

Fraunhofer IZFP Dresden

Sensor Modules for Structural Health Monitoring

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Zerstörungsfreie
Prüfverfahren

sensonet
DRESDEN

NDE Driven by Innovation

Local and Global
Networks

NDE Networks

Advanced signal
Processing
**Advanced
Electromagnetic
NDE Methods
(Multi-parameter
techniques)**

Fast Electronics

Ultrasonic Testing

High voltage generators/
Vacuum technology

Industrial x-ray inspection

1900

1950

2000

Year

Discovery of x-rays, 1895
Discovery of γ -rays, 1900

First Transistor, 1947

First Microprocessor
Intel 4004, 1971

Domain name system
Basis for today's data
communication, 1983

Application: Railway Systems

High speed trains

Task (selection)

Monitoring overhead traction line

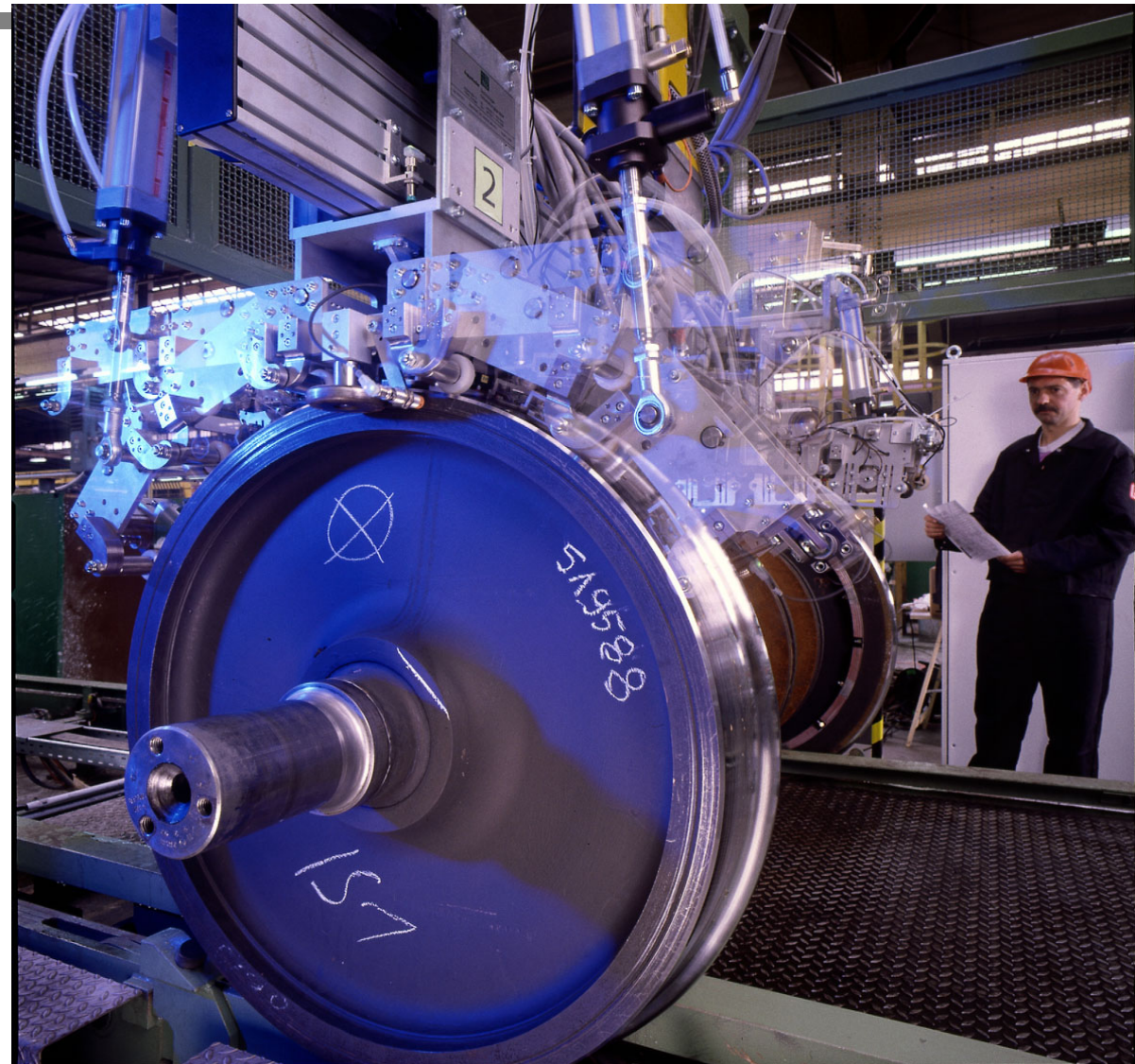
Ultrasonic inspection for
crack detection in wheels
and in rails



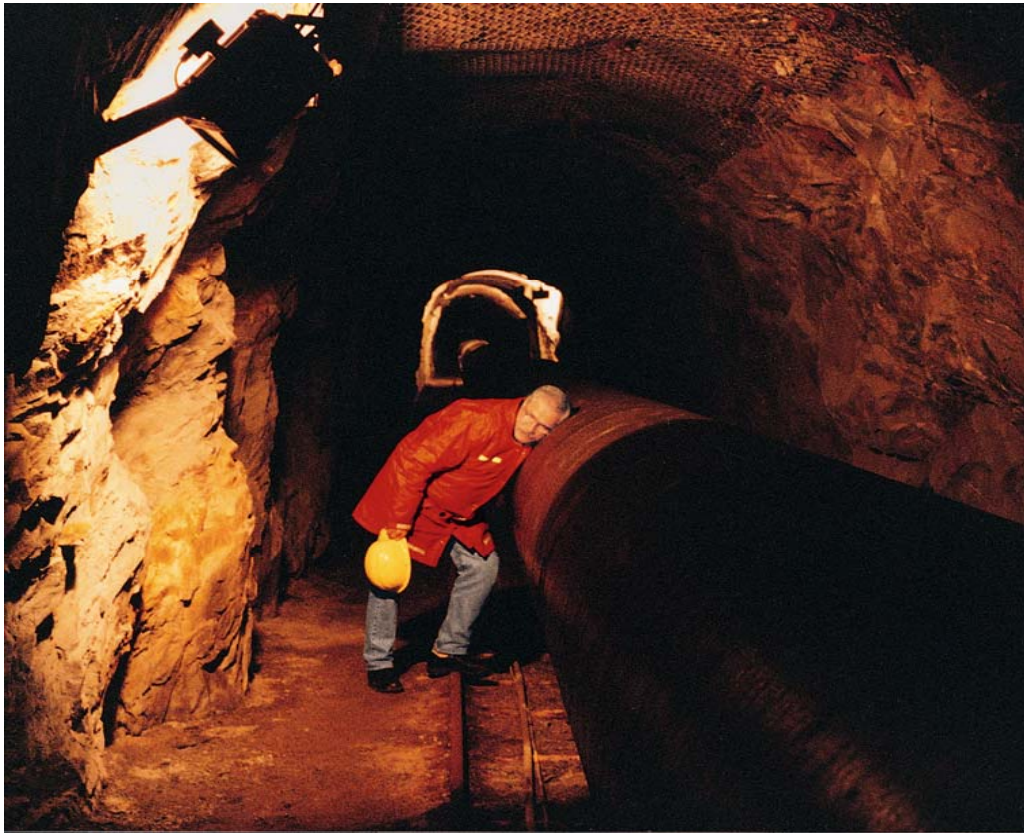
Transportation and Traffic

Automatic Ultrasonic Railroad Wheel Set Testing Station:

- Reliable Flaw Detection
- Fast Analysis
- Complete Documentation



Pig System for Pipeline Testing



Problem



Solution

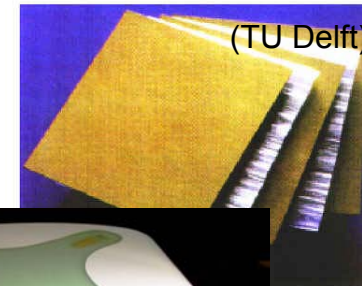
Pig System for Pipeline Testing

Induction
into
pipeline



Aircraft inspection

- Regular inspections
- Coating removal
- Fatigue testing
- Eddy current inspections
- Ultrasonic inspections



Aircraft components

SHM Benefits

The Past

Reliability by

- Over sizing
- Periodical checking

Additional weight

Extended service times in short intervalls

“Smashing a nut with a mallet”



The Future

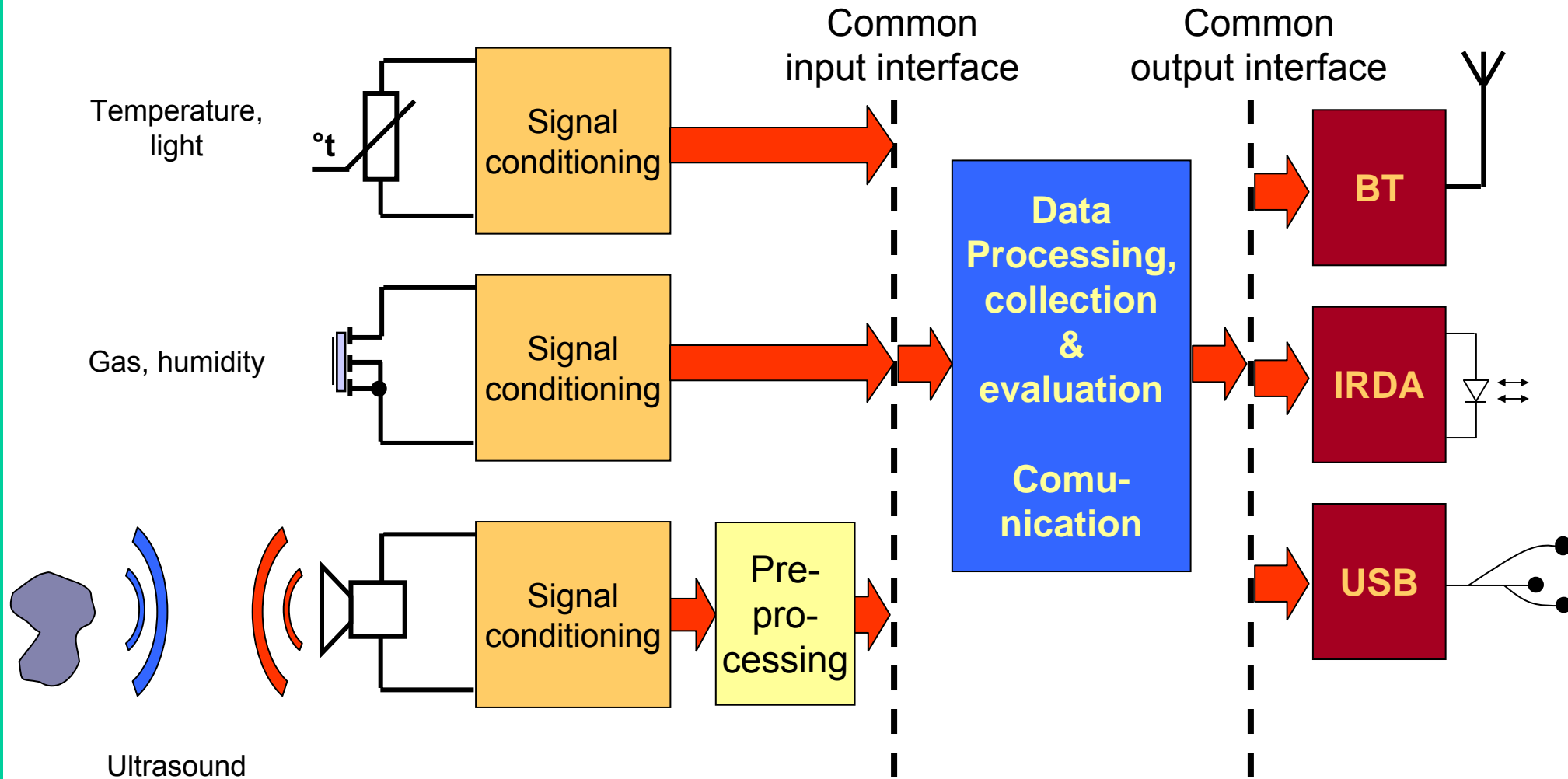
- permanent checking
“health monitoring”
- distributed sensor systems
“time-of-live” estimation



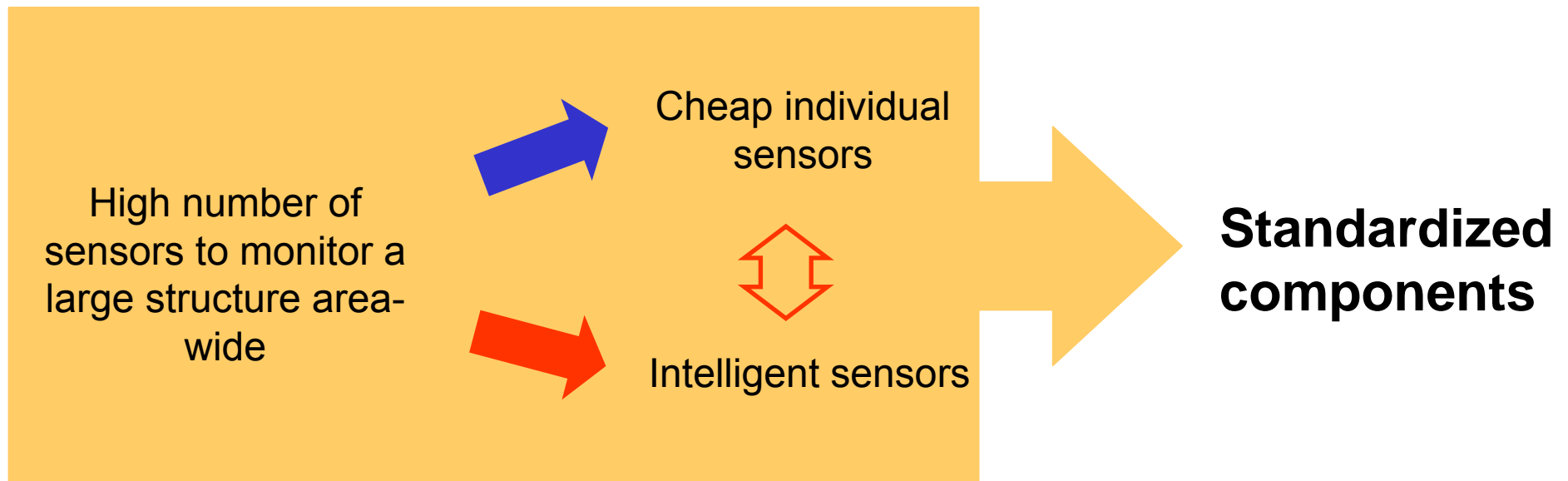
- **New design concepts**
- **Reduced weight**
- **Short service time in long intervals**



Modular Sensors



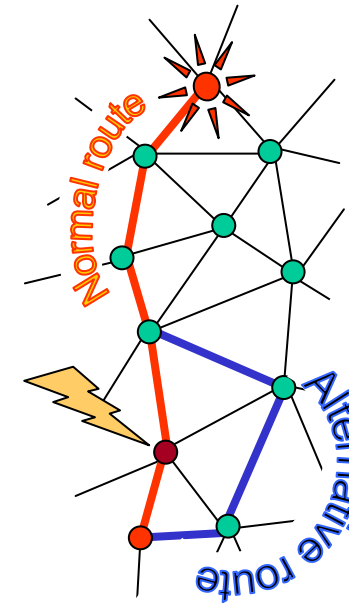
Distributed Sensor Systems



- Unique core for data processing and communication
- Modular input stages for analog/mixed signal processing
- Modular output stages for data transfer and inter-sensor-communication
 - **Sensor network: sensor redundancy**

Self Assembling Sensor Networks

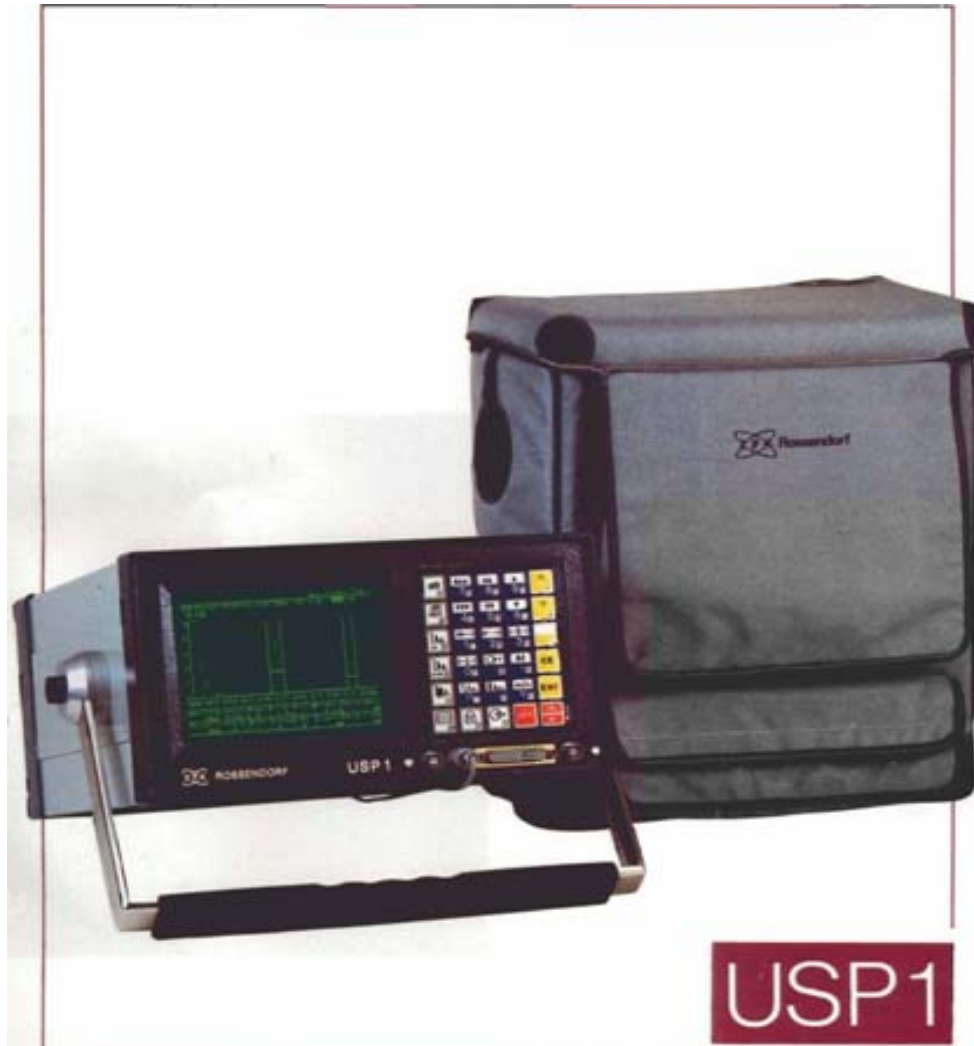
- Data on demand / data in case of need
- Inter-sensor communication
 - Networked sensors
 - Integrity of the values (plausibility checks)
 - Bypassing/virtual replacement of defect sensors
 - Need of small transmission power



Bad knot can still be addressed: Its value is interpolated by neighboring sensors of the same kind.



Miniaturization Required



Ultrasonic NDT System
ZfK Rossendorf 1988

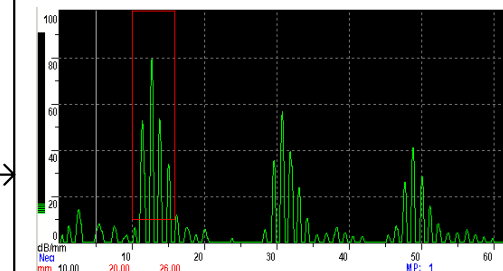
PC Ultrasonic Board

PCUS Hardware

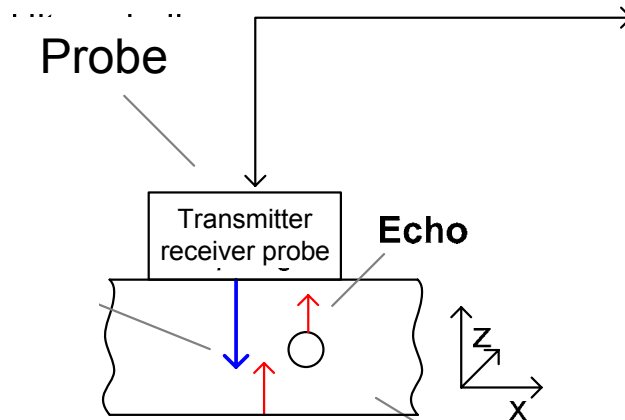


- Analogue and digital
Signal processing
Depth compensation

PCUS Software

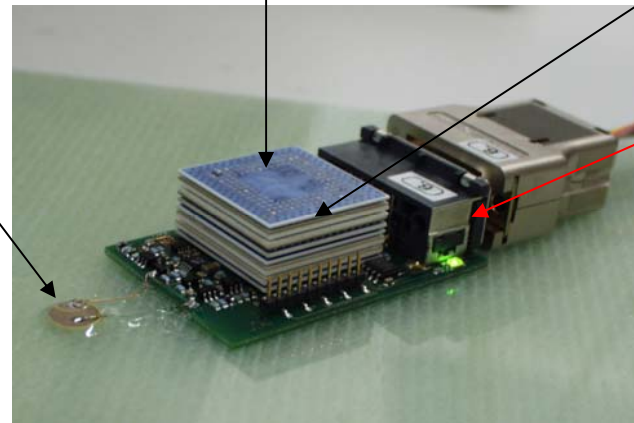
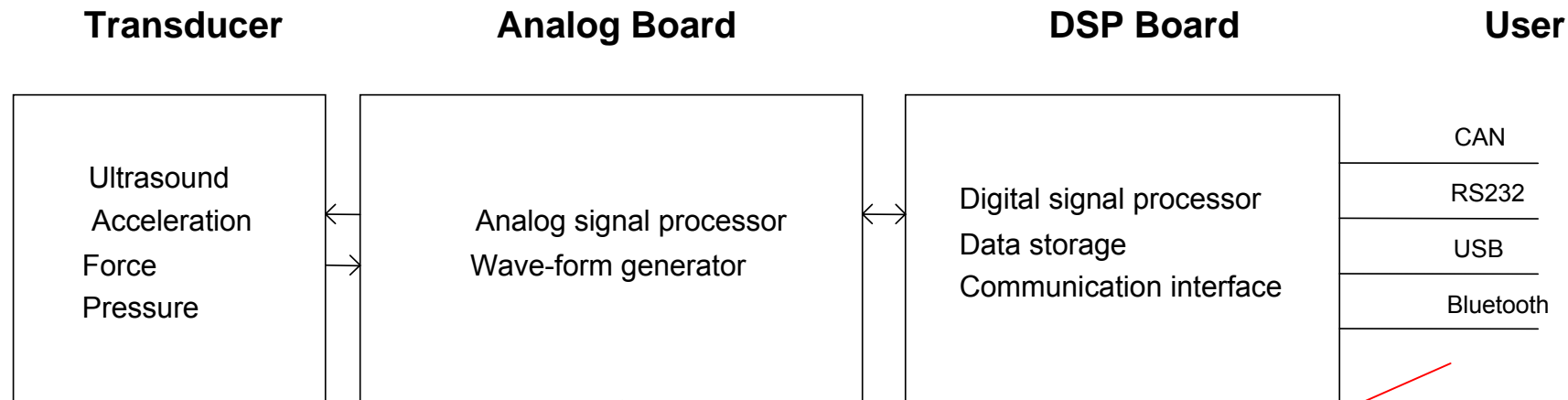


- System control
- Data analysis
- Protocol
- Presentation

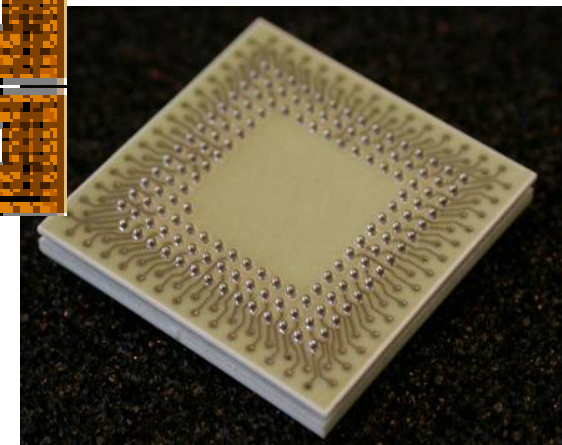
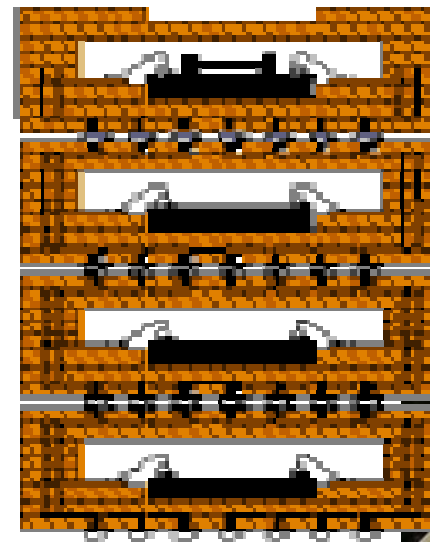
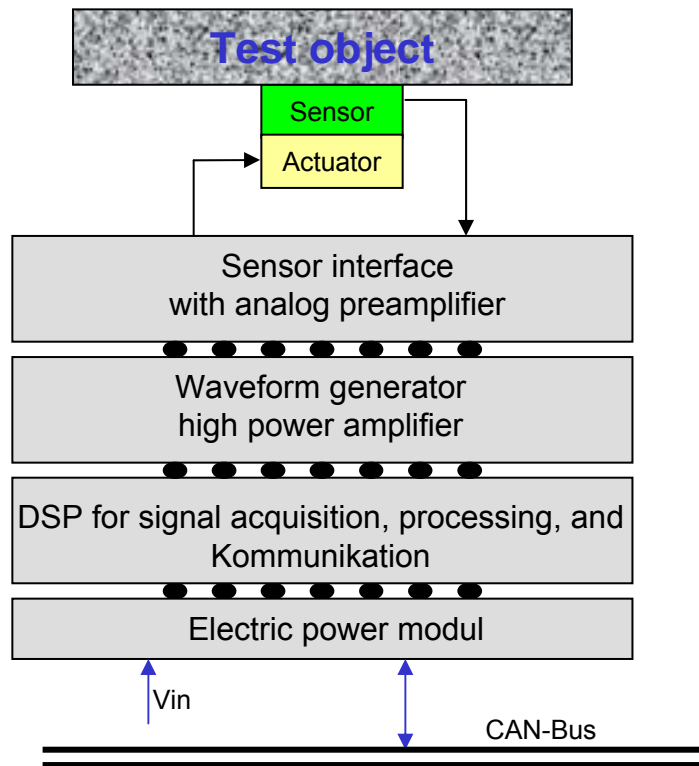


PCI-BUS

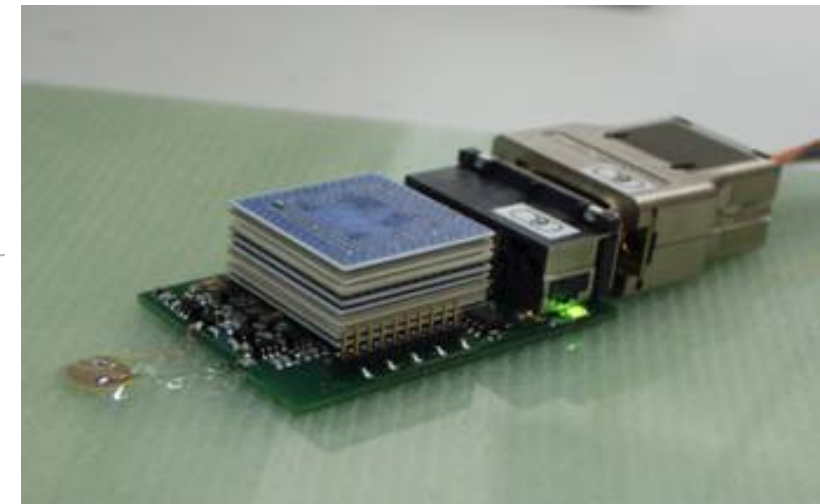
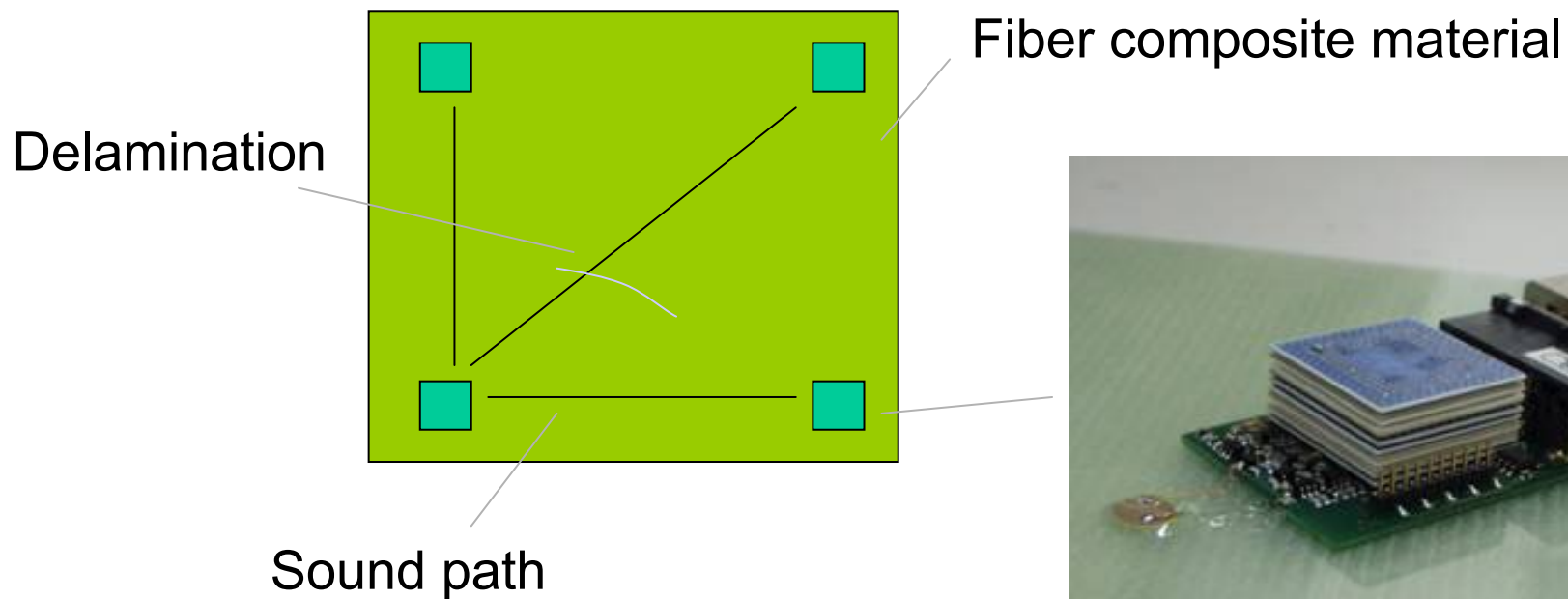
Smart Sensor



Solution



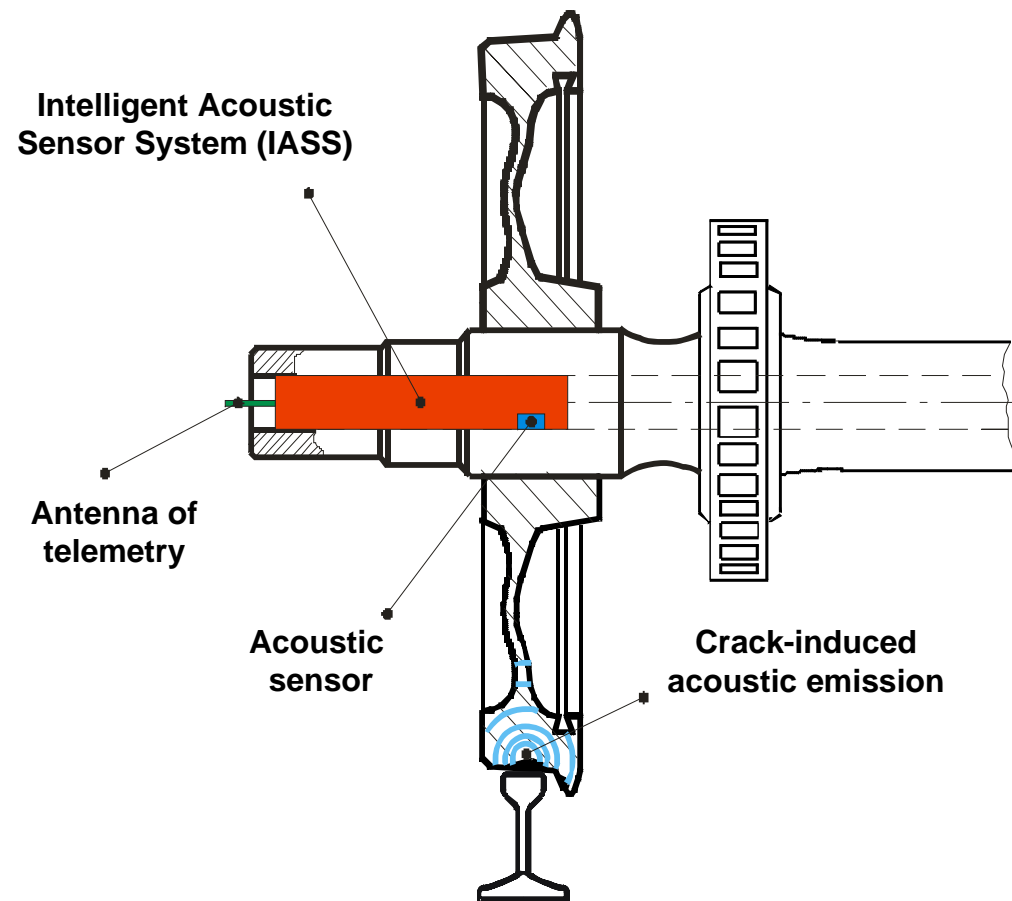
SHM with Ultrasound: Tomography



Sensor with structure integrated
signal evaluation electronics

Application: Railroad Health Monitoring

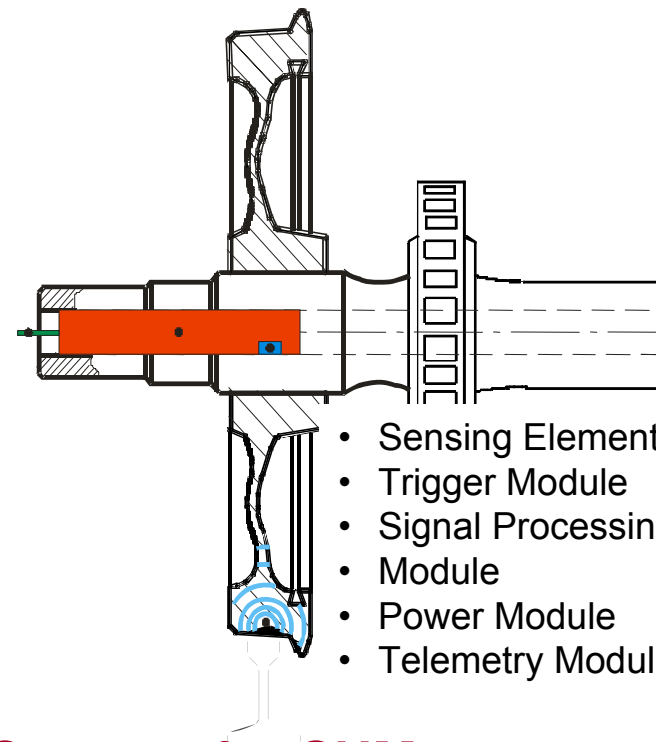
- Sensors integrated into the rotating shaft
- Data reduction within sensors
- Telemetric transmission





Sensors for NDE

- Periodical inspection
- Coupling or non-contact
- Scanning or imaging
- High performance
- Signal preprocessing on board
- Easy to replace
- Energy not critical



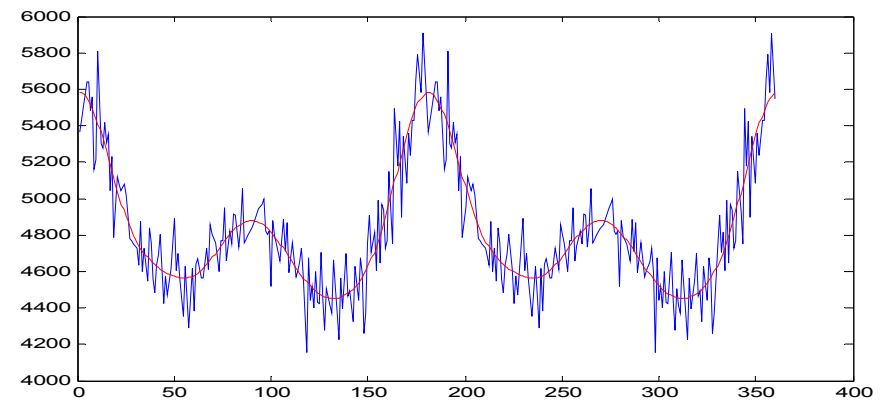
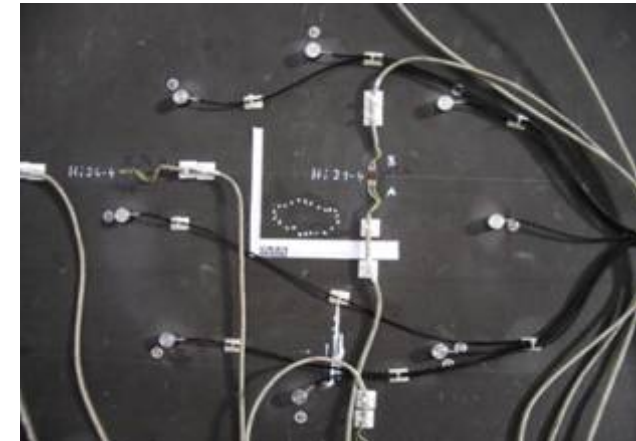
Sensors for SHM

- Sensors stay on board (cont. or periodical readout)
- Structure integrated
- Local (hot spots) or averaging (fibers, plate waves)
- Low cost
- Intelligent (processor + Interface) SAN
- Extremely high reliability (10 to 30 Years)
- Stand alone, energy management



Applications of Sensor Networks

Instrumentation of CFRP-Panel



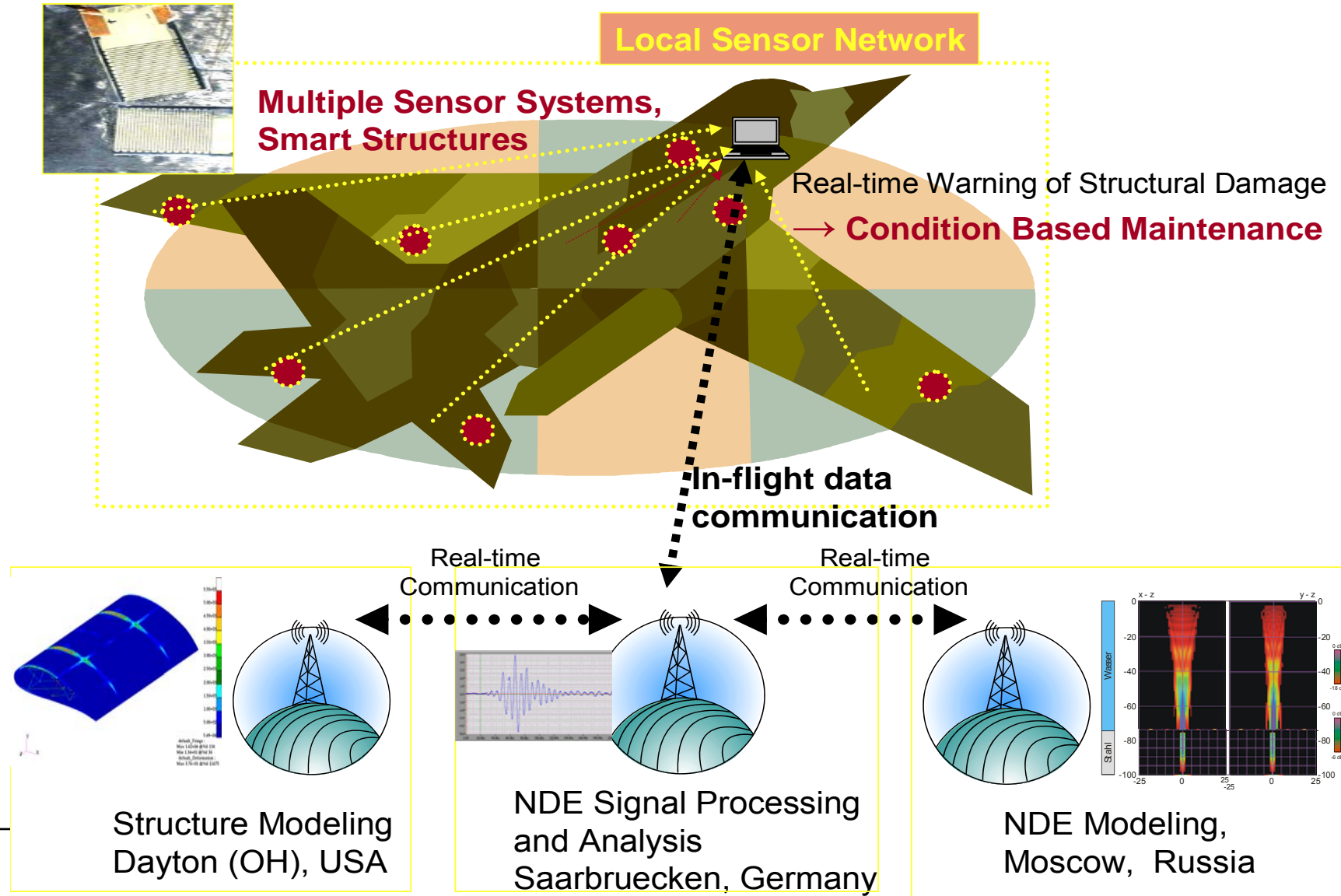
Applications of Sensor Networks

- Monitor for pipes in the chemical industry, refineries and power plants (RWE, Total)
- Combination of high-frequency, guided waves and low-frequency vibration measuring technique
- High-temperature sensors



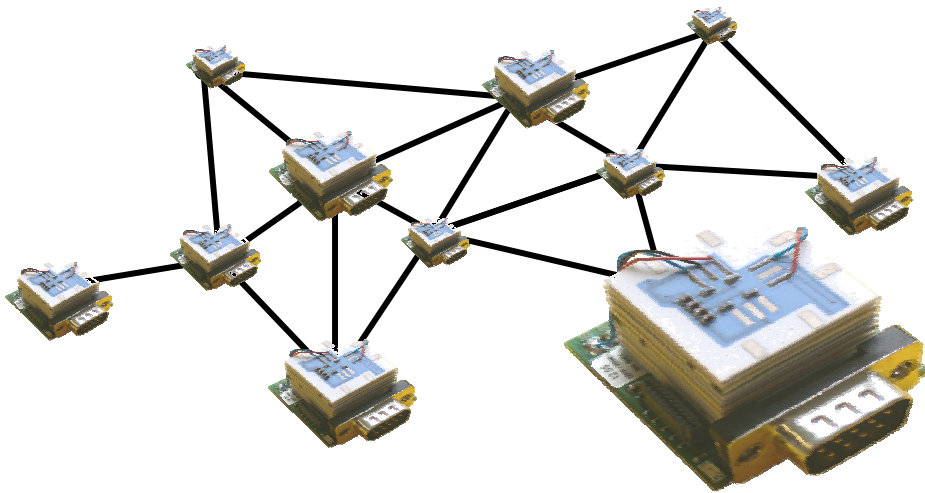
Image Total

Sensor Networks



Applications of Sensor Networks

Meshed Topology



Advantages

- Distributed management
- Unlimited extension
- Redundant layout
- High reliability

Vision:

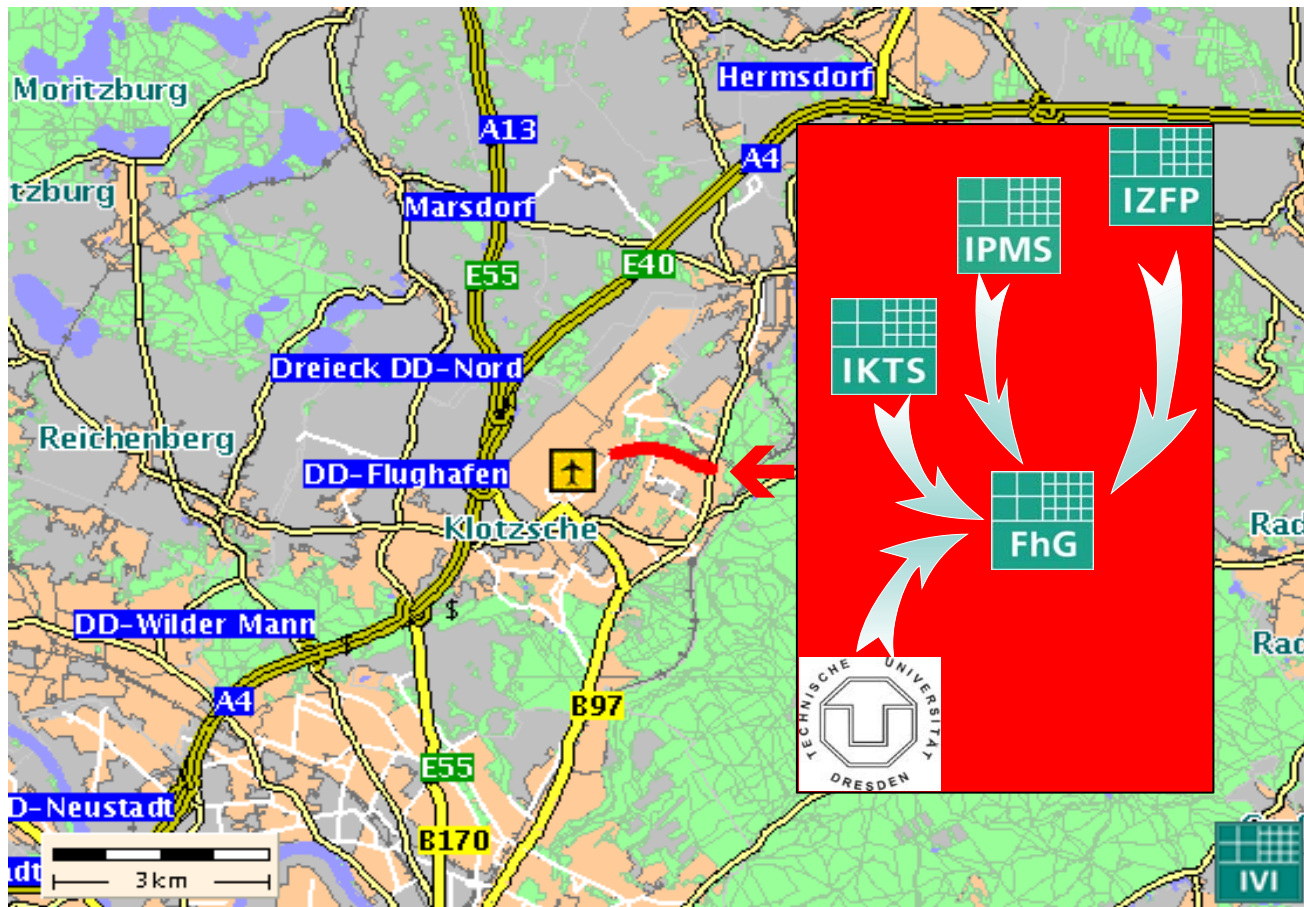
Wireless Sensor Network
Self organizing / scalable



Disadvantages

- High efforts for administration
- Expensive networking

Sensors Network Dresden



Sensors Network Dresden
Maria-Reiche-Strasse 5
01109 Dresden
Germany

Sensors Network Dresden

The "Sensor Hill"



Summary

Applications of modular sensor systems

Health Monitoring

- Airplanes
- Railroad systems
- Pipelines
- Chemical plants
- Medicine
- Environmental protection

NDE of Materials and Structures

according to codes, standards, and regulations

Process Monitoring

User Support

- Airplanes
- Railroad systems
- Automotive ...