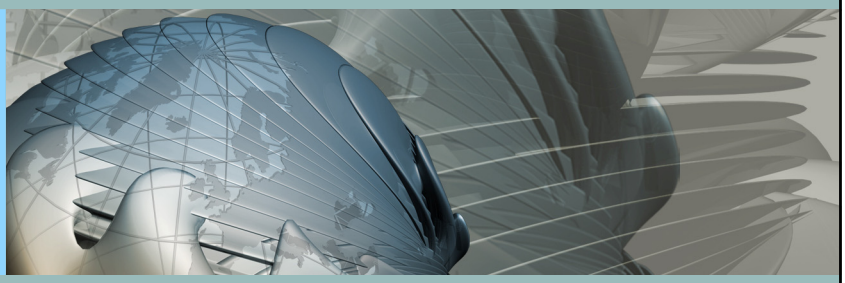
EADS INNOVATION WORKS

Concertation Meeting on Monitoring for Energy Efficiency



CHOSeN – "Intra-aircraft energy-efficient monitoring applications"

EADS Innovation Works
Sensors, Electronics & Systems Integration
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Overview

- CHOSeN - Introduction
- Aeronautic applications of WSN for monitoring & control
- Objectives
- Technical Demands
- Structure Health Monitoring - Application Examples
- Energy Harvesting
- CHOSeN – Wireless Sensor Node Architecture

- Facts Sheet -

Funding Project CHOSeN
Cooperative Hybrid Objects Sensor Networks

Timeframe: 04/2008 – 04/2011 (36 months), Budget: 5400 k€ overall

Objective: **Develop and assess** a **generic, wireless, low-power communication platform** supporting **application-specific optimizations**

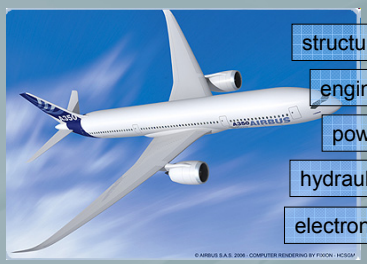
Partners: Acorde, Ardaco, CRF, EADS, IFX, IFAT, LETI, Particle, and TU Vienna

Value:

- **Top-down design flow for application-specific communication technologies** including simulation environment
- **Real-life field application trials** from in the automotive and aerospace domain
- Integration on application, system and chip level
- Development of **application-specific MAC & routing protocols** and virtualization via **communication middleware**
- Development of **2.4 GHz transceiver building blocks** and **chip-level prototype with with semi-passive wake-up receiver** and **advanced power management features**

Enabling technology for energy-autonomous wireless monitoring & control tasks in the automotive & aeronautic fields

Application Overview - System Health Monitoring



System Health Monitoring

Enables Predictive Maintenance:

- Minimize On-Ground Time
- Save Disassembly Times
- Increase Safety
- *Save Money*

CHOSeN - Objectives

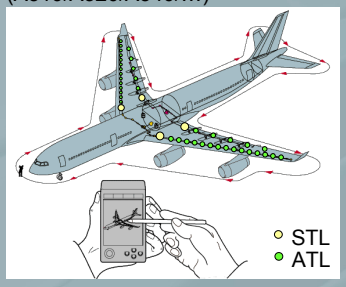
- **Wireless infrastructure for monitoring tasks**
  - Common platform for existing and upcoming sensor applications
  - Cost & maintenance effort minimization
- **Generic transceiver platform with Wake-on-RF**
  - About 80% of power is currently consumed by the radio
  - Standard RF-listening consumes most power
- **Self-organizing systems in a heterogeneous environment**
  - Configurable PHY (frequency, baseband)
  - Flexible protocols (MAC, network)
- **Autonomous wireless sensor nodes**
  - Energy harvesting
  - Auto-configuration (discovery, routing)
- **Validation in highly challenging application environments**

System Health Monitoring – Technical Demands

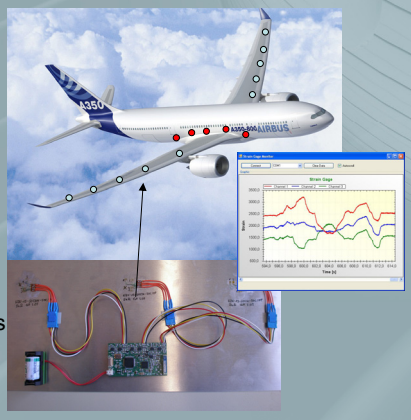
- **Sensors**
  - Highly variable in terms of data rate, energy consumption, QoS demands (e.g. latency)
    - ➔ Flexible but generic interfaces to power source and communication platform needed
- **Communication Platform**
  - Heterogeneous data sources (sensors)
    - ➔ Flexible and QoS-aware Medium Access Control (MAC) protocol
  - Limited range due to energy restrictions
    - ➔ Multi-Hop routing protocol
  - Automatic discovery & configuration
    - ➔ Plug & Play capabilities for MAC and routing protocols

Structure Health Monitoring - Application Examples

Monitoring of High Lift System Parameters (A319/A320/A340/…)



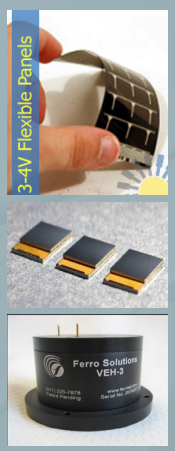
Strain Gage Sensors for SHM

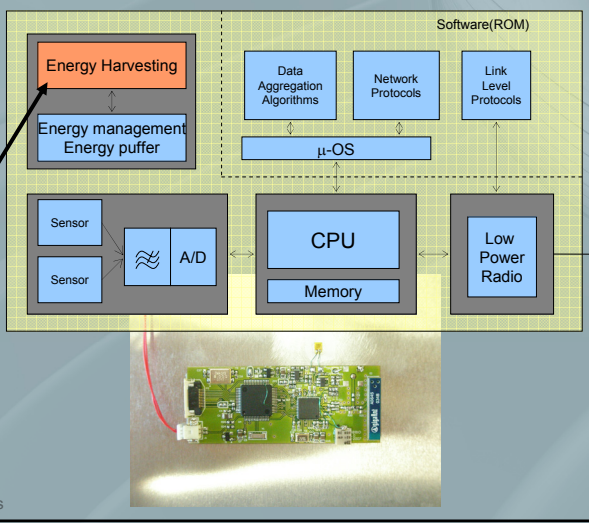


Variable: data rate, tolerable latency, data loss

Challenges:
- Common platform (PHY, MAC, Interfaces)
- Self-sufficient (energy-harvesting)

Energy Harvesting: Wireless Sensor Node





Energy Harvesting: Comparison and Conclusion

Solar Energy	Thermal Energy	Vibration Energy
• 0,41 W/m² (5 W/m² illumination) • 16,4 W/m² (50 W/m² illumination)	• 1,21 W/m² (dT=1K) • 121 W/m² (dT=10K)	• 0,23 W/m² (for 25 mg @60Hz) • 3,15 W/m² (for 100 mg @60Hz)
• 7 mW/kg (5 W/m² illumination) • 280 mW/kg (50 W/m² illumination)	• >110 mW/kg (dT=1K) • >1100 mW/kg (dT=10K)	• 3 mW/kg (for 25 mg @60Hz) • 37 mW/kg (for 100 mg @60Hz)
+ Acceptable power density + Good efficiency in management possible + Office lighting might be sufficient – Typical disadvantages of optical sensor	+ Power density is high + Aircrafts may deliver a high temperature difference (up to 40K) – Output voltage might be low – Efficiency in management has to be considered	+ Some applications deliver strong vibrations (helicopter: up to 0,5 g) – Energy density is poor – Mass and volume is high – Usually vibrations are not welcome
• Good availability, easy to integrate to a sensor node • Interesting energy source	• High Power density, improvement of performance possible • Interesting energy source	• Poor Power density, harvesters are large and heavy • Energy source interesting for special applications with large vibrations (helicopter,

CHOSeN – Wireless Sensor Node Architecture

- Low-power Wake-Up transceiver chip
- Scalable, flexible communication protocols
- Energy-harvesting & management