

Energy Harvesting for Sensor Networks in Aeronautics: True Lies?

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In recent years, Wireless Sensor Networks (WSN) have been considered for various aeronautical applications, including flight tests during the development of a new aircraft, and Structural Health Monitoring (SHM) during commercial exploitation. Up to now, these implementations use wires inducing a burden of kilometres of additional wiring (300 km on an Airbus A380 for specific sensing during flight test). However, going wireless for communication also requires being wireless for energy: isolated from the on-board electrical network, each sensor node needs to be self-powered. Environmental concerns, together with economical and safety-related issues, often prohibit the use of electrochemical batteries. Fortunately, energy may be harvested in the environment, providing a reliable and sustainable electrical power source...

But is this story true? Considering the aircraft environment and the required test procedure for avionics, are technologies mature enough to provide low volume, low mass, reliable and efficient energy harvesting solutions? The purpose of this presentation is to answer this question through examples of hands-on tests in airliners [1] [2].

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References

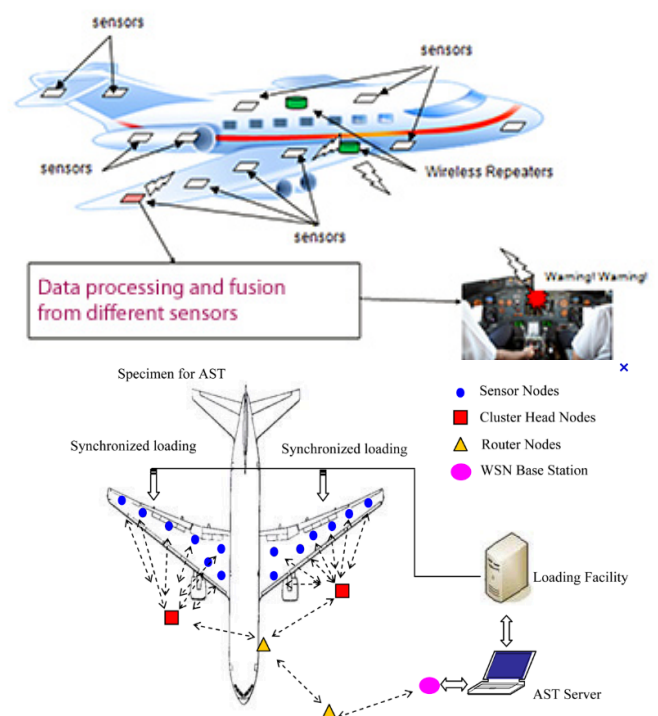
- [1] P.DURAND ESTEBE, Systèmes de récupération d'énergie pour l'alimentation de capteurs autonomes pour l'aéronautique, Ph.D thesis, INSA de Toulouse, 11 Mai 2016, 169p.
- [2] J.M.DILHAC, V.BOITIER, Energy autonomy of batteryless and wireless embedded systems, Energy autonomy of batteryless and wireless embedded systems, ISTE Ltd, N°ISBN 9781785481239, Octobre 2016, 176p.

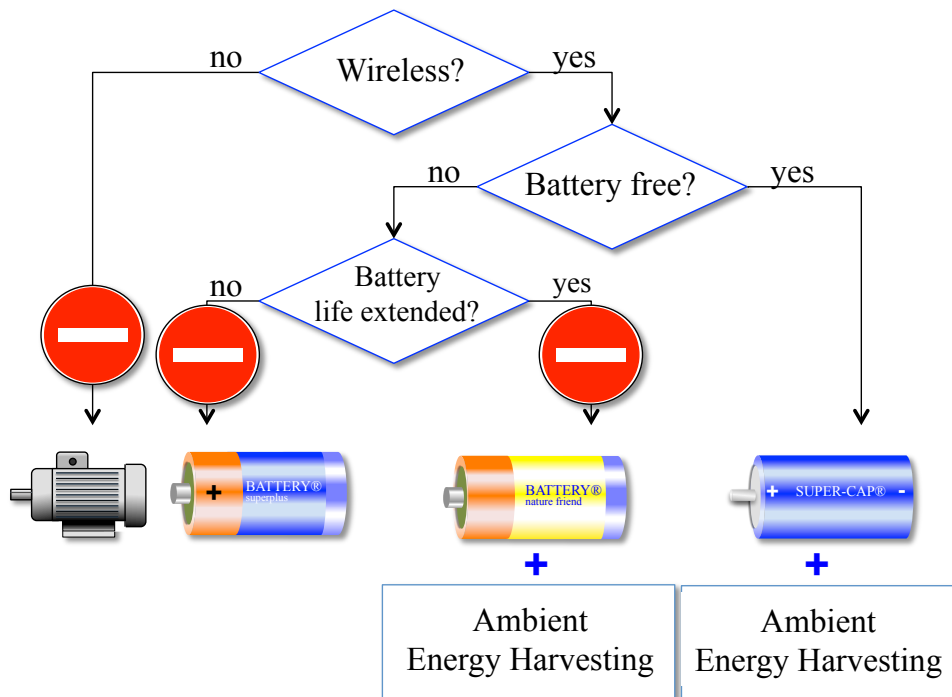
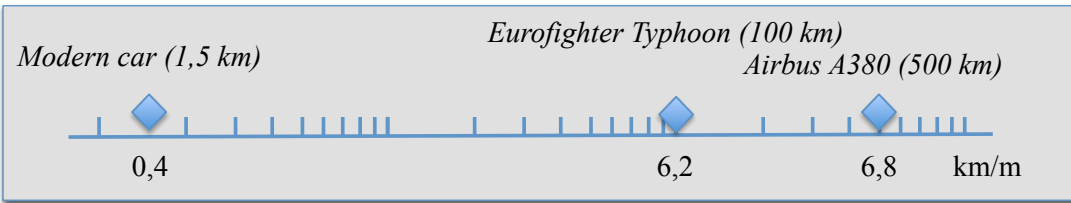
- > CONTEXT and PROMISES
- > INTRODUCTION OF APPLICATION
- > REQUIREMENTS
- > DETERMINATION of ARCHITECTURE
- > CHOICE of DEVICES
- > LABORATORY and GROUND TESTS
- > FLIGHT TESTS
- > TRUE LIES?

In aeronautics new sensor networks are needed for:

- > test flights
- > Structural Health Monitoring
- > others purposes...

but why should they be wireless?





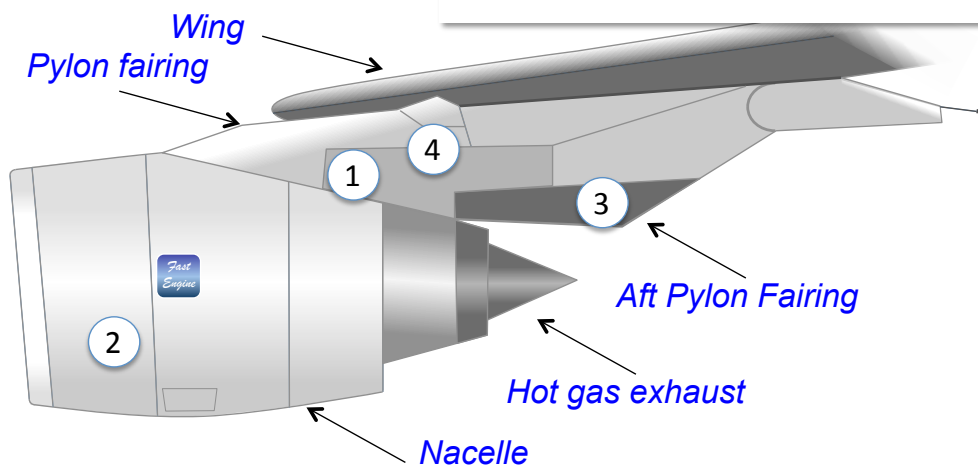
- > harvester capturing ambient energy
- > + transient storage of energy
- > + high efficiency energy management

=

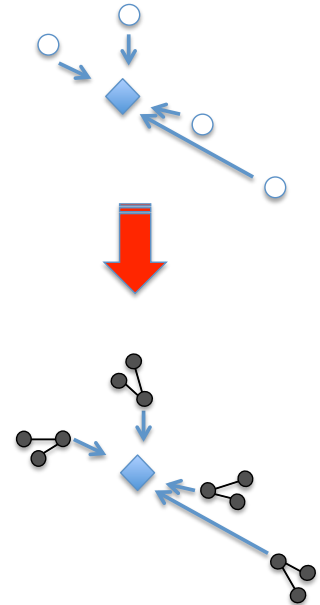
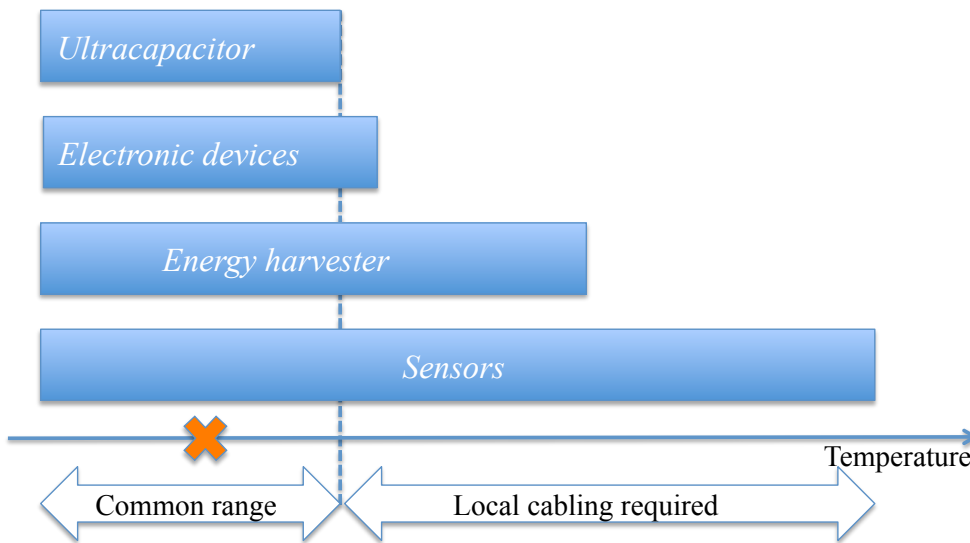
total autonomy of wireless & battery free sensors

- Wireless sensor network for Structural Health Monitoring
- Power plant area

- 1: Energy Harvesting
- 2 and 3: SHM sensors
- 4: energy management and signal processing



➤ Locally wired network!

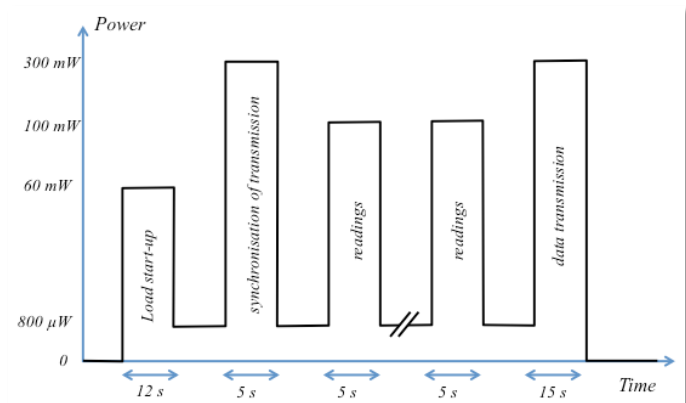


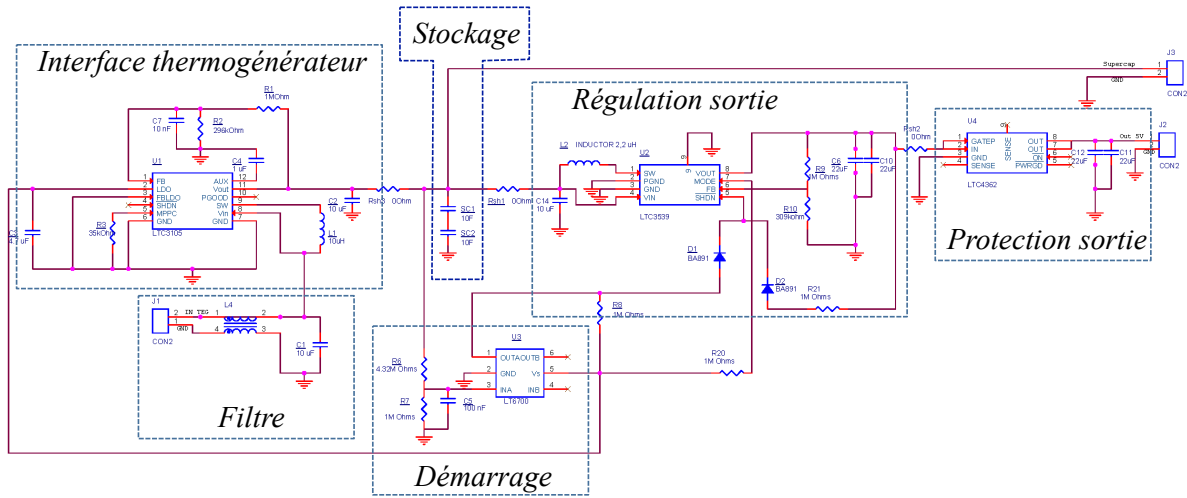
➤ Load: power vs. time
(mean value 50 mW)

➤ Storage required (UC)

➤ DO 160

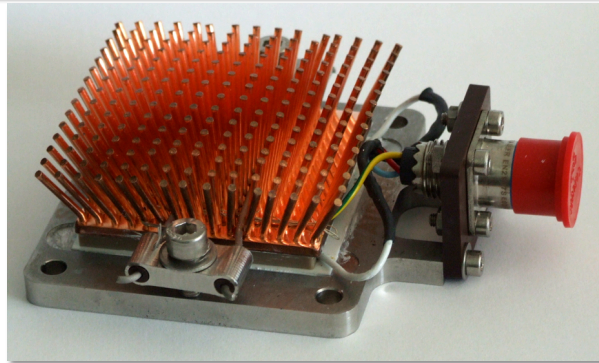
- vibrations and shocks
- acoustic load
- temperature (-60°C / + 125°C)
- fire
- EMC (radiated and conducted)



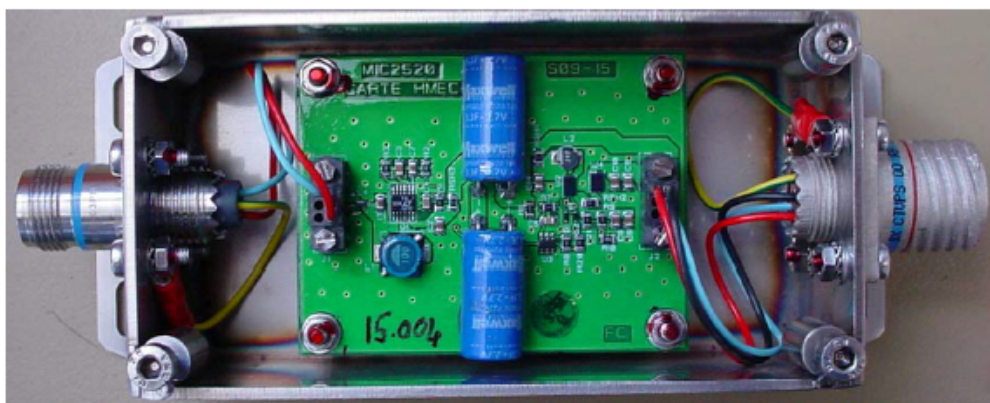


THERMOGENERATOR

ENERGY
MANAGEMENT

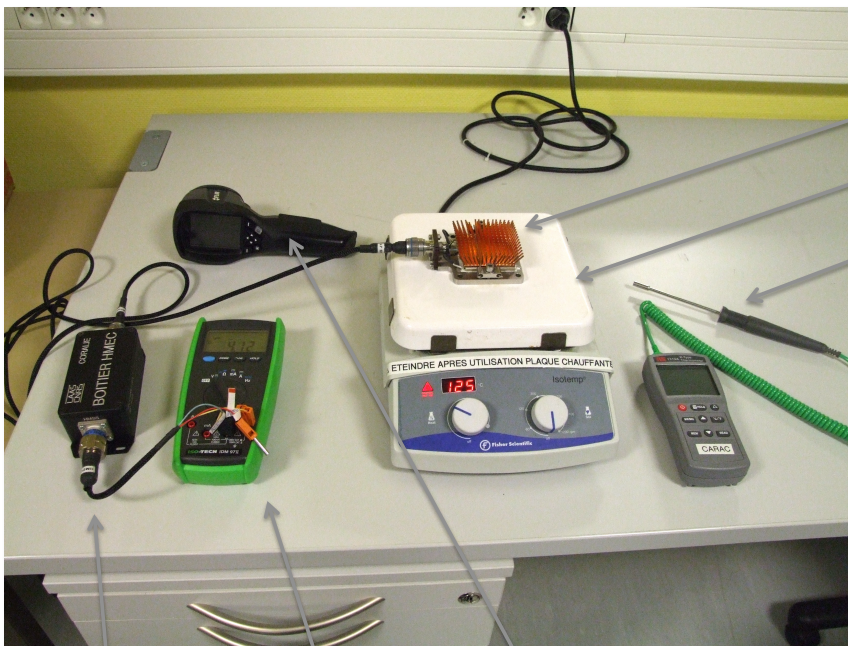


THERMOGENERATOR



LOAD

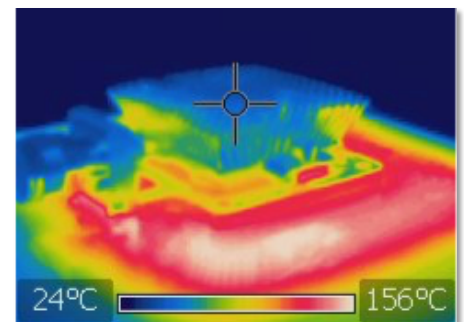
- > FUNCTIONAL TESTS
- > ENVIRONMENTAL COMPLIANCE:
 - VIBRATIONS
 - ELECTROMAGNETIC COMPATIBILITY
 - ACOUSTIC LOAD
 - SIMILARITY DEMONSTRATION
 - Extreme temperatures and temperature variation
 - Altitude and pressure, lightning, electrostatic discharge
 - Shocks, fire ($1100^{\circ}\text{C} \pm 80^{\circ}\text{C}$ during 15 minutes)
 - Explosion hazard, waterproofness, fluids susceptibility, flammability toxicity,



thermogenerator

hot plate

thermocouple

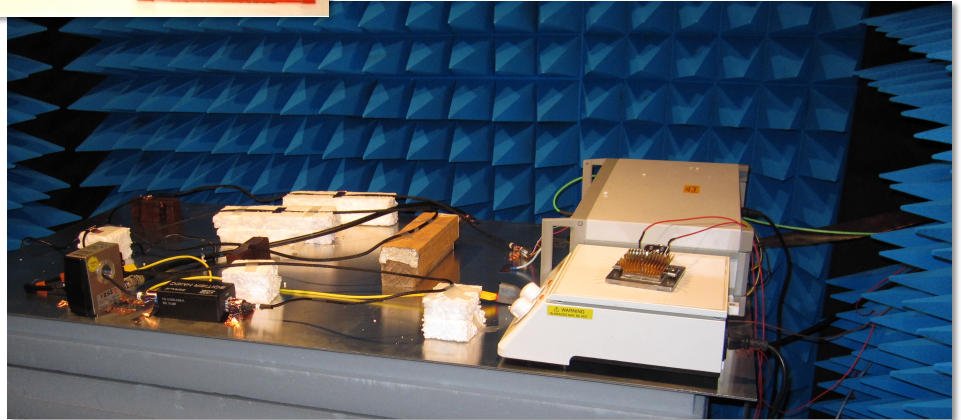
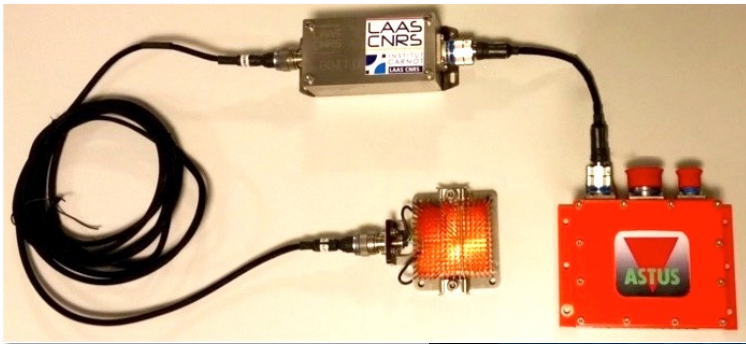


energy
management

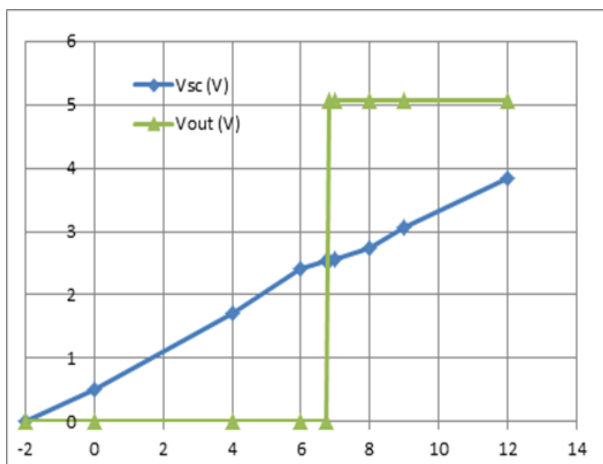
multimeter

IR camera

LABORATORY TESTS



GROUND TESTS



FLIGHT TESTS

AIB090W 3D

Airbus

FLIGHT STATUS ?

TLS ✈️ **N/A**

TOULOUSE

ACTUAL DEPARTURE **09:09** ESTIMATED ARRIVAL -

AIRCRAFT DETAILS ?

TYPE (A388)
Airbus A380-841

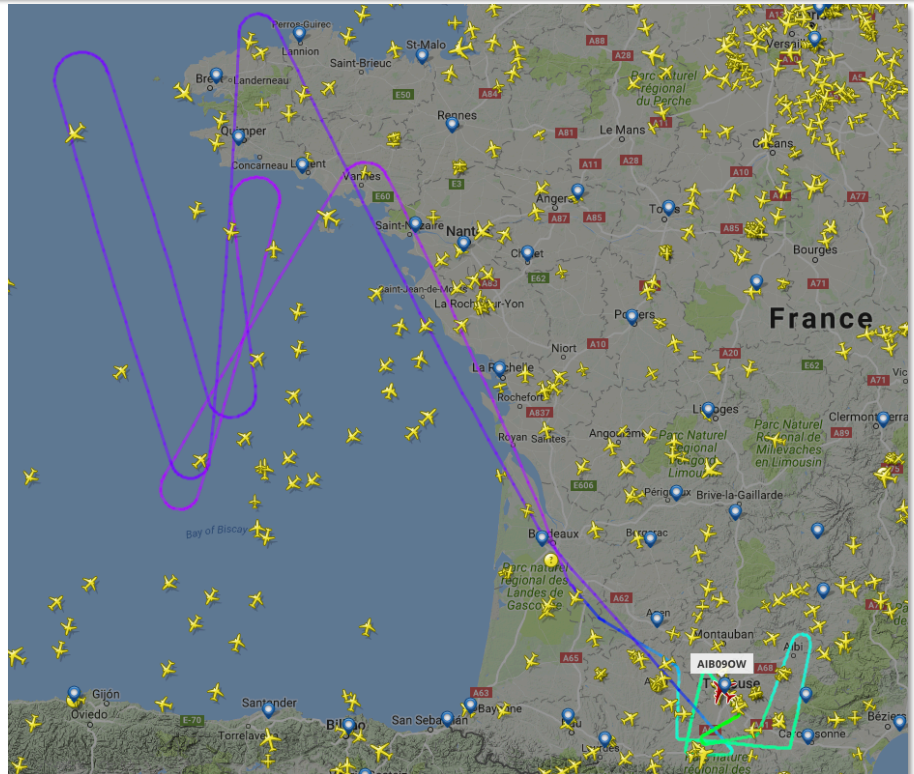
REGISTRATION F-WWOW	MODE-S CODE 383E7A
SERIAL NUMBER (MSN)	AGE

FLIGHT DETAILS ?

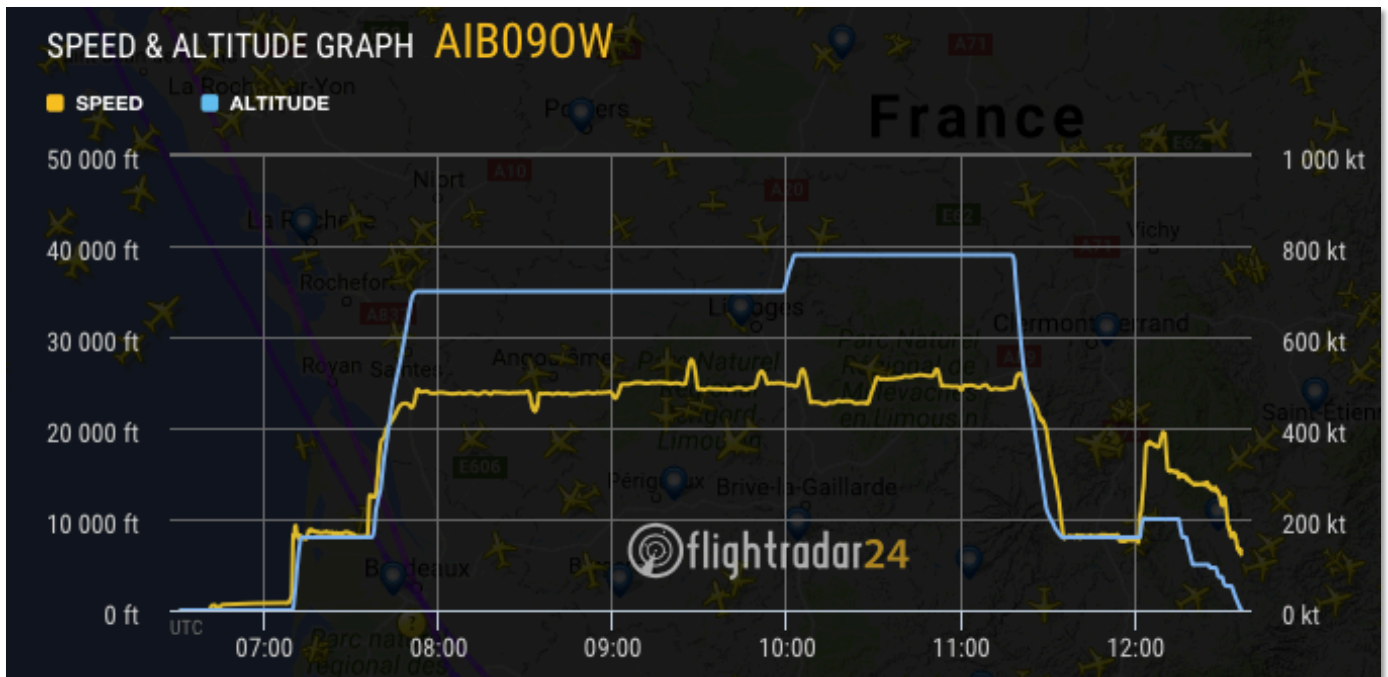
GROUND SPEED 479 kts	TRUE AIR SPEED
INDICATED AIR SPEED	MACH

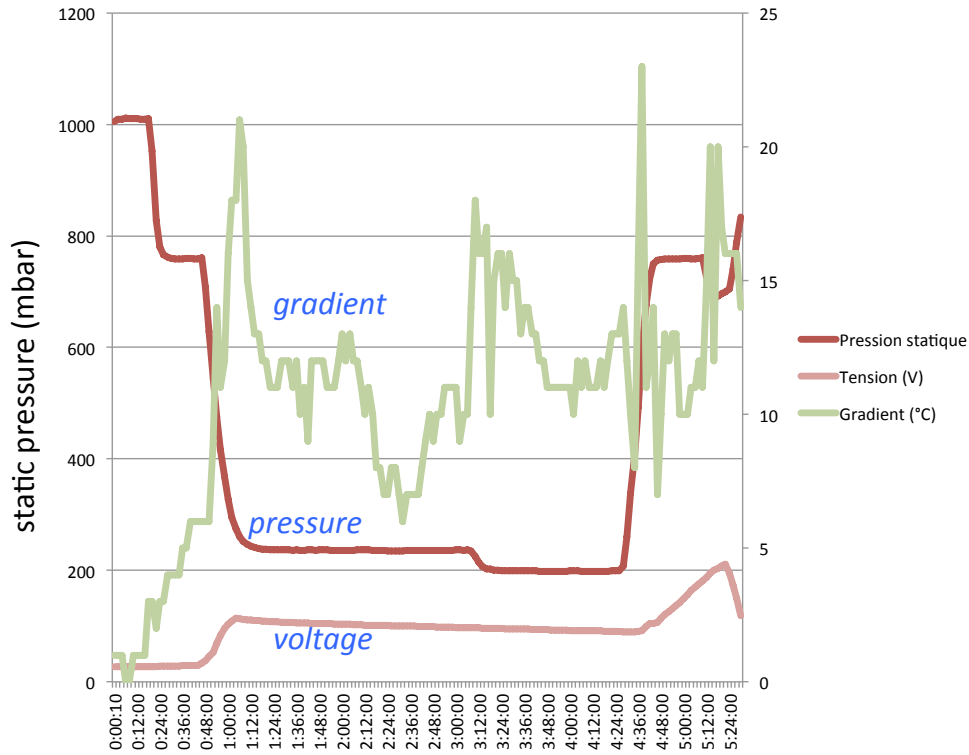
SPEED & ALTITUDE GRAPH >

CALIBRATED ALTITUDE 35,000 ft	VERTICAL SPEED
GPS ALTITUDE	TRACK 332°



FLIGHT TESTS





- > wired!!!
- > heavy!
- > bulky!

- ✓ *harsh environment*
- ✓ *DO-160 standard for the environmental testing of avionics hardware*
- ✓ *connectors*
- ✓ *classical loads (data loggers)*

More in:

