

Scaleable, Wireless Structural Testing System

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MicroStrain's sensing technology

Four wireless sensing patents issued

Five energy harvesting patents pending

Received over \$4M in Federal R&D

- Wireless sensor nets
- Sensor fusion
- Power management
- Energy harvesting



Inertia-Link™
Wireless, 3 axis accel/gyro

Structural Test & Model Validation

- Requires thousands of strain gauges
- Wiring adds labor cost, reduces reliability
- Wire weight can be significant (5000 lb)



Optical Fiber Strain Gauges

- Fiber optic strain gauges will support multiple strain measurements along a single fiber
- But ingress/egress points of optical fibers are delicate and prone to breakage

Sensing the Future



Wireless sensing networks overcome these limitations, with reduced set up time & lower maintenance costs.

Embedded sensors enable structural test under actual operating conditions

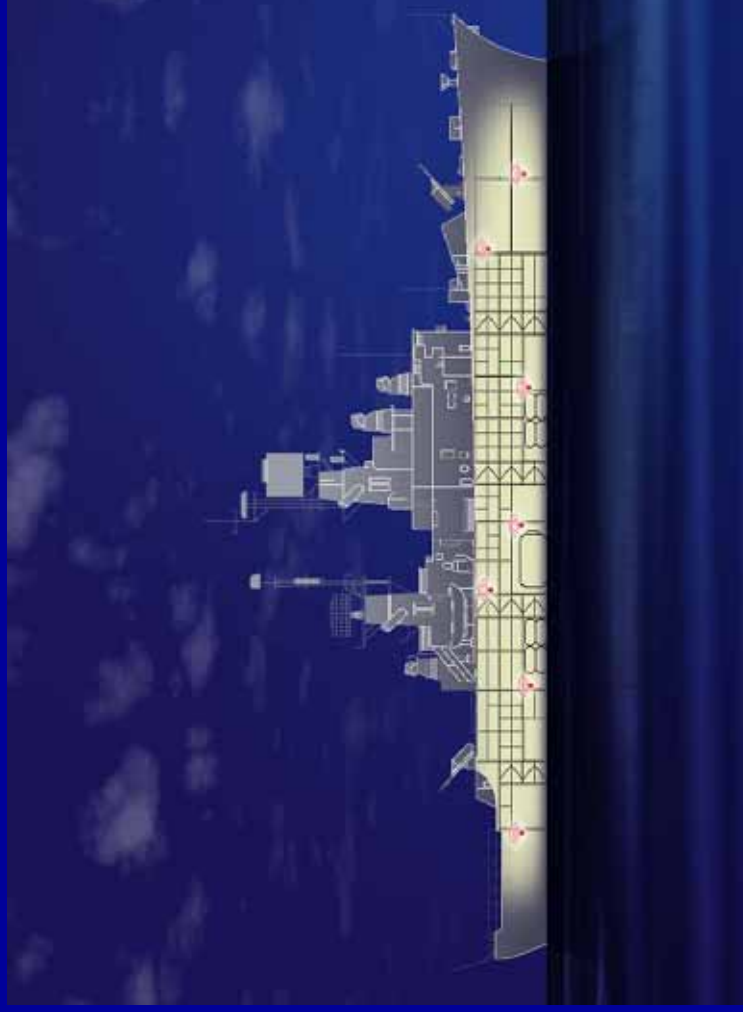
The case for monitoring



- Boeing F/A-18 designed for 6,000 flight hours
- Existing hardwired multi-channel monitoring allows F/A-18 to reach 13,000 flight hours
- New aircraft req'd to achieve the additional flight-hours would cost ~\$11B

Customers:

- Designers & owners of ships, aircraft, and ground vehicles



Advantages of Wireless Testing:

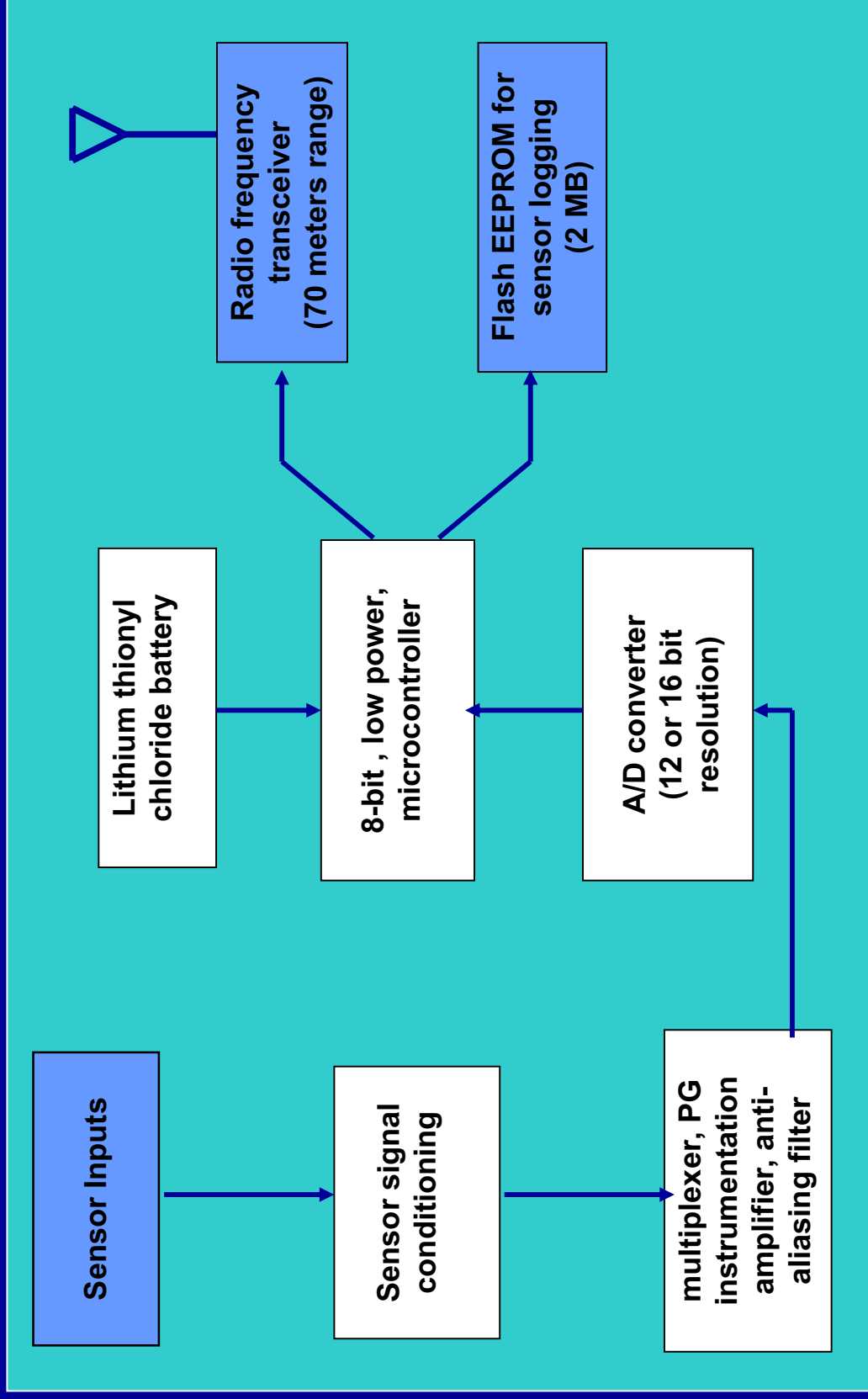
- Lower costs to procure, install, checkout, use & maintain
- Faster test schedule
- No areas/damage hidden by wire bundles
- No large structural penetrations in covers/doors/panels
- Simplification of pressurized cavity penetration sealing
- Improved physical access to/on test article
- Reduced potential for wiring damage & data loss
- Lessened interference w/ concurrent production activities
- Reduced cable counter-balance load requirements
- Simplified, faster teardown

MicroStrain's technology vs. existing hard-wired systems

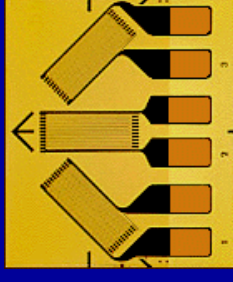
- Microstrain's patented wireless sensing nets reduce weight, eases installation, saves time
- Eliminates expensive integration w/ vehicle controls & power lines
- Supports DoD's reduced manpower initiatives
- Can save the DoD \$Billions/year through reduced need for new vehicles, fewer costly modification programs

Methods

MicroStrain's Sensing Nodes are both data loggers & transceivers



MicroStrain's embedded firmware supports wireless strain gauges



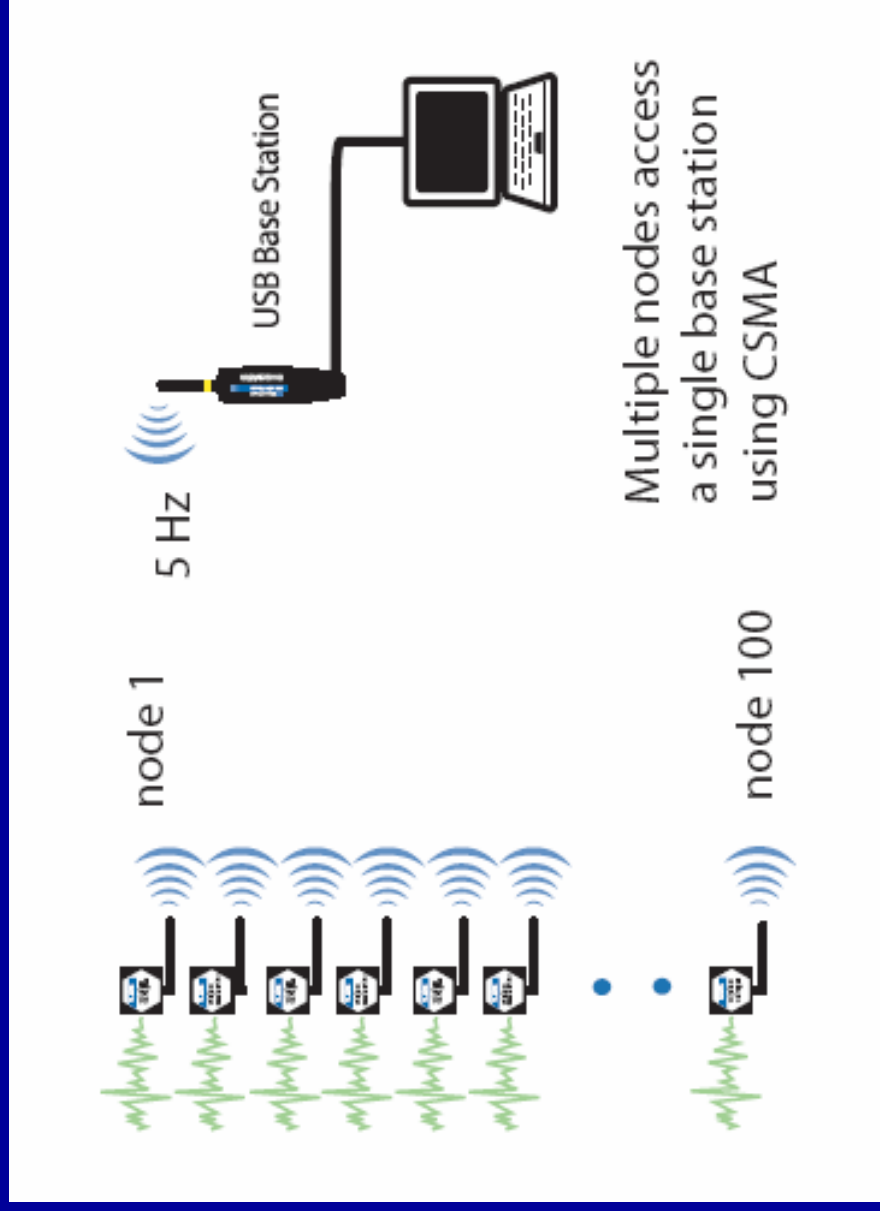
- Wireless offset adjust
- Wireless gain adjust
- Wireless shunt calibration
- Wireless control of sample rates
- Multiplexed, pulsed & regulated bridge excitation
- Scaling from bits to microstrain

MicroStrain's Scaleable Wireless Sensing Networks

(patents pending)

- Multiple nodes share one RF channel using carrier sense multiple access (CSMA)
- Uses robust 2.4 GHz direct sequence spread spectrum radio (IEEE802.15.4)
- Eliminates need to provide a dedicated base station receiver for each actively transmitting sensor node

MicroStrain's Network Architecture (patents pending)



Wireless Node Packaging:



MicroStrain's SHIELD
wireless strain rosette enclosure
w/ moisture detection
(patents pending)

IP67 compliant
automotive style wireless node
enclosure

Results

Strain Measurement Specs:

- Temp coeff. Offset: -0.007% /deg C (20-50 C)
- $-.090\%$ /deg C (0 - 20 C)
- Temp coeff. Span: $+0.004\%$ /deg C (20-50 C)
 $+0.060\%$ /deg C (0 - 20 C)
- Programmable FS range: 1000-5000 microstrain
- Resolution: ± 2 microstrain
(w/ anti-aliasing low pass filter to 500 Hz)

Sensor network density depends on update rate:

- 1Hz update rate supports ~ 500 remote sensor nodes per base station
- 5 Hz update rate supports ~ 100 remote sensor nodes per base station
- 16 base stations (max) can support from 1600 to 8000 sensor nodes

Battery life depends on update rate, battery type, sensor type (1 kohm 3 element rosette)

- 1 sample/sec/ch, AA Li lasts ~ 4 years
- 5 sample/sec/ch, AA Li lasts ~ 1.2 years
- 5 sample/sec/ch, D Li lasts ~ 10 years
- 500 sample/sec/ch, AA Li lasts ~ 3 days

Embedded Intelligence

(patents pending)

- Fully related peak-valley compression using strain gauge rosettes
- Wireless upload of unique structural S-N curve
- Fatigue estimated by rain flow algorithm

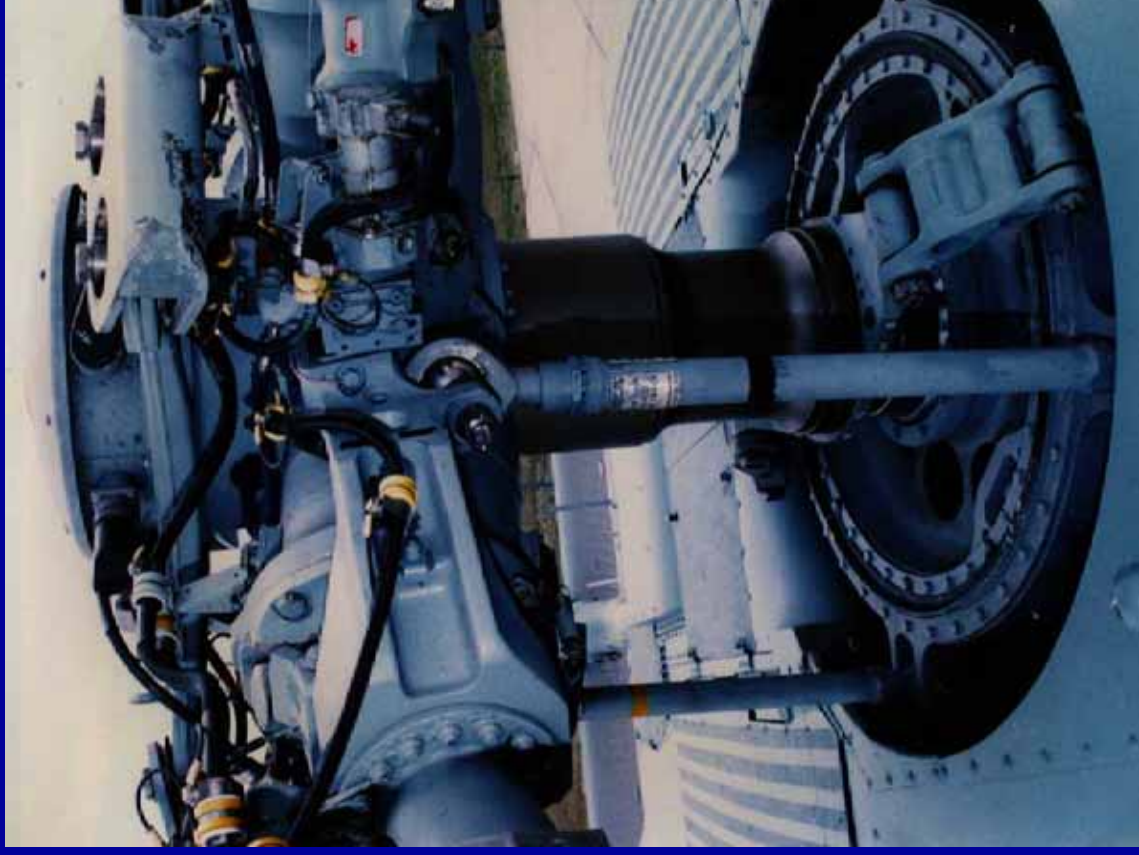
Problem:

But for long term
(embedded) tests, who's
going to replace the dead
batteries?

Solution:

- Harvest & store energy from strain, vibration, light, and motion
- Use power management to balance the energy “checkbook”
- Use embedded processors to compress data, compute fatigue life

US Navy Application: Helicopter Pitch Link



Phase I energy harvesting wireless pitch link strain node:

- Harvests 2000 μW @ +/- 200 microstrain
- Consumes <1000 μW sampling strain sensor data @ 40 Hz, transmitting these data @ 1 Hz
- Capable of background recharging
- September 2005 TRL: 6 (working prototype in relevant environment)
- US patents issued & pending

Summary

MicroStrain's Technology

patents issued & pending

Features

Benefits

embedded intelligence	nodes sense, compress, & log data; calculate accumulated fatigue damage
scaleable RF network	eliminates costly wiring, supports thousands of nodes
integrated energy harvester & micro power operation	eliminates battery maintenance
base station GSM/SAT uplink	no human intervention required to get reports
wireless offset & calibration	easy installation & test

About MicroStrain, Inc.

- Based in northern Vermont
- 22 full time employees
- 70% revenue from product sales
- products developed w/ SBIR funds
- revenues growing at 25%/year



Acknowledgements:

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Thank You!