Setting the Standard for Automation™

Practical Power Solutions for Wireless Sensing

Roy Freeland

ISA Automation Week
Orlando September 2012

Standards
Certification
Education & Training
Publishing
Conferences & Exhibits

Roy Freeland

- Roy Freeland Co-Chairs the ISA100.18 Power Sources Working Group.
- He is a Cambridge graduate engineer with wide international experience of running technology based companies. He ran Meggitt Electronics, was Group General Manager at Bowthorpe (Spirent) and CEO of United Industries.
- In 2004 he established Perpetuum Ltd, a world leading vibration energy harvesting business

Agenda

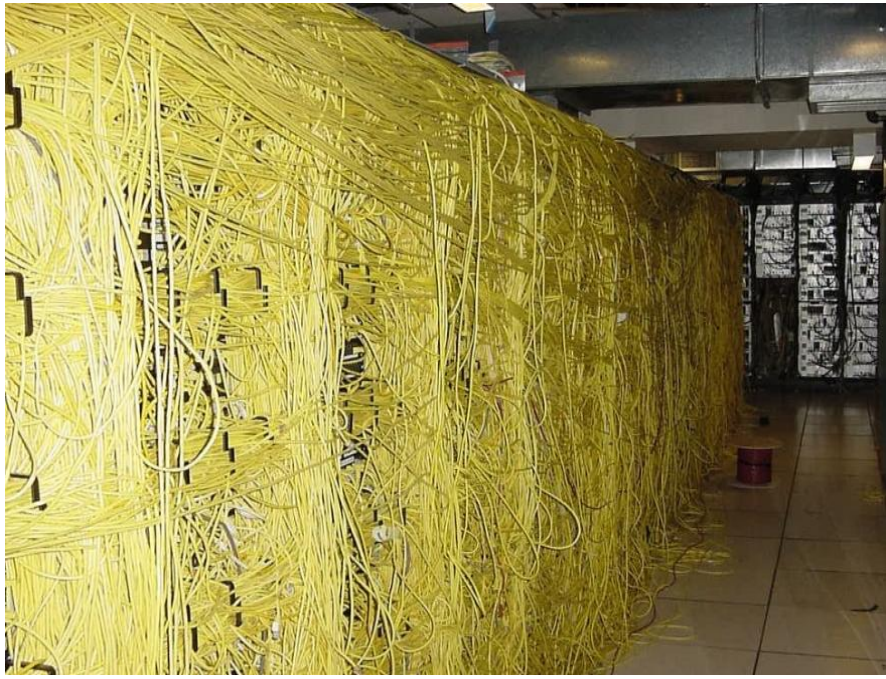
- Power required by WSN's today
- Energy Harvesters capable of powering WSN's
- Unhelpful Developments
- Standards
- Application requirements
- Practical Examples Today

Wireless Needs Wireless Power

- Wired Power

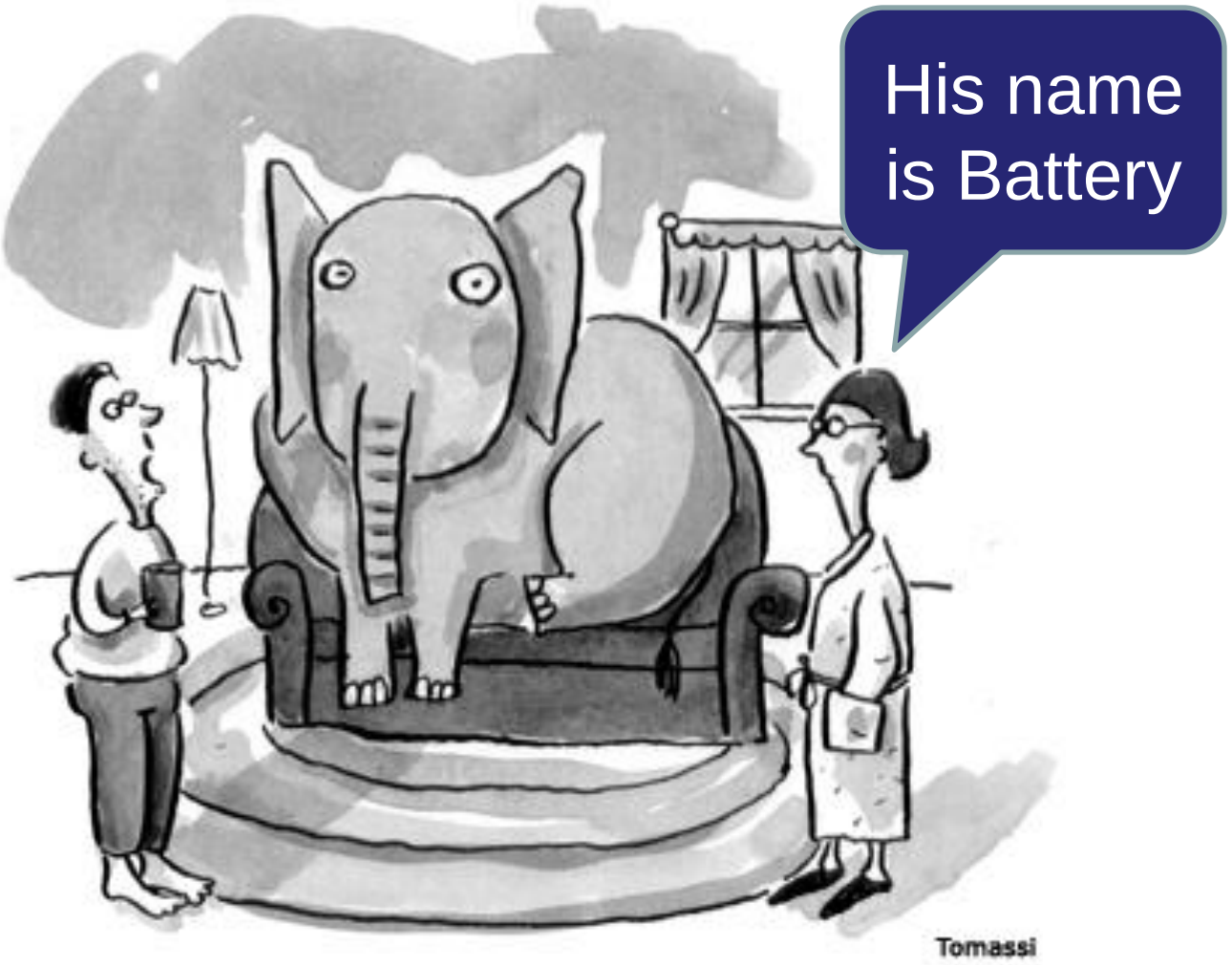
  Impact on cost, flexibility and maintenance benefits of wireless

- Wireless
  - Batteries
  - Energy Harvesters
    - Vibration
    - Thermal
    - Photovoltaic
    - Transmitted Power
    - Other Kinetic



Wiring : expensive, unreliable
Not maintenance free

There is an elephant in the room



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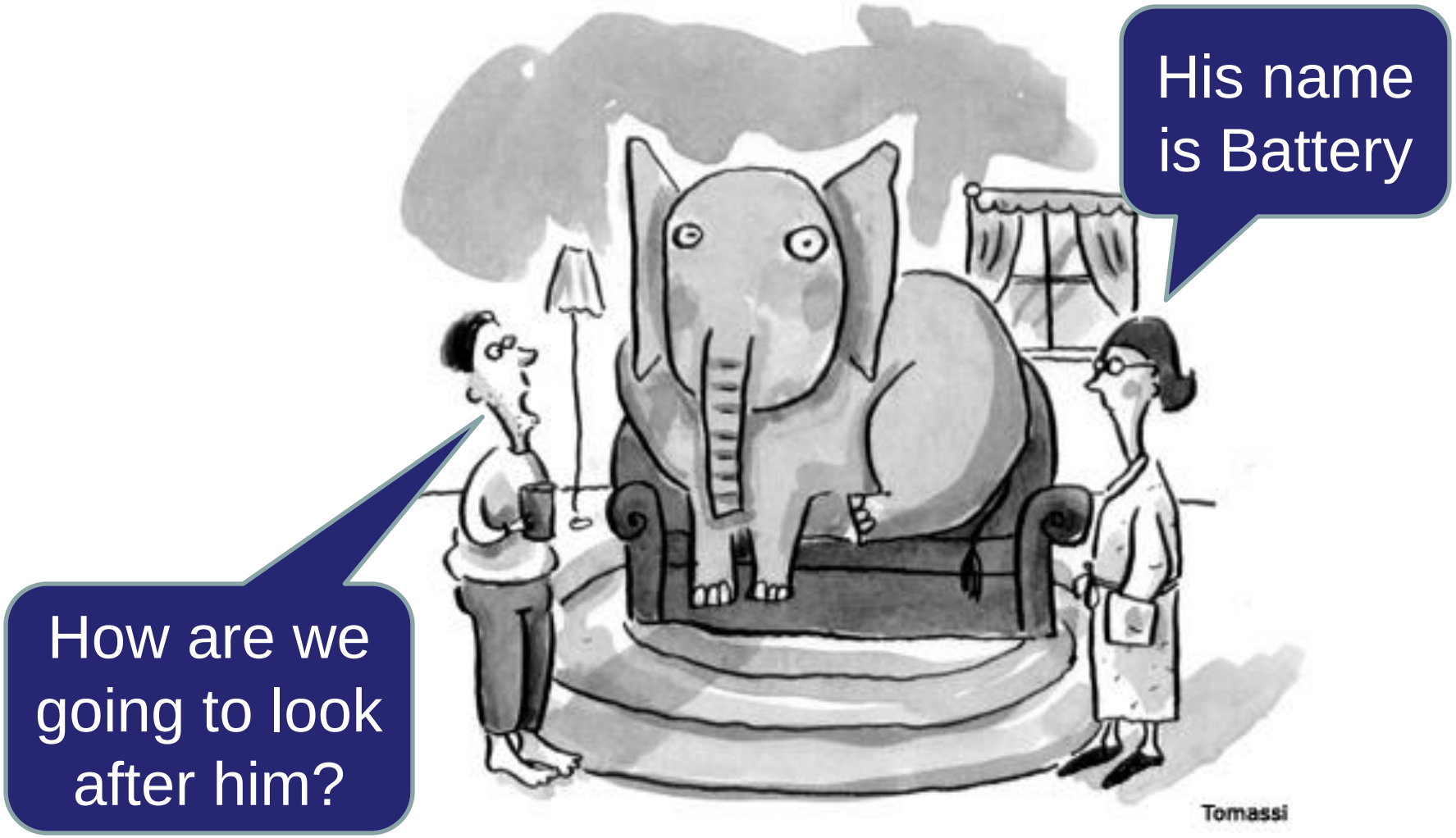

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Today's WSN Power Requirements

- Low Power RF Protocols based on IEEE 802.15.4
  - ISA100.11a
  - WirelessHART
  - Zigbee
  - WIA-PA
- Average Power Required depends on
  - Design and component selection
  - Reporting Rate
  - Data volume
  - Network Topology
- For discussion - typical **3mW average power**

Battery Life

Theoretical life can be reduced by:-

- Intermittent peak currents for RF transmission
  - Can use capacitors to help - incorporated in some new types
- Self discharge
- Low temperatures
- Need to allow safety margin for changing
- Allow 25% overall

Battery size	Nominal capacity	Life at 3mW (3.6V)
AA	2.4 Ah	Less than 3 months
C	8.5 Ah	Less than 10 months
D	19 Ah	Less than 2 years

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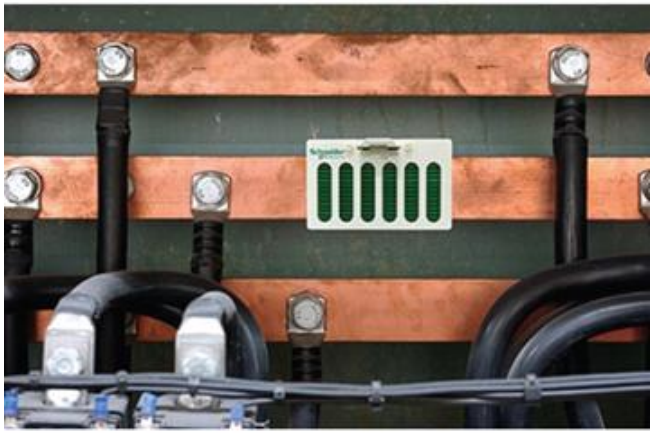
Vibration

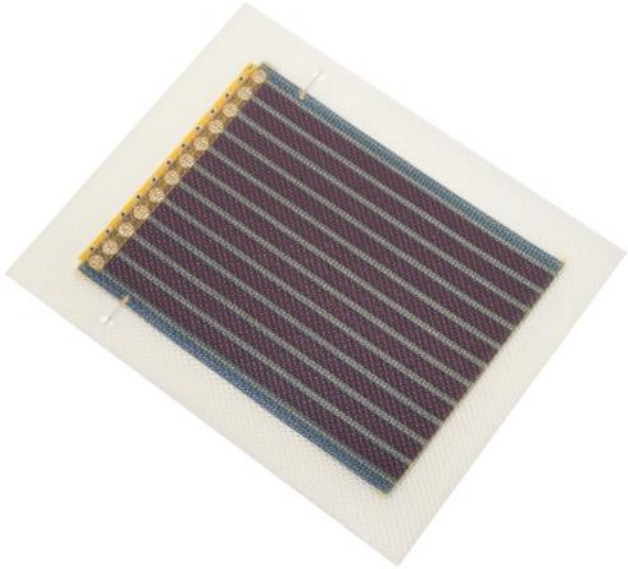
- Uses ambient vibration from rotating machinery or vehicle motion
- Example: **Perpetuum** vibration harvester
  - 3mW from about 40-50mg of vibration
  - Depends on frequency and amplitude
  - High bandwidth important to ensure good coverage of a wide range of machines

Thermal

- Requires Heat Source and good heat transfer
- Example: **Micropelt** thermal harvester
  - 3mW with heat source at about 55C assuming ambient temperature of 25C
  - Rate of heat transfer is important
  - Installing a probe which impedes convection or heat flux increases the required temperature differential.



Photovoltaic



- Photovoltaic uses ambient light externally or inside buildings

- Example: **G24 Innovations** Photovoltaic Film
  - Dye sensitized thin film photovoltaics
  - 3mW from area of 233mm x 135mm in typical industrial indoor environment with a light level of 500 lux.
  - Light source dependent and cleanliness issues

RF Transmission

- Needs Powered Source
- Example: **Powercast** RF transmission system
  - 3mW of usable power at a range of 1.2m (4ft) from a 3W transmitter
  - Multiple transmitters or receivers can produce 3mW at longer range.
  - Wireless power transmission rather than energy harvesting
  - Range Limitations

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Unhelpful Developments -1

Nokia has started demonstrating a prototype mobile phone that uses energy harvesting technology to recharge itself using only ambient radio waves - emitted from mobile antennas, TV masts and other sources.

www.technologyreview.com/news/413744/wireless-power-harvesting-for-cell-phones

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Media reports have incorrectly stated that Nokia has a prototype device which can power itself from ambient electromagnetic energy

Unhelpful Developments -2

RCA Airnergy: able to charge a Blackberry Bold all the way from 30% to full power in less than 90 minutes using only Wi-Fi harvested energy

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"Either they have broken all the laws of thermodynamics and come up with a product that will completely solve global warming and oil dependency and is the greatest advancement in all science ever…..

…. or it's a garbage product that does bugger all."

www.youtube.com/watch?v=P8s3Xjeg0sk

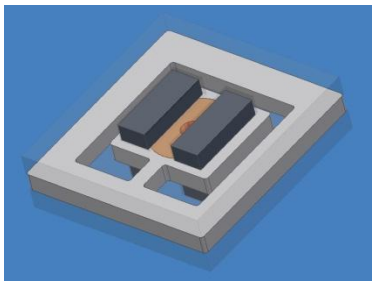
Unhelpful Developments -3

Published Claim:-

"World record vibration harvester output from MEMS device:

225μW from vibration of 2.5g at 930Hz"

5mm MEMS will never power 20kB data transmissions at 200M range using commonly available vibration sources



Which would you prefer?

2mW

Walk quickly for 300 miles

10W

Turn a handle for 1 minute

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Standards for WSN Power Sources

- ISA100.18 Working Group
- Key objectives are
  - Define specifications for the interchangeability of power sources
    - Use cases in range 0.1mW to 30mW
    - Including batteries, energy harvesters, and other power sources
  - Define performance specifications to facilitate comparison and selection of optimum power sources for application.
- Cooperating with a range of organizations
    - VDI on battery standards for WSNs
    - Other organizations using 802.15.4 (e.g. WirelessHART, Zigbee)
    - NPL and others in “Metrology for Energy Harvesting “project (EC funded European Metrology Research Programme (EMRP))

Interchangeability

- GEHAM design
  - Generic Energy Harvester Adaptor Module
- Additional circuit –often inside WSN housing
- Allows battery use if EH power not available (e.g. Start-up, maintenance)
- Uses EH power preferentially
- New standard circuit design for several major WSN manufacturers
- Simple connector interchangeability between Vibration Harvester and Thermal Harvester

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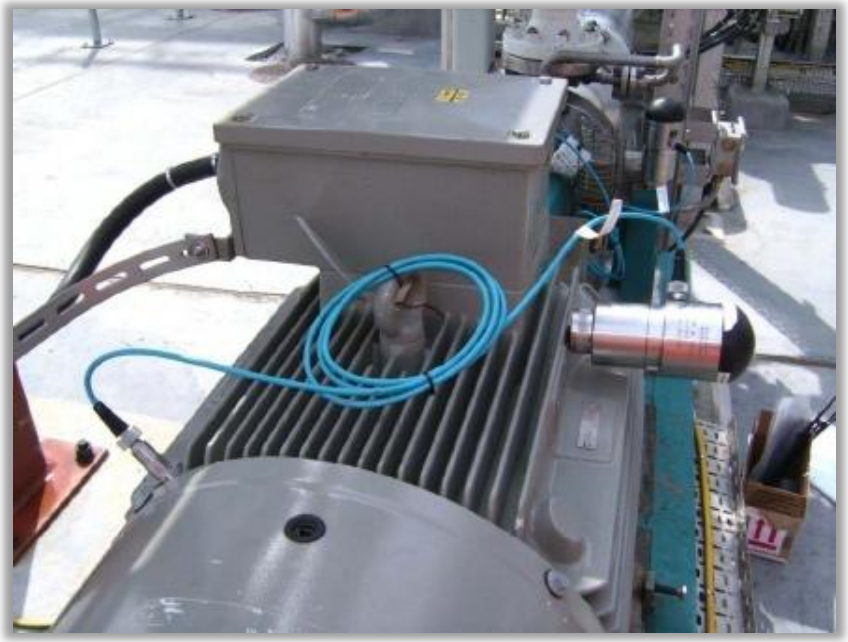
More than Enough Power

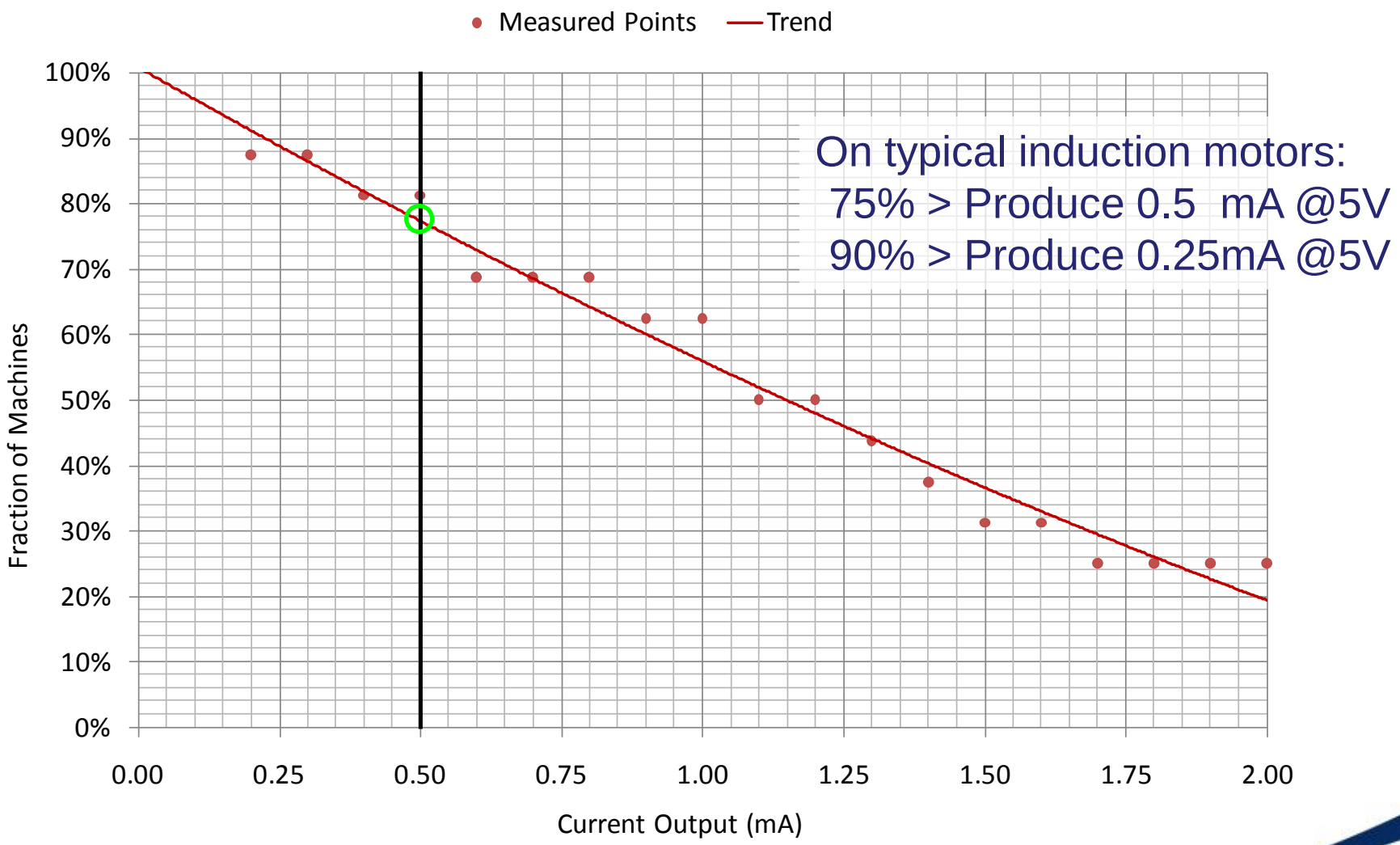
First System
One harvester powers
WSN with **One** sensor



GE Bently Nevada
Insight.Mesh

New System
One harvester powers
WSN with **Four** sensors

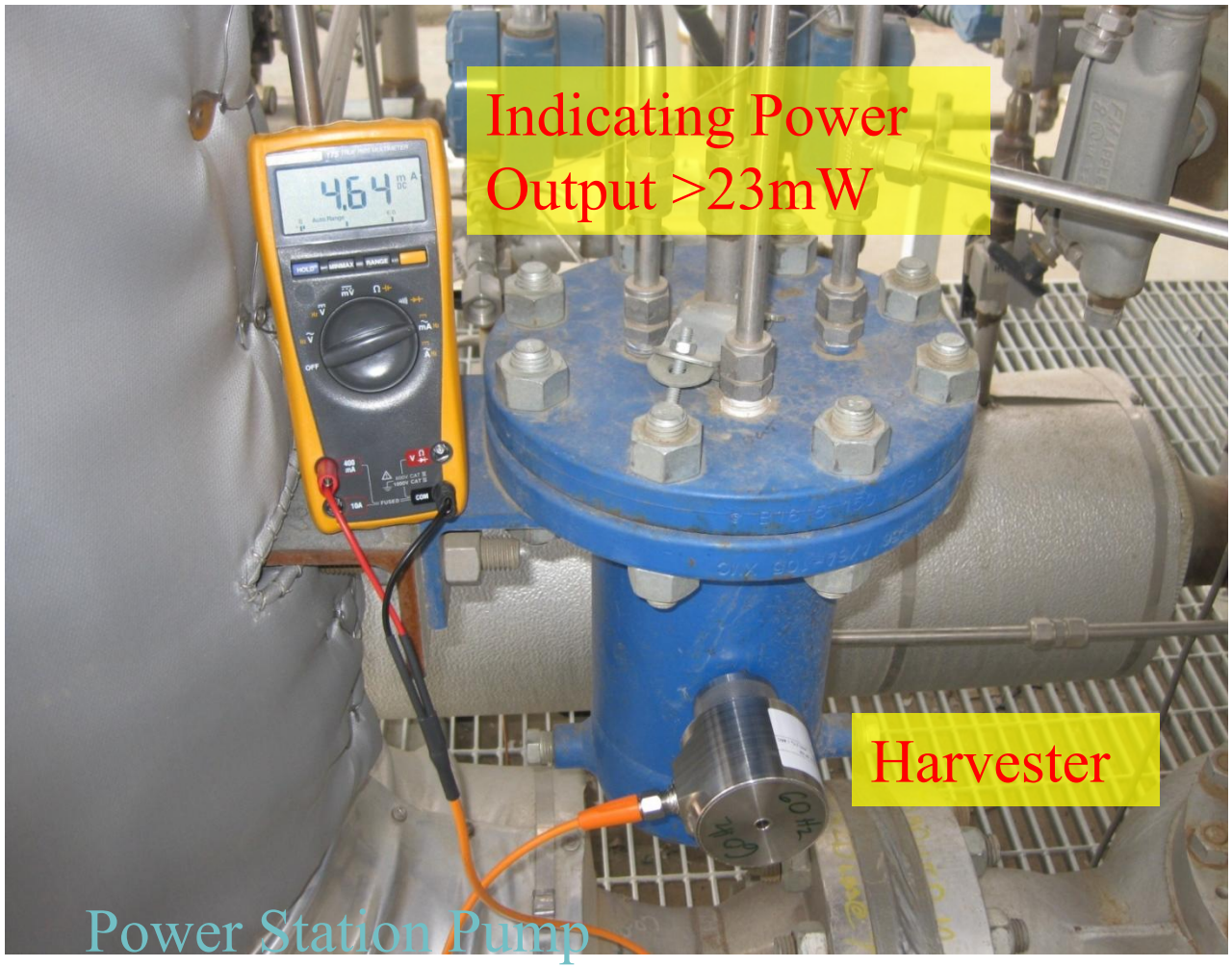
Sufficient Power – Everywhere?



Lifetime – No maintenance

- Power Source to exceed equipment life
  - Harvester designed for high reliability -890 yrs MTTF
  - Rejected materials with 200m cycles:- <7 weeks @50Hz
- Maintenance :-
  - Difficult, undesirable, impossible
  - Battery change issues
- Power Solution must be “Fit and Forget”

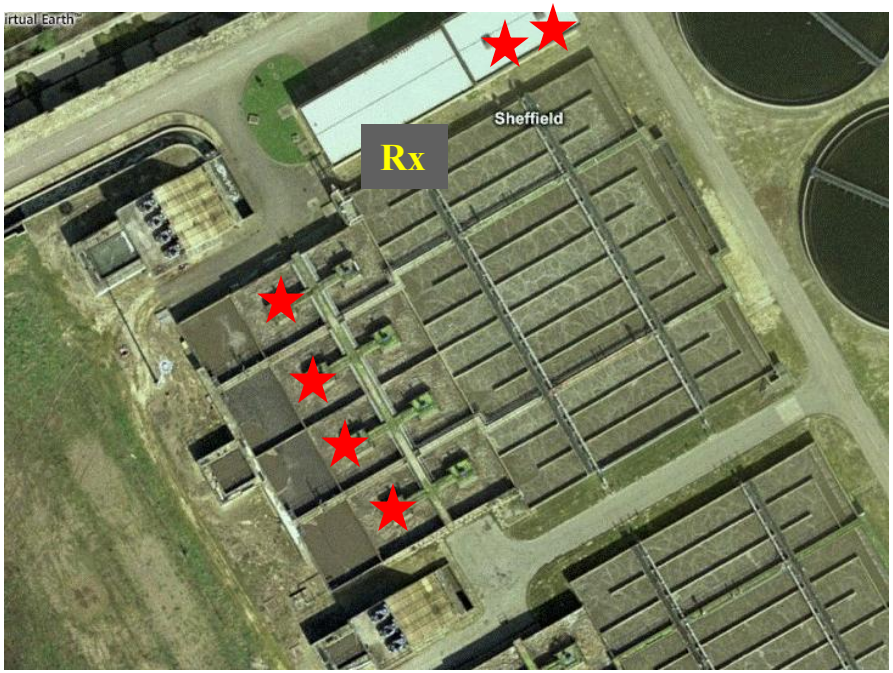
Easy to Install



- Power level seen immediately
- Non – intrusive Installation

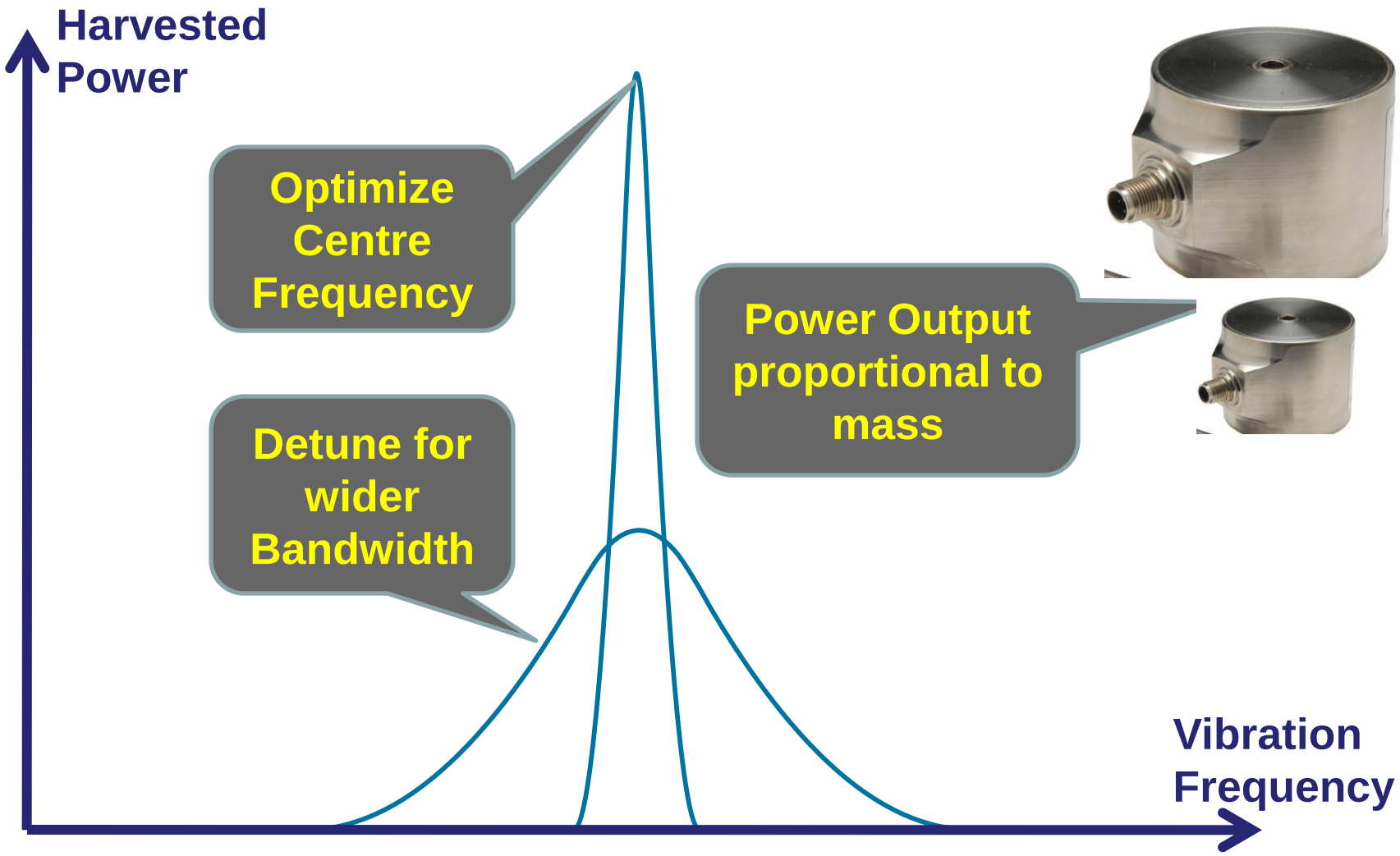
Easy Low Cost Installation

Pruftechnik GmbH
Wireless Condition
Monitoring System
At Water Treatment Plant



- 6 units installed in 40 minutes
- Wiring would need 6-8 man weeks and plant shutdown
- Unhealthy Working Environment

4. Flexibility



4.Flexibility

National Instruments
Wireless Sensor Node

•Pressure, Temperature

•4AA batteries

•Vibration Energy Harvester

Integrated Power Conditioning including Capacitor

•Solar Power Unit

http://zone.ni.com/devzone/cda/tut/p/id/12128

5. Application Specifications

- Environmental standards
  - E.g. EMC, Train washing
- Temperature range
  - E.g. -40 to +85
  - ***Warning – Energy Storage Devices may not give adequate performance over full temp range and for required lifetime***
- Shock
  - E.g. 100G
- Hazardous Zones
  - E.g ATEX Certification, Zone 0

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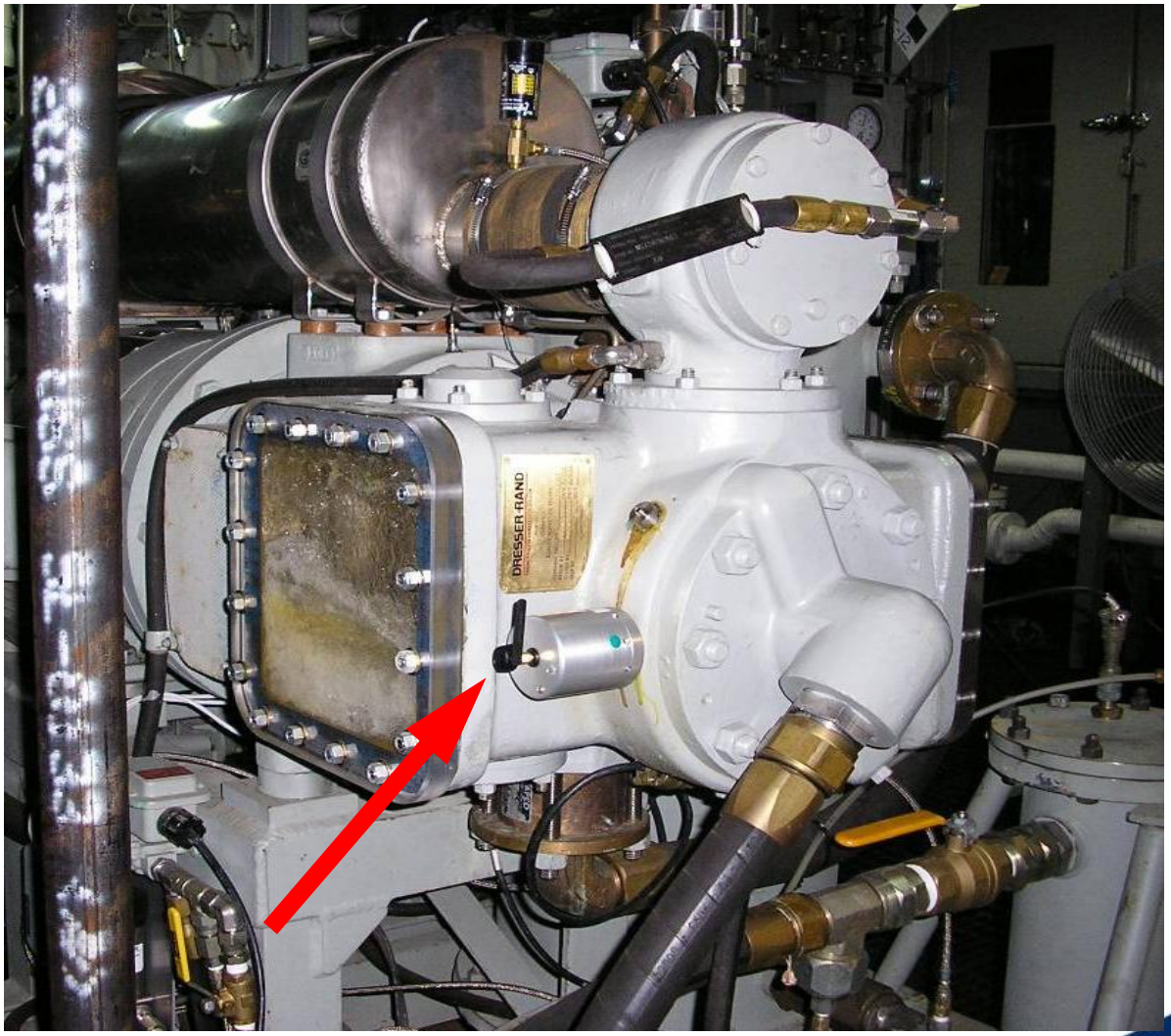
US Navy Installation 2006

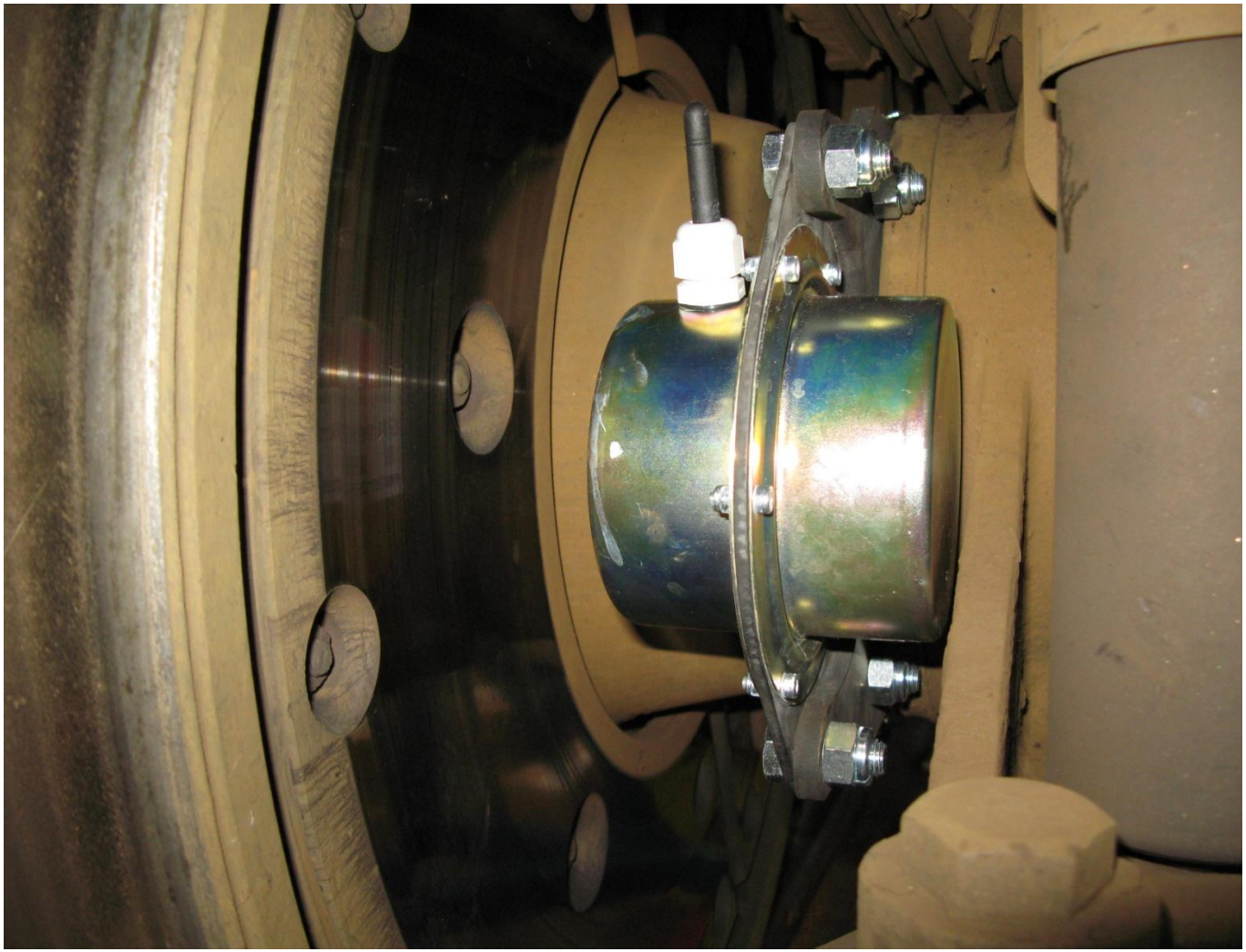
4 man weeks
or
20 seconds



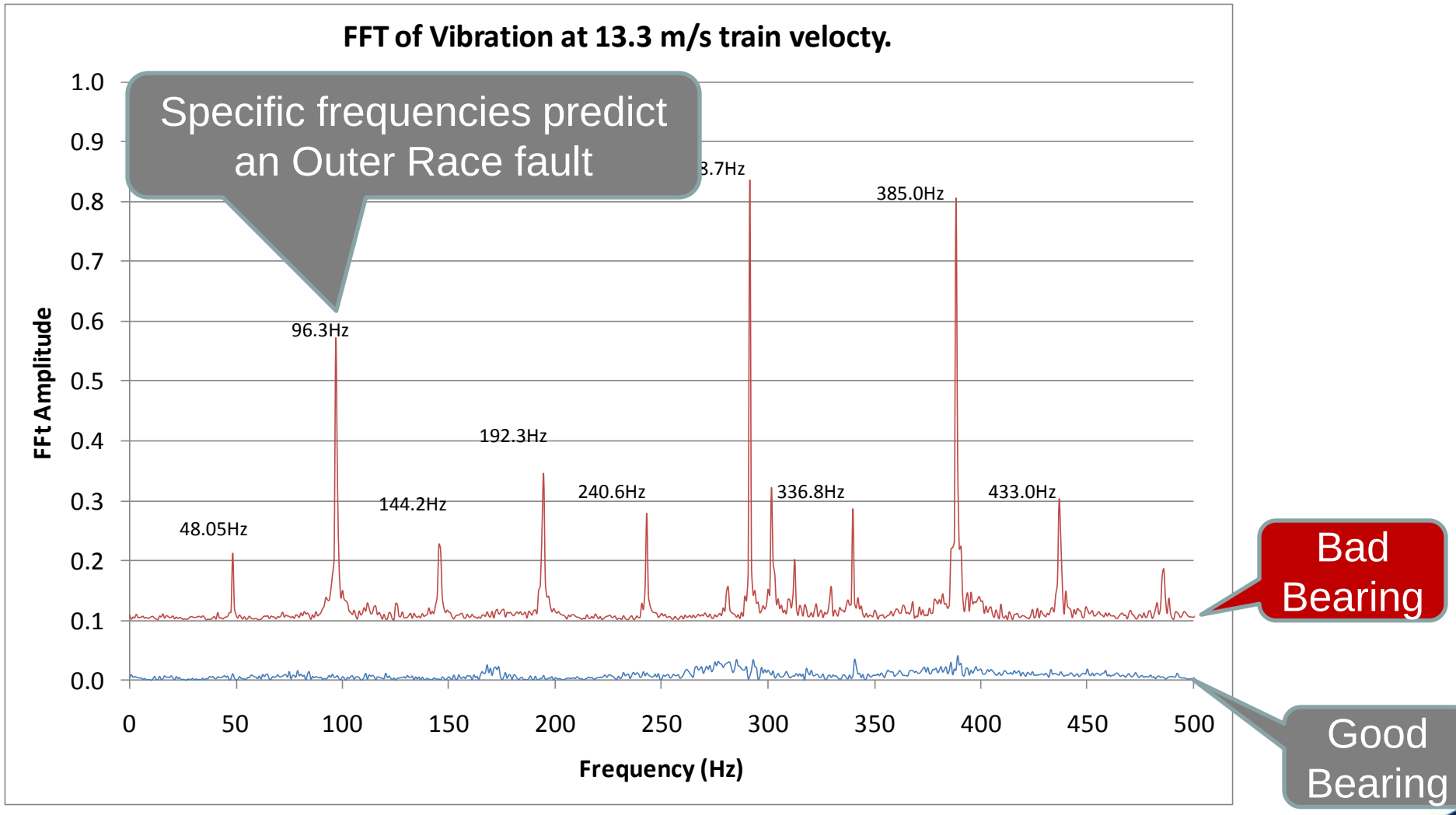
Shell Norway 2007

Power Generation Plant 2010

Train 2012



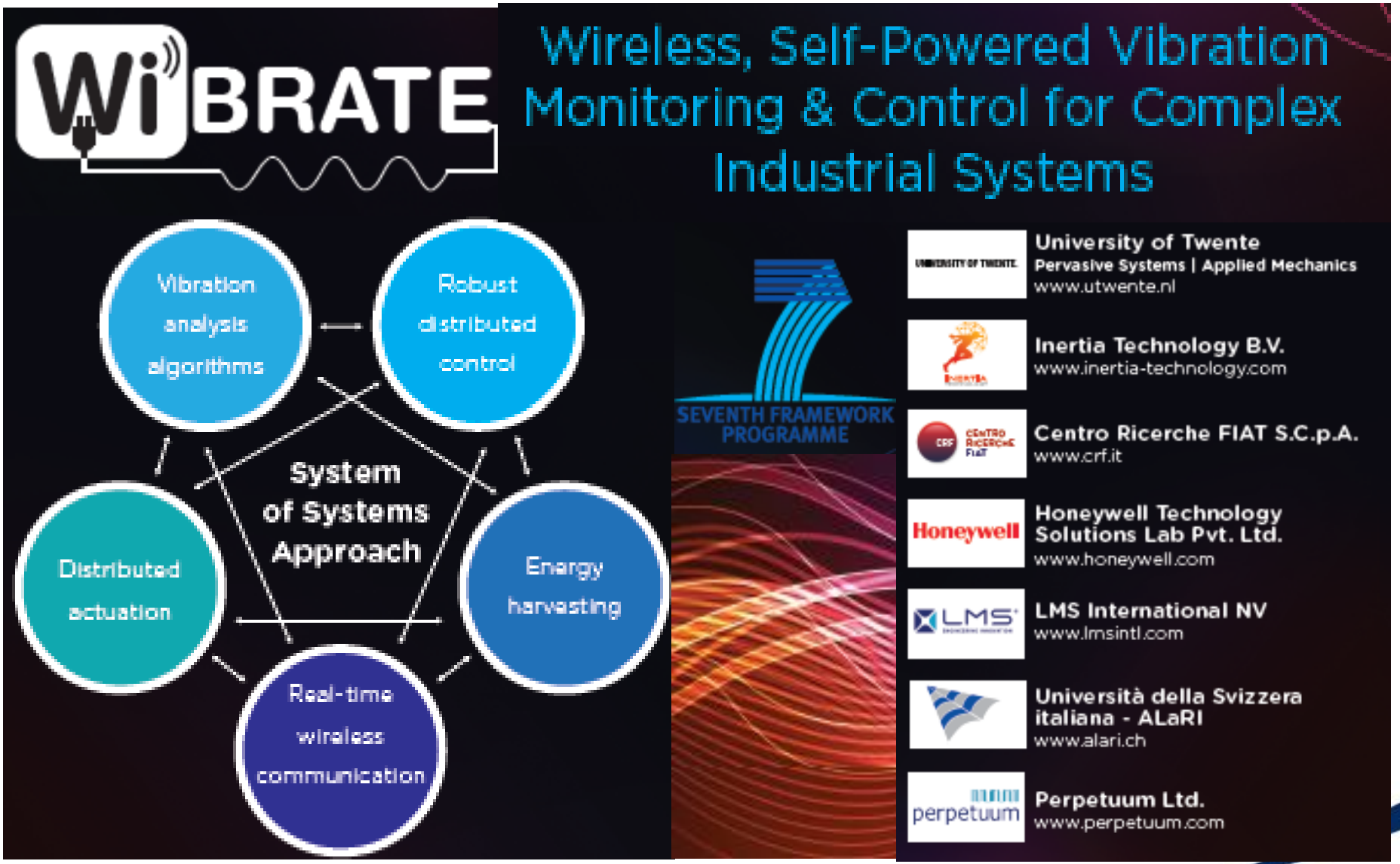
Results of Vibration Analysis



Damage as Predicted

Subsequent analysis of bearings show correct wheel and correct fault predicted

WiBRATE
Not just monitoring - also control



Conclusions

- Benefits and installation successes of WSN's resulting in explosive growth but power is major issue
- Energy Harvesting fit for application is ideal solution
- Development must match energy sources available in real world to power required
- Harvesters must be in complete compliance with application requirements
- Energy Harvesting is powering WSN's today