# ELETAD

## Electrical Tail Rotor Drive – Simulation tools, Test Rig and Prototype Development

**Background**

The trend towards increased use of "more-electric systems" in fixed-wing aircraft is motivated by improved overall system efficiency, reduced fuel burn and lower maintenance costs. The introduction of more-electric technologies in rotorcraft is far less advanced where, arguably, they have greater potential for impact than in fixed-wing aircraft. An electrically driven torque reaction system would allow completely new thinking in the design and function of the tail configuration, with the prospect of reduced aerodynamic drag and higher efficiency in forward flight. An electric tail rotor is likely to be quieter, faster and easier to control, and compound propulsion systems would be much more viable if electrically driven. Since the adoption of the electric tail rotor (ETR) drive concept will require a significant increase in the electrical capacity installed in rotorcraft, it will facilitate a more widespread introduction of more-electric technologies on rotorcraft.

This research programme funded under JTI Clean Sky Green Rotorcraft ITD will capitalise on the most recent advances in electrical machine technologies, thermal modelling, design optimisation and manufacturing processes to evaluate, realise and demonstrate a full-scale helicopter electric tail rotor (ETR) drive that is engineered for flight-critical operation and representative of an aircraft installation. The proposed direct-drive solution removes the requirement of gearboxes and drive shafts thereby reducing complexity and improving reliability. The solution will have a target specific output power capability exceeding 5kW per kg making it weight-competitive with current mechanical technology, and will be a fault-tolerant design specified to meet the requirements of the safety critical application.

**Objectives**

The project aims to evaluate a full-scale helicopter electric tail rotor motor (ETR) that is engineered for flight-critical operation and packaged in a manner that is representative of an aircraft installation. This will be achieved by capitalising on the most recent advancements in electrical machine and drive technologies, thermal modelling, design optimisation and manufacturing processes. This poses a significant challenge since any replacement system must be weight competitive with and at least as reliable as the existing mechanical solution, whilst offering demonstrable performance and whole-life cost benefits.

The objectives of the project are:
1. To deliver the capability of accurately predicting the operating temperature and reliability of concept ETR motor designs over the dynamic loads typical of a tail rotor.
2. To evaluate an innovative electrical system architecture that is capable of meeting the integrity requirement of a safety-critical aircraft application.
3. To evaluate the operation of a prototype ETR machine manufactured to standard that could be installed on an aircraft and which is weight-completive with the existing mechanical solution.

**Description of work**

The program of work is illustrated in fig. 1 and comprises three main components:

1. The development of a suite of validated software tools for modelling the electro-magnetic and thermal behaviour of the ETR motor, with a provision for assessing the impact of the resultant thermal cycling, over dynamic operating duties, integrated within a multi-physics design and optimisation environment.
2. The design and manufacture of a fault-tolerant ETR motor prototype
3. A comprehensive test characterisation supported with sufficiently detailed data to enable a full capability assessment. An automated test environment capable of emulating tail rotor dynamic loads and the ambient thermal environment of a helicopter installation will be used for this purpose. A major element of this test rig will be a complete functional representation of a redundant/fault-tolerant electrical supply and control system that would be needed for a safety-critical aircraft application.

Additional workpackages cover program management, dissemination/exploitation and collaborative training/knowledge exchange.

**Expected results**

**a) Timeline & main milestones**

The project start date was 1st October 2010 and is of 60 months duration. The following milestones have been accomplished:

*March 2012:* First full version of the ETR motor software suite released to enable trade studies for different aircraft flight missions
*May 2012:* Specification of ETR system defined to allow detailed design work to proceed
*September 2012:* Preliminary design review of ETR motor concept completed
*October 2013:* Critical design review completed to enable the final ETR motor design to be prototyped

The remaining milestones are:

*October 2014:* Integrated test rig commissioned and operational with ETR prototype motor installed
*July 2015:* Completion of Prototype ETR system testing

**b) Environmental benefits**

The major environmental benefits of the technology will be to enable new aircraft configurations and operating modes that will result in improved aircraft fuel economy and/or performance.

In replacing the existing mechanical tail rotor drive train with an electrical system, maintainability will be much improved, and the use of environmentally sensitive materials, e.g. lubricants, will be reduced.

**c) Maturity of works performed**

The work will result in a TRL5 technology demonstrator. The prototype electric tail rotor drive will be engineered and packaged in a manner that is representative of an aircraft installation. Important elements of the system operation will be supported with evidence of its potential to be qualified for flight worthiness. Beyond the project a static demonstration of a full scale electric rotordrive esystem is planned for 2016.

Picture, Illustration

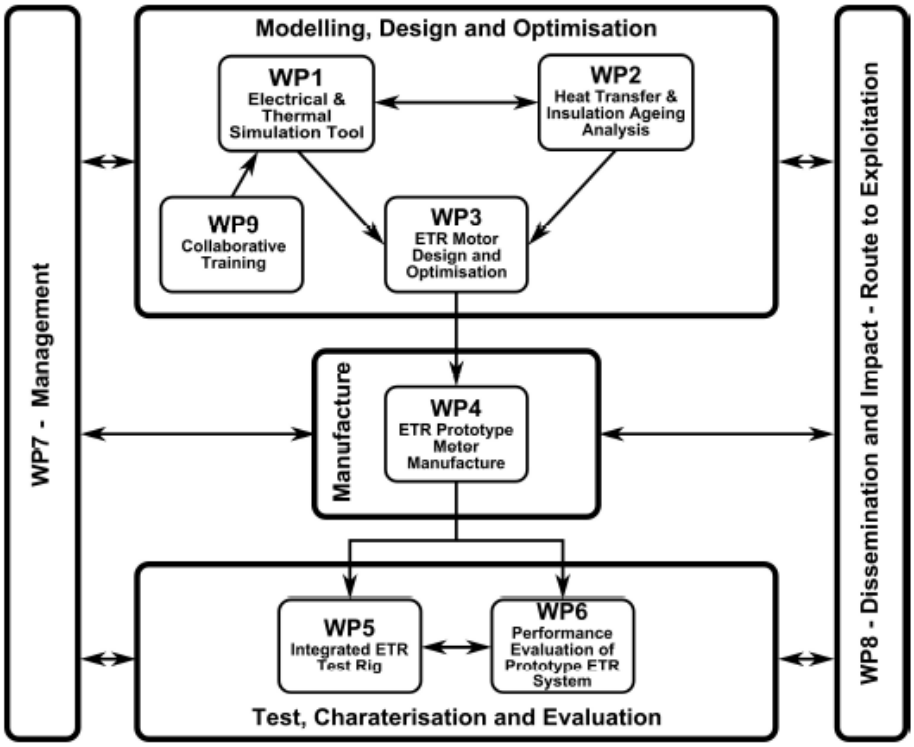


Figure 1. Programme structure

**Project Summary**

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| Acronym : | ELETAD |
| Name of proposal: | Electrical Tail Rotor Drive – Simulation tools, Test Rig and Prototype Development |
| Technical domain: | Aircraft electrical drives |
| Involved ITD | Green Rotorcraft |
| Grant Agreement: | 267322 |
| Instrument: | Clean Sky |
| Total Cost: | 2 478 436€ |
| Clean Sky contribution: | 1 858 826€ |
| Call: | JTI-CS-2009-2 |
| Starting date: | October 2010 |
| Ending date: | September2015 |
| Duration: | 60 months |


Coordinator contact details: Professor Phil Mellor

✉ Dept of Electrical and Electronic Engineering,

BS8 1UB, Bristol

United Kingdom

☎ +44 (0)1779545259

p.h.mellor@bristol.ac.uk

Project Officer: Sébastien Dubois

sebastien.dubois@cleansky.eu


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|---|---|---|
| Participating members | UNIVERSITY OF BRISTOL | UK |
| | LUCCHI R. ELETTROMECCANICA | IT |
| | MOTOR DESIGN LIMITED | UK |
| | UNIVERSITY POLITECHNICA BUCHAREST | RO |