WP 6

Deliverable 6.2

Final public report

NNEOS
NACELLE COWL NEXT GENERATION OPENING SYSTEM

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RECORD OF REVISIONS

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GLOSSARY

A/C	Aircraft
AGMA	American Gear Manufacturers Association
BLDC	Brushless Direct Current
C	Compliant
CESA	Compañía Española de Sistemas Aeronáuticos, S.A.U.
JU	Joint Undertaking
MDU	Manual Drive Unit
N/A	Not Applicable
NC	Not Compliant
NIPSE	Novel Integration of Powerplant System Equipment
NLGI	National Lubricating Grease Institute
NNEOS	Nacelle cowl NExt generation Opening System
PC	Partially Compliant
PDR	Preliminary Design Review
PFPE	PerFluoroPolyEther
TBC	To Be Confirmed
TBD	To Be Defined
TRD	Technical Requirements Document
WP	Work Package

Table 1. Acronyms and Abbreviation List

1 EXECUTIVE SUMMARY

NNEOS project aims to develop an innovative nacelle cowl opening system based on electromechanical actuation compatible with the high temperature environment of the new Ultra High Bypass Ratio (UHBR) engines.

This deliverable main purpose is to disseminate the results of the tests and the final conclusions of the project.

2 OBJECTIVES

NNEOS project is born to enable the use of new engines architectures like the UHBR (Ultra-High Bypass Ratio) that require shorter and slimmer nacelles and as a result a new approach to maintainability and accessibility of the engine.

Main objectives of the project:

-Improve safety and accessibility to engine zones for maintenance/reparation through the development of an electromechanical actuator that integrates the functionalities of opening/closing the cowls as well as holding them at the open position during maintenance task

-Optimize weight and dimensions with a design that favours the integration within the nacelle available space envelope.

-At a system level, provide a potential reduction for the volume required for the equipment by 15%

-Contribute to the reduction of the development time of the future engine architectures by 10%, through the optimisation of system integration for the power plant systems Provide a friendly design that is easy to use but ensures a safe operation of the nacelles

-Bring the technology to TRL5

3 EQUIPMENT DESCRIPTION

Taking into account requiremnst from topic manager , a new actuation system has been developed which includes an electro-mechanical actuator (EMA) and its electronic control unit (ECU).

NNEOS is composed by an electromechanical ballscrew actuator, controlled by an electronics control unit. The ECU is an individual unit, independent from the actuator, placed outside the aircraft (AC/) engine core high temperature environment, being 85ºC its maximum (survival) temperature.

The actuator includes a manual Drive Unit for maintenance operation purposes.. Accessibility to the MDU interface shall be provided to the maintenance operator through flexible shaft system installed within A/C engine nacelle structure if needed. The actuator is powered by a 300 W, 28VDC, Brushless Direct Current (BLDC) motor. Several reduction stages are used to achieve the final output torque of approximately 11Nm at the ballscrew spindle, needed to comply with the operative loads defined in the specification . Overall speed reduction of the NNEOS mechanical power transmission line is achieved by several reduction stages. Once at the full extended position, a locking segment system is used to keep the actuator in the safe holding condition. An extra axial free-play is provided to adjust the actuator length once installed in the A/C engine nacelle, allowing the absorption of an eventual mismatch between actuator full retracted nominal length and the length needed (shorter or longer) by the nacelle cowl kinematics

The NNEOS high temperature motor has been designed to comply with specification requirements and more specifically to endure the extremely demanding environmental conditions present around the core of a turbofan engine. The motor uses high temperature performance materials that allow it to perform the required operating cycle at 250 ºC ambient temperature. Therefore, the motor provides a possible template for small electric motors driving actuators around most locations in the civilian or military jet engine.

The Electronic Control Unit (ECU) was initially designed to control the operation of the EMA. It contains all the electronics needed to capture the aircraft switch state and operate the EMA in extension or retraction movement according to operator manoeuvring.

The main targets of this project for the ECU are the high temperature electronics, the sensorless control of BLAC motor and simulated EMA end-of-stroke sensorless detection.

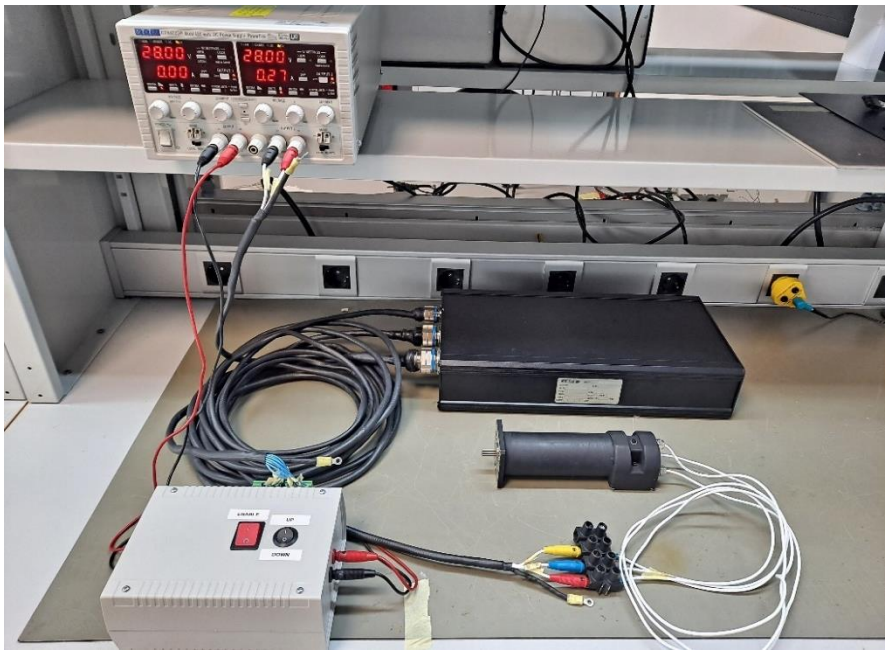
Because of cooling solutions for the ECU are not practical for this environment, the ECU is designed to operate in an 85°C environment agreed with Airbus.

The high operating temperature of EMA does not allow the use of sensors in the motor to control of rotation direction and speed. Consequently, a four-quadrant sensorless BLAC control have been configured to acquire and integrate the Back EMF (BEMF) voltage to determine the motor active phase and therefore, the motor speed.

Another important point to consider in a high temperature environment is the end-of-stroke detection. The ECU monitors the motor current consumption of the motor and detects the current increase when the actuator has reached the end-of-stroke.

4 MANUFACTURING AND TESTS

The manufacturing activities a test plan have been focused on the development of the most critical elements of these design : the hight temperature motor and the ECU.



ECU and HT Motor prototypes

Acceptance and performances tests carried out includes:

MOTOR CHARACTERIZATION

- ✓ PHASE AND FLY LEAD RESISTANCE
- ✓ BACK-EMF
- ✓ SYNCHRONOUS INDUCTANCE Ld
- ✓ COGGING TORQUE
- ✓ PERFORMANCE TESTS
- ✓ PERFORMANCE TEST AT ROOM TEMPERATURE
- ✓ PERFORMANCE TESTS AT LOW AND HIGH TEMPERATURE
- ✓ PRODUCT ACCEPTANCE TESTS

ECU CHARACTERIZATION

- ✓ PHYSICAL INSPECTION AND WORKMANSHIP
- ✓ ELECTRICAL TESTS
- ✓ IMPEDANCE CHECKS
- ✓ TVS FUNCTIONALITY TESTS
- ✓ POWER CONSUMPTION
- ✓ INTERNAL VOLTAGES MEASUREMENTS
- ✓ BONDING TEST

ECU+MOTOR CHARACTERIZATION

- ✓ VISUAL INSPECTIONS
- ✓ SINGLE ELECTRICAL TESTS
- ✓ SYSTEM ELECTRICAL TESTS
- ✓ SYSTEM FUNCTIONAL TESTS
- ✓ MOTOR PHASES COMMUTATIONS
- ✓ VOLTAGE RIPPLE TESTS

Validation/ Qualification tests carried out are summarized below,

Test at ECU level	Comments
Functional Check	PASS
Lightning Strike Indirect Effects Pin Injection	PASS
Functional Check	PASS
Voltage Spike	PASS
Power Input	PASS
Functional Check	PASS
Inrush Current	PASS
Functional Check	PASS
Lightning Strike Indirect Effects Cable Bundles	PASS
Functional Check	PASS
Bonding	PASS
Insulation Resistance	PASS
Dielectric Strength	PASS
Functional Check	PASS
Functional Check	PASS
Vibration Test	PASS
Functional Check	PASS
Functional Check	PASS
Performance & Temperature Test	PASS
Functional Check	PASS
Test at Motor level	**Comments**
Functional Check	PASS
Vibration Test	PASS
Functional Check	PASS
Performance & Temperature Test	PASS

TRL5 has been obtained for each component which have been validates validated in a relevant environment:

- A good fidelity demonstration test model of components motor and ECU have been built and a full characterization of performances has been carried out .
- Validation plan has been carried out including extended performances, electrical and environmental tests with very good results.