GARTEUR GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE

FRANCE GERMANY ITALY THE NETHERLANDS SPAIN SWEDEN UNITED KINGDOM

# FM/AG-19:
# Flexible Aircraft Modeling Methodologies

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## Background

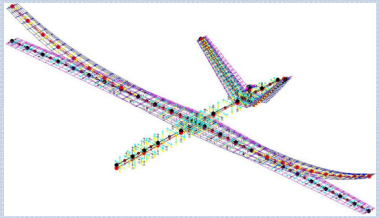
The next generation of air vehicles will have to face very challenging requirements in terms of performance, weight saving and overall performance efficiency. One way to achieve these targets is via an advanced flight control system performing multiple functions related with stabilization, envelope protection, handling qualities, loads control and configuration control. In order to successfully design the control laws algorithms in an affordable time and cost frame it is essential to get high quality mathematical models of the vehicle to be controlled.

As the structures become lighter they are more flexible, with natural flexible frequencies closer to the rigid motion frequencies. The proximity of both frequencies makes the control algorithms design more challenging, since traditional techniques based on the assumption of sufficient frequency separation become less applicable.

In the future, to get the maximum capability of the Flight Control System (FCS), the design must be done using an integrated rigid and flexible model. The level of modelling has direct influence on the final capability provided by the FCS.

The challenge is to pick up the problems associated with this modelling in order to provide the FCS designers with an accurate and suitable model to be used within a proper design and evaluation environment.

The problems associated with the model generation will deal with a real multidisciplinary task joining different disciplines such as flight mechanics, control laws, aerodynamics, load and structural dynamics.



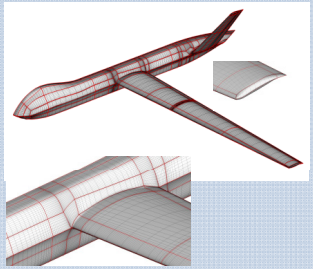
## Programme/Objectives

The aim of FM/AG-19 is to define a way of working for the integrated modelling activities, with the objective to generate an integrated aerodynamic and aeroelastic model to be used in the flight control laws design of advanced FCS. It is essential also to establish a procedure for model validation in the different stages of the air vehicle development process, from initial ground testing to final flight test validation.
With this objective a number of work packages with a balance commitment in terms of disciplines and partners to ensure that all the required work can be addressed have been defined. Main work packages activities will include:

- Definition of the requirements that should be met for the FCS design point of view by an interdisciplinary flexible aircraft model to achieve two major objectives; FCS design and validation cycles reduction and to provide an early and accurate knowledge of the adverse effects due to structural flexibility.
- Define the mathematical formulation and develop a flexible aircraft model with the constrains requirements in the sense of being suitable for control laws design and analysis and keeping the matching between this low order model and highly complex physical models. Low order , high fidelity flexible aircraft models which contain relevant high order non-linear effects and couplings of the aircraft will allow a coupled FCL optimization within an affordable computational effort.
- Define a problem where the design should be challenging enough from a structural coupling point of view.
- Built a software code including required data handling and analysis functions with a model applicable to a specific case under study that will be used for the model validation and functional application activities.
- Develop identification methods suitable for flexible aircraft allowing the definition of a process for model validation in ground and flight test. Developed methods will be assessed using data generated by the high fidelity simulation model
- Perform an integrated design exercise and compare the result with the design performed following traditional methods with three major objectives; develop and apply a FCL design work flow that fully exploits the availability of an integrated multi-disciplinary aircraft mode, compare this work flow with current practices to demonstrate the benefits in terms of design cycles reduction and to demonstrate that design quality can be improved
- Perform a continuous industrial review activity in order to steer it an gathered the maximum benefit from the industrial perspective

Organisations taking part in the FM/AG-19 are:

CIRA
DLR
ONERA
NLR
DSTL
Airbus Military
CASSIDIAN
BAE Systems
Imperial College
Univ. of Liverpool
TU Berlin



## Results

FM/AG-19 was kicked-off in November 2009. However, it had a slow start and most of the running work packages have been delayed now by about 12 months. Mitigation and recovery actions have been put in place. However, situation have not improved significantly . Main achievements comprise:

- Definition of the requirements of the flexible aircraft model for FCS design and software coding requirements agreed
- Flexible aircraft mathematical formulation (review of existing approaches and models) state of the art finished
- Benchmark specification frozen. Catia CAD and FEM benchmark model release to the partners
- Rigid aerodynamic tables generated
- Model validation (basis philosophy established)

Next actions will be:

- Building the flexible aircraft aerodynamic tables based aeroelastic calculations.
- Model development for flexible aircraft flight dynamics.
- Establish hierarchy of models from low-fidelity to high-fidelity and their application.
- Test cases definition for flexible model high fidelity simulations.