PERIODIC REPORT M42

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Periodic report: **1st** □ **2nd** □ **3rd X**
Period covered: **from** 01/09/2012 **to** 28/02/2013

Name, title and organisation of the scientific representative of the project's coordinator:
VASSY Paul, R&T Programmes Manager, SAGEM, Safran Electronics Division
Tel: 00 33 1 58 11 35 81
Fax: 00 33 1 58 11 50 18
E-mail: paul.vassy@sagem.com

Project website address: www.creamproject.eu

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Approvals

	Document Responsible	Coordinator
Name	Paul Vassy	Paul Vassy
Company	SAGEM	SAGEM
Date	19/04/2013	19/04/2013
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Version 0	20/02/2013	Template version	Marie Letailleux
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Version 2	19/04/2013	Final version after SC members approval	Marie Letailleux

Declaration by the scientific representative of the project coordinator SAGEM

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate) [1]:

  □ has fully achieved its objectives and technical goals for the period;
  X has achieved most of its objectives and technical goals for the period with relatively minor deviations.

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable
  X is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section IV) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section II.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: ....Paul VASSY...

Date: .....19......./ .....04......./ ....2013........

For most of the projects, the signature of this declaration could be done directly via the IT reporting tool through an adapted IT mechanism.

[1] If either of these boxes below is ticked, the report should reflect these and any remedial actions taken.

CONTENT

I. Publishable Summary from 01/09/2012 to 28/02/2013

1. CREAM Context

Compact and reliable Electronic integrated in Actuators and Motors

The actual political, environmental and economical trends applied to air transport lead to move in the future to the All Electric Aircraft (AEA). The goal of this concept is to eliminate as many hydraulic power sources and complicated circuit of high-pressure hydraulic lines as possible. Moreover the engine which is currently required to produce thrusts, pneumatic power, hydraulic power and electrical power must be redesigned and optimised to produce thrust and predominantly electric power.

Today, it is clear that reliable electric actuators are one of the technical bottlenecks for realizing this ambitious technological vision of all electrical aircrafts. The goal of power by wire (PBW) is to significantly reduce or eliminate altogether the hydraulic connection and its associated risks by providing electrical power straight to the actuators. However the maturity of PBW technology is lagging behind. In fact the real challenge for the implementation of the power-by-wire aircraft is the development of compact, reliable, electrically powered actuators to replace the conventional hydraulic systems allowing the replacement of all electrical hydrostatic actuators by Electro-Mechanical Actuators - EMA (flight control actuators, braking system, landing gear actuators, propulsion inverters, various pumps, various auxiliary actuators).

2. CREAM objectives

CREAM project objective was to reach new high performance and reliability capabilities of Electro-Mechanical Actuators (EMA) in harsh thermal environmental conditions ready to use in all-electric aircraft.

For this global objective, it was targeted to develop an advanced, smart, miniaturised and reliable electronic technological platform integrating new compact technologies, advanced components and assembly methods able to substantially improve the drive and control electronic modules and the EMA motors in order to:

- Provide high power density and compact characteristics of electronics modules integrated in actuators or motors (reduction by a factor 2 of the electronic volume and mass).
- Provide advanced new concept of thermal management of the electronic platform allowing higher performances and reliability.
- Provide high temperature and compact motor for actuators (reduction of 30% of the motor volume and mass).
- Integrate the new electronic and motor platform in actuator housing and a very severe thermal environment (above 200°C) providing performing thermal management.

- Provide validation of aeronautic reliability in high temperature at least at the same level than existing hydraulic systems (50.000 hours), and even better (100,000 hours) with health monitoring functionality.

3. Cream project organisation

CREAM proposed an ambitious technological research program allowing to develop and validate a number of various emerging sub-components, packaging and motor technologies and to integrate them to a high performance smart electronic and motor technological platform destined to electric actuator preparation. The project was divided in 4 technical Work Package (WP).

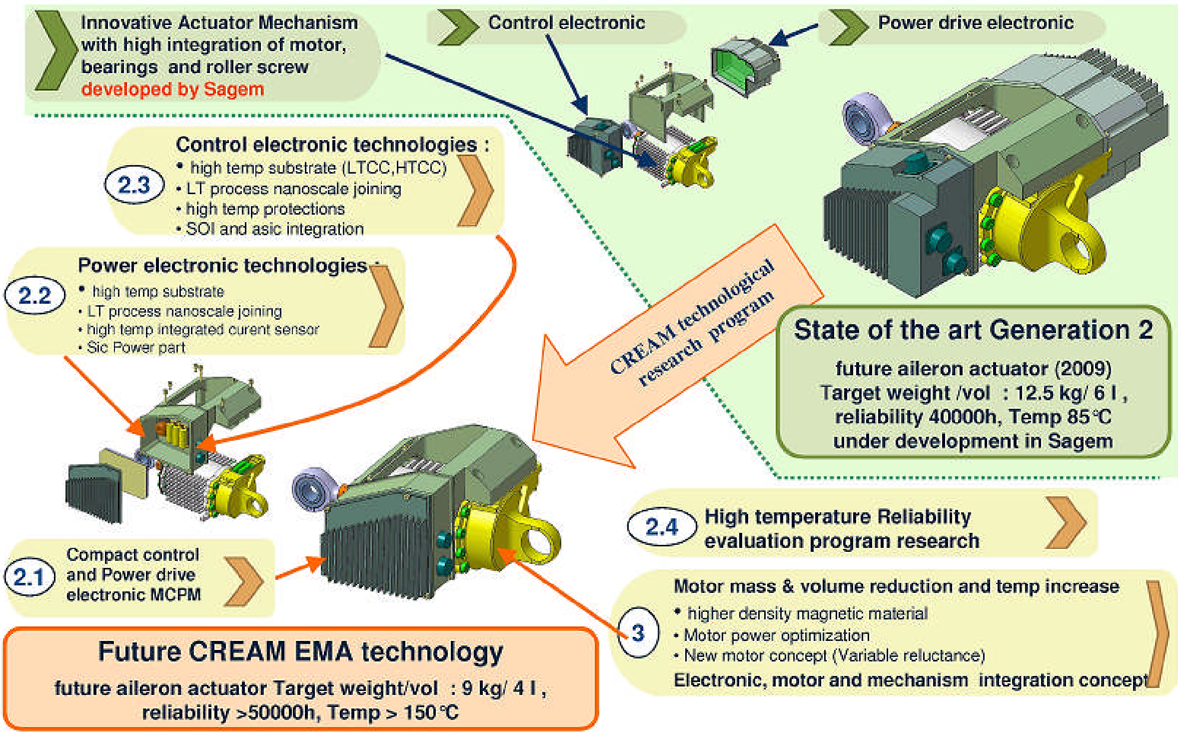


Figure 1 : CREAM technology applied to flight control actuator and developments in the different WP

- **WP1 (Specifications)** was oriented to the better understanding of the harsh environment and the complex validation plan to ensure the best implementation of the new actuator in aircrafts.
- **WP2 (Multi-Chip Power Module, MCPM Design)** was the core development of the CREAM project and led to the creation of the new electronic part of the actuator. This workpackage was divided in 4 sub-workpackages.
- WP2.1 refered to the technical coordination of this activity and all developments of the MCPM global packaging (electronic interface, global packaging and integrations between modules).
- WP2.2 refered to the development of a new power module for the actuator including power components interface with the control module and the compact high temperature power packaging.
- WP2.3 developed another electronic module dedicated to the control of the actuator for high temperature applications.

- WP2.4 dealt with the reliability of the electronic devices developed, including all assembling technologies and reliability of the modules integration.
- **WP3 (Actuator Global Integration)** was dedicated to the development of a new motor for this generation of actuator. New technologies, as new magnetic materials or new motor control method, will be evaluated to improve the actuator.
- **WP4 (Technological platform validation)** aimed at validating the new actuator to perform the Technological Readiness Level expected.
- **WP0 and WP5** dealt with project management and dissemination, exploitation and standardisation aspects.

4. Main results achieved so far

The project is balanced between two main activities: technological research aiming at assessing and selecting technologies suited to CREAM constraints and development of a demonstrator embedding the selected technologies.

The first year of the project was dedicated to the identification of the end-user application for the CREAM technological platform (D1.2), a trade-off on the requirements applicable to this platform (D1.1), the definition of the technological plan for the project (D1.3), the definition of the validation plan of the technological platform (D1.4), the architecture of the demonstrator (D3.1) and the architecture of the MCPM (D2.1.1).
Planned deliverables within this first year have been delivered.

Based on these outputs, the second year was dedicated to the evaluation of technologies in each workpackage and to the detailed studies and breadboarding of all functions**.** Reliability bases have been increased, thanks to all technological test vehicles that were built and tested at extended temperature ranges. A major decision point (DMP2) was held and allowed to select the best candidate technologies for the demonstrator. Prototypes were designed, built and successfully tested for all critical functions of MCPM and the motor, thus securing all bases for detailed design activities.

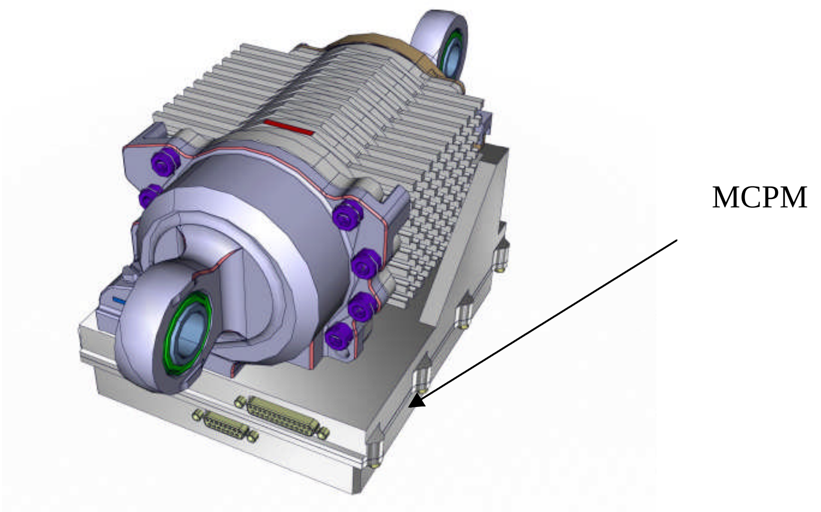


Figure 2 : CREAM EMA

The third year was dedicated to detailed design activities of the major components and boards, up to the elaboration of industrial files and the procurement of all parts for the final MCPM demonstrators. Test bench architecture was also been refined and frozen, permitting the development activities of all test tools for final activities.
All necessary outputs were elaborated and delivered and detailed organization of partners for the manufacturing of final demonstrators was set up, taking into account the definition of hardware outputs and manufacturing requirements for all parts and subassemblies. Assessment of the difficulties associated to the new technologies and processes and solving the issues of the final mixing was a major activity.
All the subparts of the EMA were manufactured, tested and made available for integration in the final MCPM demonstrators. Most technologies selected during the design were specifically evaluated in complement of the technological planned activities.
All parts were integrated, glued, bonded and interconnected into the MCPM foreseen demonstration models (4 fully assembled MPCM have been manufactured and tested).
The CREAM harsh environment dedicated test bench was developed, assembled, tested, integrated with MCPM so as to verify and tune all hardware and software items.
A test campaign allowing stressing all implemented technologies and high temperature specifically selected or developed parts was started and completed. Due to the tight schedule constraints, the campaign has been restricted to major tests that were foreseen.

WP1: Specifications
The application selected for the technological platform is an EMA for flight control application (aileron) with additional environmental constraints to remain in line with the high temperature objective of this project. (D1.1 and D1.2)

The construction of the technological roadmap of the project (D1.3) was a major objective of the first period. Technologies to be evaluated were selected accordingly with the requirements analysis on the EMA and its sub-assemblies.
Milestone DMP1 (Decision Making Point n°1) took place in April 2010: the technological plan of the project was set-up.

Milestone DMP2 took place in September 2011: the technologies selected in DMP1 to be investigated were evaluated in the Workpackages 2 and 3 and a few of them were selected to be integrated in the demonstrator.

From the system requirements on the demonstrator in D1.2, a validation plan of the technological platform was defined (D1.4).

WP2: Electronics
The architecture of the MCPM was set (D2.1.1). Several problems impacting the feasibility of the MCPM as defined in the DOW were identified and solved one by one. The design of the subassemblies of the MCPM was done as well. The design of the power electronics (D2.2.1) and of the control electronics (D2.3.1) was completed. Breadboards were developed, manufactured and successfully tested for critical functions.
Technological research activities improved the consistency and completeness of reliability data bases. They delivered useful inputs for technological choices (DMP2).
The design of the critical parts of these modules has then been frozen in order to secure the global schedule of the project. The CPU was designed, simulated and developed. Test vehicles were manufactured with initially selected technology. Due to cost issues and

unavailability of critical compiling tools, another high temperature compliant technology was finally selected for the CPU development and wafers were manufactured. Successive test boards were developed for CPU testing. CPU test campaign at ambient temperature ended successfully with the validation of all CPU functionalities.

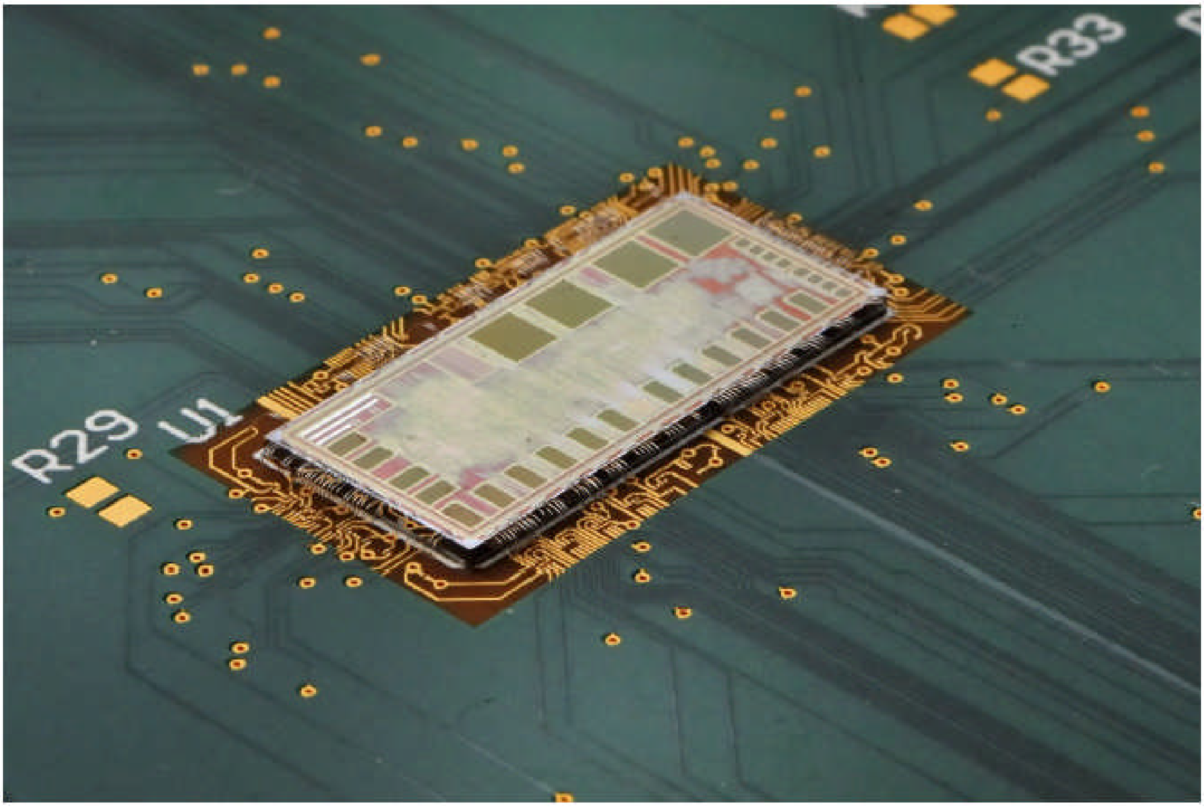


Figure 3 : H.T. CPU

All detailed studies were completed for all functions, development activities for all MCPM parts, subassemblies, mechanical parts and frames were completed also and industrial manufacturing files including layouts for all assemblies and modules are now finalized. MCPM architecture was broken down into all necessary physical parts. List of materials were consolidated and part procurement was done (electronics parts, baseplate and other items). An important issue was associated to the careful checking of the compatibility for all technologies foreseen to be finally integrated and mixed in the final demonstrator and to the finalization of associated mounting processes, from the individual parts up to the demonstrator with its mechanical frame.

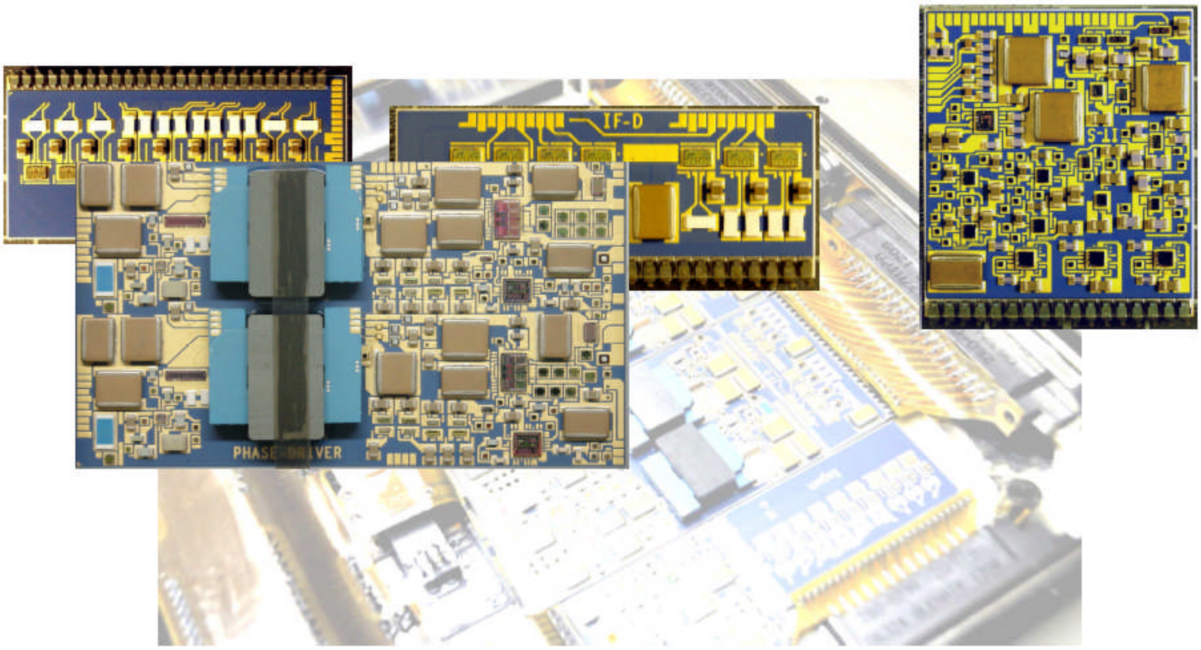


Figure 4 : MCPM Control functions

A dedicated organization was set between partners so as to enable a smooth integration of the MCPM. The integration of the main subparts of the MCPM was successfully carried out.
Thanks to high manufacturing that were obtained, 4 full MCPM units were manufactured. One additional partial MCPM was also manufactured with available parts, dedicated to testing.

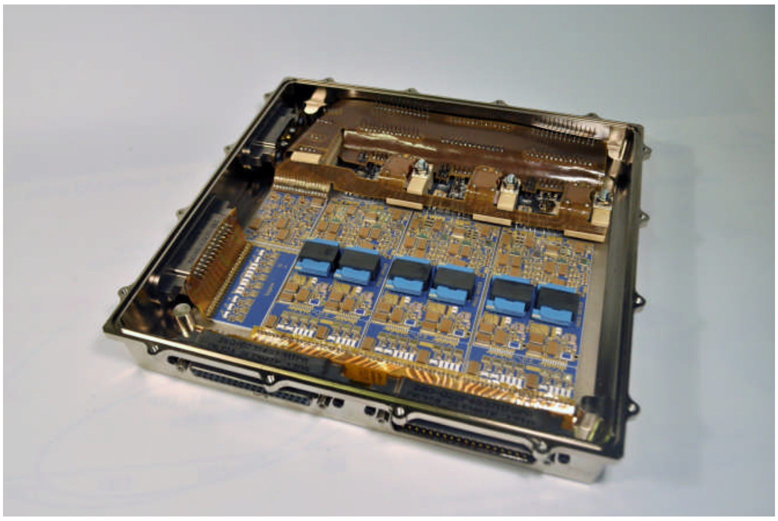
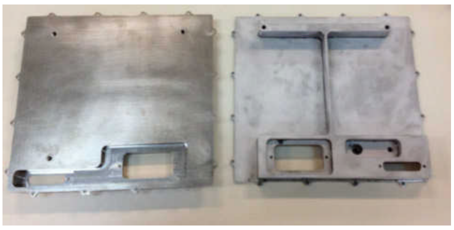


Figure 5 : MCPM

WP3: Motor

Independently from paper analysis and simulations under finalisation on an optimised global architecture according to several criteria (D3.1), it was agreed that the demonstrator will be an assembly of two blocks integrated together: a mechanical block containing the actuator (linear roller screw), the motor, some sensors and other mechanical interfacing mechanical components and a physical block (optimized in volume, weight, reliability etc.) containing the MCPM.

CREAM Motor



MCPM Housing

Figure 6 : Motor and MCPM (items)

A first prototype of the motor was built and delivered promising results. Thermal analyses and simulations were carried out. A second prototype with improved insulation and thermal performances was developed and successfully tested. A third prototype was also manufactured and acceptance tested. (D3.4)

Studies for optimization of control algorithms were carried out.

The mechanical parts of interface between the MCPM (electronics) and the actuator were designed and manufactured and finally delivered for MCPM manufacturing.

WP4: Validation

Validation strategy was put in place at WP4 KOM. Due to Consortium reorganization in November 2011, Sagem took the lead of WP4 and was the major contributor for all WP4 activities.

Based on previous analyses and Sagem knowhow and available tools, the architecture of the test bench was studied, detailed and frozen, with the aim of permitting final validation of the demonstrator, mainly through thermal stress cycling.

All hardware and software parts were developped, assembled and integrated in the benches and test softwares. The test benches were connected to MCPM units so as to tune and verify all parts and test sequences.

A dedicated MCPM unit for test bench integration has been manufactured, allowing determination of all test parameters and activation scenari.

Once all items ready for final validation campaign, tests have been carried out on dedicated MCPM units so as to stress all parts and technologies. Due to schedule constraints, the testing sequences focused on major configurations that were foreseen in harsh environment.

Figure 7 : CREAM Test Bench

WP5: Dissemination/Exploitation
The plan for use and dissemination was established (D5.1) and CREAM website was created (D5.2). Several actions of dissemination were made, through publications and dedicated conferences (D5.4).
Encouragement on further dissemination activities were regularly made, especially at all Consortium meetings. Two cross-fertilization meetings with Actuation 2015 representatives were held.

5. Expected final results

The following technological outputs of CREAM project led to further economic impacts:
- Reliable “application-ready” high-temperature electronic modules: Establishment of European know-how in the field of high-temperature electronics,
- Successful development of high thermal conductive materials with high thermal stability: Such materials are of interest in many areas where reliable cooling is a topic,
- A new technology & design for measuring current in harsh environment, reusable in various sectors,
- High temperature & compact motor controller: foreseen applications in valves and pumps,
- Reliable EMA actuators in hard thermal environment: reduced operational cost for maintenance.

Immediate benefits derived from the wider application of electrical power and electronics in actuation include higher performances and reliability, benefits of overall weight reduction, easier maintainability, reducing operating costs (including reduced fuel burn) and enhanced safety.
Europe needs to answer rapidly to USA investigations in order to remain competitive in the challenging aeronautic market. CREAM project results will support the European aeronautical industry in the strong competition between Europe and USA. CREAM results are able to establish the credibility of electric actuation as a primary reliable method for aircraft actuators including flight critical control surfaces, by integrating innovative concepts and sub-systems and reliability testing methods.

Address of the project public website:
http://www.creamproject.eu

Coordinator contact:
Paul Vassy: paul.vassy@sagem.com

PARTNERS

Order	Partner	Country
1	Sagem	France
2	Hispano-Suiza	France
3	SEMELAB PLC	United Kingdom
4	Austrian Institute of Technology (until the 1st of October 2010)	Austria
5	Ecole polytechnique Fédérale de Lausanne EPFL	Switzerland
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