FRONT PAGE

PROJECT FINAL REPORT

Grant Agreement number: 632614

Project acronym: HiTEAS

Project title: High Temperature Energy Autonomous System

Funding Scheme: Article 171 of the Treaty

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[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

4.1 Final publishable summary report

1.1.1 Executive Summary

HiTEAS project has demonstrated it is possible to wirelessly acquire data from an autonomous sensor node withstanding aeronautics temperature and vibrations constraints.

The core of the demonstrator developed in HiTEAS is a Wireless Sensor Node (WSN) compatible with aeronautic environment and wirelessly interrogated by an ISO18000-63 RFID reader. The WSN can be powered either from the RFID Electro-Magnetic field or alternatively, from a wind micro-turbine also developed in the frame of HiTEAS. The sensor node is connected to a standard aeronautic-grade sensing element. A dedicated high temperature Application Specific Integrated Circuit (ASIC) insures power conversion, RFID communication and sensor interfacing.

The WSN has been validated and characterized in high temperature environment (180°C and up to 250°C for the wind micro-turbine).

The RFID reader is connected to a dedicated RFID antenna with a 20m cable. Distance between WSN and reader antenna can be up to 2m for communication purpose, and 30cm in case the WSN is RFID remote powered.

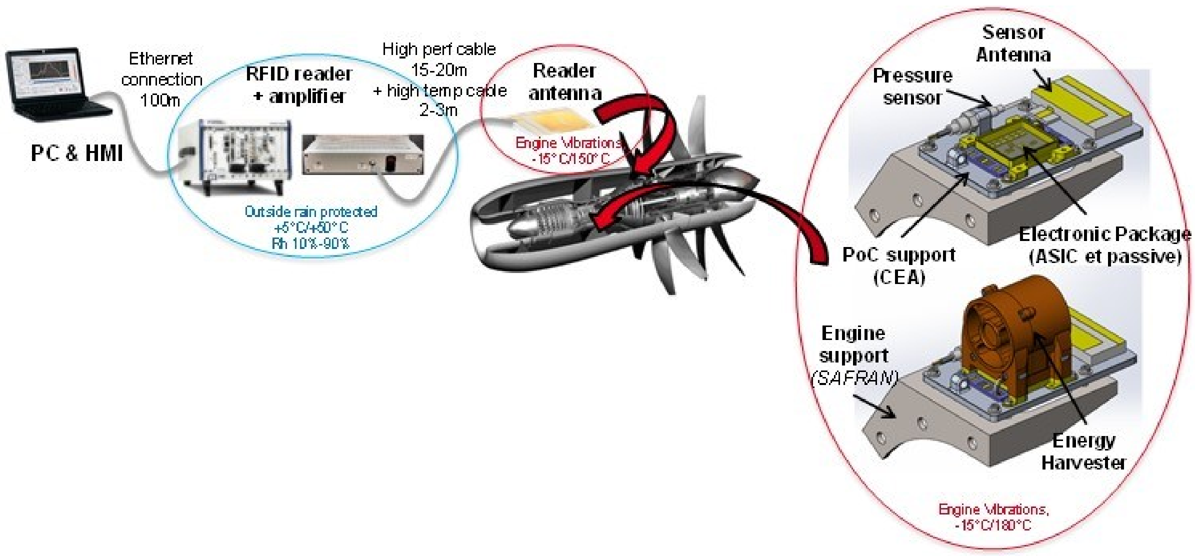


Figure 1: HiTEAS' demonstrator overview

1.1.2 Summary Description of Project Context and Objectives

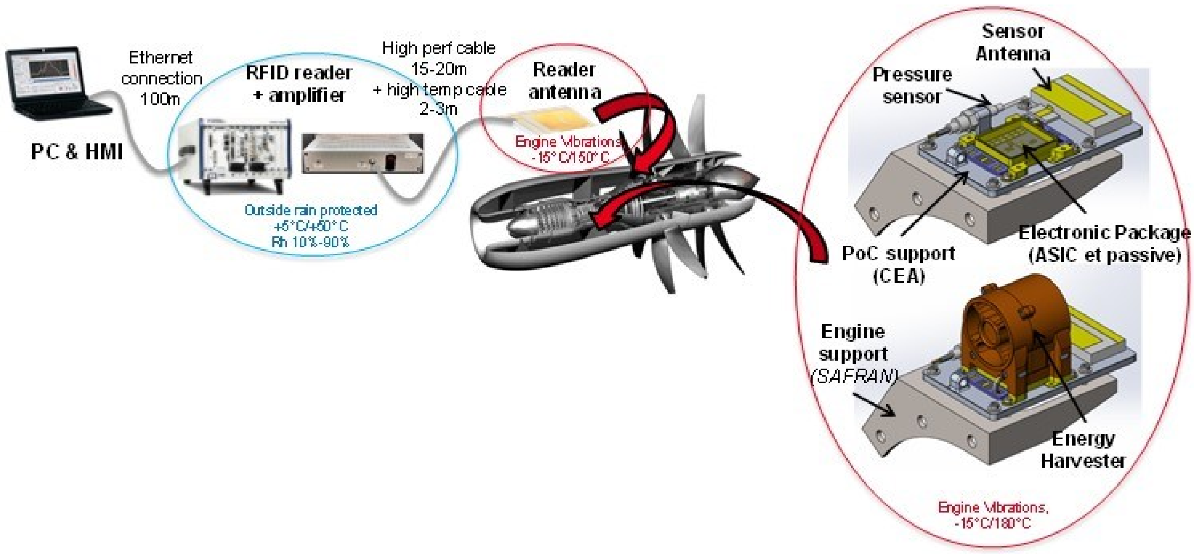
In the European project Clean Sky, SAGE 2 (Sustainable And Green Engines) project aims at designing, manufacturing and testing an energy efficient Counter-Rotating Open-Rotor Demonstrator (with a drastic reduction of CO_2 and NO_x emission compared to conventional airplane engines).

Reduction of emissions in such jet engines requires a deep knowledge of physical parameters inside the engine, and so requires a large number of sensors to be implemented in the engine. Current aeronautic-compatible sensors require cables to wire-connect the sensor to the FADEC. Number of cable becomes an issue when many parameters need to be acquired. Moreover rotating part in jet engines cannot be monitor with wired sensors.

Objective of HiTEAS project is to demonstrate it is possible to wirelessly acquire data from a cable-free sensor node during jet engines ground testing, withstanding aeronautics temperature and vibrations constraints. The targeted temperature is from -30°C up to 250°C. HiTEAS's demonstrator includes the complete acquisition chain, including a Wireless Sensor Node (WSN), an interrogator with its antenna, and a host controller (PC). The demonstrator is developed for being mounted and tested in SAGE2's demonstrator in Istres.

1.1.3 Description of the main ST results/foregrounds

The final HiTEAS demonstrator is a complete acquisition chain, compliant with jet engine environment. It is illustrated hereunder:



The complete demonstrator is made of building blocks, which have been developed and characterized independently.

A battery-less Wireless Sensor Node (WSN) that integrates an Application Specific Integrated Circuit (ASIC), a wind micro-turbine and a RFID antenna, insures the sensing of physical parameter, the data coding, and can be interrogated over the air from a RFID reader. The WSN is supplied from UHF RFID's Electro-Magnetic field or from a low-frequency AC signal provided by the wind micro-turbine.

The ASIC is fabricated in a high temperature CMOS SOI silicon process from XFAB. It integrates a versatile 8Sps-1kSps sensor interface to address both pressure and strain sampling rate requirements. In addition a dynamic excitation scheme lowers transducer excitation current, thus enabling cable-less powering of aeronautic-grade 350Ω-to-3kΩ resistive bridges. The ASIC also integrates an ISO18000-63 front-end which is connected to a dedicated antenna. An automatic mechanism embedded in the ASIC selects the most efficient power source and generates internal voltage supplies.

Silicon process is qualified up to 175°C, consequently ASIC is limited to location in the jet engine where the temperature is below 175°C.

A wind micro-turbine has been developed and tested, it is able to power the WSN with only 3m/s air flow. It is compatible with high temperature (up to 250°C) and withstand vibration specifications. Main characteristics of the wind-turbine are summarized below:

- Size : 45 x 40 x 48 mm3
- Weight : 50 g
- Maximum vibration level: 20 G
- Maximum operating temperature: 250°C
- Output power at 2,5 m/s (25°C): 1000 µW
- Output voltage at maximum power point at 2,5 m/s (25°C) : 2.2 Vrms
- Reversible temperature loss (alternator efficiency) : -8% at 180°C and -34% at 250°C

The WSN is interrogated with a standard RFID reader, nevertheless specific RFID antennae have been developed in order to cope with temperature constraints. Two antennae, reader and tag, have been simulated, realized and measured. They cover a 15MHz bandwidth (905MHz-920MHz) and have a maximum gain of 4.9dBi for the reader antenna and 1.4dBi for the tag antenna. These antennas have been printed on a high temperature Rogers RO4003C dielectric substrate. Measurements have confirmed the reflection coefficient of both antennae is stable over the temperature range. Finally, link budget studies have shown it is possible to communicate to more than 2 meters tag-to-reader distance, and to remote power the WSN up to 30 cm.

The system developed in HiTEAS project is versatile, building blocks can be arranged or programmed in different ways to address a large spectrum of usage scenario.

Current maturity level of the demonstrator is low at current stage, but no showstopper has been identified for increasing the maturity level of the system.

Improvements are possible in term of volume or reading distance for instance.