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].

Acknowledgement
This work has been partially funded by the Direction Générale de l’Armement (DGA) and by the French program “Investissements d’Avenir” within the framework of CORALIE project.

References

CONTEXT and PROMISES

INTRODUCTION OF APPLICATION

REQUIREMENTS

DETERMINATION of ARCHITECTURE

CHOICE of DEVICES

LABORATORY and GROUND TESTS

FLIGHT TESTS

TRUE LIES?

CONTEXT

In aeronautics new sensor networks are needed for:

- test flights
- Structural Health Monitoring
- others purposes…

but why should they be wireless?
**CONTEXT**

Modern car (1,5 km)  
Eurofighter Typhoon (100 km)  
Airbus A380 (500 km)

0,4  6,2  6,8 km/m

**Battery free?**

- no
- yes

**Wireless?**

- no
- yes

**Battery free?**

- no
- yes

**Battery life extended?**

- no
- yes

**Ambient Energy Harvesting**

- +

- +

- +
Promises

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

= total autonomy of wireless & battery free sensors

EXAMPLE OF TRUE DEPLOYMENT

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

1: Energy Harvesting
2 and 3: SHM sensors
4: energy management and signal processing
EXAMPLE OF TRUE DEPLOYMENT

Locally wired network!

- Ultracapacitor
- Electronic devices
- Energy harvester
- Sensors

Local cabling required

Common range

Temperature

REQUIREMENTS

> 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)
DETERMINATION OF ARCHITECTURE

CHOICE OF DEVICES

THERMOGENERATOR

ENERGY MANAGEMENT

LOAD
LABORATORY TESTS

> 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°C ± 80°C during 15 minutes)
    • Explosion hazard, waterproofness, fluids susceptibility, flammability toxicity,
**FLIGHT TESTS**

![Graph showing static pressure, tension, and gradient over time.](image)

**TRUE LIES?**

- wired!!!
- heavy!
- bulky!

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

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**More in:**

*Energy Powering of Battery-Free Wireless Embedded Systems*

Jean-Marie Dubois and Vincent Balier