

The principal objective of the Action Group is to gain a better understanding of the various components that contribute to the definition and perception of rotorcraft simulation fidelity. This may subsequently result in the development of new criteria for fidelity assessment. This activity would require an examination of the influence of the flight loop tolerances on predicted fidelity assessment together with an investigation of the role of simulator cueing on subjective or perceived fidelity assessment.

The research outcomes will be in the form of new metrics which would define rotorcraft simulation fidelity boundaries together with guidelines for the subjective fidelity assessment process.

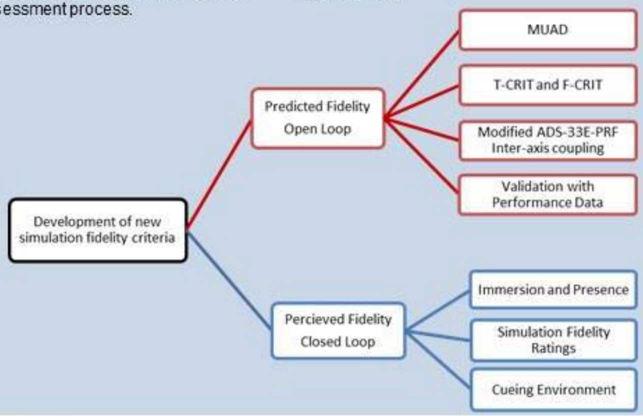
The work programme has two strands:

Predicted Fidelity assessment using off-line flight models with a range of standard control inputs

Perceived Fidelity assessment using ground-based pilot-in the-loop simulations at partners' own facilities.

Specific areas of interest for helicopter flight simulation device fidelity include:

1. An investigation of validation techniques for the definition of predicted or flight loop fidelity
2. Definition of new criteria for predicted fidelity assessment
3. Definition of new rotorcraft flight test manoeuvres to be used during the subjective evaluation of a simulator
4. An investigation of the effect cueing on the subjective assessment of fidelity
5. Development of metrics for subjectively perceived fidelity
6. Development of an overall methodology for fidelity assessment.



Results

It is anticipated that the outputs from this AG would be used to enhance the fidelity criteria that exists in current and emerging flight simulation qualification standards for rotorcraft.

An initial set of simulator test manoeuvres have been identified to be used as candidate fidelity test points. Work is underway on the development of flight loop fidelity metrics which could be used during the simulator qualification process.

Questionnaires have been developed to subjectively assess the fidelity experienced by users in virtual environments. The questionnaires will be test during simulator trials in 2015.

Members of the HC/AG-21 group are:

M White	University of Liverpool
G.Meyer	University of Liverpool
M. Pavel	TuDelft
O. Stroosma	TuDelft
J. vd Vorst	NLR
C. Seehof	DLR
F. Cuzieux	ONERA
B. Berberian	ONERA
M. Theophanides	CAE
S. Richard	Thales

GARTEUR Responsable:
J. Haakkart NLR

UNIVERSITY OF LIVERPOOL THALES TUDelft Delft University of Technology CAE NLR ONERA THE FRENCH AEROSPACE LAB DLR

GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE
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HC/AG-22: Forces on Obstacles in Rotor Wake

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

Background

Helicopters are largely 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. A helicopter sling load is another, yet particular, case of obstacle subjected 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 wind conditions, the distance of the helicopter from the obstacles, the space between the obstacle and the height of the helicopter from the ground are the main factors due to which the wake generated by the obstacle may result in: (a) high compensatory workload for the pilot and degradation of the handling qualities and performance of the aircraft; (b) 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. The intensity of the interaction increases with the proximity of the rotor to the ground and/or the obstacles.

A bibliographic research, performed during the Exploratory Group HC/EG-32 "Forces on Obstacles in Rotor Wake", highlighted that there is a general lack of:

- experimental databases including the evaluation of the forces acting on obstacles when immersed in rotor wakes;
- both numerical and experimental investigations of the rotor downwash effect at medium-to-high separation distances from the rotor, in presence or without sling load.

Programme/Objectives

Objectives

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

- primarily, 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;
- secondarily, 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.

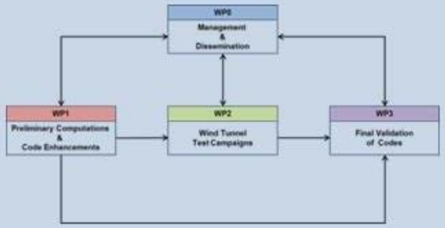
The timescale for the project is three years during which the following activities are planned:

- 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 know-how acquired by the HC/AG-17 about the wake modelling in the presence of ground obstacles, would be capitalized and would set-up the basis for this new research activity.

The work programme is structured in four work packages:

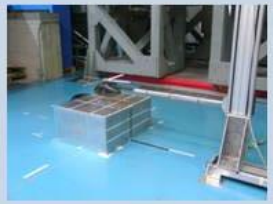
- WP0 – Management & Dissemination: is aimed at the fulfilment of all the obligations concerning the project management and the dissemination of the results;
- WP1 – Preliminary Computations & Code Enhancements: deals with a preparation phase during which partners are involved in literature review and preliminary computational activities;
- WP2 – Wind Tunnel Test Campaigns: concerns the performance of the following four wind tunnel test campaigns:
    1. HOGE/HIGE rotor with a loose/sling load (CIRA);
    2. HIGE rotor in proximity to a well-shaped obstacle (ONERA);
    3. HIGE rotor in proximity to an obstacle in windy conditions (PoliMi);
    4. HIGE rotor in proximity to an obstacle without wind (Univ. Glasgow).
- WP3 – Final Validation of Codes: is aimed at the final validation of the numerical tools proposed by partners.



Results

The action group started the activities in November 2014.

An experimental database, dealing with a helicopter rotor in HOGE/HIGE conditions in the vicinity of a cuboid obstacle, was provided by Politecnico di Milano with the aim to help partners in evaluating the initial modelling capabilities and the possible improvements applicable to the available numerical tools.



The four foreseen wind tunnel test campaigns are all in a preparation phase.

Members of the HC/AG-22 group are:

A. Visingardi	CIRA
F. De Gregorio	CIRA
T. Schwarz	DLR
R. Bakker	NLR
S. Voutsinas	NTUA
B. Rodriguez	ONERA
G. Gibertini	Politecnico di Milano
R. Green	University of Glasgow
G. Barakos	University of Liverpool

GARTEUR Responsable:

K. Pahlke	DLR

Centro Italiano Ricerche Aerospaziali

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HC/AG-23: Wind Turbine Wakes and Helicopter Operations

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

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 dedicated 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 more 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

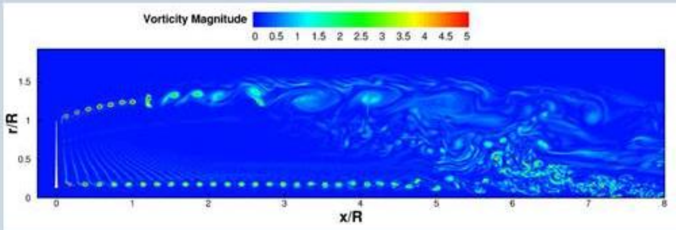
Despite the amount of literature on both wind turbine wakes and helicopter – fixed wing tip vortex encounters, not much research has been done on the interactions of wind turbine wakes and helicopter flight.
The aim of the Action Group is to set up a team of researchers from universities and research 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

It is anticipated that the outputs from this AG would be used to provide recommendations for legislation and disseminate the findings to the appropriate authorities and parties concerned.

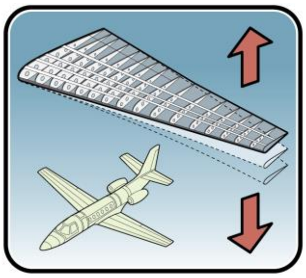
Members of the HC/AG-23 group are:

G. Barakos	University of Liverpool
M. Pavel	Technical University Delft
A. Visingardi	CIRA
P. M. Basset	ONERA
F. Campagnolo	Technical University Munich
S. Voutsinas	NTUA
P. Lehmann	DLR
R. Bakker	NLR

GARTEUR Responsable:
J. Hakkaart NLR

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

5.5. Group of Responsables - Structures and Materials (SM)



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. 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:

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

Computational modelling of bird strike and experimental validation, from SM/AG-24 on "Bird strikes"

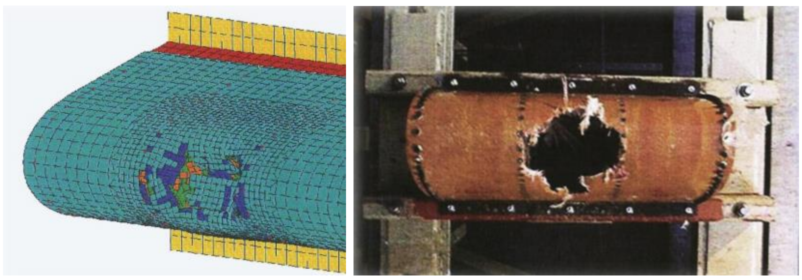


Figure 5: Illustrations of the Group of Responsables "Structures and Materials"

During 2014 GoR - SM monitored the following Action Groups:

- SM/AG-34 "Damage repair with composites":
  This AG started in the second half of 2012 and is a result 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.

For these two Action Groups one page summary posters are included on the following pages.

The situation regarding Exploratory Groups and New Topics under review was as follows at the end of 2014:

- GoR - SM Exploratory Groups:
  - SM/EG-39 "Design of High Velocity Impact on Realistic Structure":
    This EG will become an AG in 2015.
  - SM/EG-42 "Bonded and bolted joints":
    This EG has started end of 2013 and no meeting has been held yet.
  - SM/EG-43 "Development of additive layer manufacturing for aerospace applications": this EG was formally started at the SM GoR Fall 2014 meeting and the first SM/EG-43 meeting is scheduled on 10th April 2015.

- New Topics:
  The following topics for future Exploratory Groups are discussed:
  - Thermo-Structure Interaction;
  - Aeroelasticity and aero-servo-elasticity;
  - Multi-functional Material;
  - Structural Uncertainties;
  - Damping in joints.

The following topics have not received sufficient interest by the GoR-SM members and industrial point of contacts and are therefore dropped from the list of potential new EGs:

- Large scale calculations – Virtual testing;
- Benchmarking activities;
- Hydrodynamic ram in the tanks;
- Virtual manufacturing – predict distortion of structure due to thermal effects;
- Ply-drop-offs and stringer run-outs.

Other information:

- The book on SM/AG-32 'Damage growth in composites' (2009-2012) has been published by Springer and is available with the following link:
  http://www.springer.com/engineering/mechanical+engineering/book/978-3-319-04003-5.

The membership of GoR-SM in 2014 is presented in the table below.

Chairman		
Jean-Pierre Grisval	ONERA	France
Vice-Chairman		
Peter Wierach	DLR	Germany
Members		
Umberto Mercurio	CIRA	Italy
Aniello Riccio[10]	Univ. II Naples	Italy
Henri de Vries	NLR	The Netherlands
Jose Maroto Sanchez	INTA	Spain
Tomas Ireman	SAAB	Sweden
Joakim Schön	FOI	Sweden
Industrial Points of Contact		
Caroline Petiot	Airbus AGI	France
Walter Zink	Airbus	Germany

[10] Associated member

Roland Lang	Airbus DS	Germany
Massimo Riccio	Alenia	Italy
Luc Hootsmans	Fokker	The Netherlands
Angel Barrio Cárdaba	Airbus DS	Spain
Hans Ansell	SAAB	Sweden
Sören Nilsson	SICOMP	Sweden
Andy Foreman	Qinetiq	United Kingdom

Table 6: Membership GoR-SM in 2014

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

SM/AG-34: Damage Repair with Composites

Action Group Chairman: Aniello Riccio (aniello.riccio@unina2.it)

Background

Composites are much more prone to be damaged in service than metals, for example, by mechanical impact. Reparability of such damage is an important consideration in the selection of composites for aircraft applications.
In addition, metal structures can be repaired by using composite patches with great potential benefits such as costs reduction and time saving.
Repair techniques can be considered applicable to a wide range of structures both metallic and composites (laminates or sandwich).
The repair scheme used for structural restoration should be the simplest and least intrusive that can restore structural stiffness and strain capability to the required level and be implemented in the repair environment, without compromising other functions of the component or structure.
It is usually necessary to restore the capability of the structure to withstand the ultimate loads of the design and to maintain this capability (or some high percentage of it) for the full service life.
Important functions that must be restored include: aerodynamic shape, balance, clearance of moving parts and resistance to lightning strike. The requirement in military to restore the stealth properties of the component may also have to be considered and may influence the type of repair chosen.
The growing use of composite structures but also the need to reduce costs (both for metals and composites) have lead to an increasing interest in repair and especially in repair with composites and its potential applications.
However, uncertainties remain in the behavior of repaired structures that generally lead aircraft manufacturers to perform repairs only in secondary structures and to prefer bolted repair (mechanical fastened repair) over bonded repair (adhesively bonded repair) limiting the use of bonding only to moderate-size damage.

Programme/Objectives

Objectives
Based on of the emerging needs (detailed in the previous section) related to the composites usage in aerospace applications, the main objective of this Action Group is:

"Definition of effective repair techniques both for civil and military aircraft structures through the development of numerical/experimental methodologies"

This objective addresses the following issue:

repair criteria, design of patches and repair strategies, analysis of the repair, manufacturing and test, repair strategies and technology, effective repair methods

The activities have been split in Work Packages:

WP 1 REPAIR CRITERIA (WHEN UNDERTAKING REPAIR)

task 1.1) Methodologies for the assessment of residual strength in damaged composite components to decide when repair has to be undertaken

task 1.2) Crack growth analysis (static and fatigue);

WP 2 DESIGN OF PATCHES AND REPAIR STRATEGIES

WP 3 ANALYSIS OF THE REPAIR

WP 4 MANUFACTURING AND TEST

task 4.1) Manufacturing and repair procedure issues;

task 4.2) Experimental tests

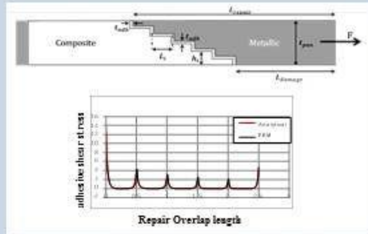
WP 5 EFFECTIVE REPAIR METHODS

task 5.1) Optimization of the patching efficiency;

task 5.2) Certification issues;

task 5.3) Technologies for repair;

task 5.4) Definition of guidelines for an effective repair of both civil and military aircraft structures.



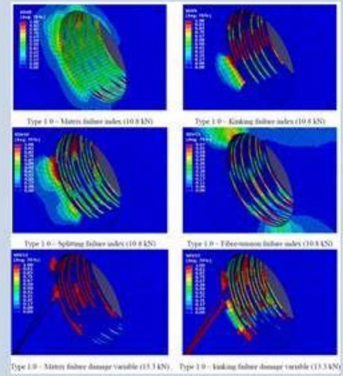
Development of an Analytical tool for Repair Design

Expected Results

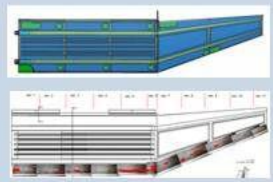
The effective outcomes can be summarized in:

1) minimize down-time of the aircraft for repair operations;
2) minimize costs for repair;
3) promote the repair of components instead of their substitution;
4) reduction of the costs and time for certification of repaired structures

A number of benchmarks have been selec ted for models validation.



Numerical Analysis - progressive Damage in composite Joint



Repair of an UAV wing

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SM/AG-35: Fatigue and Damage Tolerance Assessment of Hybrid Structures

Action Group Chairman: Jaap Laméris
(jaap.lameris@nlr.nl)

Background

A major challenge in the fatigue analysis and subsequent fatigue testing of hybrid structures originates from the differences in deriving fatigue spectra for metal and composites and incorporation of required environmental load factors for composites. Specifically, the following aspects can be addressed:

1. Composite structure is sensitive to environmental conditions, metal parts usually are not. If it is decided not to perform fatigue- or residual strength tests under these conditions, which aspects should be taken into account via environmental factors on the applied loads?
2. Material scatter for composites is much larger than for metals; this is usually covered by a combination of a life factor and a load enhancement factor. However, to avoid non-linear behaviour of test set-up and too high stress levels in the metal parts a maximum overall load increase should be respected.
3. In general, damage growth in composite materials is most sensitive for compression-compression cycles, where metal fatigue initiation and crack growth are more sensitive to tension-compression and tension-tension cycles. A generic process for a load spectrum reduction technique covering both aspects should be discussed.
4. Spectrum truncation levels must be different for metals and composites. Where composites experience high damage from high peak loads, metals will experience crack retardation after application of a severe load condition.

Since metals are most sensitive to fatigue damage, it is often chosen to relax one or some of the aspects from the list above for the composite fatigue justification. However, since operational strain levels in new composite designs, using improved material systems, constantly increase, the validity of this approach will be limited in the near future.

Programme/Objectives

Objectives
The main objectives are listed below:

- Validation of the basic assumptions for any applied spectrum manipulation techniques;
- Examination of the capabilities and benefits of a probabilistic approach;
- Determination of the optimum way to account for thermal loads in a non-thermo test set-up;

leading to a joint 'best practice' approach for testing of hybrid airframe structural components.

Task 1 Determination of a Test Spectrum
A benchmark will be defined that will address as much aspects of fatigue and damage tolerance testing/justification as possible, for both the metal and composite structures, for both bolted and bonded joints. The benchmark spectrum will be equivalent to known definitions such as FALSTAFF (fighter wing) or TWIST (transport wing), modified for application to hybrid structure. Testing will be done on hybrid coupons and, if possible on more complex components, addressing all phases of static, fatigue and damage tolerance certification, using a number of derived spectra in order to investigate effects on fatigue and damage tolerance behaviour.
Phase 1 Benchmark definition
Phase 2 Spectrum development
Phase 3 Validation of assumptions

Task 2: Probabilistic approach
Application of probabilistic analyses in combination with virtual testing techniques can be used to incorporate scatter in material properties, loading, etc. The most important scatter sources (model parameters) will first be identified by means of a probabilistic sensitivity analysis. The probabilistic methods will then be applied on a failure model to determine the scatter in derived properties, from which allowable values can be obtained. In case of sufficient correlation with experimental data, the probabilistic simulation model allows for (extensive) virtual testing, reducing the number of tests required in a fatigue material qualification program.

Task 3: Environmental influences
As one of the most important effects of the environment on a hybrid structure, thermally induced interface loads due to the differences in coefficient of elongation between metals and carbon composites come in addition to the 'mechanical' loads. In non-thermo fatigue testing, it is a challenge to apply these loads mechanically.
Phase 1 Identification of the thermal stress condition
Phase 2 Impact on fatigue life
Phase 3 Testing

Results

The AG should results in establishing a joint 'best practice' approach for full scale fatigue testing of hybrid airframe structural components.

The second progress meeting was held at DLR on 19-05-2014 in Cologne and the third progress meeting was at Fokker Aerostructures at Papendrecht on 12-11-2014.

Task 1:
A conceptual definition of a specimen geometry was proposed in order to be able to observe the behavior of the test specimen with respect to the various (conflicting) requirements associated with a hybrid (metal-CFRP) fatigue test. Further detailing of the test specimen needs to be done.
A proposal for a load spectrum to which the benchmark test specimen will be subjected was made.

Task 2:
Work has been performed by DLR to solve some problems with the probabilistic approach using Weibull theory.

Task 3;
-FK/NLR studies on a hybrid material (FML) with respect to curing temperature induced stresses in the metal layers were compared with test results.
-DLR presented results of studies of adhesion and degradation mechanisms of metal-polymer interfaces.
-FOI presented results of static and fatigue tests in a bi-axial test rig at elevated temperature on composite specimens.
- Saab conducted FEM studies on the static and fatigue test specimens of the FOI tests conducted in the bi-axial test rig.

DLR FOI FOKKER AEROSTRUCTURES NLR SAAB

6. GARTEUR SUCCESS STORIES AND LINKS TO OTHER EUROPEAN PROGRAMMES

In this chapter examples of GARTEUR success stories are presented as well as the links between GARTEUR projects and other European Programmes.

6.1. GARTEUR success stories

Two examples are presented in more detail on the following pages: “Air Intakes Aerodynamics” from the GoR Aerodynamics and “Rigid Body and Aeroelastic Rotorcraft-Pilot-Coupling - Prediction Tools and Means of Prevention” from the GoR Helicopters.

The first example “Air Intakes Aerodynamics” illustrates how dedicated joint European efforts coordinated by GARTEUR Aerodynamics Action Groups led to the advancement of hybrid numerical simulation methods and an improved understanding of complex instantaneous internal flow fields, thus preparing the basis for future time-accurate predictions of vital performance parameters, such as dynamic intake distortion and engine/intake compatibility, with accuracy levels meeting industrial requirements.

The second example “Rigid Body and Aeroelastic Rotorcraft-Pilot-Coupling - Prediction Tools and Means of Prevention” clearly illustrates how joint European knowledge in mathematical modelling of helicopters, and in particular in modelling Rotorcraft-Pilot Coupling phenomena, has largely been built up over the past decades through national efforts coordinated via GARTEUR Action Groups. There is no other organisation in Europe where such a collective effort was done for the specific topics of Rotorcraft modelling for prediction of performance, flying and handling qualities.

Other examples of success stories regarding the GoR “Flight Mechanics, Systems and Integration” and “Structures and Materials” can be found in previous GARTEUR reports.

The success story presented in the GARTEUR Annual Report 2012 on “Damage Mechanics, Damage Tolerance, Bolted Joints in Composite Materials/Structures” illustrated how the joint European knowledge in this field had largely been built up through national efforts coordinated via a series of GARTEUR Action Groups. The GARTEUR activities led to other European projects within EU Framework and WEAG (now EDA) programmes.

The Action Group FM/AG-17 “Nonlinear Analysis and Synthesis Techniques for Aircraft Control” received the GARTEUR Award 2008 and resulted in a text book “Non-linear Analysis and Synthesis Techniques for Aircraft Control” which was published by Springer-Verlag in 2007.

6.1.1. Intake Aerodynamics

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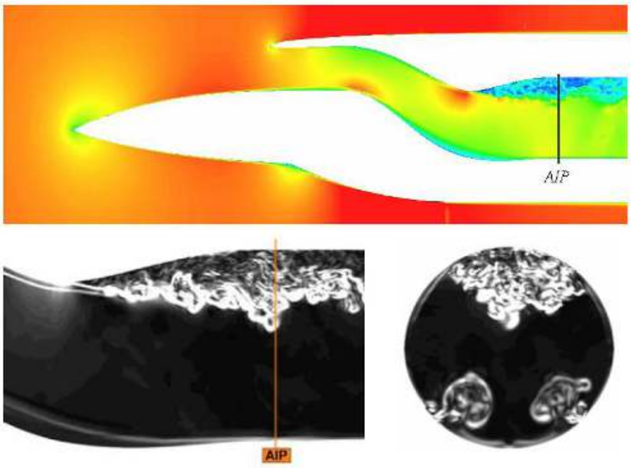
INTAKE AERODYNAMICS – A GARTEUR SUCCESS STORY

Aerodynamic integration of intakes into the airframe of unmanned aerial vehicles assuring high performance and minimized aerodynamic drag is of vital importance for innovative vehicle configurations. The accurate prediction of the instantaneous total pressure distribution in the aerodynamic interface plane as the basic parameter for the assessment of dynamic intake distortion and engine/intake compatibility is a key for successful design and for reducing system development time and cost.



Modern Computational Fluid Dynamics methods such as Detached Eddy Simulation (DES) to analyze unsteady flow phenomena are a vital means for improving performance prediction capabilities and thus possess a great potential to support efficient design for highly integrated low-observable intakes of advanced aerial vehicles.

Based on a strong commitment of the AD-GoR to the application of CFD methods, several Action Groups have been addressing research areas within the field of intake aerodynamics with enhanced emphasis on dynamic simulations of internal flow fields applying hybrid methods:

AD/AG-34 Aerodynamics of Supersonic Air Intakes

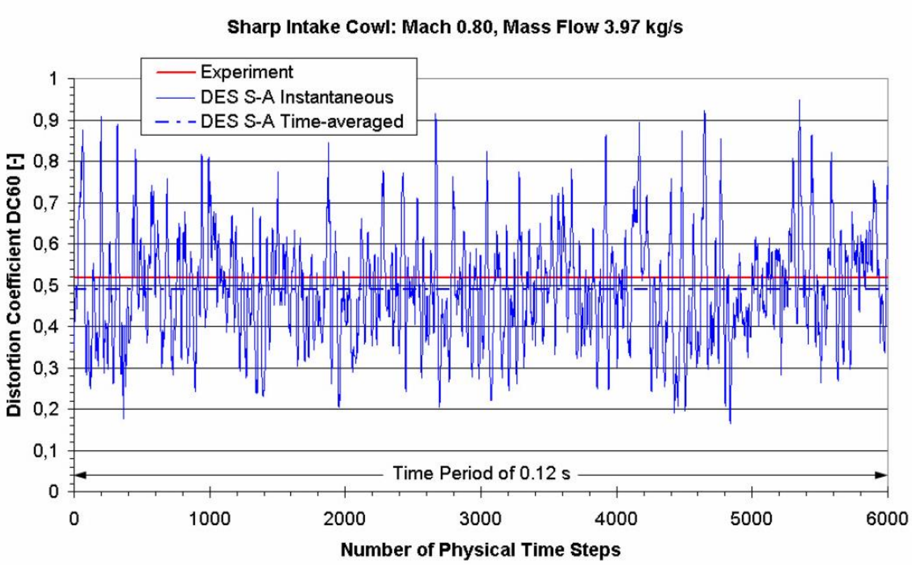
AD/AG-43 Application of CFD to High Offset Intake Diffusers

AD/AG-46 Highly Integrated Subsonic Air Intakes

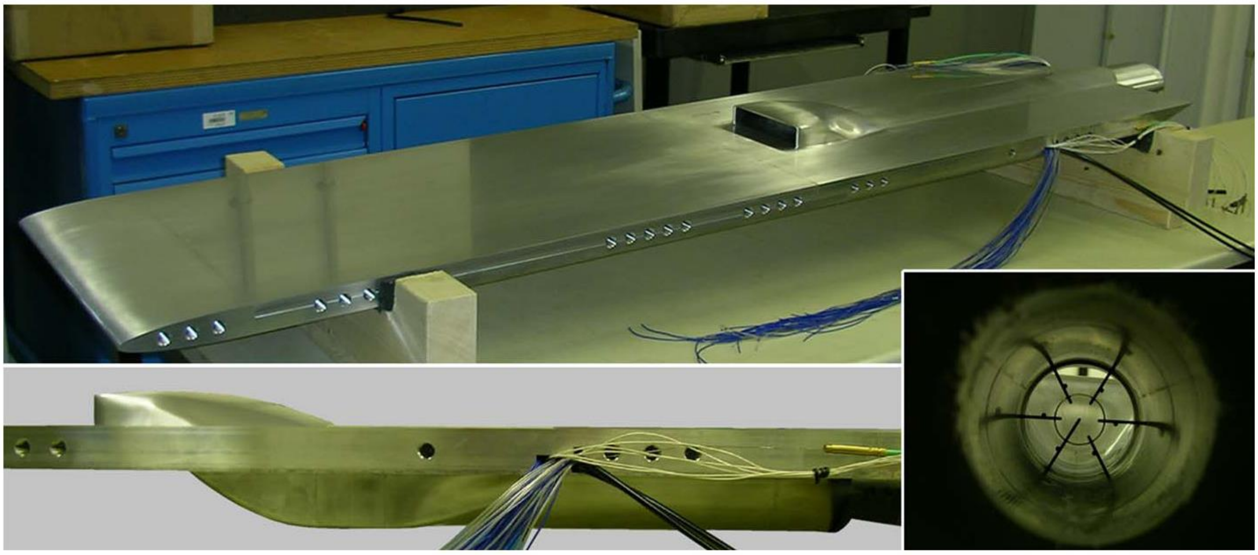
AD/AG-49 Scrutinizing Hybrid RANS-LES Methods for Aerodynamic Applications

These Action Groups investigated the capability of advanced CFD techniques for predicting complex internal flow phenomena and supported the improvement of numerical tools for time-accurate predictions of intake performance parameters. They essentially contributed to prepare the groundwork for engine/intake compatibility assessment with accuracy levels meeting industrial demands. Mid-term prospects for fulfilling these requirements and for successfully applying these methods for project oriented work are considered most promising.

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



Besides numerical simulations fundamental experimental investigations of decisive intake design parameters were performed, advancing the knowledge innovative configurations of compact air induction systems require.



In summary, dedicated joint European efforts coordinated by GARTEUR Aerodynamics Action Groups led to the advancement of hybrid numerical simulation methods and an improved understanding of complex instantaneous internal flow fields, thus preparing the basis for future time-accurate predictions of vital performance parameters, such as dynamic intake distortion and engine/intake compatibility, with accuracy levels meeting industrial requirements.

6.1.2. Rigid Body and Aeroelastic Rotorcraft-Pilot-Coupling - Prediction Tools and Means of Prevention

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

RIGID BODY AND AEROELASTIC ROTORCRAFT-PILOT-COUPLING - PREDICTION TOOLS AND MEANS OF PREVENTION

A GARTEUR SUCCESS STORY

DLR BO105 Experimental Helicopter **Biodynamic test campaign featuring pilot sensors**

There is a long commitment since late 1980s of GARTEUR HC-GoR on the mathematical modelling of helicopters for the prediction of performance, flying and handling qualities as illustrated in the following action groups:

- **HC/AG-03 Mathematical modelling of helicopters for handling qualities and performance**
- **HC/AG-05 Advanced rotorcraft evaluation**
- **HC/AG-06 Mathematical modelling for the prediction of helicopter flying qualities, phase II**
- **HC/AG-07 Helicopter performance modelling**
- **HC/AG-09 Mathematical modelling for prediction of helicopter flying qualities, phase III**
- **HC/AG-11 Helicopter yaw axis handling qualities modelling**
- **HC/AG-12 Validation criteria for helicopter real-time simulation models**

Unintended and unexpected oscillations or divergences of the pilot-rotorcraft system have become a critical issue for augmented helicopters with modern flight control systems. The rapid advances in the field of high response actuation and highly augmented flight control systems have increased the sensitivity to aspects that lead to complex oscillations related to unfavourable Aircraft/Rotorcraft-Pilot Coupling.

HC/AG-16 achieved an improvement in the physical understanding of both rigid body and aeroelastic Rotorcraft Pilot Coupling (RPC) by developing procedures and validating appropriate prediction methods during simulator experiments. Guidelines and criteria have been defined to prevent or suppress critical RPC incidents in the future, making use of a PIO toolbox.

Participants: Industry (Airbus Helicopters), Research Establishments (DLR, ONERA, NLR) and Universities (Delft, Liverpool, Milano and Roma Tre)

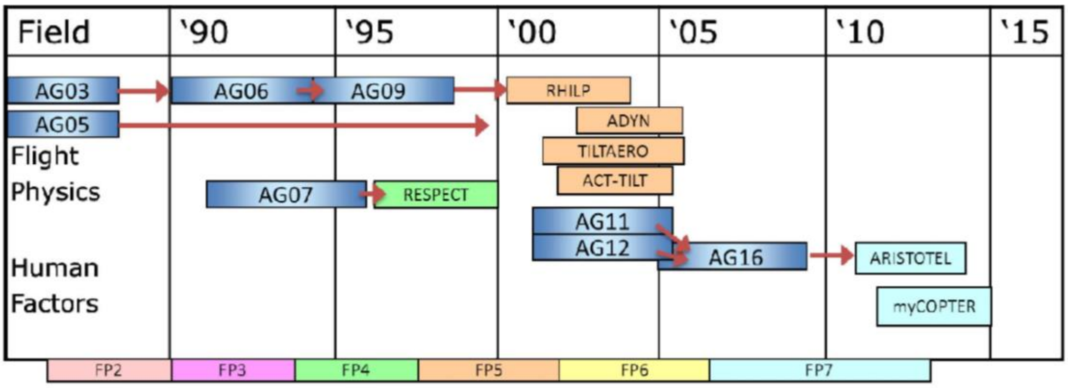
This Action Group was awarded the GARTEUR Award of Excellence 2010/2011.

Results of the HC/AG-16 work have been successfully published in 27 scientific papers and presented both in Europe and the US at prestigious aeronautical events.

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

Due to the high complexity and the large variety of RPC phenomena still to be solved, follow-on activities have been defined to further refine the methods and enlarge the experimental database.

In particular, based on this GARTEUR project the EU-FP7 project ARISTOTEL (lead by TU-Delft) was established: "Aircraft and Rotorcraft Pilot Couplings / Tools and Techniques for Alleviation and Detection". Funded with more than 3M€ by the European Commission, ARISTOTEL is a collaborative project involving a large number of research institutions and universities from the Netherlands, France, UK, Italy, Poland, Romania and Russia. End products of the project will be: Advanced vehicle-pilot-FCS simulation models for "rigid body" and aero-servoelastic A/RPC analysis; A/RPC design guidelines and criteria; Protocols and guidelines for A/RPC flight simulator training. At the 39th European Rotorcraft Forum, September 3-6, 2013, a special session was dedicated to the ARISTOTEL project and Prof. Marilena Pavel, the coordinator of the ARISTOTEL project, won the Cheeseman Award.



The figure below illustrates how HC-GoR projects are interlinked with projects performed within EU Framework Programmes.

In summary it can be stated that the joint European knowledge in mathematical modeling of helicopters, and in particular in modeling Rotorcraft-Pilot Coupling phenomena, has largely been built up over the past decades through national efforts coordinated via GARTEUR Action Groups. There is no other organisation in Europe where such a collective effort done for the specific topics of Rotorcraft modeling for prediction of performance, flying and handling qualities.

6.2. Links with other European Programmes

As illustrated in the example on the previous page there have been strong links between GARTEUR projects and EU Framework projects since the early 1990-ies, when the Framework programmes started.

As there are no dedicated budgets available for GARTEUR projects it was logical that the GoRs looked for possibilities for external funding from EU or other sources as illustrated in the figure below. The members of the GoRs are involved in setting up cooperation projects within different European fora.

Figure 6: Illustration of how links are established between GARTEUR and other European programmes

The nature of many GARTEUR projects often concerns low TRL topics and benchmarking of methods and the possibilities to get funding for this type of projects (Level 1 projects) within the Framework Programmes vary over time.

However, as illustrated in the example on the previous pages the knowledge and methods developed within the GARTEUR projects are the basis for participation also in projects on higher TRL levels.

Additional illustrations of the links between GARTEUR Action Groups and EU projects, as provided by GoR Aerodynamics and GoR Helicopters, are included on the following pages.

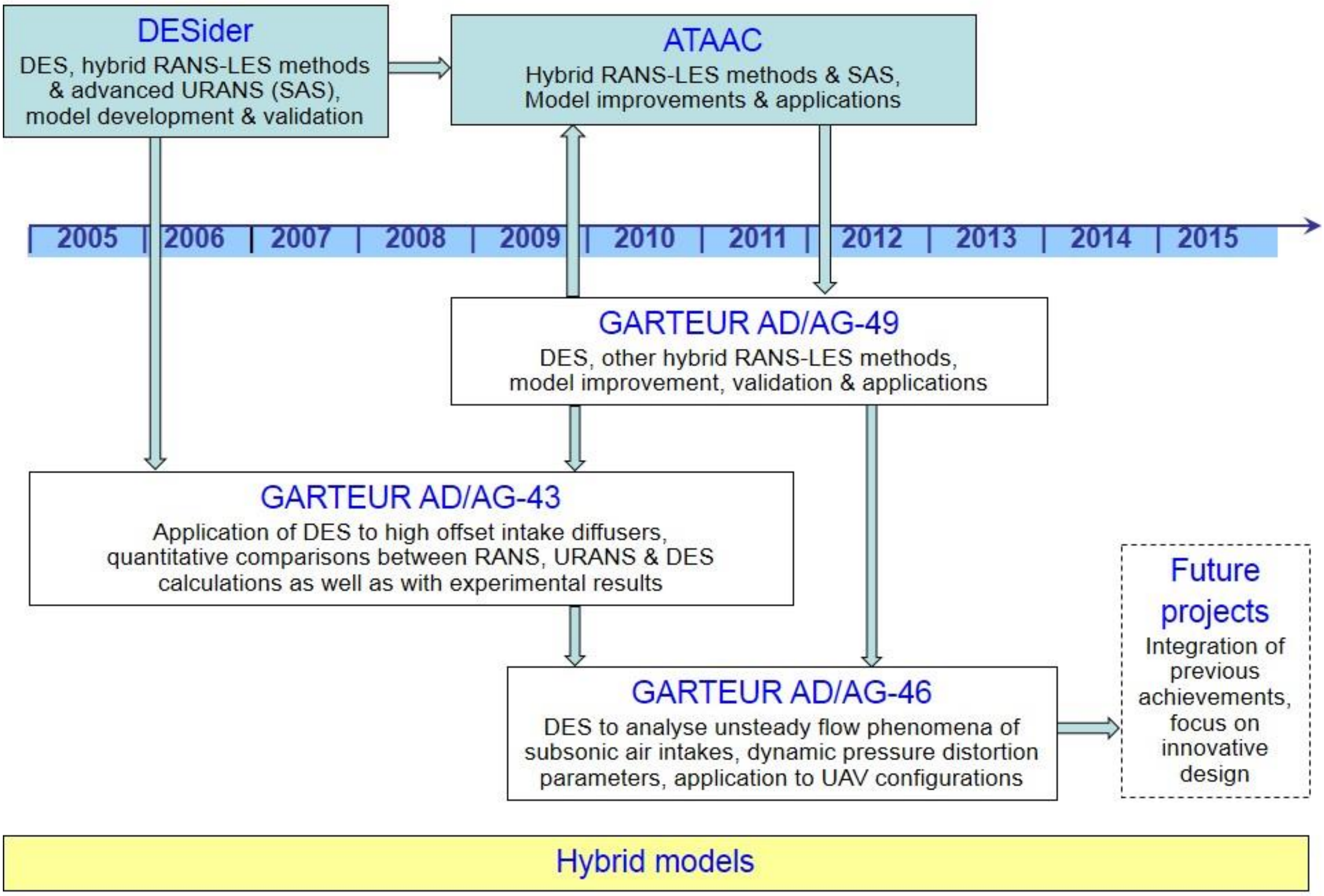
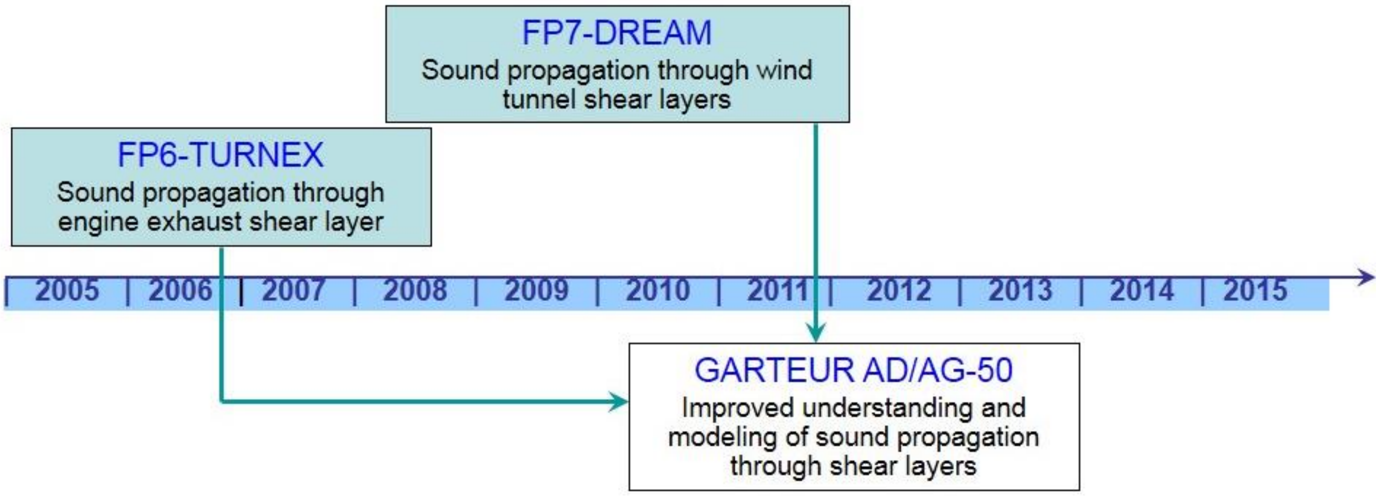


Figure 7: Links between EU-projects/proposals and GARTEUR AD/AG-43, AD/AG-46 and AD/AG-49



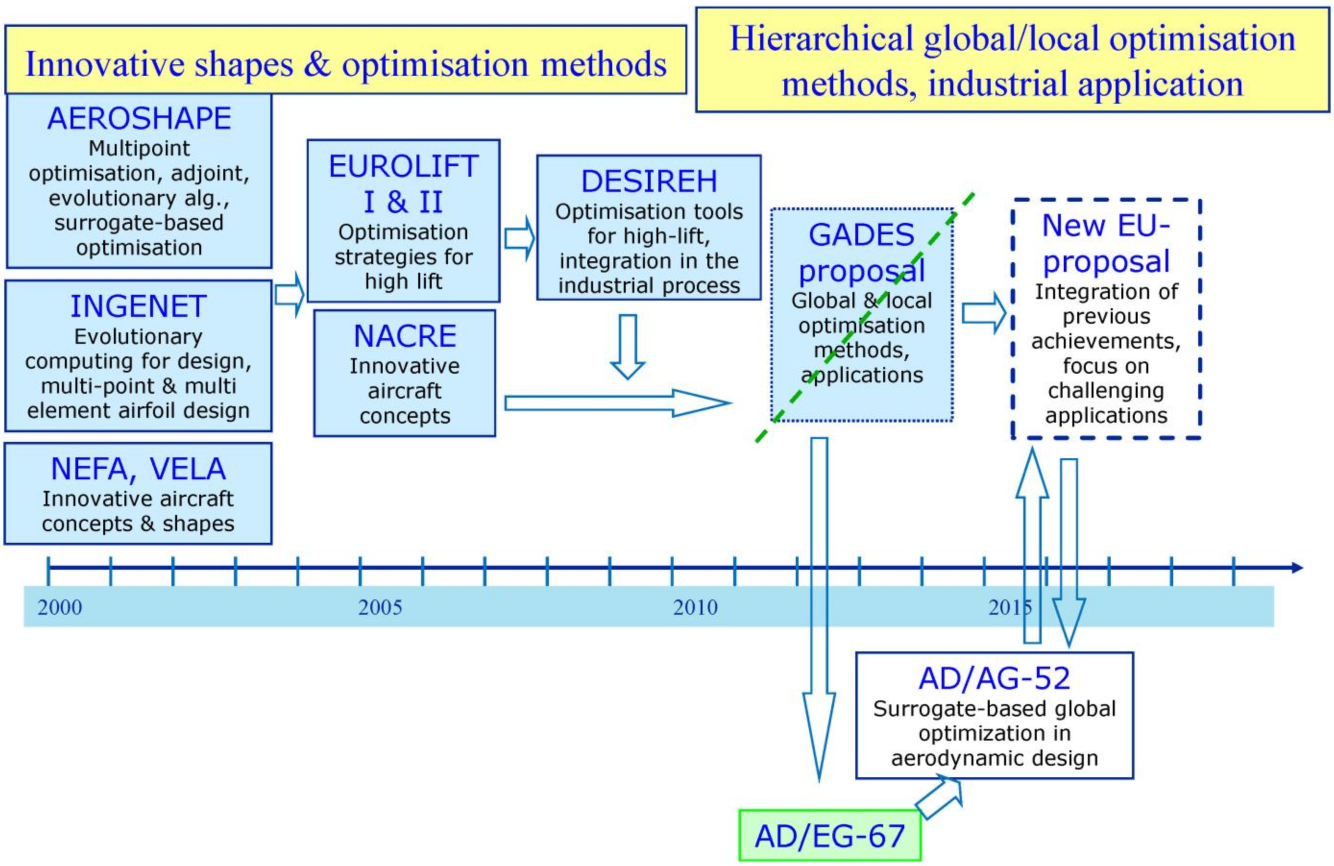
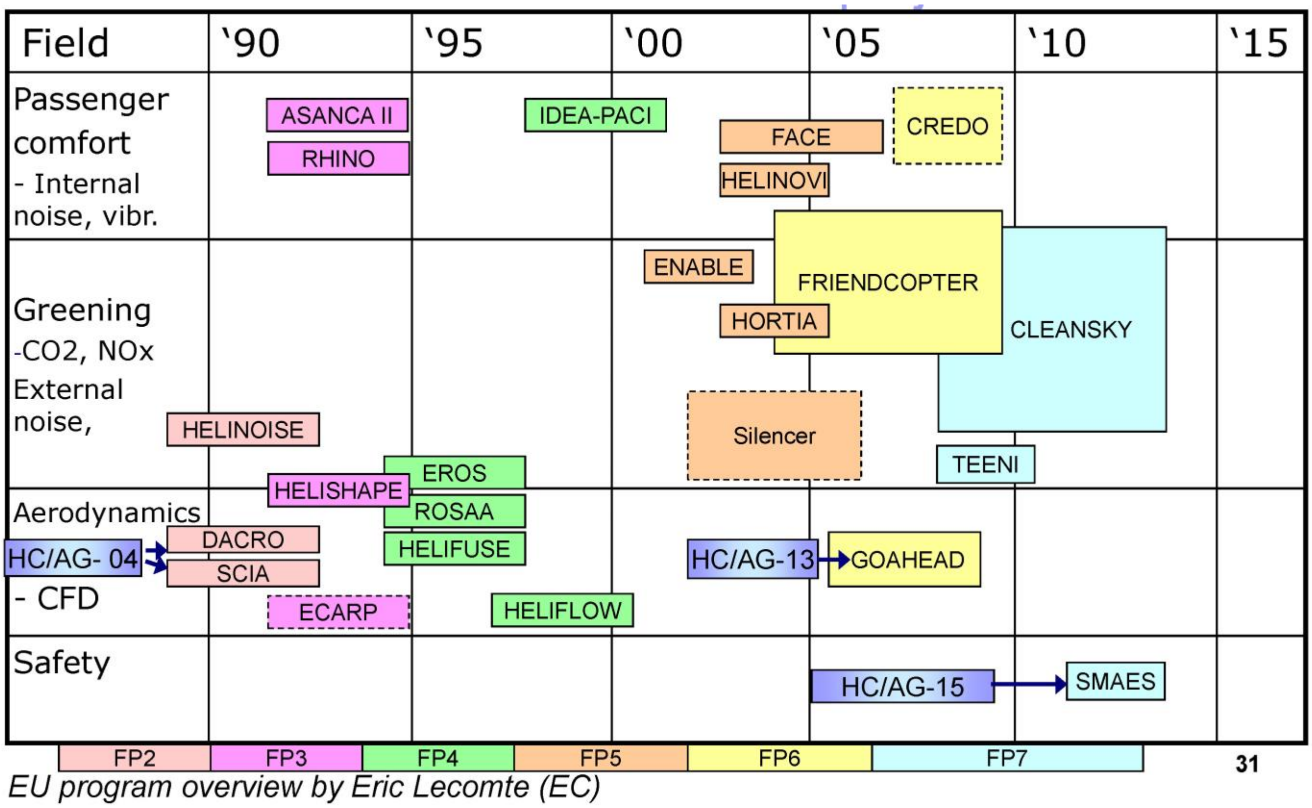


Figure 8: Links between EU-projects/proposals and GARTEUR AD/AG-50 and AD/AG-52



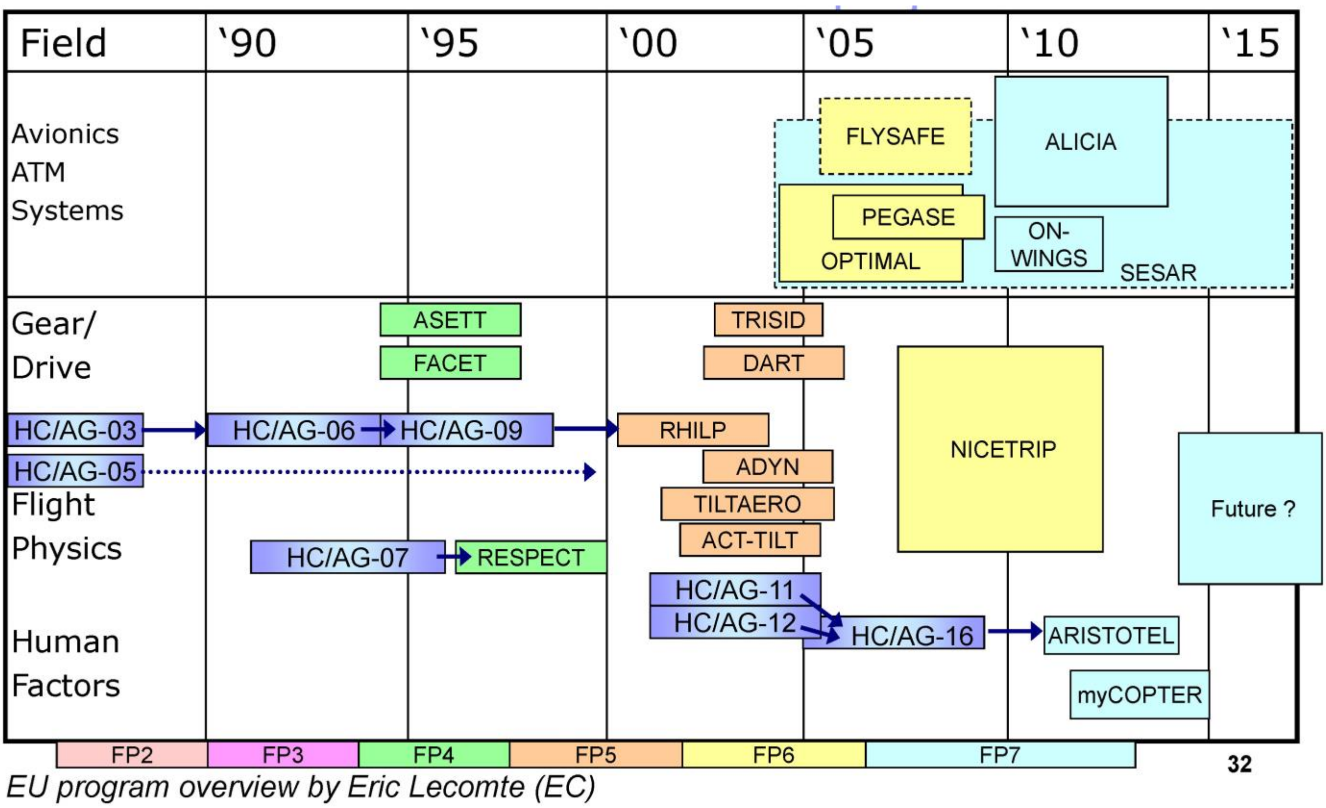


Figure 9: Links between EU-projects and a number of GARTEUR HC/AGs

7. REFERENCES

[1] GARTEUR Annexes to Annual Report 2014.
GARTEUR Document X/D 50, June 2015.

8. LIST OF TABLES AND FIGURES

9. APPENDIX 1: GARTEUR ORGANISATION

GARTEUR ORGANISATION

December 2014

GARTEUR Chair Country 2013-2014: France
Council Chair: Dr. Hervé Consigny, France

XC Chair: Dr. Olivier Vasseur, France
Secretary: Ms Anne-Laure Delot, France

GARTEUR COUNCIL

Function	France	Germany	Italy	Netherlands	Spain	Sweden	United Kingdom
Head of Delegation	H. Consigny	J. Bode	L. Vecchione	T. de Laat	B. Marques	G. Hult	TBD
XC Member	O. Vasseur	F. König	M. Amato	B. Thuis	F. Muñoz Sanz	B. Jonsson	TBD
Other Members of Delegation	C. Griseri P. Desvallees	H. Konrad H. Hueners	D. Cucchi	H. van Leeuwen C. Beers	J.F. Reyes-Sánchez	A. Blom E. Lindencrona	

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. Ogilvie UK chair 2014-15 K. de Cock NL (vice-chair) E. Coustols FR G. Mingione IT H. Rosemann DE F. Monge Gómez ES G. Schrauf DE E. Totland SE N. Wood UK T. Berglind SE (chair 2012-13)	**V. Wiels** FR chair 2014-15 I. Ehrenpfordt DE (vice -chair) B. Eberle DE R. Wiegers NL F. Muñoz Sanz ES A. Eriksson SE	**F. Muñoz Sanz** ES chair 2014-15 R.C.J. Ruigrok NL (vice-chair) B. Korn DE A. Vitale IT M. Hagström SE P. Mouyon FR E. Cortet FR	**L. Notarnicola** IT chair 2013-14 M. White UK (vice-chair) J. Hakkaart NL K. Pahlke DE B. Demaret FR A. Antifora IT P. Krämer DE E. Zoppitelli FR R.-H. Markiewicz UK	**J.P. Grisval** FR chair 2014-15 P. Wierach DE (vice-chair) U. Mercurio IT J. Maroto ES J. Schön SE H. de Vries NL T. Ireman SE (chair 2011-13) A. Riccio IT (Associated member)
Industrial Points of Contacts	Industrial Points of Contacts	Industrial Points of Contacts	Industrial Points of Contacts	Industrial Points of Contacts
T. Berens DE L.P. Ruiz-Calavera ES N. Ceresola IT M. Mallet FR D. Pagan FR C. Newbold UK	AS IPoCs included above	F. Asensio-Nieto ES L. Goerig FR F. Karlsson SE M. Hanel DE	HC IPoCs included above	H. Ansell SE A. Barrio Cardaba ES L. Hootsmans NL R. Lang DE S. Nilsson SE C. Petiot FR W. Zink DE A. Foreman UK

Figure 10: GARTEUR organization

10. APPENDIX 2: OVERVIEW OF GARTEUR TECHNICAL ACTIVITIES

The table below presents the 6 years rolling plan 2011-2016 of GARTEUR Action Groups. Regarding new Action Groups in preparation see chapter 5.

Aerodynamics

No	Topic	2011	2012	2013	2014	2015	2016
AD/AG-44	Application of transition criteria in N-S computations - Phase II		Final report finalised in 2014				
AD/AG-45	Application of CFD to predict high G Wing Loads						
AD/AG-46	Highly Integrated Subsonic Air Intakes						
AD/AG-47	Coupling of CFD with Flight Mechanics						
AD/AG-48	Lateral Jet Interactions at Supersonic Speeds				Final report finalised in 2015		
AD/AG-49	Scrutinizing Hybrid RANS-LES Methods for Aerodynamic Applications						
AD/AG-50	Effect of wind tunnel shear layers on aeroacoustic tests						
AD/AG-51	Laminar-Turbulent Transition in hypersonic flows	EG65 =>					
AD/AG-52	Surrogate-based global optimization methods in Preliminary Aerodynamic Design		EG67 =>				
AD/AG-53	Receptivity and Transition Prediction: Effects of surface irregularity and inflow perturbations		EG66 =>				
AD/AG-54	RANS-LES Interfacing for hybrid and embedded LES approaches			EG69 =>			
AD/AG-55	Countermeasure Aerodynamics				EG71 =>		

Flight, Mechanics, Systems and Integration

No	Topic	2011	2012	2013	2014	2015	2016
FM/AG-18	Towards Greater Autonomy in Multiple Unmanned Air Vehicles						
FM/AG-19	Flexible Aircraft Modeling Methodologies			X			

Helicopters

No	Topic	2011	2012	2013	2014	2015	2016
HC/AG17	Helicopter Rotor Wakes in the Presence of Ground Obstacles			=> EG32			
HC/AG18	Error Localisation and Model Refinement for FEM		x				
HC/AG19	Improvement of Structural Dynamic FEM using In-Flight Test Data						
HC/AG20	Simulation methods and experimental methods for new solutions for internal noise reduction	EG28 =>					
HC/AG21	Rotorcraft Simulation Fidelity Assessment		EG30 =>				
HC/AG22	Forces on Obstacles in Rotor Wake				EG32 =>		
HC/AG23	Wind Turbine Wake and the Effect on Helicopters				EG32 =>		
HC/AG24	Helicopter Fuselage Scattering Effects for Exterior/Interior Noise Reduction				EG34 =>		

Structures and Materials

No	Topic	2011	2012	2013	2014	2015	2016
SM/AG-30	High velocity impact			Report pending			
SM/AG-31	Damage Management of Composite Structures						
SM/AG-32	Damage Growth in Composites						
SM/AG-33	RTM Materials Properties during Curing			Report pending			
SM/AG-34	Damage repair with composites	EG40 =>					
SM/AG-35	Fatigue and Damage Tolerance Assessment of Hybrid Structures	EG38 =>					

X Stopped
Closed
In preparation
Active
EGxx => EG number xx resulting into AG number yy

Table 7: GARTEUR Action Groups – 6 years rolling plan 2011-2016

11. APPENDIX 3: PARTICIPATION IN ACTIONS GROUPS BY NATIONS / ORGANISATIONS IN 2014

Country	Participants	GoR (Number of Action Groups)				
		AD(10)	FM(1)	HC(3)	SM(2)	TOTAL(16)
France	ONERA	7	0	4	0	**11**
	Industry	6	0	1	0	**7**
	Academia	3	0	0	1	**4**
Germany	DLR	6	0	4	1	**11**
	Industry	4	0	1	0	**5**
	Academia	4	0	0	0	**4**
Italy	CIRA	5	0	3	1	**9**
	Industry	2	0	2	0	**4**
	Academia	0	0	4	1	**5**
The Netherlands	NLR	2	0	5	1	**8**
	Industry	0	0	0	0	**0**
	Academia	0	0	3	0	**3**
Spain	INTA	3	0	0	1	**4**
	Industry	3	0	0	0	**3**
	Academia	1	0	0	0	**1**
Sweden	FOI	7	0	0	2	**9**
	Industry	3	0	0	2	**5**
	Academia	1	0	0	1	**2**
United Kingdom	DSTL	0	0	0	0	**0**
	Industry	1	0	1	1	**3**
	Academia	2	0	6	1	**9**

GoR	AG number	Research Establishments	Industry	Academic Institutes	TOTAL
AD	46	3	6	0	**9**
	48	3	2	2	**7**
	49	6	0	1	**7**
	51	3	1	2	**6**
	52	4	3	2	**9**
	53	4	2	2	**8**
	54	5	2	2	**9**
	55	2	3	0	**5**
FM	/	0	0	0	**0**
HC	19	1	1	3	**5**
	20	4	1	1	**6**
	21	3	3	2	**8**
	22	4	0	4	**8**
	23	4	0	3	**7**
SM	34	3	2	4	**9**
	35	3	1	0	**4**

Table 8: Participation in Actions Groups by nations / organisations in 2014

12. APPENDIX 4: RESOURCES DEPLOYED WITHIN ACTION GROUPS: PERSON-MONTH AND OTHER COSTS IN K€

GoR	AG	2011		2012		2013		2014		2015		2016*	
		pm	k€	pm	k€	pm	k€	pm	k€	pm	k€	pm	k€
	44					1	0						
	45	5	10	5	5	1	0						
	46	10	0	3	0	3	3	0	0				
	47	10		10		1	0	0	0				
	48	11	7	3	6	6	8	1	0				
	49	20	170	15	100	7	70						
	50	16	60	8	0	10	20						
	51			13	40	12	40	12	40				
	52					20	45	23	63	23	63	23	63
	53					10	12	13	24	13	24		
	54							18	100	22	140		
	55									0	0		
AD	TOTAL	72	247	57	151	71	198	67	227	58	227	23	63

GoR	AG	2011		2012		2013		2014		2015		2016*	
		pm	k€	pm	k€	pm	k€	pm	k€	pm	k€	pm	k€
	18	36	6	30	6	12	8						
	19	21	2	0	0								
FM	TOTAL	57	8	30	6	12	8	0	0	0	0	0	0

GoR	AG	2011		2012		2013		2014		2015		2016*	
		pm	k€	pm	k€	pm	k€	pm	k€	pm	k€	pm	k€
	17	13	18	1	1								
	18	0	0	0	0								
	19	14	10	12	5	3	0						
	20		2	1	1	18	10	20	28	18	28		
	21					18		14,5	10	18			
	22									15	20	18	33
	23									18		22	
HC	TOTAL	27	30	14	7	39	10	34,5	38	69	48	40	33

GoR	AG	2011		2012		2013		2014		2015		2016*	
		pm	k€	pm	k€	pm	k€	pm	k€	pm	k€	pm	k€
	31	2	10	3									
	32	4	0	2									
SM	33												
	34			6	0	50	49						
	35			1	1	10,5	16	11	41,5	10	35		
SM	TOTAL	6	10	12	1	60,5	65	11	41,5	10	35	0	0

	2011 pm	2011 k€	2012 pm	2012 k€	2013 pm	2013 k€	2014 pm	2014 k€	2015 pm	2015 k€	2016* pm	2016* k€
GRAND TOTAL	162	295	113	165	182,5	281	112,5	306,5	137	310	63	96

Table 9: Resources deployed within Action Groups: person-month and other costs in k€

** NOTE: Several Action Groups are planned to end during 2015, while others are in preparation to be started during 2015 and 2016. Hence it is not meaningful at this stage to estimate resources for 2016.*

13. APPENDIX 5: LIST OF GARTEUR REPORTS ISSUED IN 2014

13.1. Technical Reports

GARTEUR number	Action Group	National reference	Date of issue	Title	Authors	Distribution Classification Remarks
TP-181	AD/AG-46	/	Jan. 2014	GARTEUR AD/AG-46 "Highly Integrated Subsonic Air Intakes"	T.M. Berens et al	GARTEUR Open
TP-182	AD/AG-49	FOI-S--4866--SE	Nov. 2014	GARTEUR AD/AG-49 "Scrutinizing Hybrid RANS-LES Methods For Aerodynamic Applications"	S.-H. Peng et al	GARTEUR Open

Table 10: List of GARTEUR Technical Reports 2014

13.2. Executive Committee and Council

GARTEUR number	Date of issue	Title	Distribution Classification Remarks
X/D-47	May 2014	GARTEUR Annual Report 2013	GARTEUR Open
X/D-48	May 2014	GARTEUR Annexes to Annual Report 2013	GARTEUR Open

Table 11: List of GARTEUR reports issued by Executive Committee and Council in 2014

13.3. Conference Publications

The different Action Groups and GoRs did also make presentations at various technical conferences. This is noted in the respective GoR chapters in the Annex report (also included on the GARTEUR website).

13.4. Availability of technical reports

The GARTEUR Council decided the following regarding older GARTEUR technical reports:
- to make Open GARTEUR reports available on the website after 3 years;
- that the titles of all GARTEUR reports (also GARTEUR Limited) should be listed on the website;
- that most older reports should be declassified to GARTEUR Open and made available on the website;
- to implement these decisions available older reports have been scanned. Some reports are still missing.

By the end of 2014 the number of reports available on the website was 162.
Another 50 reports are still GARTEUR Limited and kept by the secretariat.

14. APPENDIX 6: LIST OF ABBREVIATIONS

ACARE	Advisory Council for Aviation Research and Innovation in Europe
AD	Aerodynamics
AS	Aviation Security
AG	Action Group
AirTN	Air Transport Net
ASD	Aerospace and Defence Industries Association of Europe
ASG	Aircraft Sectorial Group (within ASD)
ATM	Air Traffic Management
ATS	Air Transport System
AVT	Applied Vehicle Technology
BERR	Department for Business, Enterprise and Regulatory Reform, UK
BMWi	Federal Ministry of Economics and Technology, DE
BWB	Federal Office of Defence Technology and Procurement, DE
CDTI	Centre for the Development of Industrial Technology, ES
CFD	Computational Fluid Dynamics
CIRA	Italian Aerospace Research Center
DLR	German Aerospace Centre
DSTL	Defence Science and Technology Laboratory, UK
EADS	European Aeronautics Defence and Space company
EASA	European Aviation Safety Agency
EC	European Commission
EDA	European Defence Agency
EDTIB	European Defence Technological and Industrial Base
EFAPS	European Future Air Power Systems

EG	Exploratory Group
ERA	European Research Area
ERF	European Rotorcraft Forum
EREA	(Association of) European Research Establishments in Aeronautics
ESDP	European Security and Defence Policy
ESRP	European Security Research Programme
ETAP	European Technology Acquisition Programme
EU	European Union
FAS	Future Air Systems
FCAS	Future Combat Air Systems
FE	Finite Element
FM	Flight Mechanics, Systems and Integration
FOI	Swedish Defence Research Agency
FP	Framework Programme
GARTEUR	Group for Aeronautical Research and Technology in Europe
GMES	Global Monitoring for Environment and Security
GoR	Group of Responsables
HC	Helicopters
IMG4	Industry Management Groups
INTA	National Institute for Aerospace Technology, ES
JAR	Joint Aviation Requirements
JTI	Joint Technology Initiative
NLR	National Aerospace Laboratory, NL
NS	Navier-Stokes
ONERA	Office National d'Etudes et de Recherches Aérospatiales (The French Aerospace Lab)
PIO	Pilot-In-the-loop Oscillations
PPP	Public-Private Partnership
R&T(&D)	Research and Technology (and Development)
RE	Research Establishment
STO	Science & Technology Organization (NATO)
SCT	Supersonic Civil Transport
SeNTRE	Security Network for Technological Research in Europe
SESAR	Single European Sky ATM Research
SM	Structures and Materials
SME	Small to Medium Enterprise
SRIA	Strategic Research and Innovation Agenda
SSA	Specific Support Action
TDP	Technology Demonstration Programmes
UAV	Unmanned Aerial Vehicle
XC	GARTEUR Executive Committee