Reliability of GE's 1.5MW Turbine
A Component View

John T. Murphy
Product Service and Warranty
GE Wind Energy

June 17, 2009

imagination at work

Wind Services – GE Perspective

GE differentiation

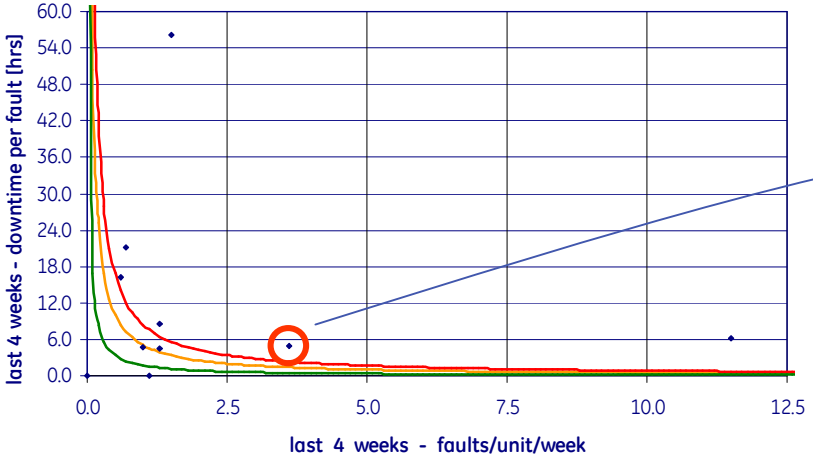
- Resources to scale
- Fleet understanding
- Technology

Scale to 20% → managing large systems

- Organization
- Processes
- Systems and Metrics

Cumbersome at 1000 units
Effective at 10,000
Essential technology at 100,000

Top Level Metrics Drive Reliability Focus

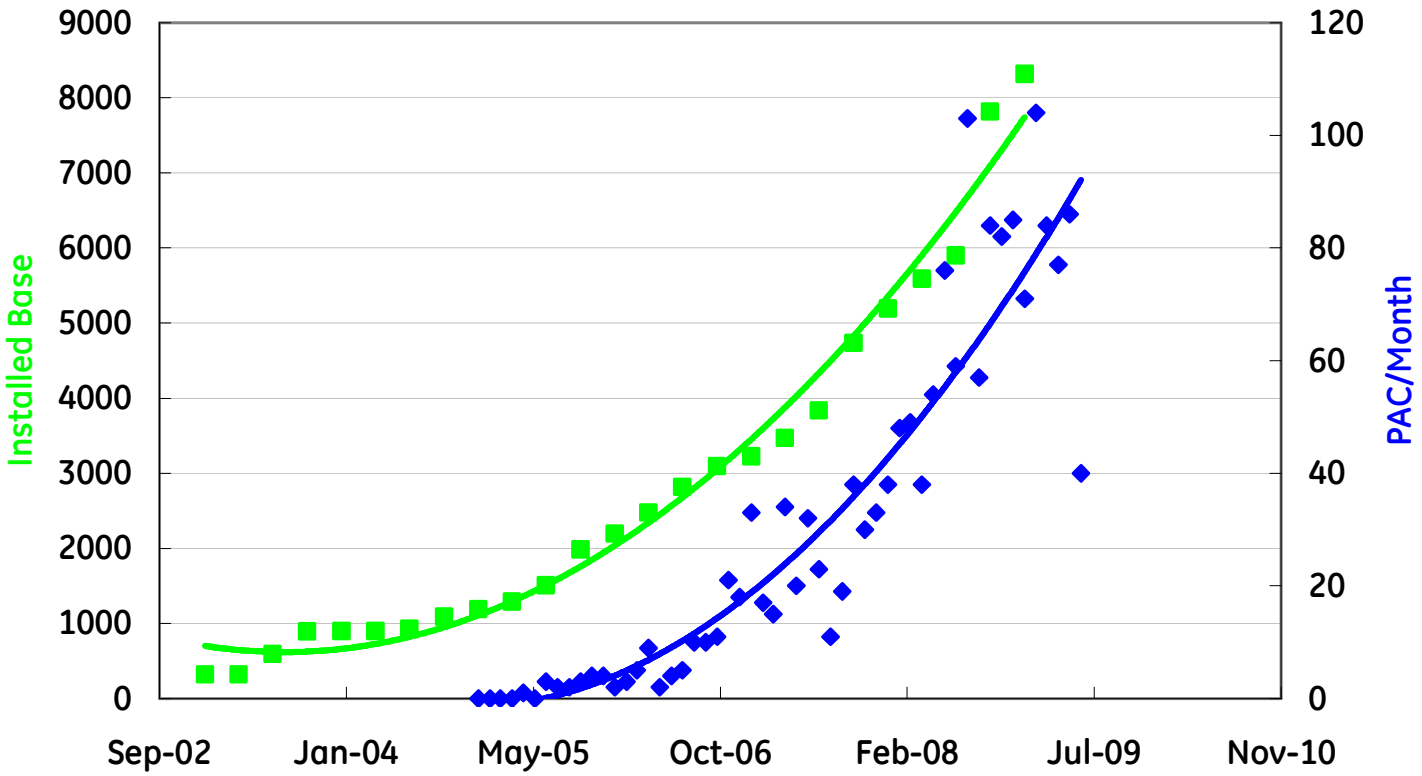


09FW21 Availability Review

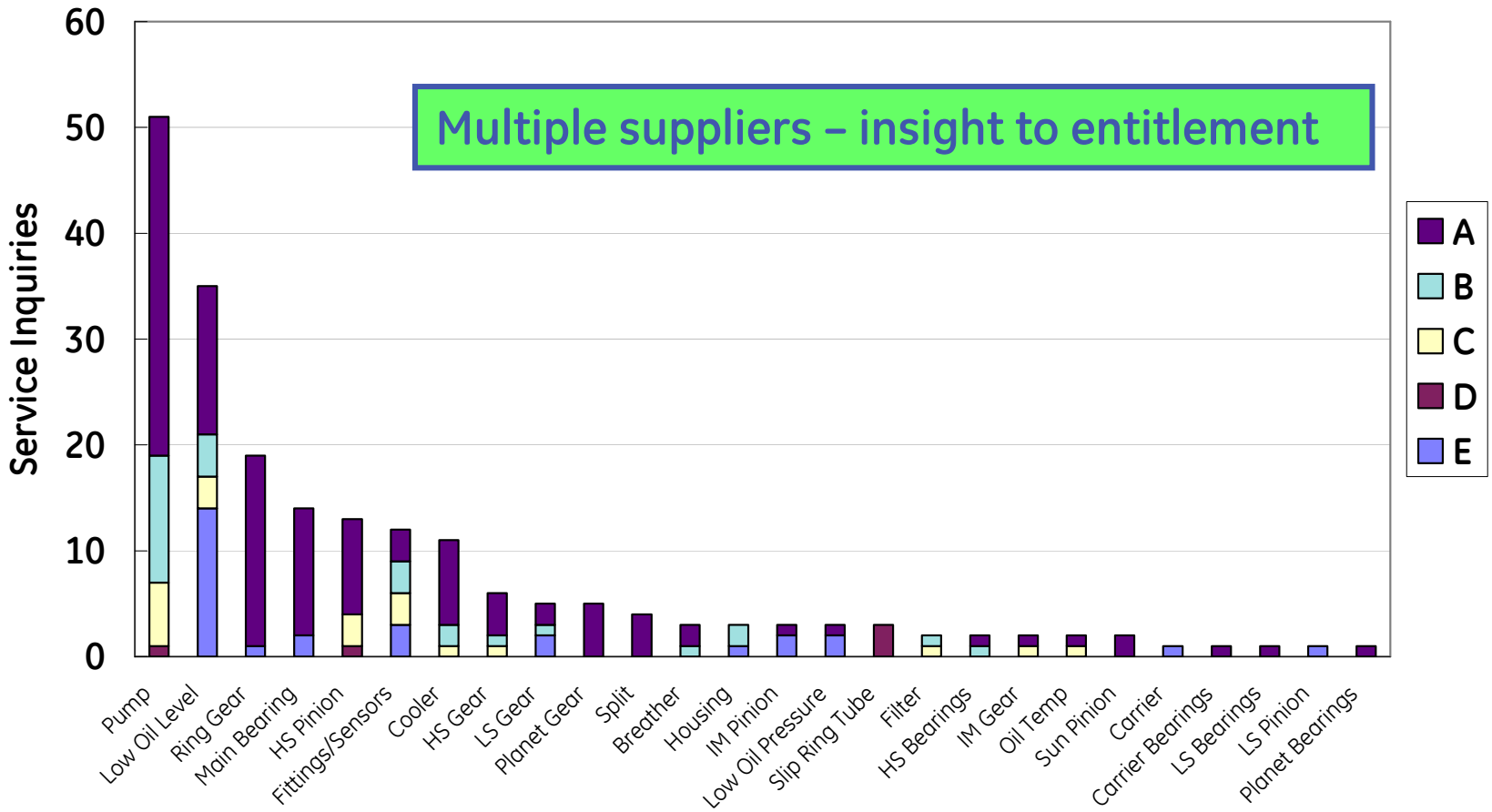
turbine	Avail FW21	Relia FW21	fault rate	DT/Fault [hrs]
Froidchapelle 2	91.1	91.9	3	5.0
Froidchapelle 7	98.7	98.7	6	0.4
Froidchapelle 8	100	100	1	0.0
Kleisthoehe II 8	96.1	98.4	0	0.0
Kleisthoehe II 9	98.3	99.8	1	2.9
Wilhelmshaven 2.5xl DEWI	98.8 (95.7)	100	0	0.0
FLEET	97.2	98.1	1.8	3.1

Mandate:
"The best-performing fleet in the world."

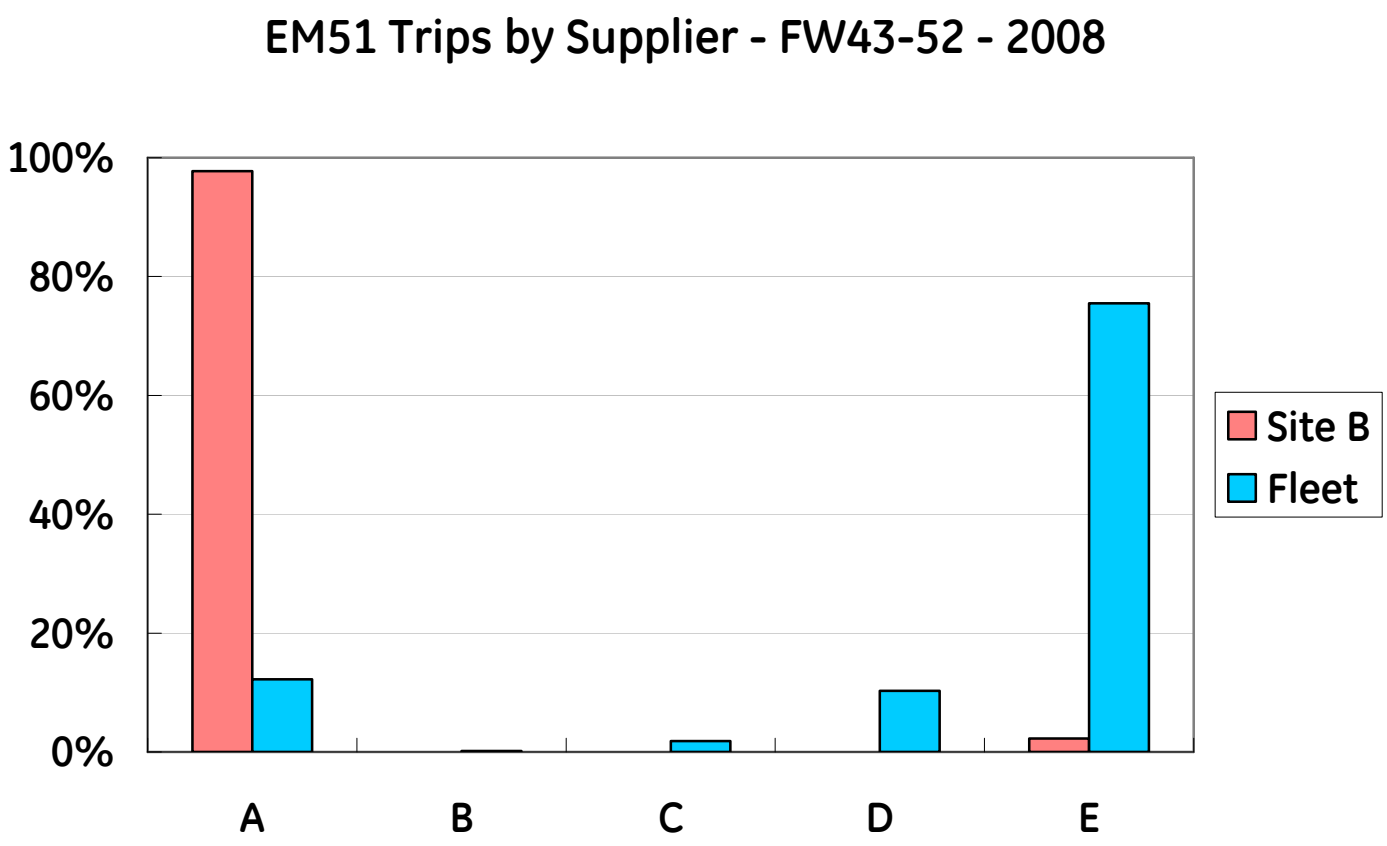
Fleet and Services Growth



Gearbox Issue Breakdown

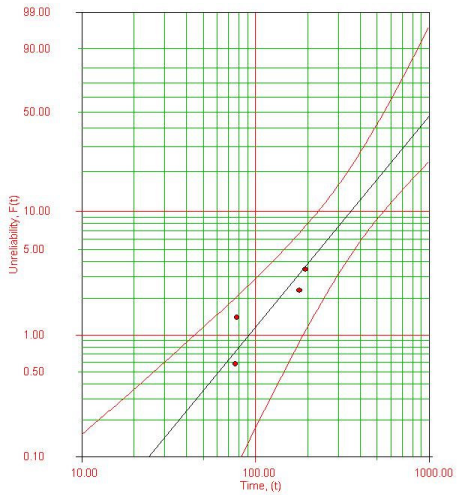


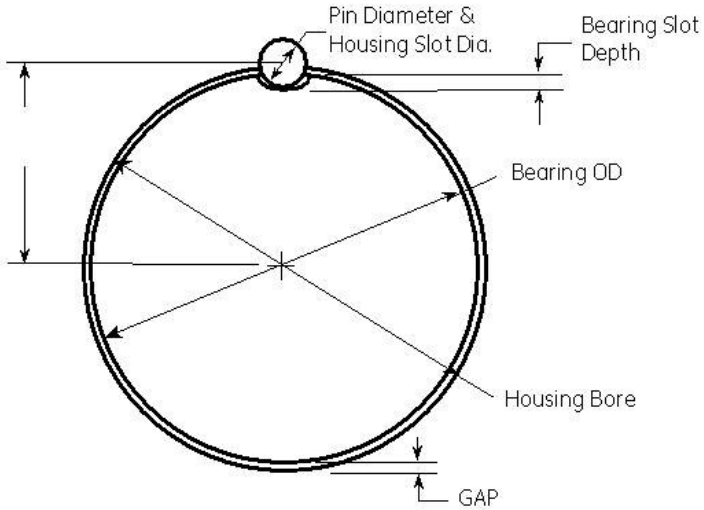
Site B vs. Fleet – Gearbox Low Oil Faulting



GE Fleet knowledge informs corrective actions for site issues

Supplier A High-Speed Bearing Failure

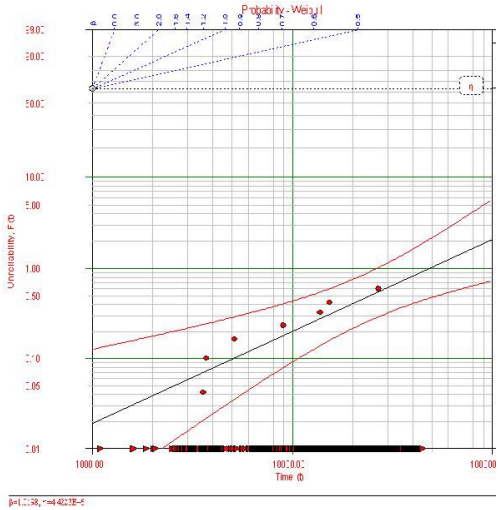




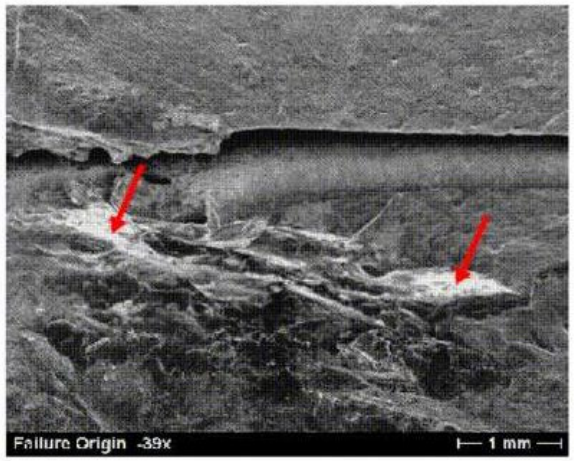
’07 – 1.7, 1300 hrs

Failure of HS shaft tapered roller
RCA: root cause fit tolerance, housing detail
Identified LAT, monitor, replace as required
Weibull would have predicted >150 failures
11 total incidents, all repaired up tower

Supplier B Sun Pinion Failures

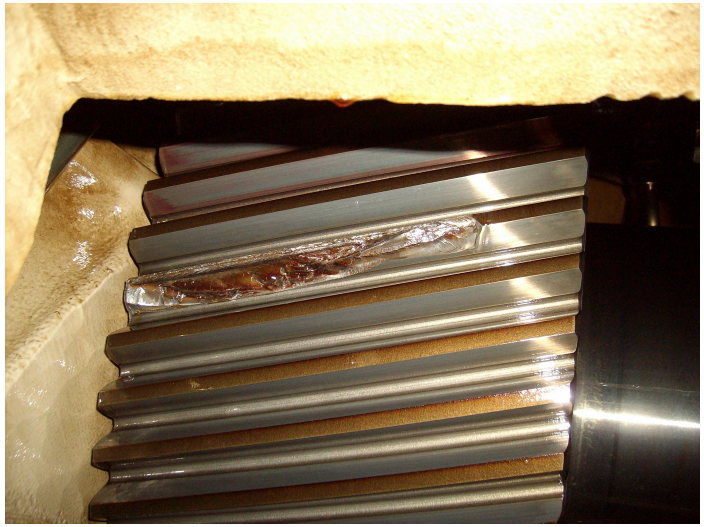


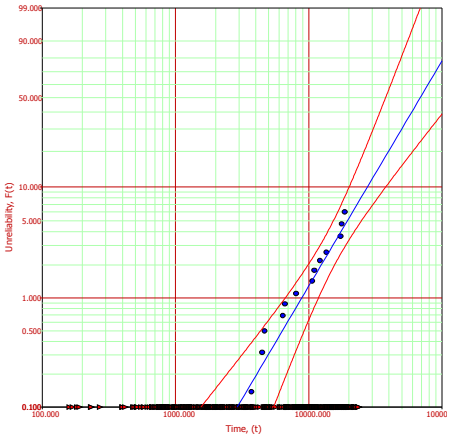
’08 – 1.0, 4.4M hrs



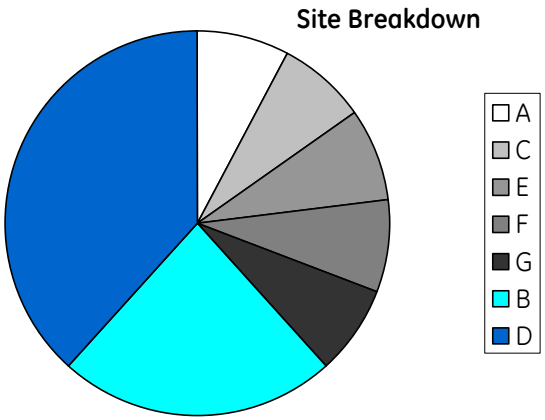
Fracture of sun pinion gear teeth
RCA with supplier
Majority associated with 1 melt
Identify affected population, monitor
No additional failures since ‘08
GE supplier audit, process improvements
Supplier proactively tightening specifications

Supplier C LS Gear Failure



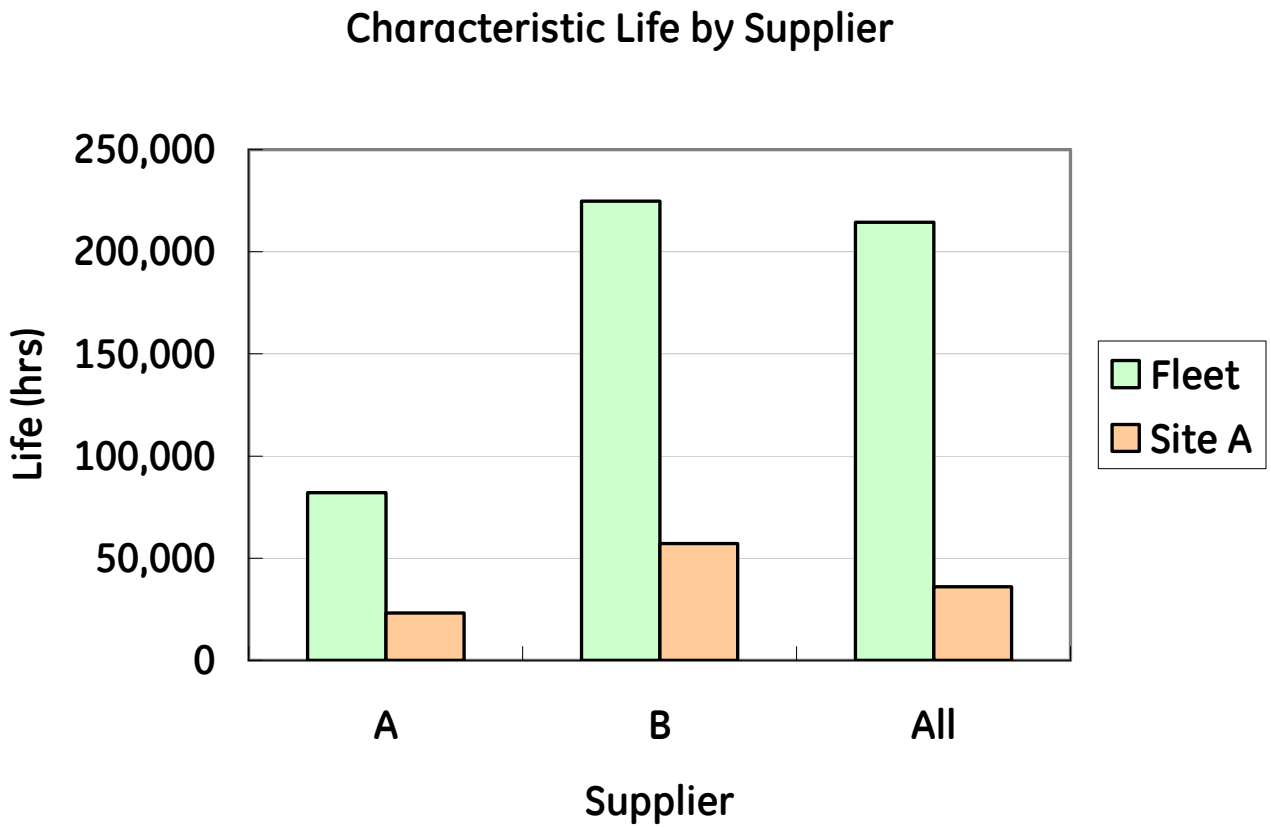


’09 – 2.1, 82k hrs



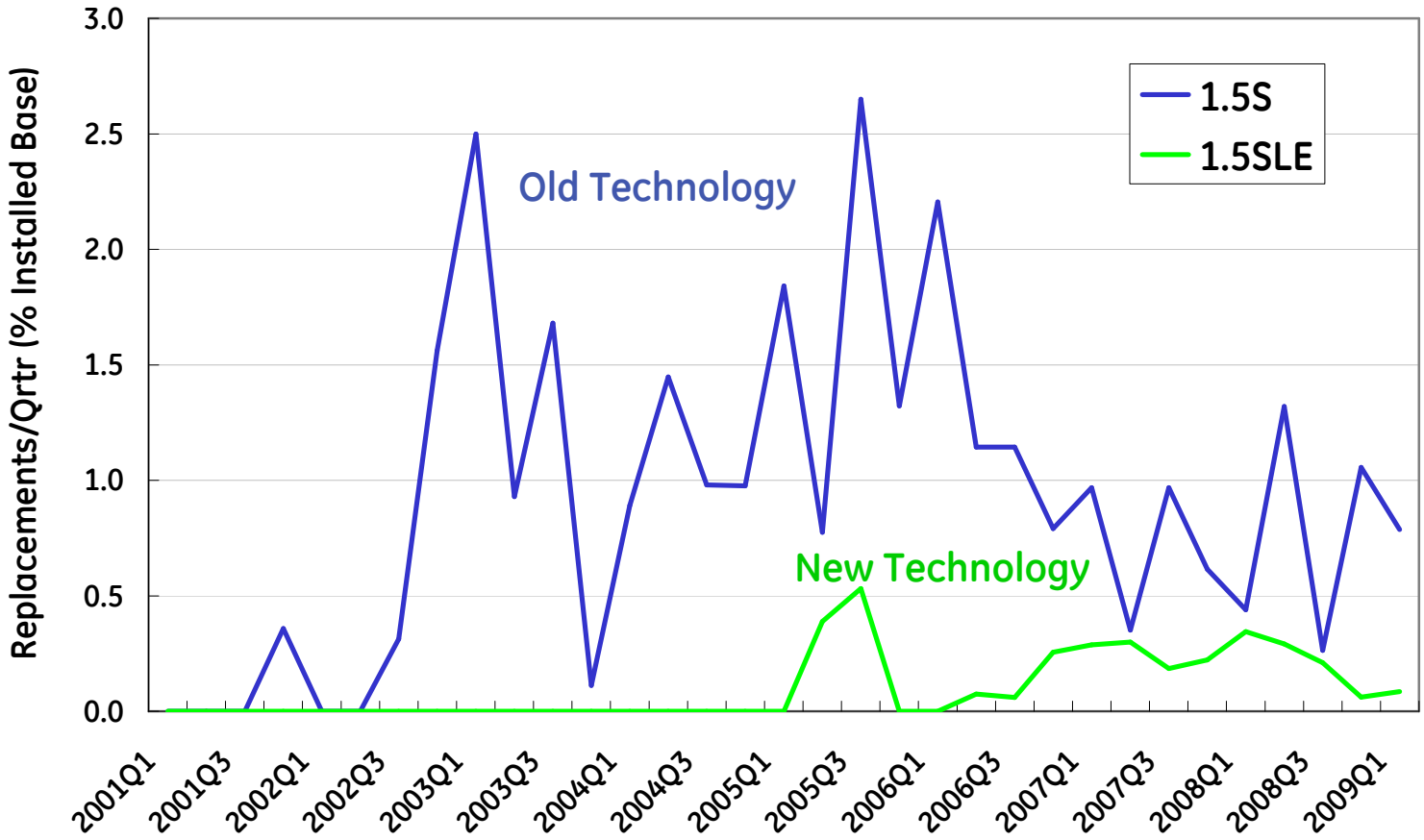
Fracture of 1 or more LS gear teeth
Failure not always obvious
    Failure times distorted
Site concentration
    2/3 of all failures at only 2 sites
RCA needs to accommodate operator

Site A vs. Fleet – Gearbox Replacement



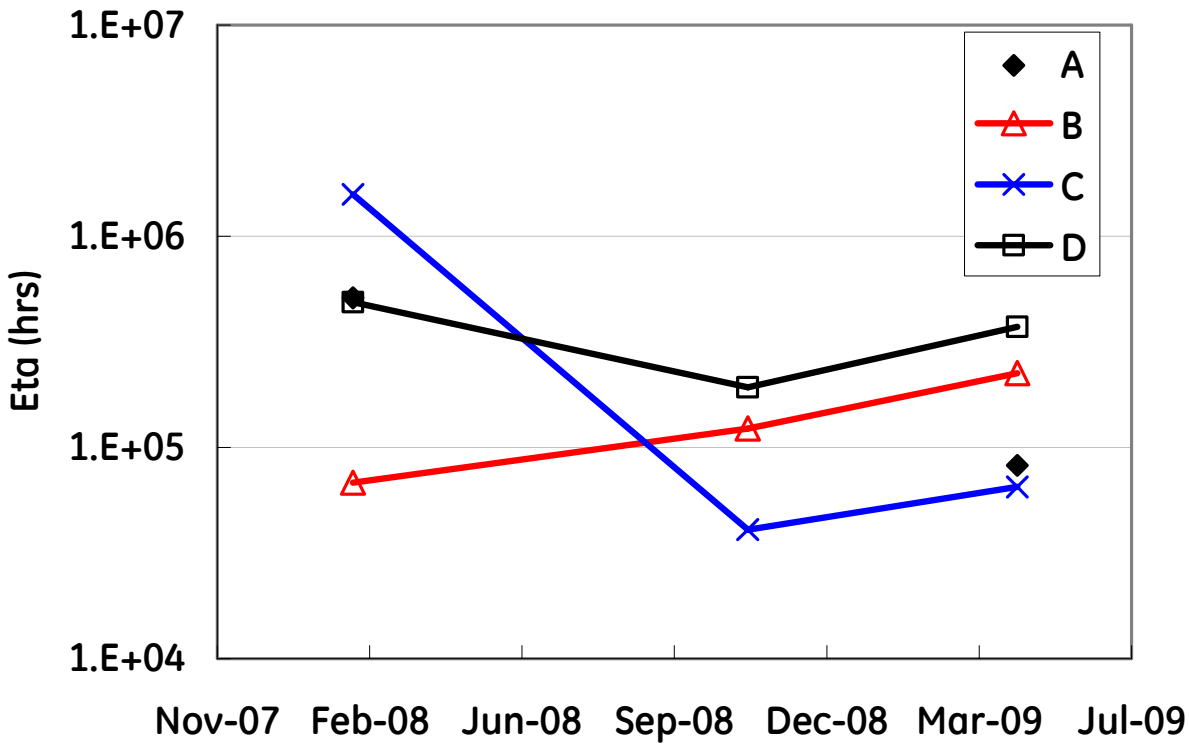
Fleet big picture vs. particular site or customer

Gearbox Replacement Rate



Generational improvement, SLE's better than S's
Replacement rate for both improving

Weibull Characteristic Life



More consistent results among suppliers
Relative supplier performance shifts over time

Material Cleanliness

Fatigue fracture of gears

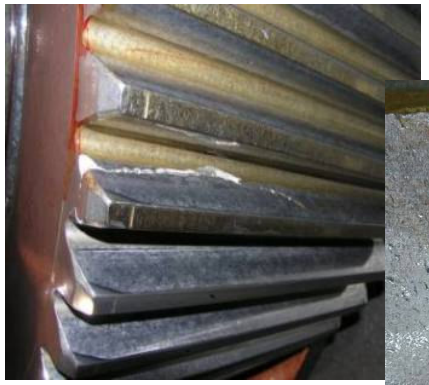
> Frequently able to trace to actual inclusion, type and size

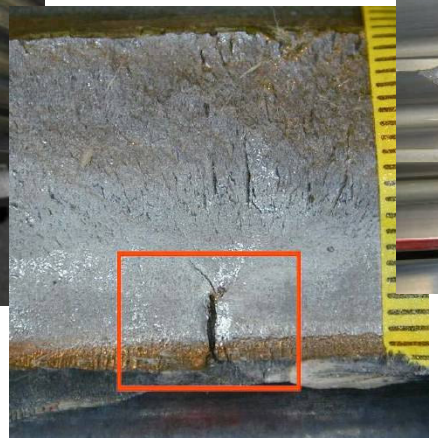
> Several suppliers, steel producers tightening requirements

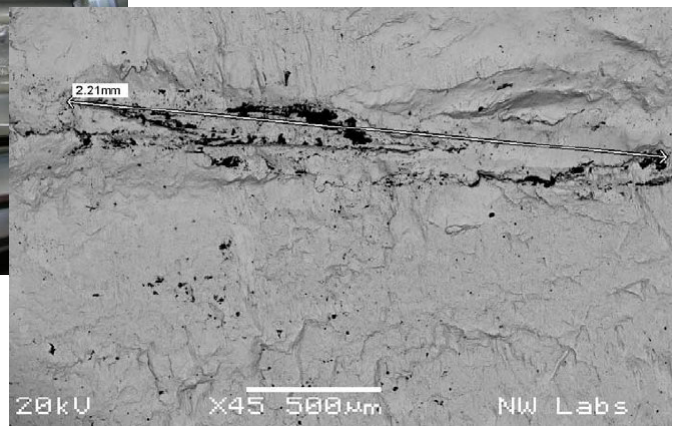
GE finalizing gear specification

> In line with supplier/producer trend

> Reference more common specs, American and European



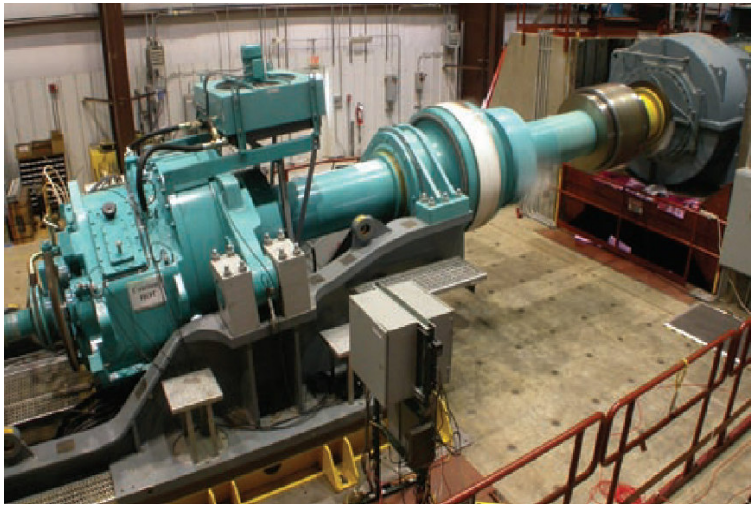




HALT Testing

Introduced as requirement by GE in 2004-5 time period

- Standardize test and evaluation among suppliers
- Enable more rapid endurance testing of gearbox
- Reproduce observed field failure modes in controlled environment
- Need to continue to evaluate results and requirements in context of field observations



Inspection and Characterization

Phased Array UT Inspection of Ring Gear

- Extension of GE Energy process for steam turbine rotors
- Instrumention available from GE Inspection Technologies
- Enables examination of entire ring gear from outer surface

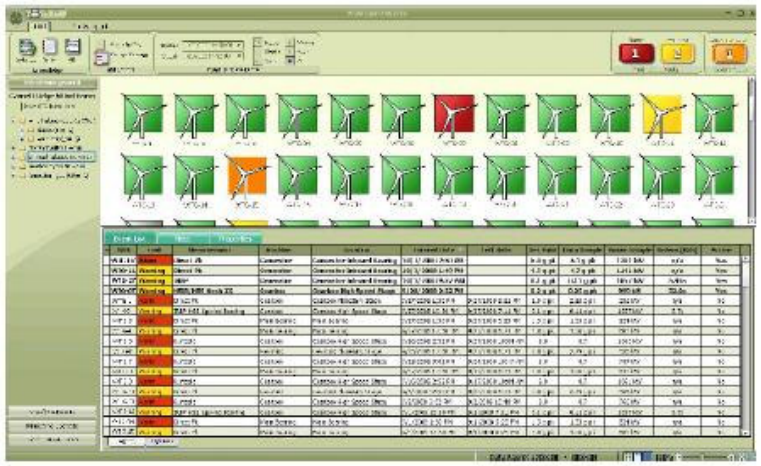
CBM

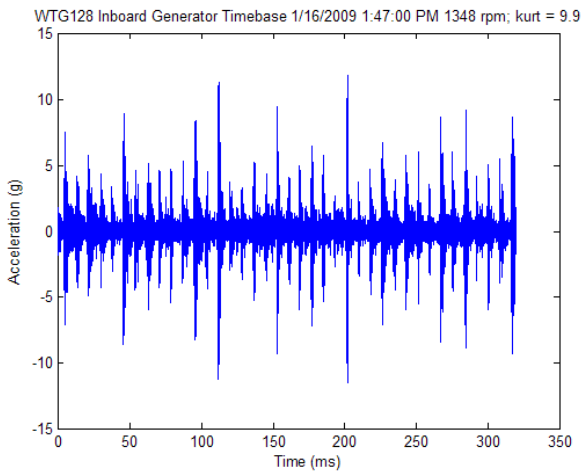
Vibration and particle monitoring

Reduce unplanned downtime

Coordinate with planned maintenance

Reduction of collateral damage





- Based on high particle count, gearbox was inspected ... WTG ran until new gearbox arrived
- $16.4k avoided revenue loss ... 23 days production loss (time from gearbox order to the time gearbox replaced).

Thank you!

imagination at work