Final Report Summary - E-SEMA (Development of Electric Smart Actuator for gas turbine engines)

Executive Summary:
The E-SEMA project aims is the design, manufacture and test of an innovative concept of light, reliable and smart electrical actuator for an inlet guide vane or stator vane application of gas turbine engines that will be capable of interfacing and connecting to the engine control unit in a plug-and-play manner. This innovative concept of smart electrical actuator will be based on a multi-disciplinary approach that will consider mechanisms, the control electronic, the control software and the power supply. The main topics that are going to be developed are related to the temperature levels and environmental conditions (combustion gas, oxidation) that are the normal aero engine working conditions.

Project Context and Objectives:
The E-SEMA project developed and tested an innovative concept of extremely light, reliable and smart electrical actuator for control systems of turbine engines capable of interfacing and connecting to the engine / turbine control unit in a plug-and-play manner. The electrical actuator will be used to control in position the IGVs (Inlet Guide Vanes) of an engine for aircraft application, replacing the current hydraulic actuators.

This innovative concept of smart electrical actuators is based on a multi-disciplinary approach that considers mechanisms, control electronics, control software and power supply in an integrated way.

The main topics dealt with are related to the temperature levels and environmental conditions (combustion gas, oxidation) that are the normal aero engine working conditions, and result to be highly demanding for any electromechanical system working under these conditions.

So forth, the trend is to design a more electrical aircraft, and in consequence a more electrical engine for actuation and control. The energy from the engine is converted to electrical energy and distributed through a net to cover all the energy aircraft needs. EMA represents the next generation of actuation system for most of the commercial aircrafts and aero engines.

E-SEMA Project developments and achievements can be grouped into 2 categories:

- Developments related to the electro mechanical actuator (mechanical hardware, electronic control unit and control software) and its integration within the general aircraft avionics.
- Developments of auxiliary equipment necessary to perform validation procedures.

Regarding the EMA and its integration within the aircraft avionics, the following paragraphs describe the main innovations achieved:

1) Development and design of an electronic architecture able to work properly in aero-engines and turbines which means in
severe temperature and vibration conditions

2) High power density EMA development for its application in engines and replacing current hydraulic systems.

3) Optimized control interface with current aero-engines control systems, and even with the aircraft flight control system.

4) A Failure analysis and safety assessment applied to all stages of the actuator development: design, manufacturing, assembly and testing.

Main objectives are:

1) Development and design of an EMA with electronic architecture that will be able to work properly in aero-engines and turbines, which means in severe temperature and vibration conditions. Electronic design to be done considering the actuator as a flight critical actuation system. Possible impacts of DO178 and DO254 on the electronic design to be taken into account while choosing the electronic implementation.

2) New motor materials and insulation techniques to be investigated. Metallic materials for high temperature levels to be considered (taking into account weight/resistance ratio). Insulation techniques to be adopted to protect the electronic and sensors taking into account cooling effects.

3) As main development has been in the current EMA project for a similar application (HP-SMART-EMA / Topic addressed: JTI-CS-2009-1-SAGE-05-006) under contract CS-GA-2009-255819) that allows to start an upgrade situation from smaller systems to the present proposal actuator, here it is included a step ahead (SENER is involved in proposal ACTUATION2015), with the aim to standardize and produce modular actuation systems to avoid extra certification costs and obtain families of actuator rapidly configurable. This objective is more thinking in serial production phase (for optimization of the recurrent costs).

4) Health monitoring issues are potentially applicable for this project and will be investigated taking into account end user needs. SENER is working currently in these issues (ACTUATION2015 where SENER is leading the task of Health Monitoring in EMAs with British Aerospace - BaE Systems)

Project Results:
SENER has been the focal point with the Topic leader and have coordinated, monitored and report the project progress as well review of updated exploitation plans.

The main objective has been to develop a robust design taking into account the electrical power actuation in extremely severe conditions. A benchmarking has been performed on power and control electronics capability. A preliminary design (mechanical & electronic) has been done for review and approval, ans was successfully. Special care has been considered taking into account previous similar tasks performed in a previous similar Clean Sky project, with the same consortium working (lessons learnt).

SENER has looked for mechanical solutions satisfying robustness and precision requirements as well as meeting the high demanding working environment for the EMA system. The mechanical solution defines materials, tolerances, manufacturing issues and assembly methods that will allow the system to work in severe temperature conditions. Based on similar problematic already studied in a previous Clean Sky project, the lubricant has been defined for the current application.

SENER is also in charge of the Electronics and Control of the EMA with special care to face the severe conditions. Health monitoring capacities has been considered to be applied to the actuator in order to improve the maintenance tasks. SENER has prepared inputs for the motor specification to MACCON. Motor issues has been investigated and developed by MACCON.
The detail design of the EMA has been performed according to the recommendations and solutions identified in the previous tasks, to face the severe working environment. SENER has been the leader this work, bringing all its experience in previous actuators developments. The work package has been performed as follows:

**EMA Mechanical and Electronic detail design: (SENER, ACITURRI)**, from the conceptual design of the solution allowing concurrent engineering regarding to the solutions to be implemented and order to face the several environment working conditions, in this task the EMA selected as referenced architecture has been detailed sizing and dimensioning in a detailed design by SENER:

- Mechanical design (3D CAD) – SENER
- Electronic design - SENER
- Analytical validation (documentation to verify the design by analysis or test if needed) - SENER
- Manufacturing drawings (detail 2D drawings) – SENER with ACITURRI manufacturing concurrent engineering
- Assembly drawings – SENER

Motor development: (SENER, MACCON): MACCON has performed the motor development (detail design and sizing)

Actuator manufacturing: The aim has been the integration of the EMA in order to produce a final integrated component to be tested and validated. This work package has been dedicated to the manufacturing of the prototypes of the EMA, according to the recommendations and solutions identified.

Mechanical manufacturing and commercial purchasing: (SENER, ACITURRI)

Mechanical parts manufactured and mounted by ACITURRI and delivered to SENER. Commercial components purchasing (brake, sensors, and electronic parts) performed by SENER.

Motor manufacturing: (MACCON)

Assembly and validation: (SENER): EMA assembled by SENER. All electronics assembled and final prototypes mounted. Cabling and control elements added to prototypes.

**Smart Electric Actuator Validation**

Validation tests performed at CTA to demonstrate the capability of the design to meet requirements. Test Smart Electric Actuator in a bench environment has validated performance and durability (CTA)

Auxiliary electronic equipment development and manufacturing for testing: (SENER, CTA, TECNALIA)

Test Set up configuration and Test Plan: (SENER, CTA, ACITURRI, TECNALIA)

Internal tests realization: (CTA, SENER, TECNALIA, ACITURRI)

**Potential Impact:**

The development of these innovative high power density electrical actuators will be in line with the following expected areas:

- Developing “an advanced concept contributing to the all-electric aircraft, reducing engine bleed and systems weight, including power generation and distribution”

- Developing an “Advanced concept and technology for increased modularity and integration of avionics components and systems”

This project is thus relevant to ACARE Strategic Research Agenda: This objective of the work programme is coherent with the technological challenges and socio-economic scenarios defined in the Strategic Research Agenda 2 of ACARE (www.acare4europe.org) the European Technology Platform on aeronautics. In particular, this project contributes to this SRA
Correlation with the JTI Clean Sky:

- it will provide a step forward in the technology capability of environmentally friendly systems: integration of advanced technologies
- it will improve on the overall impact on environment: emission reduction and fuel consumption

A successful project will ensure a strong strategic impact and will have clear Socio-Economic benefits within the next five to ten years by contributing to:
- Enhance European aeronautic industry competitiveness
- Enhance European employment
- Meet societal needs for more environmental friendly, safer and efficient air transport
- Meet societal needs for more environmental friendly manufacturing

Generating and maintaining high technology industries is essential to the maintenance of employment within Europe. Currently the European aircraft industry employs 380,000 directly and a further 650,000 indirectly through its supply chain, which includes a significant number of SME’s.

Predicted growth in aircraft traffic is expected to be 5 % per annum and it is forecasted [Global Market Forecast 2008-2027, Airbus] that until 2020 the world jetliner fleet will grow by nearly 11,000 aircrafts. Considering the number of aircraft to be retired in this period, 15,800 passenger aircraft and freighters will be delivered until 2020, representing a potential market of about €1500 Billion. The European aerospace industry has a long-term goal not just to retain existing market share but also to increase it from the current level in the next 10 years. The technologies and tools that will result from this proposal are essential to achieve these goals but they will also lead to an increased role of synergistic industries such as sensors, electronics and data processing units, parts manufacturers and offer opportunities for the employment of highly skilled professionals. This would contribute in solving of heavy societal problems interconnected with the high unemployment in Europe. Thus, the benefits to be realised from the implementation of advanced actuators will give the European aerospace industry the opportunity to provide better solutions (operational, environmental and technological) than their competitors, to reduce the direct operating costs and thus to increase their market share.

Societal Benefits

The main outputs are expected to have essential societal impact. Through the decreased aircraft weight and the associated fuel consumption an emission reduction up to 5% is expected in an estimated time scale of 5-10 years. A successful implementation of smart electro-mechanical actuation systems can be linked to an improved design of respective parts. The research included in the project will provide the opportunity for student research at the participating universities and research institutes. The work programme will be an ideal subject for upstream research and will help in educating the new generation of European aerospace engineers.

DISSEMINATION ACTIVITIES

Information concerning E-SEMA actuator is subjected to strict confidentiality and non-disclosure conditions. Topic Manager Company wants to protect carefully any transfer of sensible information to undesired public. Due to this reason only internal dissemination activities have been performed.

It is in the aim of the consortium to present the project results through traditional dissemination routes (publications, articles, technical papers for scientific journals, presentations at suitable events and conferences) in future events as:
• Le Bourget aero show
• Company’s annual memory
• HEGAN (Aerospace Cluster of the Basque Country) annual memory & AEROTRENDS exhibition
• Aerospace & Defence Meetings
• Airtec - International Aerospace Supply Fair
• Aerodays
• Clean Sky General Forum

Partner’s participation in the Project has been published in their corresponding webpages.

EXPLOITATION PLAN
SENER Broad dissemination and use intentions for the expected outputs focused on EMA industrialization by means:
• Low cost design
• Industrialization approach to the concept developed
• Close contact with customer
• Improvement of the supplier chain
• ILS definition
• Potential commercial phase with customer

SENER Overview of main project results: A customized EMA for engine application (H/C, A/C) with the aim to develop a product range for similar applications with low cost approach for easier market introduction.

SENER POTENTIAL OFFERED FOR FURTHER DISSEMINATION AND USE: E-SEMA developed as a prototype demonstrator to be exploited as industrial phase where low cost concepts, industrialization issues, ILS and other topics should be analyzed in detail with the potential customers. Open to review a concept for a better customer needs. More electrical engine is a trend in the future H/C and A/C that will allow an important impact in better performance and reliability optimization.

SENER PROFILE OF ADDITIONAL PARTNER(S) FOR FURTHER DISSEMINATION AND USE: Focused on end users as H/C or A/C engine manufacturer (TIER 1) but open to other actors as TIER 2 or A/C and H/C flight control systems.

Regarding the EGSE equipment, TECNALIA foresees different ways of exploiting this developed auxiliary test bench:
• Exploiting the test bench with aeronautic companies interested in this validation mean. This is a possibility that is being explored; in fact the contacts and meetings that are being held with aeronautic companies in the context of dissemination activities are a base for this possibility.
• The test bench could be used by TECNALIA, for selling testing services to aeronautic companies.
• The test bench could also be used as a demonstrator of technologies. The knowledge acquired in the project will be surely exploited for carrying out new projects related with the field of testing aeronautic EMAs and components.

CTA will use the test bench developed and the know-how acquired in future programs of EMA actuators with SENER.

A more detailed plan will be defined with the results of the several dissemination activities and commercial contacts that will be performed in the near future, in order to identify the potential interests of the aeronautic companies in E-SEMA project results.

List of Websites:
Javier Vinals
SENER
Project Manager
Related information

Result In Brief

Aircraft gas turbine becomes electric

Reported by

SENER INGENIERIA Y SISTEMAS S.A.
Spain

Subjects

Scientific Research

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