EULOSAM (325940)

Design and Manufacturing of a Baseline Low-Speed, Low-Sweep Wind Tunnel Model

State of the art – Background

According to the Air Transport Action Group (ATAG), aviation is responsible for 12% of CO2 emissions from all transport sources and accounts for around 2% of all humanly-generated CO2 emissions. As the aviation industry thrives and passenger traffic doubles over the next twenty years, it's incumbent upon the aeronautical community to take responsibility by creating and cultivating powerful technologies that are environmentally benign.
Laminar flow is a key technology to reduce aircraft drag and fuel consumption. As part of Clean Sky program, research activities have been initiated to increase the knowledge on laminarity to feed the future strategic decision towards the development of laminar wing aircrafts.
As a first step the aerodynamic behaviour of the laminar wing has to be studied to enable its characterisation and support the assessment of expected performance of the laminarity. This can be done via computations and wind tunnel experiments for different flight configurations: take-off, climb, cruise, approach, and landing.
The present project will support experimental studies for laminar wing investigation for business jets during the low-speed phases.

Objectives

The objective of the EULOSAM project is the manufacturing of a large scale half-model of a business jet for testing in a pressurized low speed wind tunnel. An original model of the fuselage has been provided by the aircraft manufacturer. Its design has been modified for this test in such a way that it can be rebuilt to its original condition for future use in another wind tunnel.

The model to be manufactured is composed of:

- A left-hand side modular wing, including:
  - A removable leading edge for different leading edge concepts
  - Spoilers and airbrakes
  - Ailerons
- A set of body-wing fairings to fit with the fuselage;
- Adaptations to the left-hand side cross-shaped horizontal tail plane that fits with the former root chord of the tail model;
- A simplified main landing gear and its cavity.
- An adaptor for mounting the model onto the wind tunnel balance.

The wing is an innovative low-sweep high aspect ratio design with an aerofoil conceived to be laminar in cruise conditions (M = 0.75 at 43 kft). Innovative high-lift systems are outputs from former studies and include Krueger slats and innovative flap devices.

The design and the manufacturing of the model present some challenging aspects:

- Due to the high aerodynamic loads in the pressurised wind tunnel, the usual wing-"box" must be replaced by a massive and solid steel billet. Hundreds of very long channels must be drilled to install the tubes that conduct the local pressures at the wing surface to the scanivalve pressure sensor.
- Expensive steel qualities must be used for all model parts in order to cope with the high stresses induced by the high loads.
- Due to the wind tunnel pressurisation, the Reynolds number is high and, consequently, the boundary layer much thinner than it would be if the wind tunnel were not pressurised. Therefore, in order to prevent premature boundary layer transition, a very smooth surface must be realised and only very small tolerances are acceptable for gaps and steps between assembled parts of the model.

Major difficulties were experienced during the manufacturing of the different parts, due to the deficiency of one of the party in charge of it. The partial transfer of these activities to a new party allowed to partially recover the situation and to deliver the most critical elements as per listed in the results. This has allowed the project to continue beyond the horizon of Clean Sky in order to meet the initial objectives.
The results presented in this document about the EULOSAM project are then limited to activities actually completed by end of December 2016.

Description of work

The work performed is divided into four work packages and may be summarised as follows:

- **WP 1: Coordination and administration of the consortium**

- **WP 2: Follow-up and finalisation of the design**
  This WP aims at completing the design of the model inherited from results achieved within the project DEAFCON (271784 - DEAFCON). The

existing design was then analysed thoroughly in order to detect all errors and also to create a so-called "two-dimensional set" of drawings for all parts that is needed for manufacturing. Furthermore, due to the non-existence on the steel market of standard raw steel billets in the required dimensions, the choice of the steel qualities had to be adapted to available billets and the factors of safety had to be recalculated for the new steel properties.

- **WP 3: Study of the measurement equipment** (pressure taps and strain gauges) with respect to the quantity and quality of all needed elements, the installation within the model and the connection to the measuring apparatus of the wind tunnel.

- **WP 4: Manufacturing of model parts** that respects the tight acceptable tolerances.
  The outcomes of this WP are given in the results part.

Results

The results of the project may be summarised as follow:

- All necessary design data (CATIA data, drawings, material specification and measurement equipment) for manufacturing the complete model is available.
- Factors of safety as specified by the wind tunnel operator are guaranteed for all parts by an appropriate choice of steel qualities.
- Measurement equipment is defined with respect to quantity and quality of all elements to purchase and to mount into the model.
- The model itself consists presently of
  - The wing-"box",
  - One set of leading edges,
  - One set of trailing edge flaps and an aileron,
  - The balance adapter,
  - The drillings finished in all parts so far manufactured to install the pressure taps.

Figure 1 shows the model in its present state.

a) Timeline

The main milestone of the project and associated timeline are:

- Reception of preliminary design data from DEAFCON project - May 2014
- Finalisation of model design - July 2014
- Preliminary Design Review (PDR) - September 2014
- Critical Design Review (CDR) - June 2015
- Start of model manufacturing - July 2016
- End of model manufacturing within ELOSAM project - Dec. 2016

b) Environmental benefits

Laminar flow wing promises significant environmental benefits and the activity performed within EULOSAM will be a key enabler to support Dassault in the characterisation and assessment of the efficiency of laminar wings at low speed conditions.

c) Dissemination / exploitation of results

Dissemination activities linked to the objectives of EULOSAM project have currently mainly been performed by Dassault, as part of general presentations & scientific papers made on the business jets related research activities performed under Clean Sky.

The completion of the model and the experimental test are still to be performed. This is an important input to the orientation of future laminar wing studies and to the strategy concerning designed laminar wing business jets. The results will be disseminated in the frame of Clean Sky 2, if conclusive.

Fig. 1: View of EULOSAM manufactured parts

Project Summary

Acronym:	EULOSAM
Name of proposal:	Design and Manufacturing of a Baseline Low-Speed, Low-Sweep Wind Tunnel Model
Involved ITD:	Smart Fixed Wing Aircraft ITD
Grant Agreement:	325940
Instrument:	Clean Sky
Max Clean Sky contribution:	749.497,00 Euro
Call:	Clean Sky, JTI-CS-2012-02-SFWA-02-029
Starting date:	1st June 2013
Ending date:	31st December 2016
Duration:	43 months
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