

Wireless Sensor Networks for Aerospace Applications

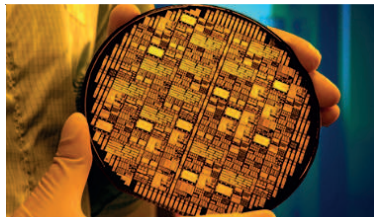
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June 9, 2017



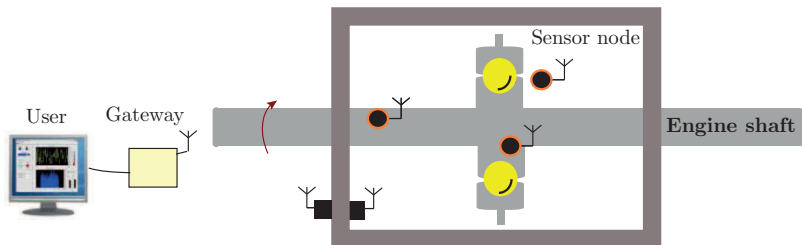
In 1961, the University of Southampton made aviation history with the first human-powered flight.



Challenges

- ▶ **Regulations and standards for radio transmission**
- ▶ **Energy consumption of a sensor node**
 - ▶ Supplying power
 - ▶ Manage power requirements
 - ▶ Scheduling of sleep-wake up patterns for sensors
- ▶ **Security, reliability, and robustness of the wireless sensor network**
 - ▶ Metal blocks RF signals
 - ▶ Harsh environment (high temperature, pressure, and vibration)
 - ▶ Interference with other systems

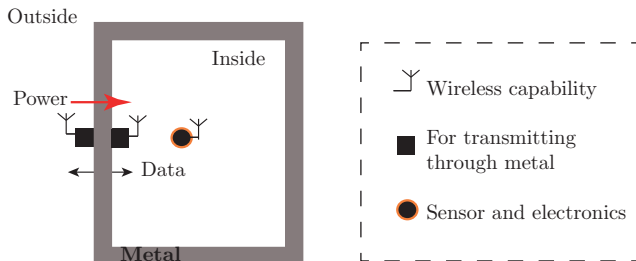
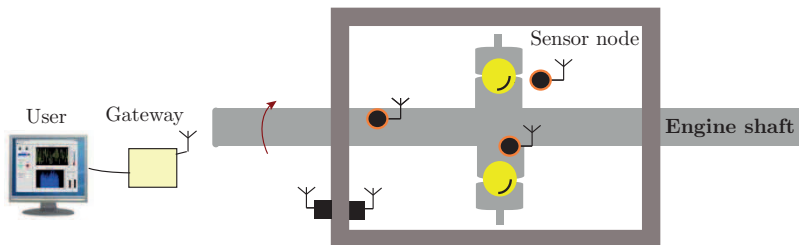
Future of Aerospace Wireless Sensor Network (AWSN)



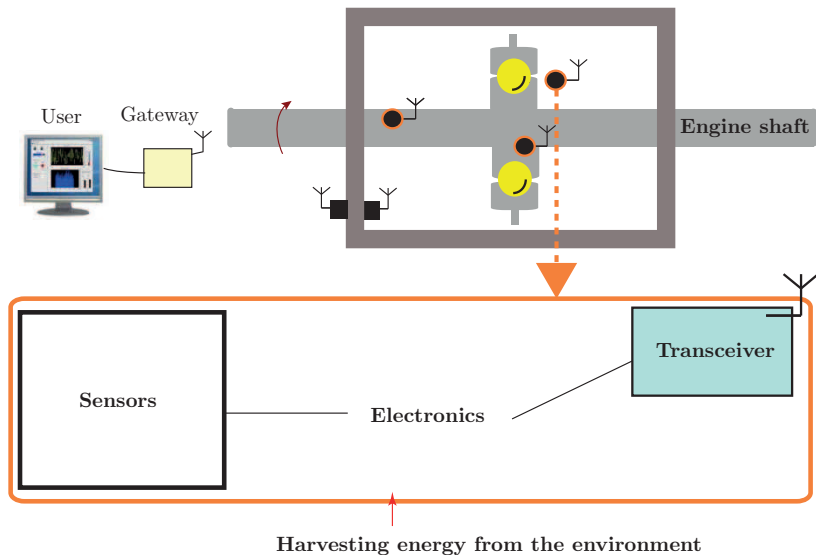
Ball bearing schematic as
part of the jet engine

Objective: To develop a **smart system** incorporating multiple sensors, energy harvesting, wireless communications, and data analytics for **intelligent monitoring** of aero-engines.

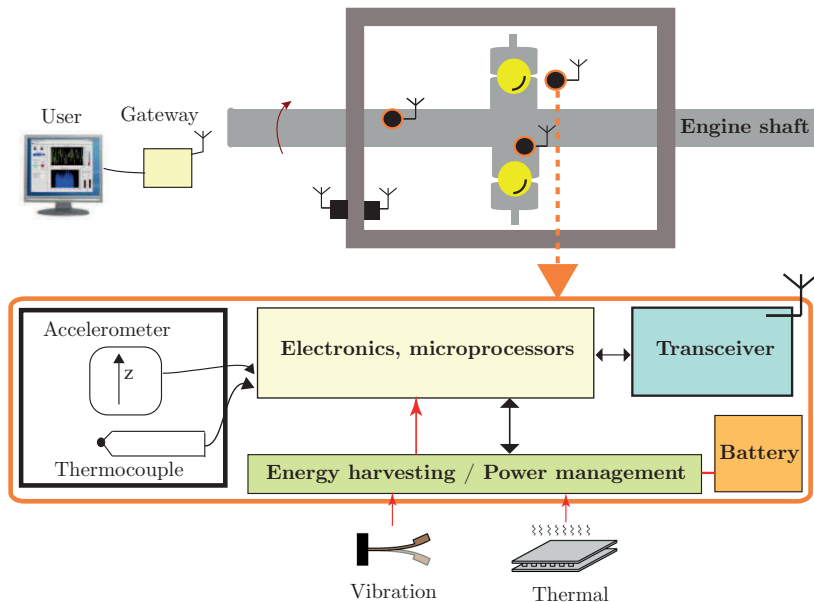
Future of Aerospace Wireless Sensor Network (AWSN)



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2000s

- Wireless internet widespread
- ISM band comms commonplace, wireless sensor deployed, Bluetooth widely used for simple tasks
- ZigBee alliance announced availability of specifications

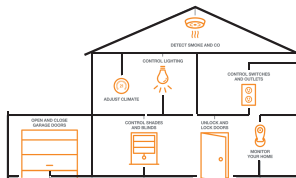


Future

- Opportunity for energy harvesting
- Smaller device size
- Higher bit rate available
- Lower costs of system-on-a-chip
- Electronics for harsh environments

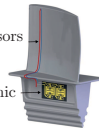
1980s

- ISM band regulation free for use without license.
- Cellular radio
- GPS navigation, early wireless internet



Temperature sensors

Electronic



1970s

- Almost everything wired
- Radio was used by military, space,...
- Low power, short range wireless

1990s

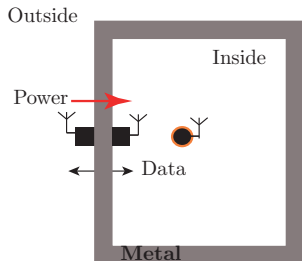
- Wireless internet starts to be deployed, mobile phone
- ZigBee was conceived
- Bluetooth standards begins drafting



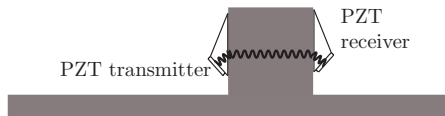
2010s

- DSSS modems cost reduction
- Semiconductor's size and cost reduction (microelectronics)
- The Internet of things (IoT)

Data Communication Through Metals



Generating shear or longitudinal wave



Generating shear wave



Generating surface acoustic wave



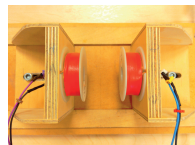
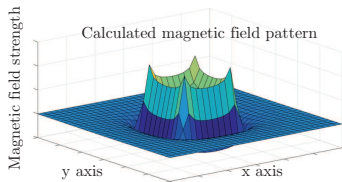
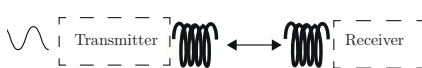
Wireless capability

For transmitting through metal

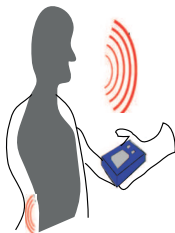
Sensor and electronics

Power Delivery

Inductive coupling



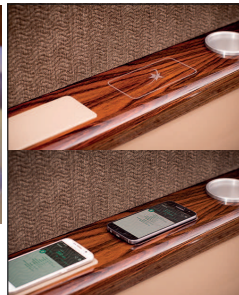
University of Southampton



Wireless sensing and monitoring
of biomedical applications
(NASA Technology Transfer Program)



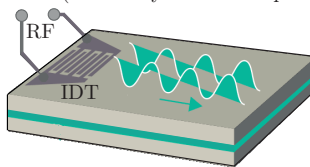
In-flight wireless power transfer for drones
(Imperial College London)



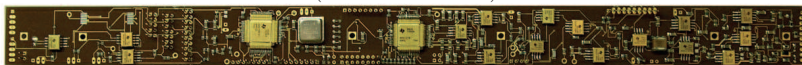
Wireless charging module
(from Cobalt aerospace)

Electronics for Harsh Environment

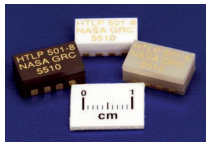
High Temperature (800°C) Interdigital transducer (IDT) devices
(University of Southampton)



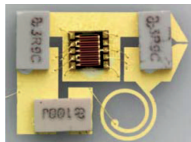
Harsh Environment Acquisition Terminal (H.E.A.T) up to 210°C with RS485 transceiver
(Texas Instruments)



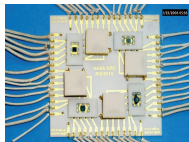
Wireless sensor operating at high temperature (500°C) (NASA Glenn Research Center)



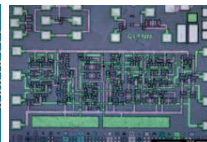
Harsh environment
packaging



High temperature RF
components



AC amplifier based on
SiC MESFET and
ceramic packaging



High temperature
signal processing and
wireless
(2.4 GHz Rectenna)

Summary

- ▶ **Wireless communication solves many problems for aero-engines.**
 - ▶ Cabling
 - ▶ Maintenance
 - ▶ Health monitoring and problem diagnosis
- ▶ **But it comes with other challenges.**
 - ▶ Wireless communication through metals
 - ▶ Powering remote sensors, and managing power
 - ▶ Electronics in a harsh environment
- ▶ **These other challenges can be solved.**
 - ▶ Communication: Wave propagations
 - ▶ Power: Inductive coupling method, solution architecture
 - ▶ Environment: Electronics for harsh environment

Thank you