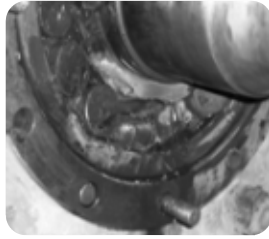


# Increase System Efficiency with Condition Monitoring

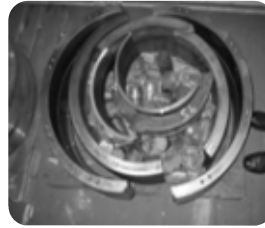
Control & Monitoring Technology Day  
National Instruments



## Collateral Damage



Bearing with problems  
\$5000 repair

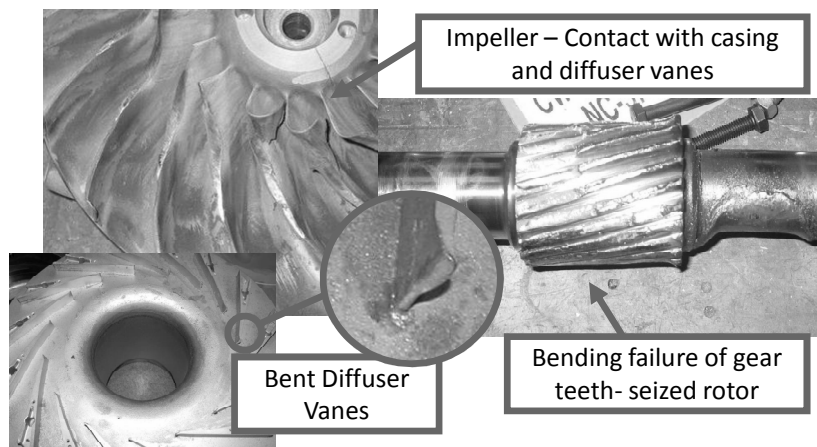


Bearing with problems not  
detected \$150,000 repair

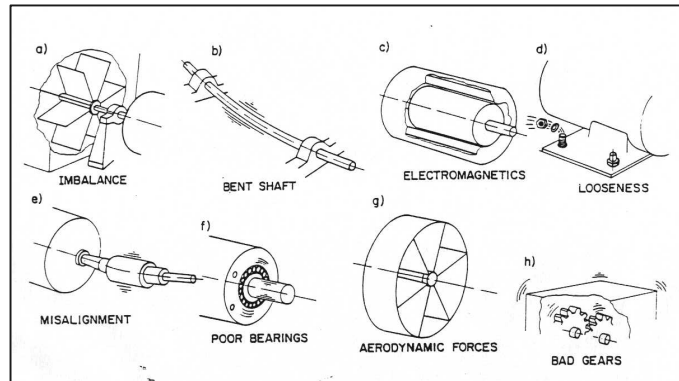
---

---

## Motivation of Condition Monitoring



## Types of Machine Failures

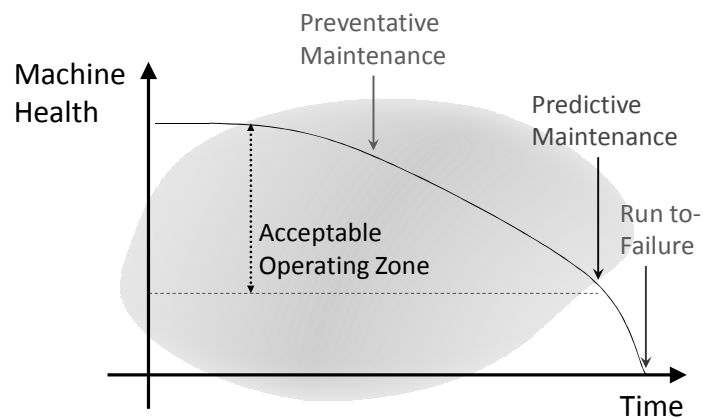


Sources of Mechanical Failure

## What is Condition Monitoring



## What is Condition Monitoring



## Machine Availability

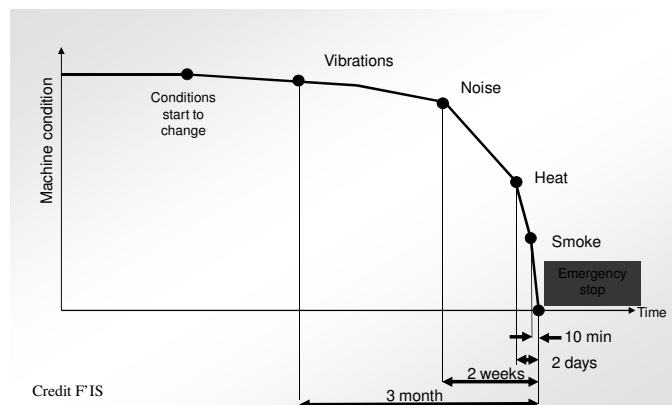




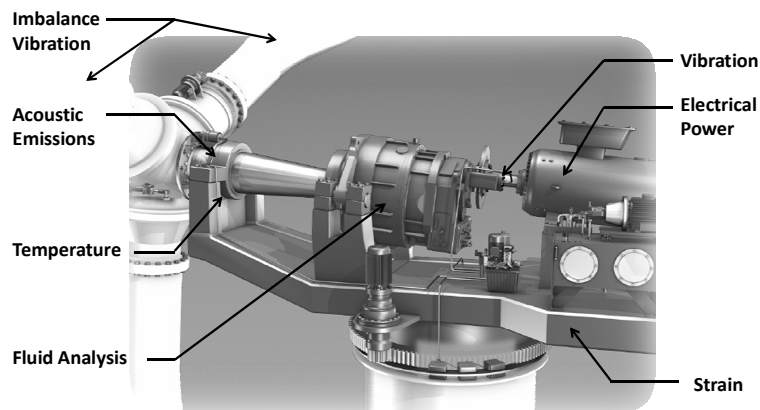
## Why Condition Monitoring?

<ul style="list-style-type: none"> <li>• Increase customer co</li> <li>• Increase production c</li> <li>• Reduce scrap and raw</li> <li>• Increase product qua</li> <li>• Reduce repair time ar</li> <li>• Lengthen maintenanc</li> <li>• Stop unscheduled ou</li> <li>• Optimize machine pe</li> <li>• Prevent catastrophic</li> <li>• Avoid injury, environr</li> </ul>	<div>Increase Revenue</div> <div>Quality Control</div> <div>Reduce Costs</div> <div>Production Assurance</div> <div>Safety</div>
---	--

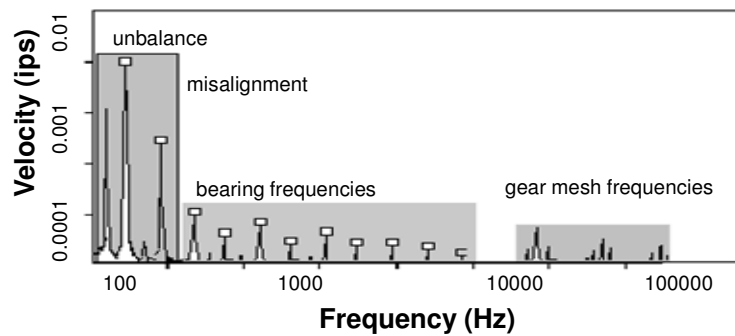
## What to Monitor and Test



## Condition Monitoring Signal Sources

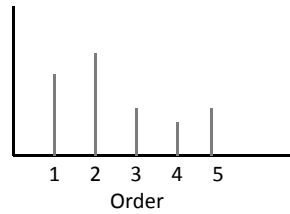
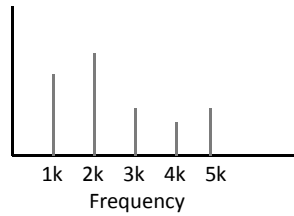
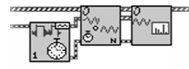


## Basic Fault Frequency Analysis

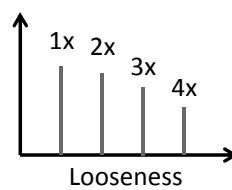
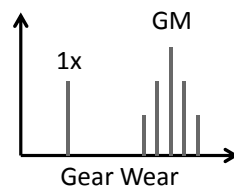
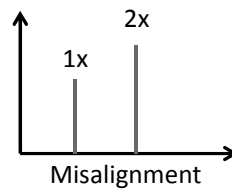
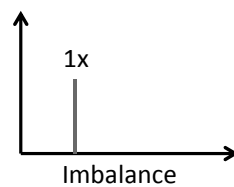


# Order Analysis

- Resample frequency information to order information

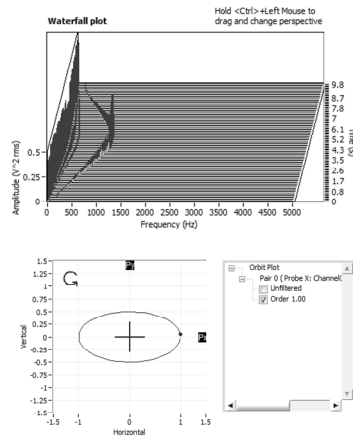


# Order Analysis



## Additional Signal Processing

- Waterfall
- Colormap
- Orbit Plot
- Shaft Centerline
- Envelope Analysis
- Limit Masks



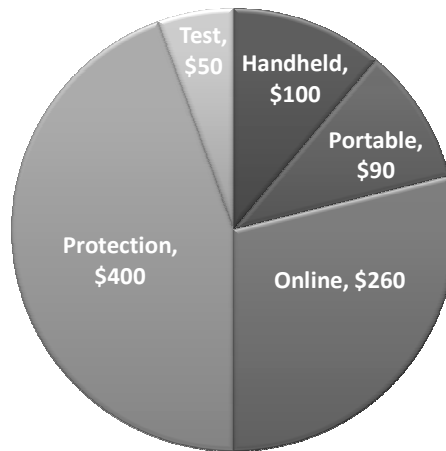
## Traditional Route Based Monitoring

- Small, portable data recorders
- Easy connectivity
- Basic analytics



## Types of Monitoring Today

Market Size (In Millions \$)



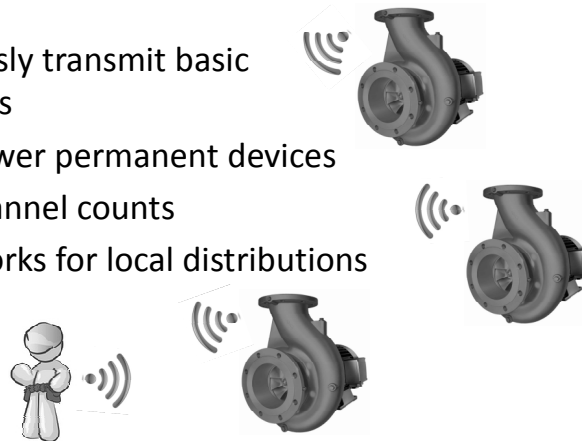
Source: Frost and Sullivan  
Market Survey

---

---

## Wireless Sensor Nodes

- Wirelessly transmit basic analytics
- Low power permanent devices
- Low channel counts
- Only works for local distributions



## Portable

- More advanced analysis
- Larger channel counts
- Usually used with a laptop

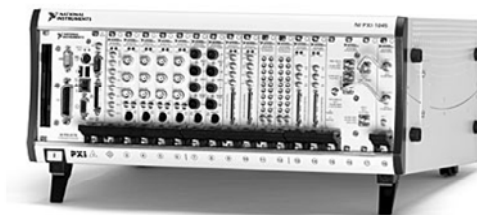


---

---

## Factory Assurance Test

- Large channel count
- Many different sensor types
- Lots of signal processing



## Online

- Embedded intelligence
- Limited signal processing
- 10's of channels
- High fidelity data



---

---

## Protection

- Triggers machine shutdown
- Safety certifications required

## Challenges in the Application Today

- Data overload
  - Remote locations
  - Prognostics
- 
- 

## Decision Based Data Logging

8 Accelerometers x 51.2 kS/s x 32 bits  
1.64 MB/s  $\approx$  **1 Terrabyte/week**

- Reduce volume of data by only recording relevant data based on:
  - Time
  - Measured Parameters
  - User Input





## Decision Based Data Logging

RMS Trend  
Channel



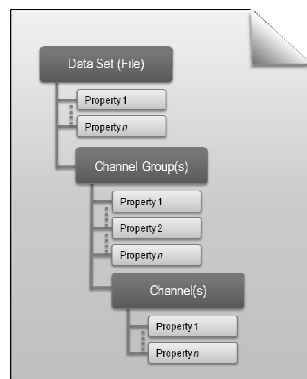
Time  
Waveform

Speed **150 CPM**

Sensor Location **Shaft 90 deg**

Operating Condition **High Load**

## TDMS File Format



- Single, streaming binary file
- Three levels of hierarchy for better organization
  - File, groups, and channels
- Customizable, descriptive properties at each level

Read TDMS Files in Excel, Math Packages, C, etc.

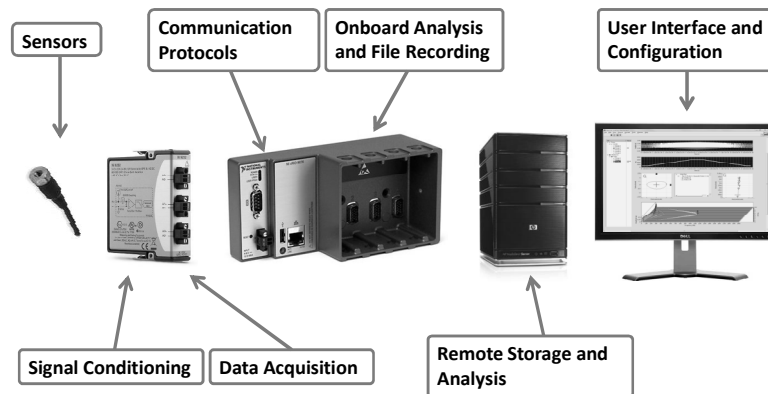
## Remote Data Collection

- Assets are geographically distant
  - Analysts spend too much time collecting
- 
- 

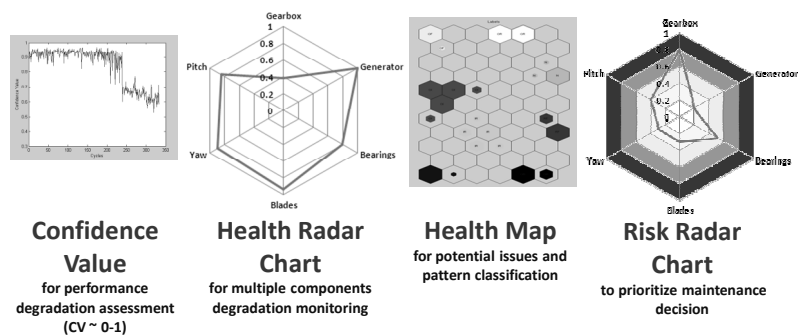
## Remote Data Collection

- Data acquisition
    - Vibration
    - Temperature
    - Strain
    - Voltage
    - 4-20 mA
  - Onboard storage
  - Communication
    - TCP/IP
    - FTP
    - Modbus
  - Rugged casing
  - Onboard computer
    - decision based data logging
- 
-

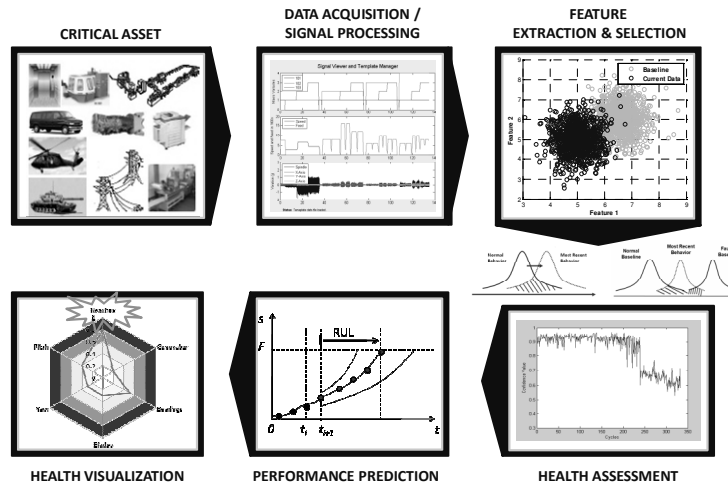
## Embedded Condition Monitoring System



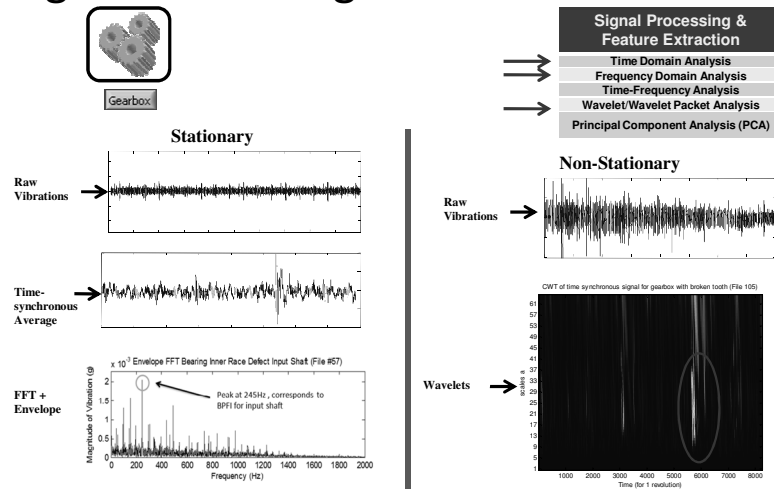
## Prognostics



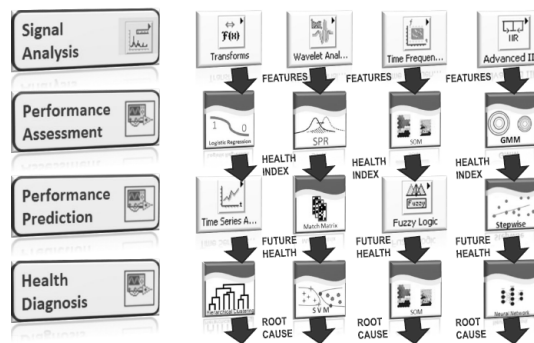
# IMS Instrumentation Approach



## Signal Processing & Feature Extraction

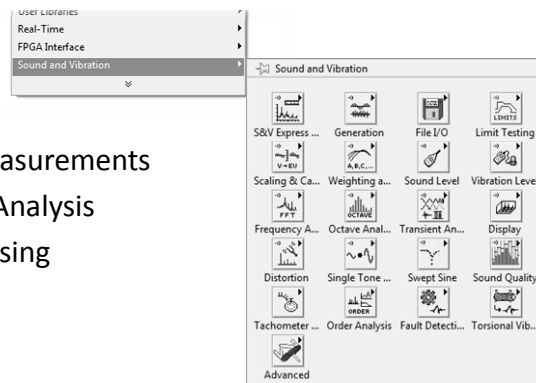


## Watchdog Agent™ Prognostics Toolkit for LabVIEW



## Sound and Vibration Measurement Suite

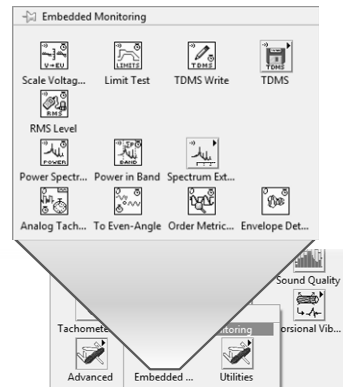
- Vibration Measurements
- Tachometer Analysis
- Signal Processing
- Visualization



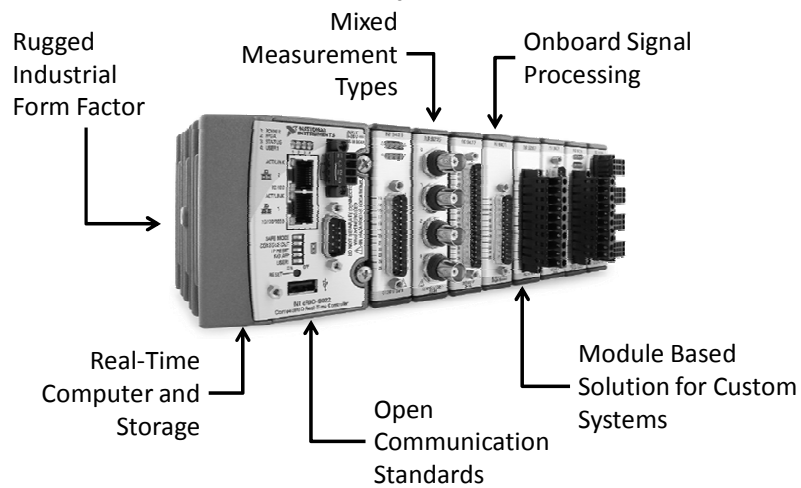
# Sound and Vibration Measurement Suite

## Optimized for Embedded

- Similar functionality
- Analysis only, no GUI



## NI CompactRIO



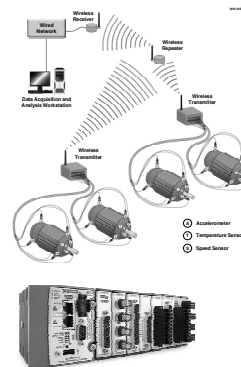
## Measurement Modules

- ✓ Accelerometer
- ✓ Strain Gauge
- ✓ Load Cells
- ✓ Digital I/O
- ✓ Microphone
- ✓ DC Voltage
- ✓ Thermocouples
- ✓ 4 to 20mA
- ✓ Time (GPS)
- ✓ RTD
- ✓ Resistance
- ✓ Power (Volts/Amps)

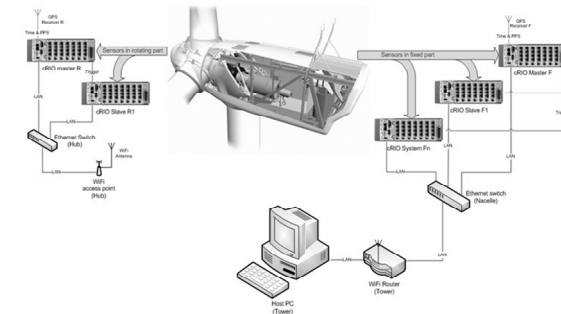


# Online Monitoring of Nuclear Power Reactors

- **Products:**  
Sound and Vibration, LabVIEW, NI CompactRIO
- **The Challenge:**  
Developing an online monitoring (OLM) solution for boiling water reactors, which contain machinery in hazardous and difficult-to-access areas.
- **The Solution:**  
Using an integrated, embedded NI CompactRIO system to develop the EWW-1 and OLM-32 hardware to provide live, wireless monitoring of plant assets in conjunction with AMS' monitoring software



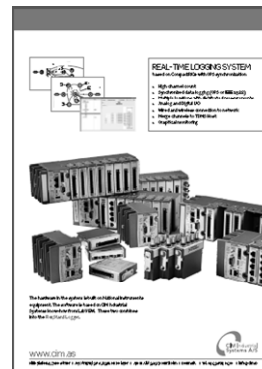
## Generic high-channel-count system for design verification and reliability tests



- Vestas Wind Systems

*The big challenge is the sample-by-sample data synchronization between different sensor types in the rotating hub and the nacelle.*

## FLEXSTAND LOGGER





## Embedded Measurement System for Remote Monitoring of Wind Turbines

**Industry:**  
Energy/Power

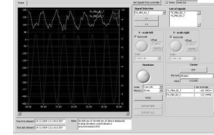
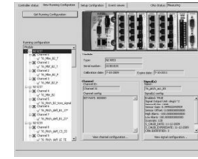


**Products:**  
Reconfigurable Chassis, Real-Time Module, NI 9853, NI 9239 BNC,  
Real-Time Controllers, NI 9237, NI 9401, LabVIEW

**The Challenge:**  
Replacing existing remote monitoring systems with new monitoring systems that are time synchronized for performing measurements at a higher sample rate and with higher accuracy. The system will be installed on remote wind turbines and cannot be replaced or repaired easily.

**The Solution:**  
Developing a flexible NI LabVIEW software application based on the NI CompactRIO platform that not only acquires measurements, but also filters analog and digital signals, applies a timestamp, temporarily stores data to prevent data loss, and transmits data to a database server.

<http://sine.ni.com/cs/app/doc/p/id/cs-13221>



---

---

## Open Pit Mining Shovels

- **Products:**  
Sound and Vibration, LabVIEW, NI CompactRIO
- **The Challenge:**  
Developing a highly specialized continuous monitoring system for electromechanical mining shovels to enable a predictive maintenance strategy for these critical machines.
- **The Solution:**  
Creating a fully functional, tailor-made vibration and stress continuous monitoring system using the NI CompactRIO platform and NI LabVIEW software.



## Oil Well Fracture Pump Monitoring and Analysis using LabVIEW and NI RIO Technology

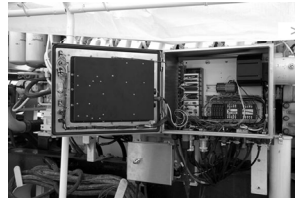
**Industry:**  
Oil and Gas



**Products:**  
FPGA Module, LabVIEW, Single-Board RIO,  
LabVIEW Real-Time Module, CompactRIO

**The Challenge:**  
Building an advanced monitoring system that can survive being mounted directly to an oil well servicing pump in a rugged environment while performing advanced analysis on sensor data.

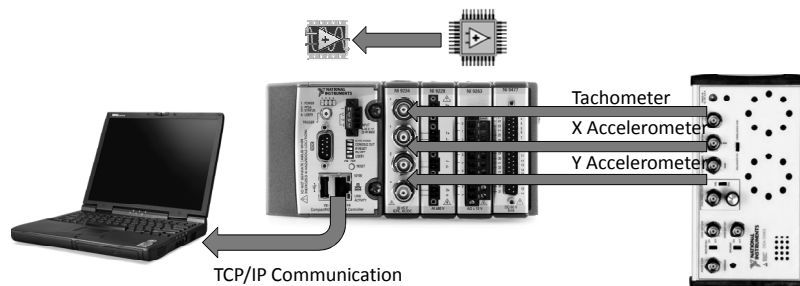
**The Solution:**  
Using NI CompactRIO and NI Single-Board RIO hardware along with NI LabVIEW software to design a pump monitoring system that monitors the operating parameters of a reciprocating pump used in well servicing applications.



<http://sine.ni.com/cs/app/doc/p/id/cs-11315>

## Demonstration

- Embedded Vibration Monitoring



**Thank you for attending the  
NI Embedded Control & Monitoring  
Technology Day**

**For more information, please visit  
[www.ni.com/embeddedsystems](http://www.ni.com/embeddedsystems)**

