Acoustic Emission Monitoring of locomotive traction motor bearings proves successful setting the stage for Wind Turbine application

Early Warning System

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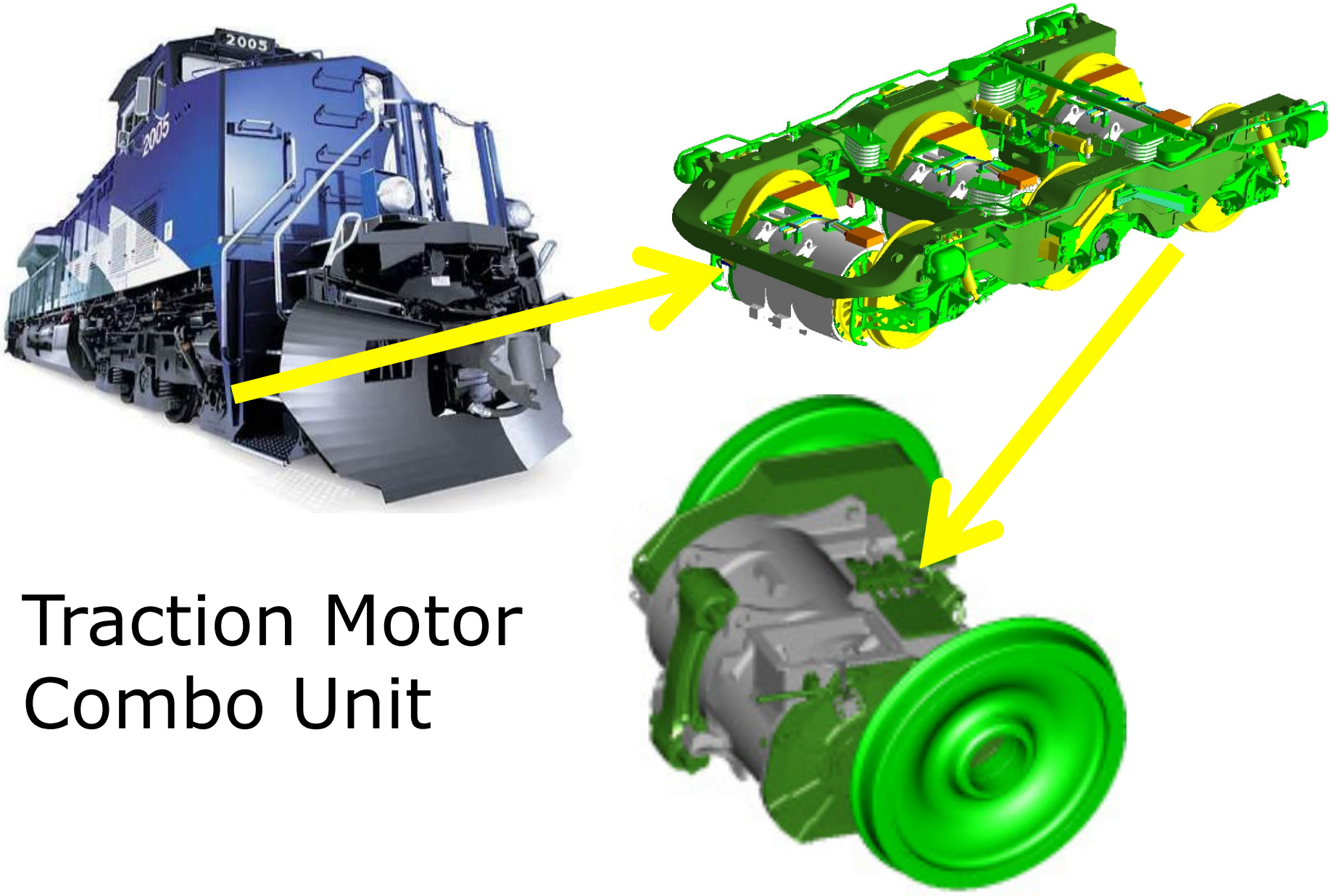
Wind Energy Workshop, New Orleans, OCT 15, 2013

The Problem

- Large US Railroad experiencing major failures on the traction motor combo unit bearings.
- Failures caused:
  - Derailments – "Off track experiences"
  - Blocked tracks
  - Out of service locomotives
  - Expensive repairs in the field
- Locomotive service center missing damaged bearings.

- Service center contract cost ~ $40K/failure

- Cost to Railroad for failure on tracks minimum $100K +

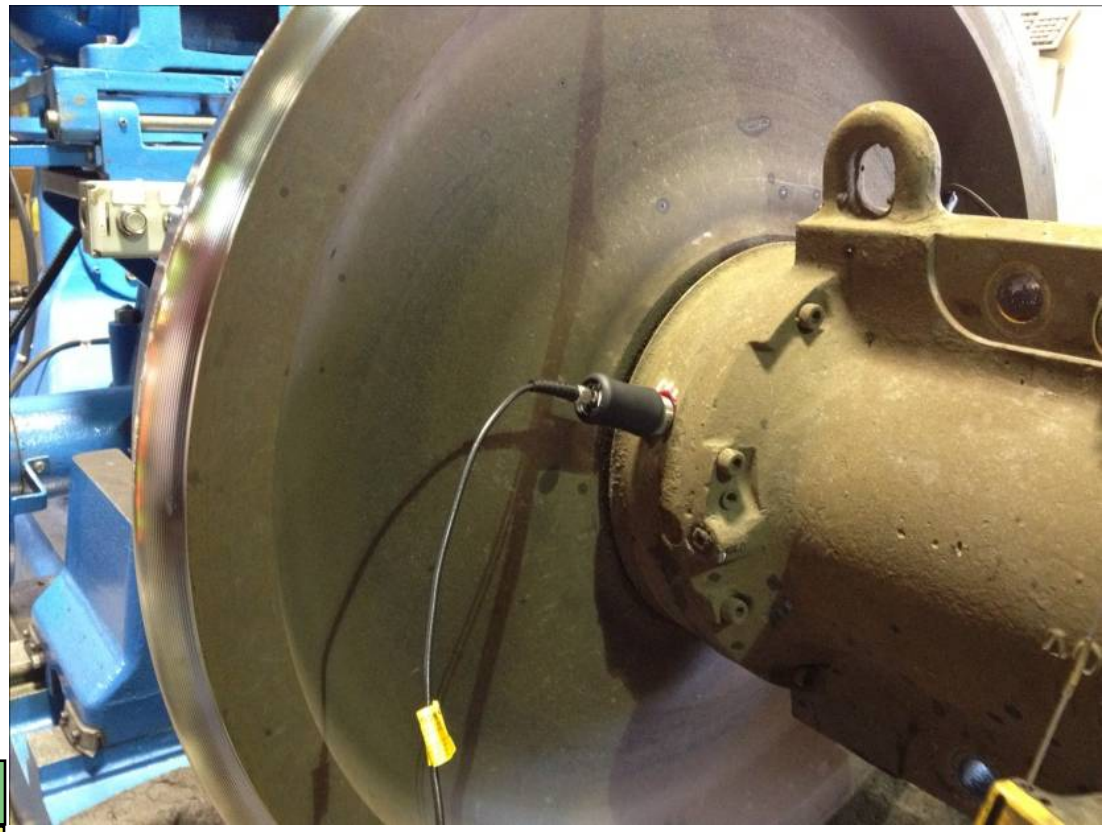


Traction Motor Combo Unit

Courtesy of ParkerKittiwake

Kittiwake Holroyd Acoustic Emissions - Machinery Health Monitoring

A simplified, effective system



Distress® less than 5 is very good

Distress® between 5 & 10 is OK

Distress® 10 or above is Suspect

Courtesy of ParkerKittiwake

Bearing 1 - before and after re-greasing

Before re-greasing

Distress® = 14
Vibration Meter = 0.03

After re-greasing

Distress® = 20
Vibration Meter = 0.02

AE indicates “Suspect, VIB indicates “Normal”

Courtesy of ParkerKittiwake

Bearing 2 – Before and after re-greasing

Before re-greasing

Distress® = 14

Vibration Meter = 0.04

After re-greasing

Distress® = 13

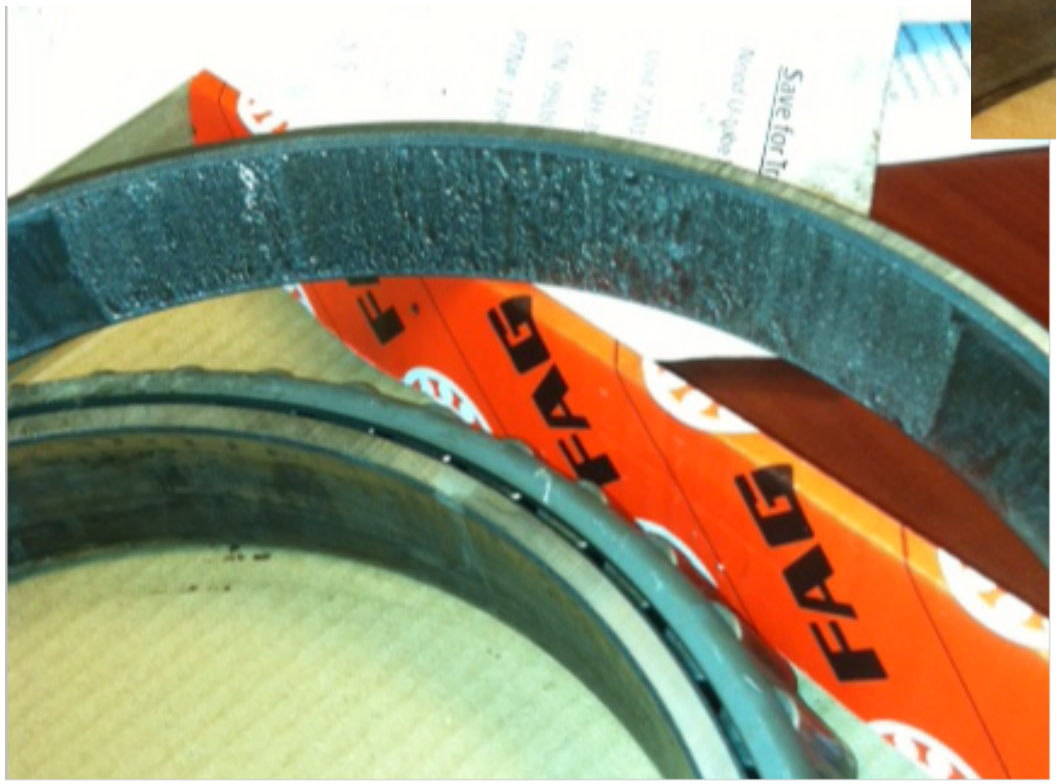
Vibration Meter = 0.04

AE indicates “Suspect, VIB indicates “Normal”

Courtesy of ParkerKittiwake

Traction Motor 1

- 6 locomotives Tested
- Allowed to pull two worst cases



Significant Wear

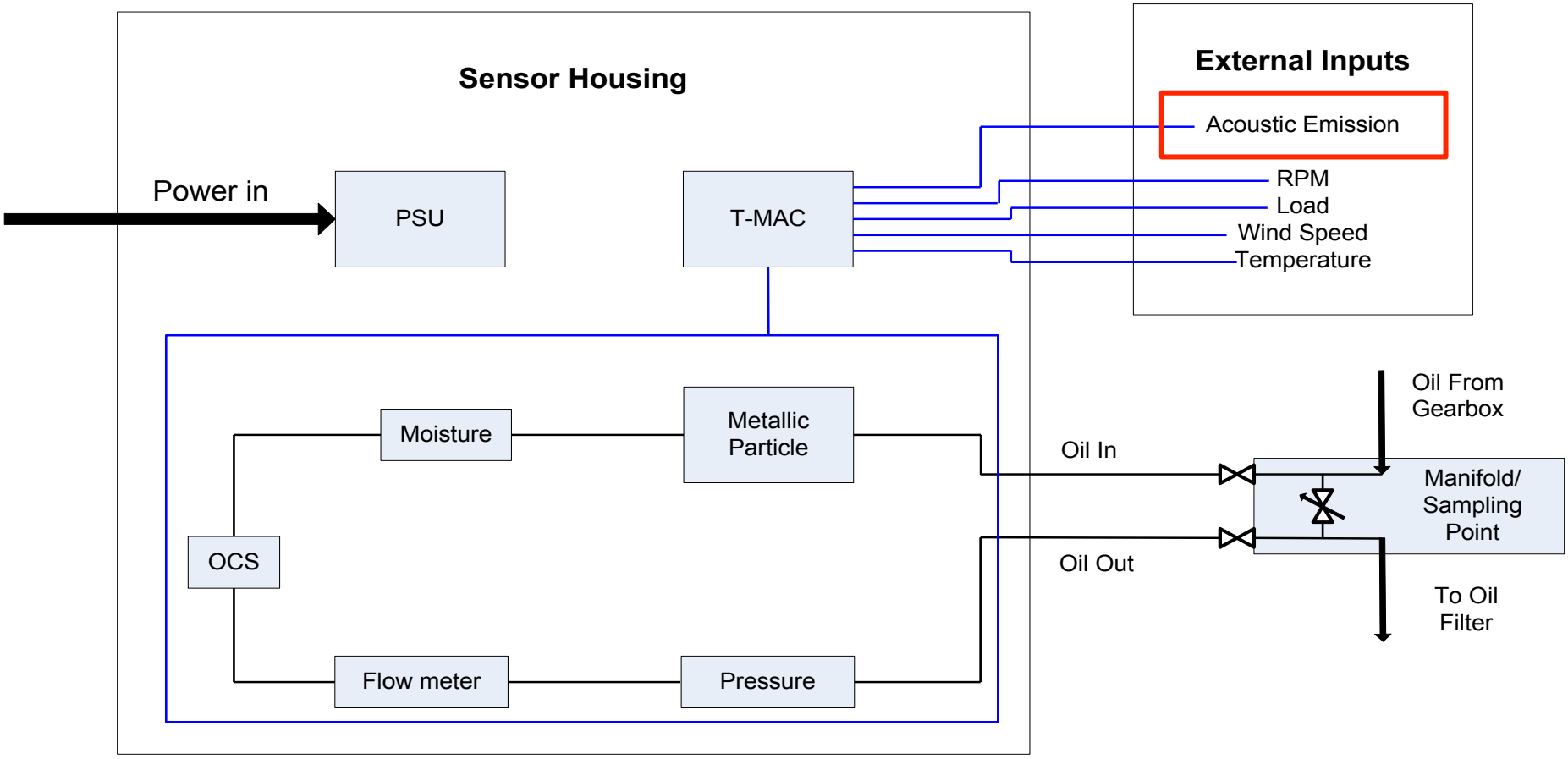
Courtesy of ParkerKittiwake

Traction Motor 2

Significant Wear

Courtesy of ParkerKittiwake

Proposed Monitoring System

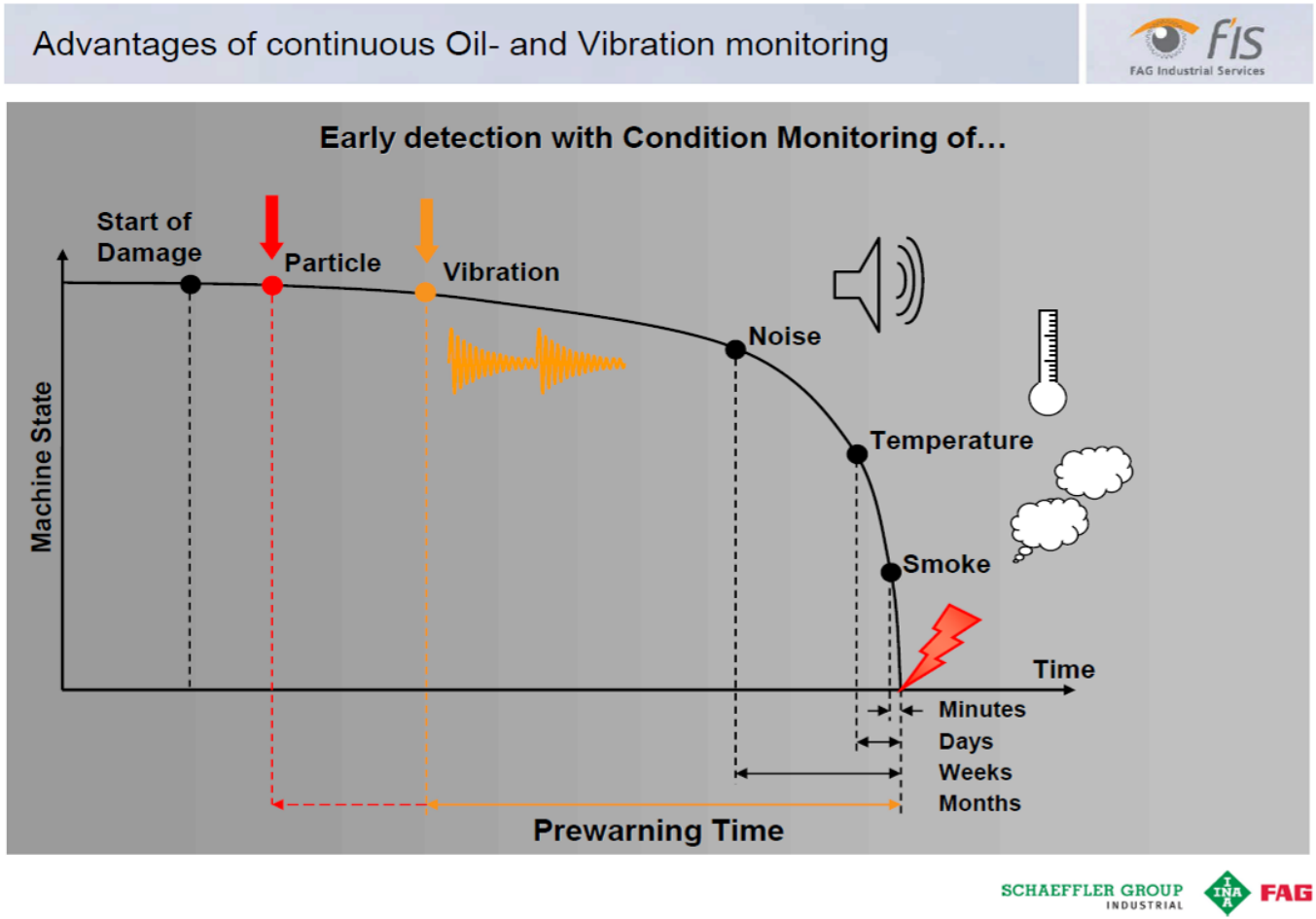


Courtesy of ParkerKittiwake

What the Sensors Measure

- Wear Debris sensor to monitor metallic (ferrous and non ferrous) debris within the gearbox oil – indicates wear on gear teeth, bearings etc
- Oil Condition sensor – gives an overall health picture of gearbox oil condition
- Oil Moisture sensor – monitors water ingression into oil
- Acoustic Emissions sensors – placed on main gearbox bearings to “listen” for any degradation of either roller elements or lubrication issues
- All integrated into a single box with simple connections to the turbine (Oil in, oil out, power)

What does it offer - Wear Debris & Vibration

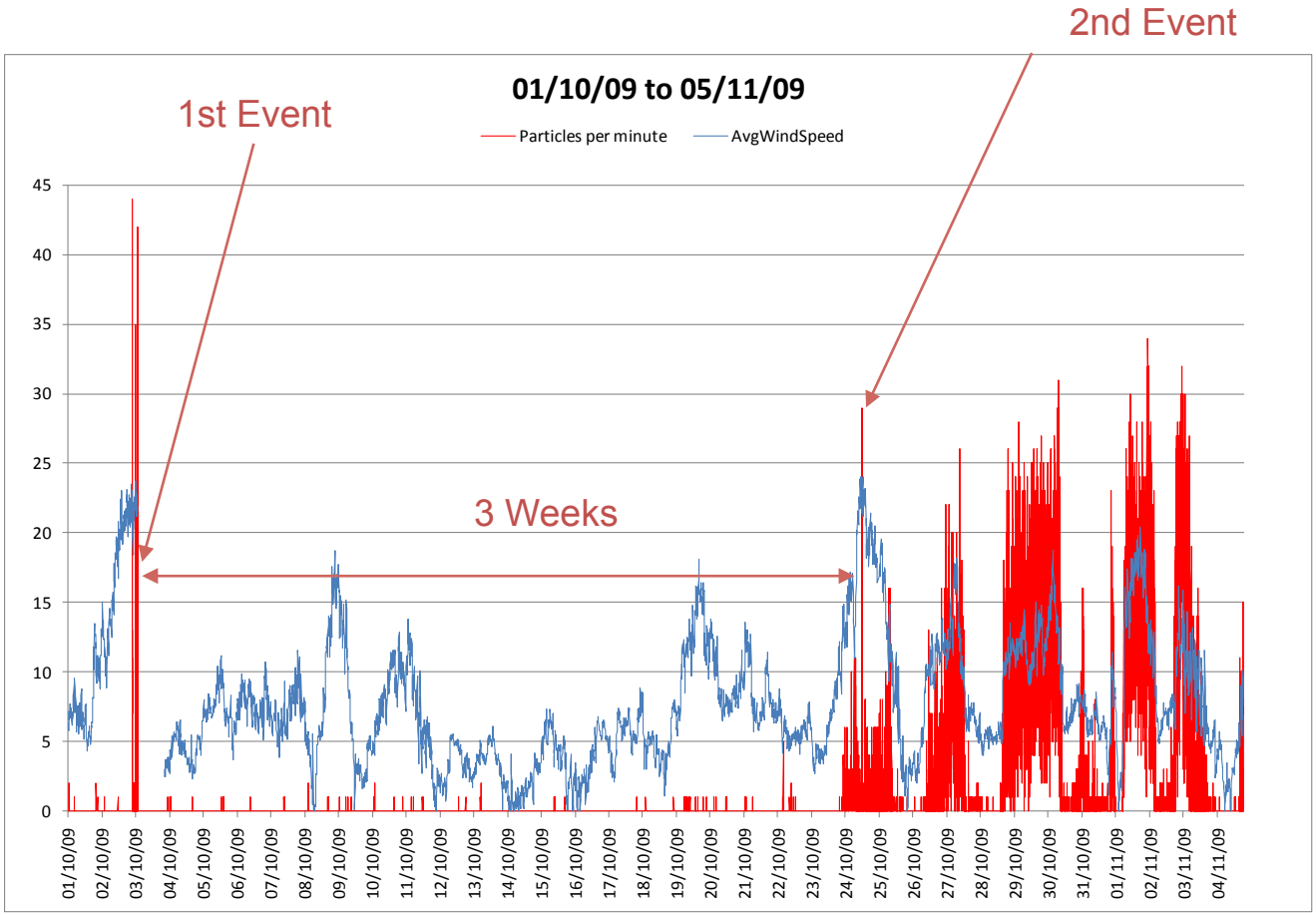


Wear Debris Sensor

- ***Detects Metallic Wear Debris Particles in Oil***
- ***Reports Size, Number, Ferrous/Non-Ferrous & Rate***
- ***Puts particle numbers into different "Bin's" depending on size and material composition (Fe vs. Non-Fe)***
- ***Early Detection of Increased Wear, Change in Wear Mechanism, Advanced Wear and Catastrophic Wear***

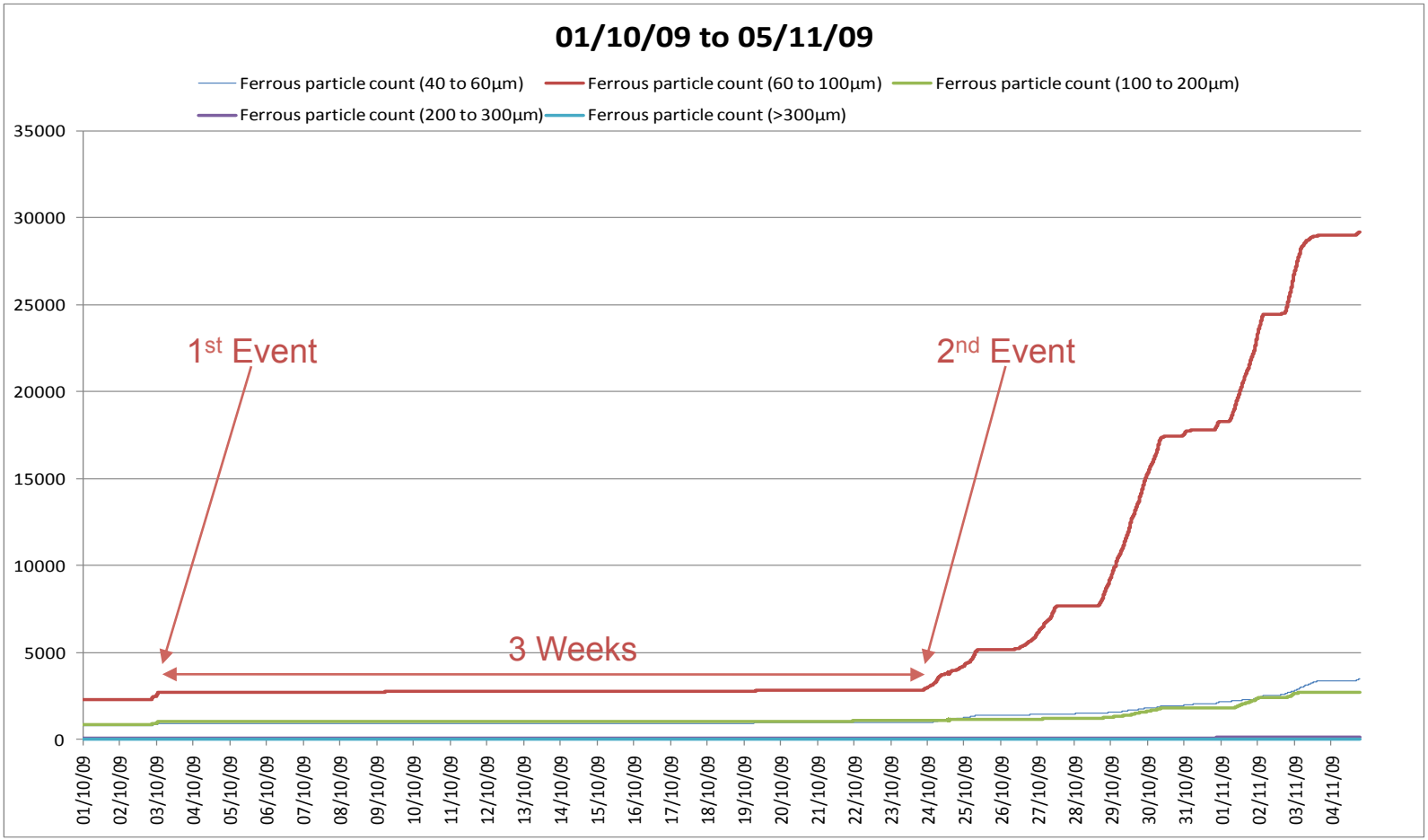
Courtesy of ParkerKittiwake

Wear Events – Wear Rate vs. Wind Speed



Courtesy of ParkerKittiwake

Wear Events – Particles Generated

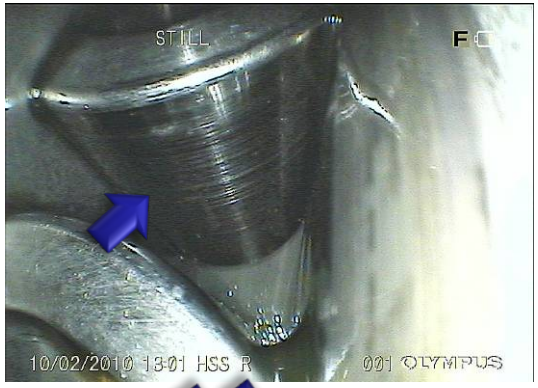


Courtesy of ParkerKittiwake

Post Event Gearbox Inspection

Magnetic Dip-Stick

Ferrous Metallic Wear Debris Evident



High Speed Shaft Roller Element

Circumferential Surface Scoring Evident

Shaft Gears

Slight Scuffing Evident

Courtesy of ParkerKittiwake

Moisture Sensor

- Smart sensor with internal processing power
- Wide range of interface options
- Stainless Steel housing - rugged and long life
- High integrity sealing
- Thread options, for quick and easy installation

- Robust & IP67 rating
- High pressure rated
- -40°C to 100°C
- Temp sensing +/-1%
- Saturation +/-2%

Courtesy of ParkerKittiwake

Oil Condition Sensor

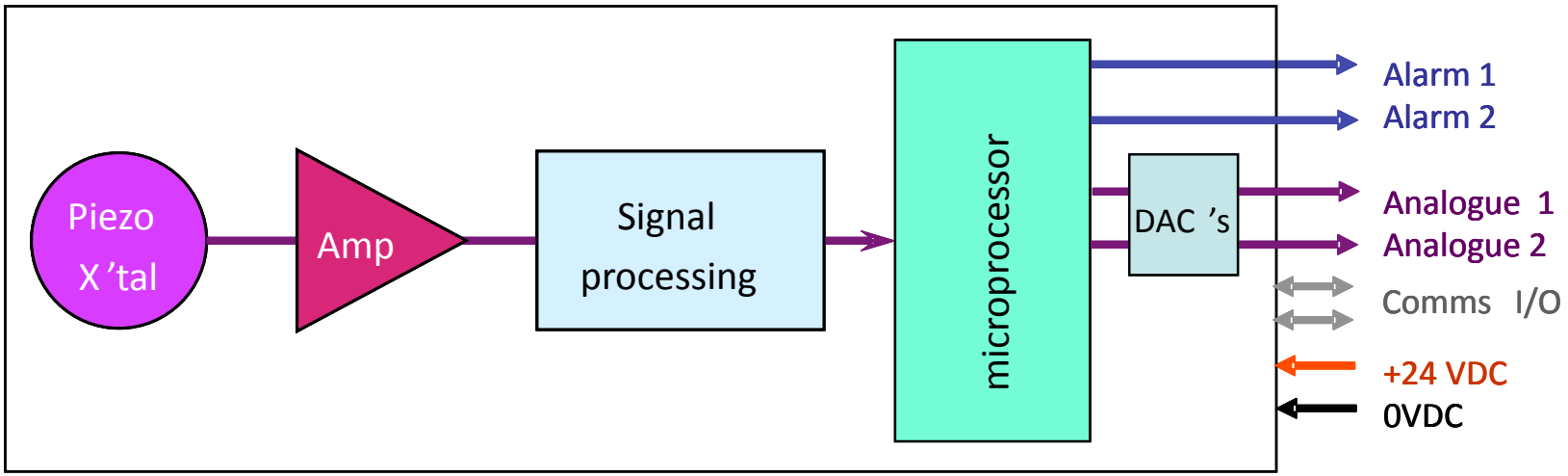
- Stainless Steel housing – rugged and long life performance
- Internal processing power – offers wide interface options
- Widely used ½" BSP thread – quick and easy installation to a wide range of machinery
- Gold oil sensing contact – long life and sensitivity
- High integrity sealing using standard automotive techniques

- Unique, patented technology
- Robust & IP67 rated
- -40°C to 100°C
- Temp sensing +/-1%
- Output as Oil Quality Units

Courtesy of ParkerKittiwake

Acoustic Emissions – DS1 Smart Sensor

- Smart AE sensor that connects direct to PLC's, SCADA etc.
- For speeds down to 35 rpm.
- Internally calculates & outputs *Distress*® & *dB Levels*.
- Built-in alarm with hold-off & user set level criteria.
- Set-up via PC interface.



MHC – DS1 sensor

Courtesy of ParkerKittiwake

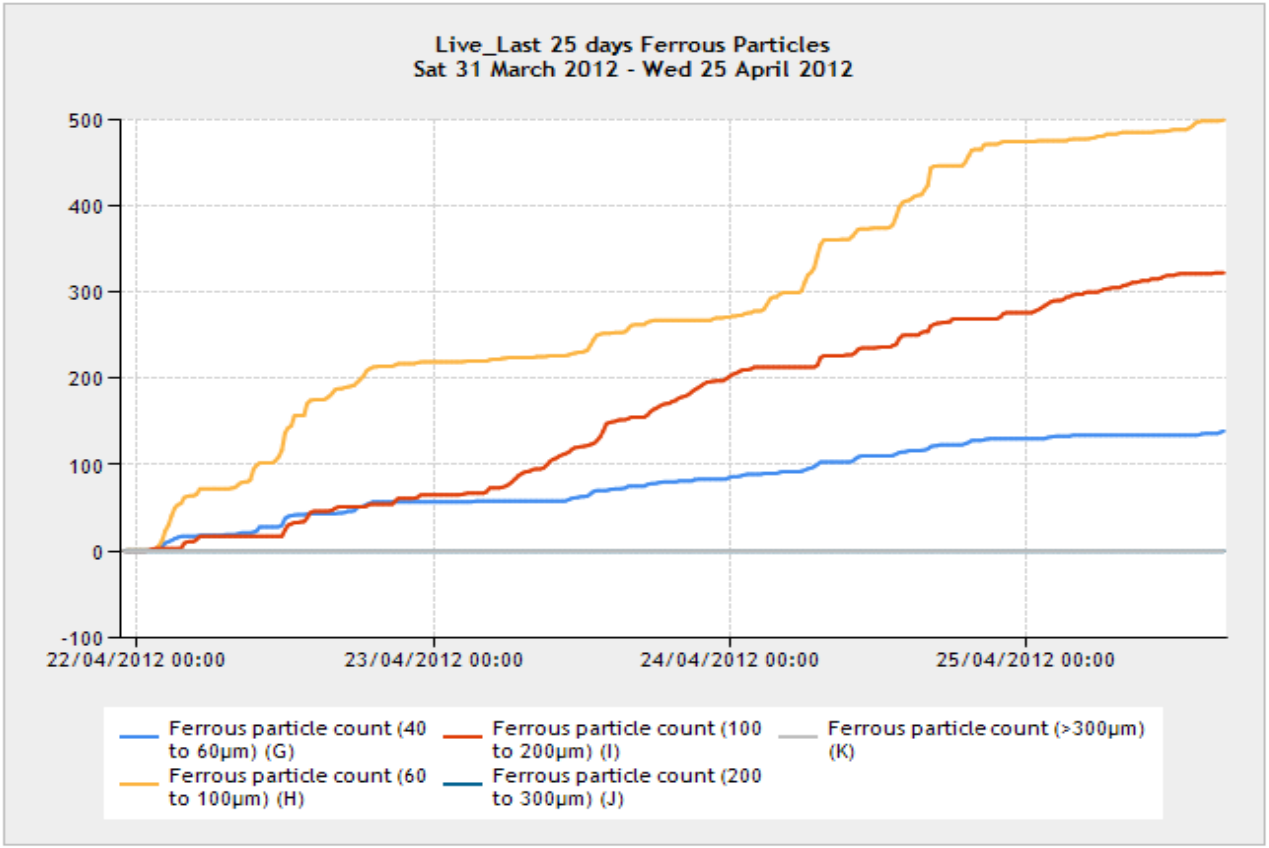
Data Acquisition and Reporting

- Utilise a T-Mac system for data acquisition from sensors
- Depending on sensors deployed, communication is achieved internally via RS232, RS485, 4 – 20 mA current loops, 0 - 10 volts etc. Easy to add in other external sensors (i.e. anemometers, rpm meters etc)
- External communications achieved using a Quad band GPRS Modem
- Switched Power and Relay outputs available for control of other equipment
- All measured values available through real time web interface. User settable alarms and e-mail notifications available for instant alerts of issues

Courtesy of ParkerKittiwake

Real Time Web Interface

LIVE_LAST 25 DAYS FERROUS PARTICLES

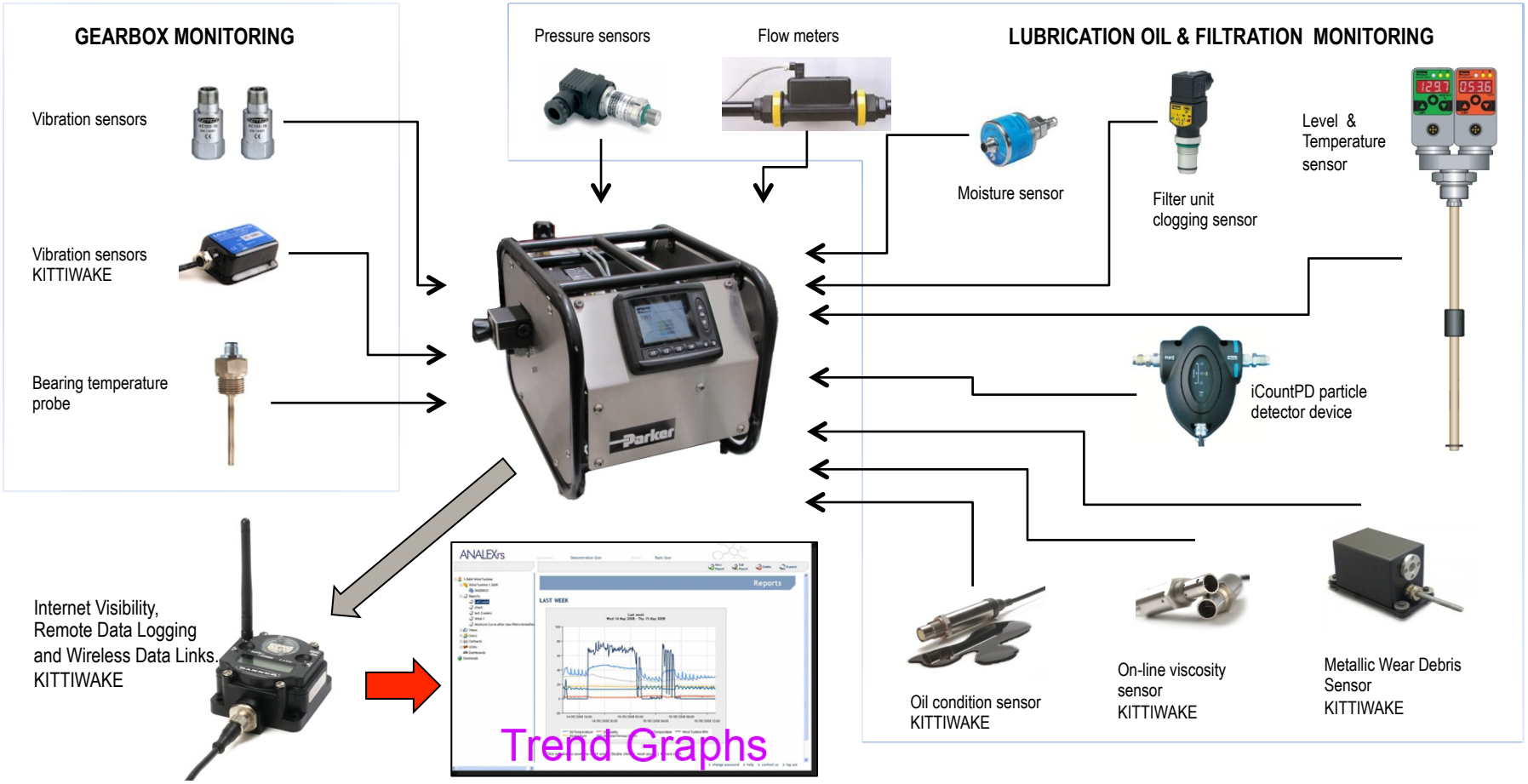


Click and drag to zoom the chart area. | Double click to reset zoom. | Expand chart

Courtesy of ParkerKittiwake

Early Warning System [EWS] Combining Oil Analysis & Vibration

- Health management technology for Wind Gearboxes = EWS
  - HFDE - Condition Monitoring solution combining existing Parker products with new products from Kittiwake aquisition
  - Final product will lead to a Predictive Maintenance solution on Gearboxes
  - Target customers Wind Turbine OEMs, Gearbox manufacturers, service cos



Courtesy of ParkerKittiwake