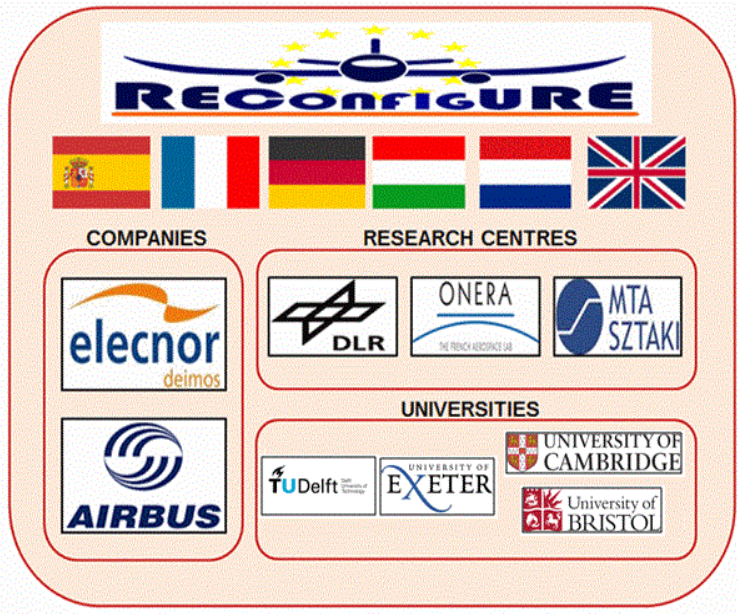
Publishable summary

RECONFIGURE is a European wide research project, with a consortium drawing together industry, institutional and academic partners, in the common goal to investigate and develop advanced aircraft GNC technologies that facilitate the automated handling of off-nominal and abnormal events.

The consortium of this 3-year project (2013-2016) is composed of 9 beneficiaries from 6 European countries. Deimos Space S.L.U. and Airbus represent the two industrial partners, with the project coordinated by Deimos Space S.L.U.. The research centers of DLR, ONERA and MTA SZTAKI represent the three research centers. TU Delft, the University of Exeter, the University of Cambridge and the University of Bristol represent the academic partners. This industry- academic partnership is one of the key strengths of the consortium. It brings together a wide variety of know-how, experiences and interests, with the consortium having the necessary skills, experience, and competences to support the life cycle of such a collaborative R&D project.



The main goal of RECONFIGURE is to investigate and develop aircraft guidance and control (G&C) technologies that facilitate the automated handling of off-nominal/abnormal events and optimize the aircraft status and flight. The automatism of the G&C will help alleviate the pilots task and optimize performance by automatically reconfiguring the aircraft to its optimal flight condition. This automatism and optimization must be performed while maintaining the current aircraft safety levels.

This goal is achieved by pursuing four main scientific & technological (S&T) objectives:

1. Advanced parameter estimation and fault diagnosis approaches.
2. Reconfigurable G&C approaches.
3. Integration issues and approaches for estimation, diagnosis and G&C.
4. Clearance approaches for the above type of systems (individually and integrated).

Currently, commercial aircraft fault tolerant control (FTC) strategies in the flight control system (FCS) are based on fail-safe approaches whereby a nominal ("normal") control law is switched first to a robust ("alternate") solution and then if necessary to a "direct" law. Note that despite its name, the later law ensures a minimal level of stability augmentation independently of the type of abnormal event. The advantages of the current approach are the ease of design, analysis and certification.

Each control law is designed off-line for different levels of robustness and each includes a set of specific guidance and control (G&C) functions which assist the pilot during the flight. Some of these functions are switched off as the control law is switched from "normal" to "direct" and even though this state-of-practice is safe, it is also known to decrease the easiness of the piloting task and as functions get de-activated the use of automatic guidance (Auto-Pilot) or navigation systems (Flight Management) is prevented.

More advanced and less conservative FTC-FCS approaches have not been used due to mainly:

1. A lack of demonstrated maturity of reconfigurable G&C methods for aircraft.
2. A lack of research in the practical limitations arising from the interaction of reconfigurable G&C systems with the estimation and diagnostic systems that feed the first with the required information to reconfigure or adapt their behaviour.
3. A definite gap in terms of the clearance problem, which is a precursor for FCS certification, for this type of G&C systems.

The previous standard FTC-FCS approach was programmatically pursued since aircraft makers seek above all safety and acceptable performance (Robust Stability). But for the future aircraft, it has been identified the need to change the design paradigm towards a performance-oriented one:

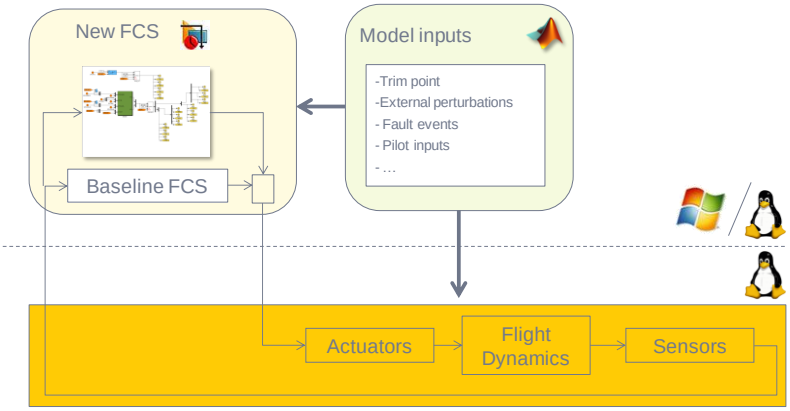
"Full-time & all-event availability of performance-optimized G&C functions"

This paradigm can be translated into the desire to extend the operability of the G&C functions designed to assist the pilot in keeping the flight safe and making the flight task easier and the mission optimal.

Significant progress towards the goals of the projects have been made since the beginning of the project, putting the project consortium now in the position to capitalise on this development and mature the results of the investigations performed to date.

The project is made up of five main work packages, WP0 through to WP4. The technical activities of the project are carried out in WP1, WP2 and WP3.

WP 1 “Industrial Benchmark & Assessment Tools” has been active for almost two years. During this time the primary activity has been the definition and development of the RECONFIGURE benchmark, being the high fidelity Airbus aircraft model, together with the off-nominal scenarios. This is a key achievement for the project, as the high fidelity BENCHMARK provides the basis for all latter design, development and industrial validation tools.

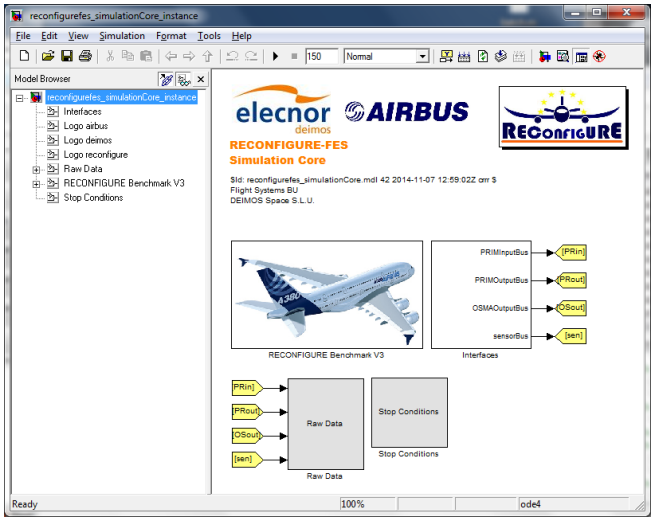


Airbus benchmark architecture

Additional results achieved during the present reporting period are:

- the definition of the designs' selection matrix and the V&V process and tools to be used in WP3.
- Installation and execution of the AIRBUS benchmark software in partners laboratories
- First prototype FES software with capability to run single and parametric benchmark simulations. This FES software is used by the partners both for algorithm design and also validation via MIL simulations, and calls internally the AIRBUS benchmark software.

This constitutes a very advanced status for WP 1, which should be completed within 2014, setting the basis for further advances in WP2 and the start of WP3.



Deimos RECONFIGURE FES

WP 2 "Advanced G&C Design and Clearance Methods and Tools" lasts for the entire project. It is where the main research and development activities are performed. It is divided into three main phases: an R&D phase, an application phase, and an evolution phase where the methods from the R&D phase can be evolved based on the lessons learnt from the application phase.

The main results achieved by the partners during the present reporting period were as follows:

- the thorough review of a myriad of methods, applicable to fault detection and estimation and/or reconfigurable G&C, as well as integrated detection, estimation, and reconfigurable

G&C, including, but not limited to, H-infinity / μ synthesis, Kalman Filter (KF) design, Classical Gain-Scheduling (GS) & advanced Linear-Parameter-Varying (LPV), Multiple-Model (MM) schemes, Model Predictive Control (MPC), and sliding mode control.

- the application of a subset of these methods to the linearized model of the Airbus longitudinal dynamics, also referred to as the *simplified benchmark*.
- the preliminary application of a subset of these methods within the current version of the nonlinear benchmark, by considering some of the faulty and non-faulty scenarios described by AIRBUS.

Given the advanced status of WP1, WP3 will soon start (beginning of 2015). WP 3 "Industrial V&V" starts at the end of the application phase of WP2, and aims to evaluate the technological readiness level (TRL) of the developed approaches by performing a traditional industrial V&V in two-steps: verification of the designs in a functional engineering simulator (MIL) with traditional Monte Carlo analysis (WP3.1), and validation of the designs in the Airbus V&V process, including tests with pilot-in-the-loop simulations using real flight code and avionics (WP3.2).

WP 4 "Dissemination & Exploitation Activities" is active for the entire duration of the project. During the first reporting period, numerous publications of the consortiums activities have been made in conferences and journal papers. The current number of publications is 28.

The final result, and the main goal of RECONFIGURE, is to investigate and develop aircraft guidance and control (G&C) technologies that facilitate the automated handling of off-nominal events and optimize the aircraft status and flight while keeping its safety level compliant with current regulations –or even improving its safety level with a view to upcoming and more challenging regulations. This goal of RECONFIGURE has a long-term perspective, with the aim of helping to develop the FBW systems of tomorrow, one that will be "Full-time & All-Event Availability of Performance-Optimized FBW". The development of such a FBW will provoke a major change in the design paradigm currently followed by the aeronautical industry, where a conservative design is favoured over a performance-oriented one. But it is highlighted that RECONFIGURE does not aim to be able to provoke such a change, but rather to achieve the "small steps" necessary to initiate such a change of design mentality. With respect to a mid-term perspective, the goal of RECONFIGURE is to provide solutions that can extend the operability, or improve the design, of the GNC functions implemented in the current FBW to assist the pilot in making the flight task easier and optimize the mission.

Further information can be found at the public website, which includes the contact details of the partners and the list of publications, among other relevant details:

http://reconfigure.deimos-space.com