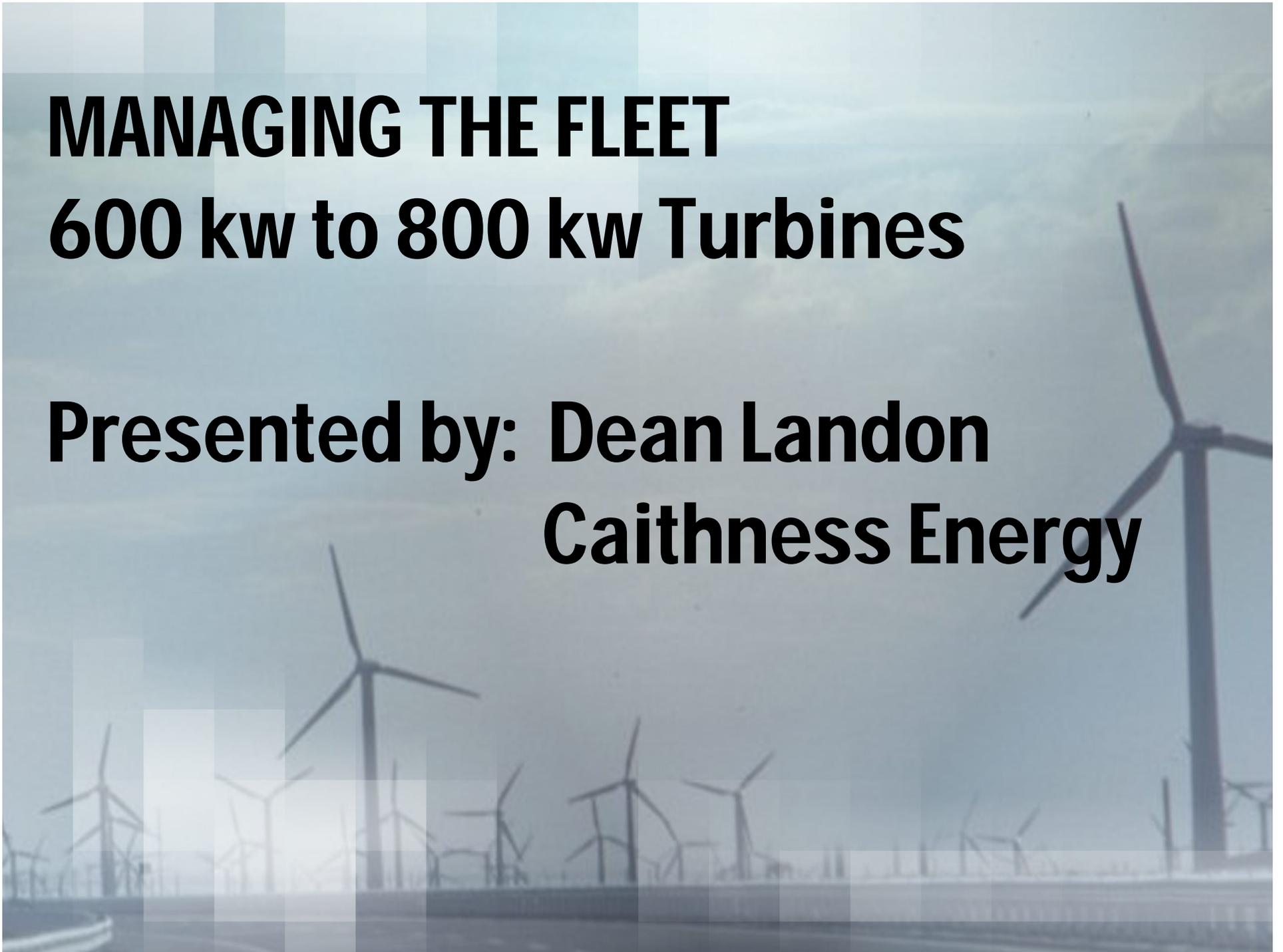


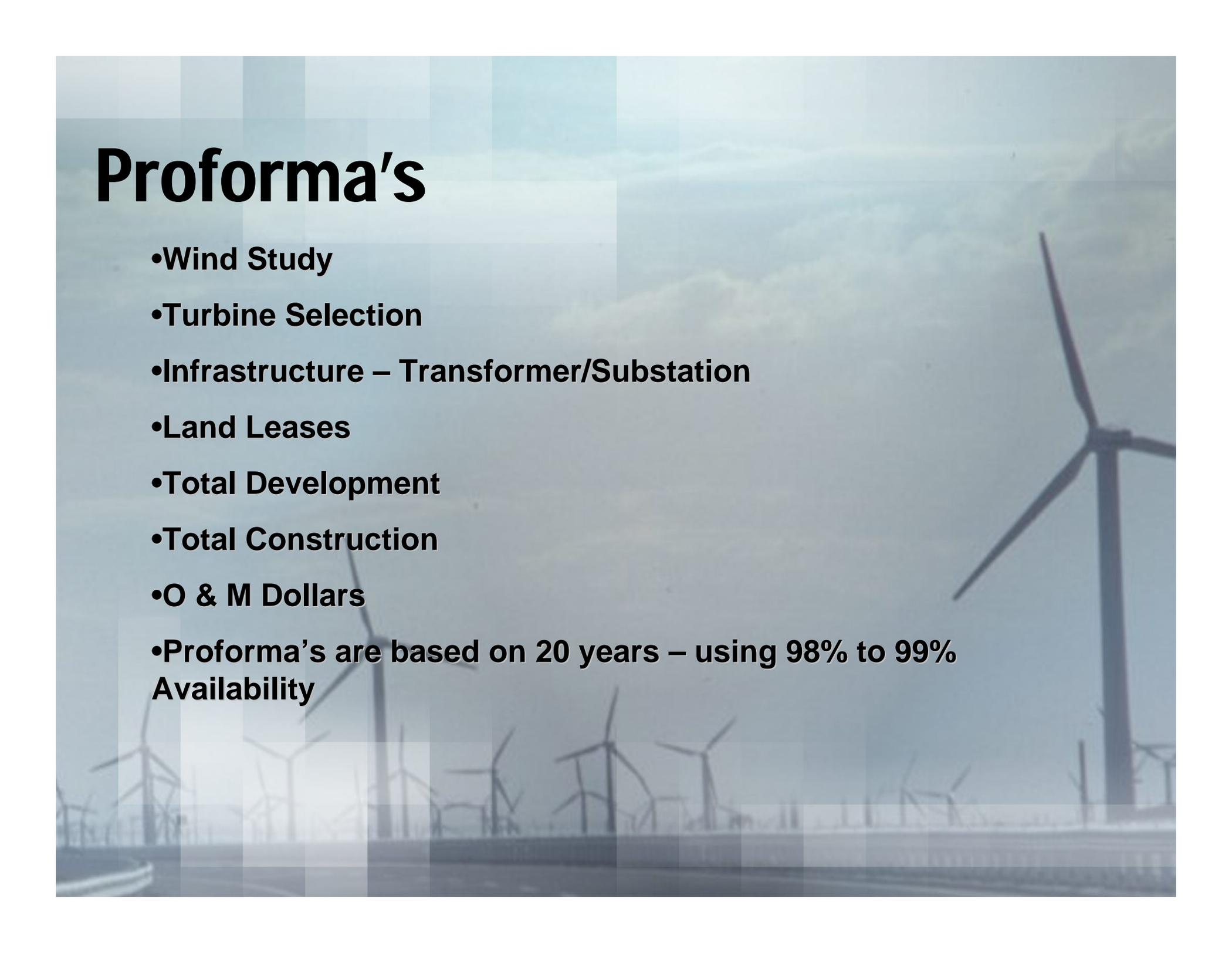
# **MANAGING THE FLEET**

**600 kw to 800 kw Turbines**

**Presented by: Dean Landon  
Caithness Energy**



# Proforma's



- Wind Study
- Turbine Selection
- Infrastructure – Transformer/Substation
- Land Leases
- Total Development
- Total Construction
- O & M Dollars
- Proforma's are based on 20 years – using 98% to 99% Availability

# O & M Model

- Cost of Labor Maintenance
- Cost of Labor Operations
- Cost of Labor High Voltage
- Cost of Consumables
- Cost of Standard Replacement Parts
- Depreciation/etc.
- Land Leases

***All Items above are very predictable  
year after year...***

# O & M Major Repairs

What are considered to be Major Repairs?

1. At the top of the list – Gearboxes
2. Generators
3. Blades
4. Controllers

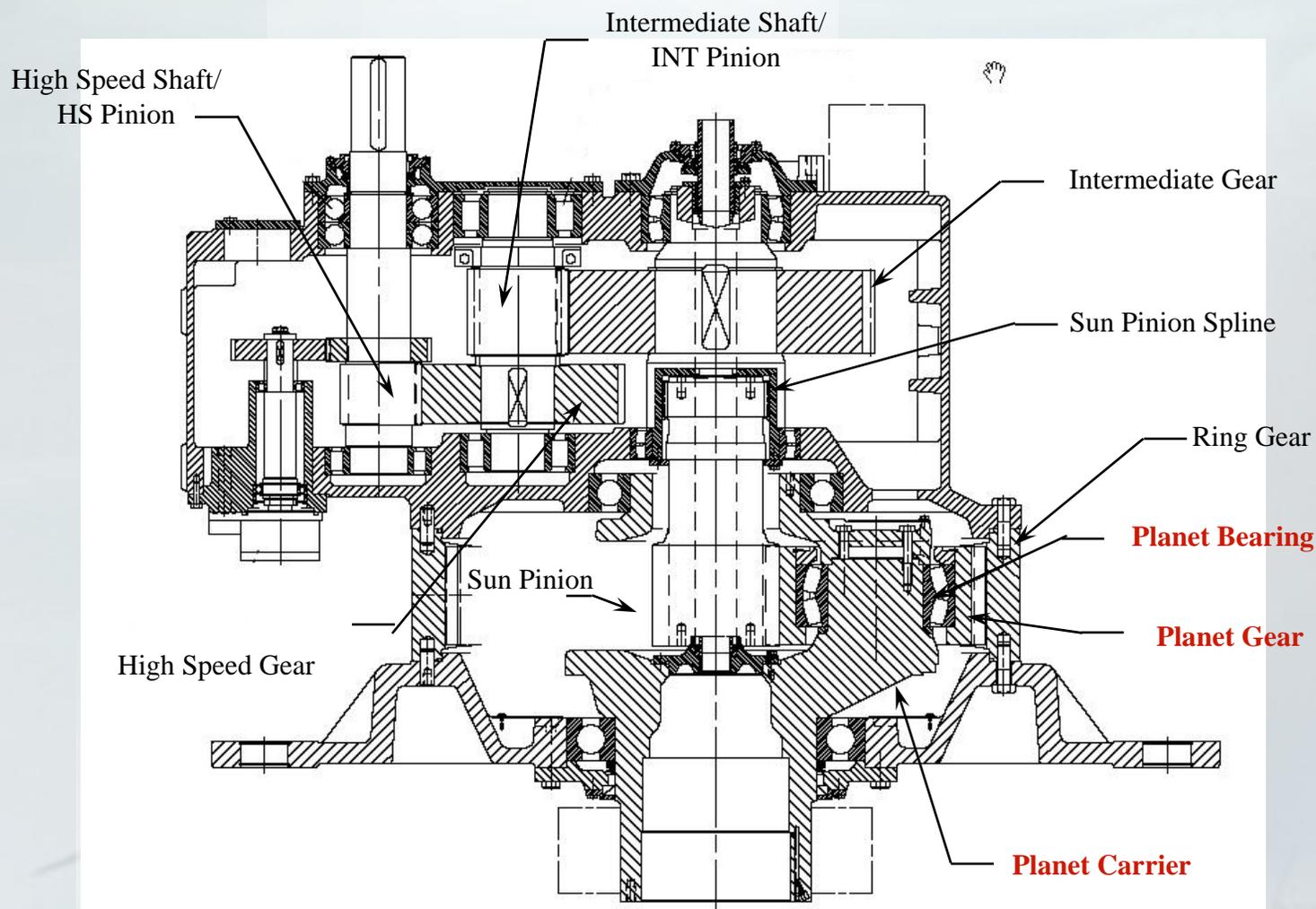
***Let's talk about #1 – Gearboxes***

# Projection vs. Reliability

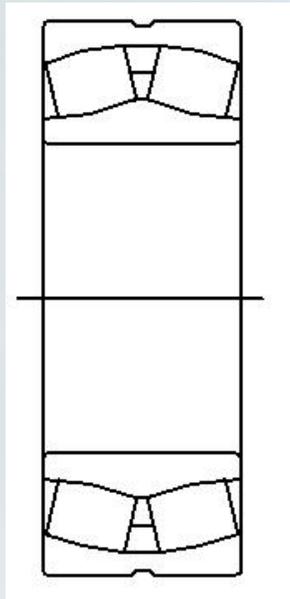
## Gearboxes

- Gearboxes were based on a 20 year design life from Manufacturer using their maintenance procedures
- Gearboxes start failing in the 2nd to 4th year - most failures are covered under warranty
- Years 4 to 7 gearbox failures (on the rise)
- Cost of gearbox failure (parts only) \$50K to \$100K
- Cost of lost revenue
  - with no spares approx 6 month repair, plus crane cost
- With Spare gearbox
  - Crane – move in/out & labor – Approximately \$20K
- Planet Bearings failures (see photos)

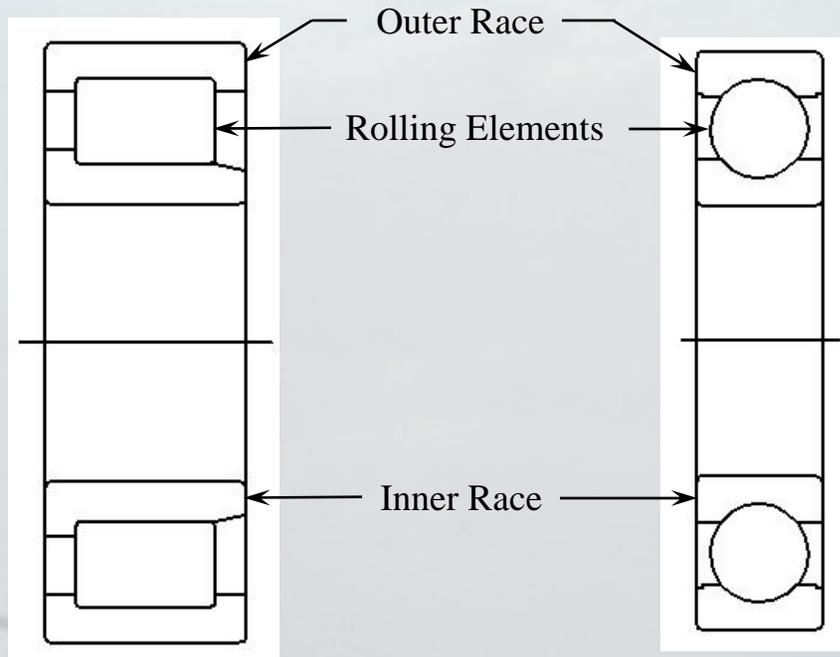
# Hansen EH552 Assembly Drawing



# Bearing Types

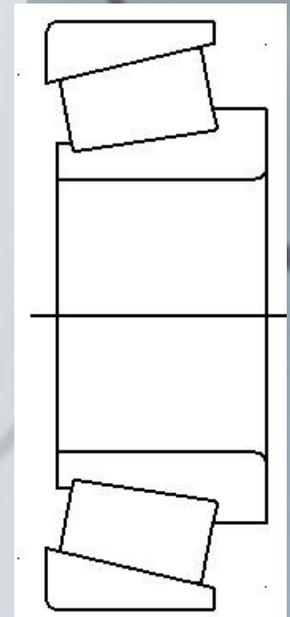


Two row spherical roller bearing (SRB)



Cylindrical roller bearing (CRB)

Ball bearing (BB)



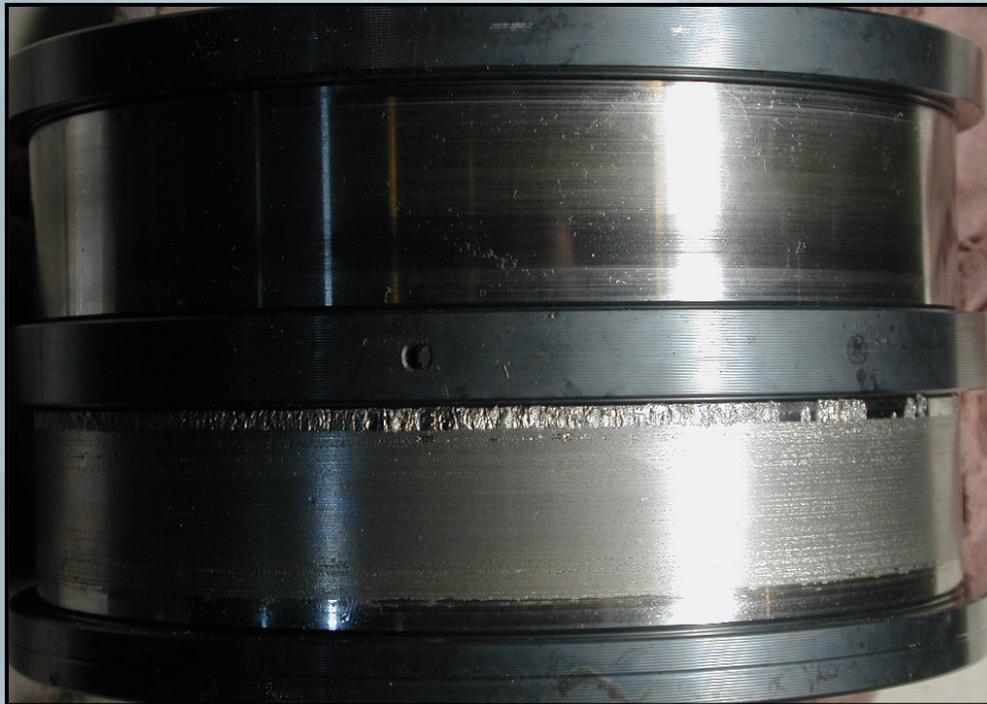
Taper roller bearing (TRB)

# Hansen EH55 Failure Mode



Planet bearing failure

# Flender PEAC 4300 Failure Mode

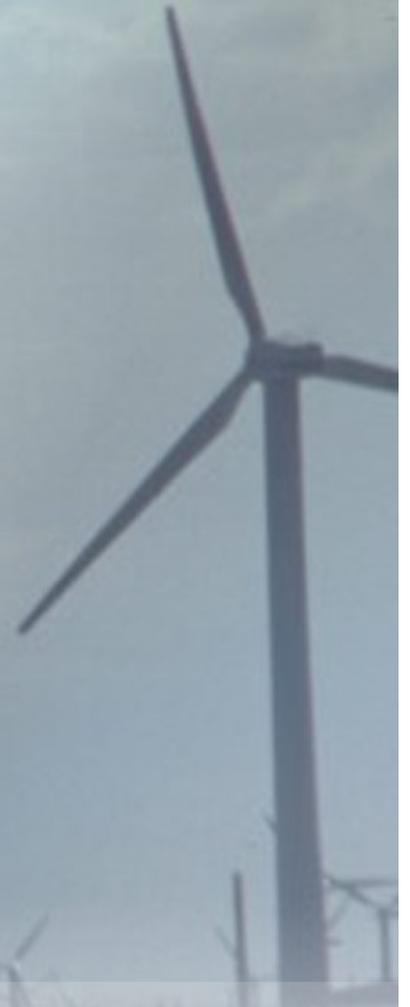


Micropitting and macropitting of inner race of planet bearing

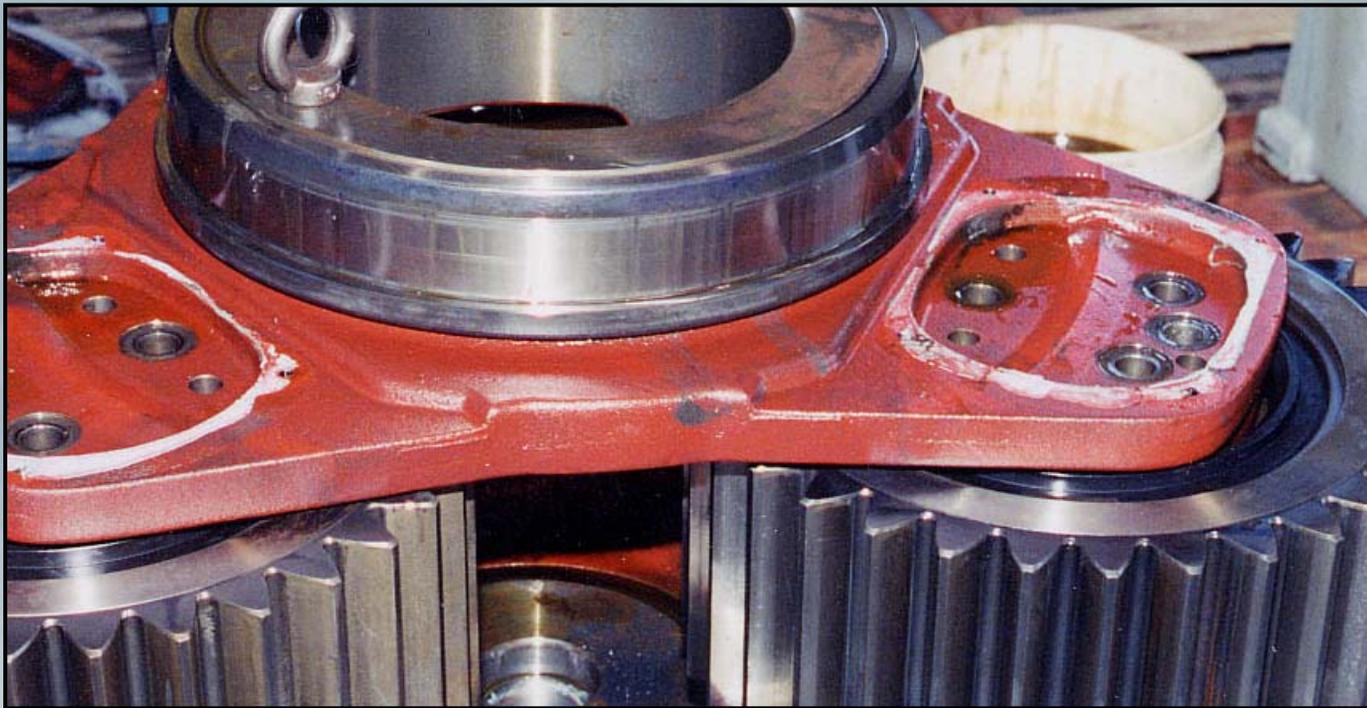
# Hansen EH552 Failure Mode



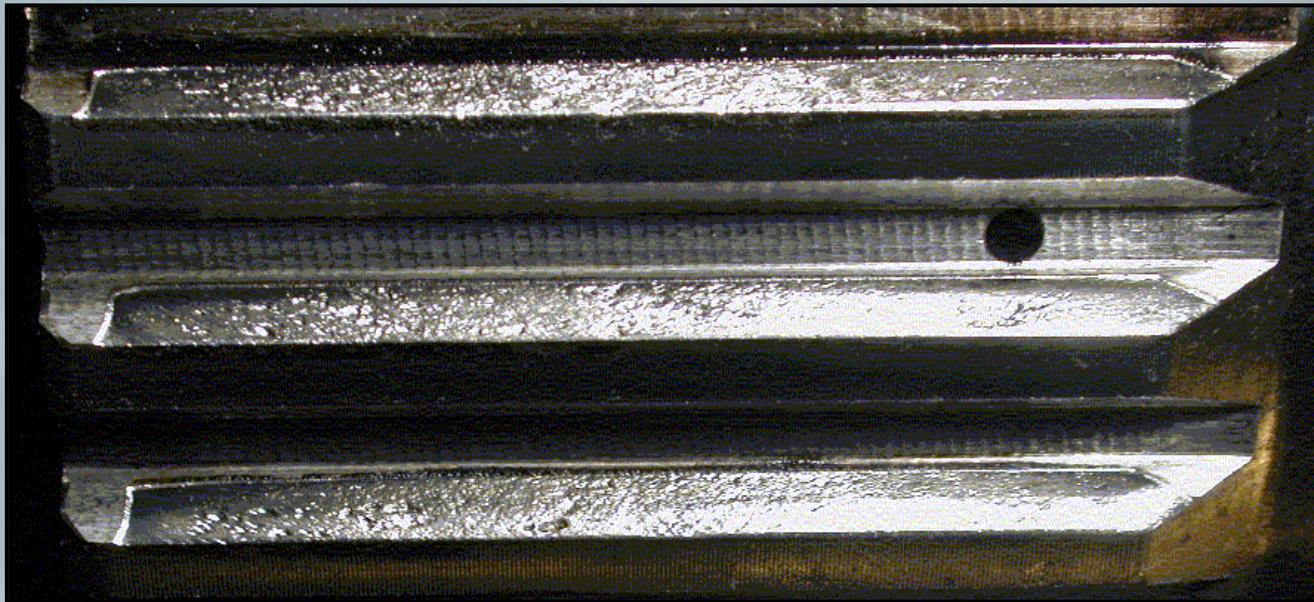
Planet bearing failure



# Planetary Section



# 4300 Pictures



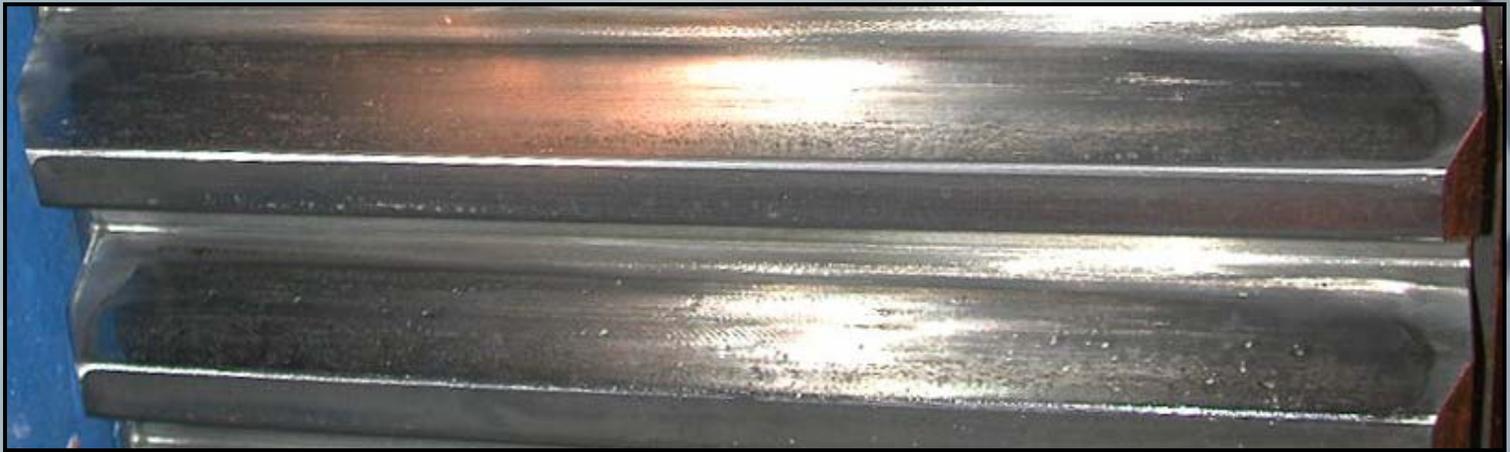
**Sun Ext Spline**

# 4300 Pictures



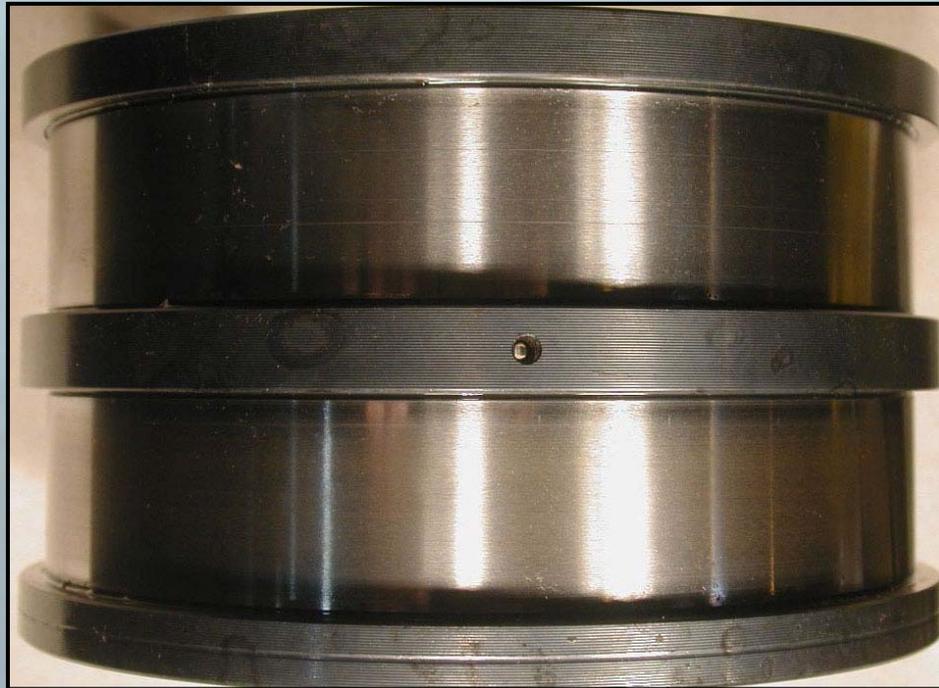
Ring DF at 6

# 4300 Pictures



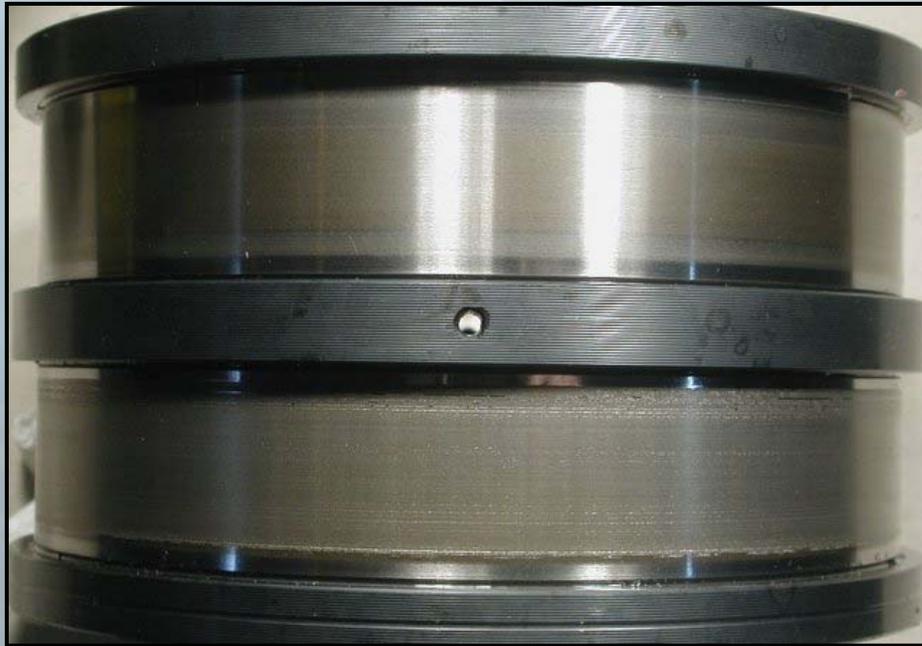
Ring DF at 12

# 4300 Pictures



**IG Inner OD**

# 4300 Pictures



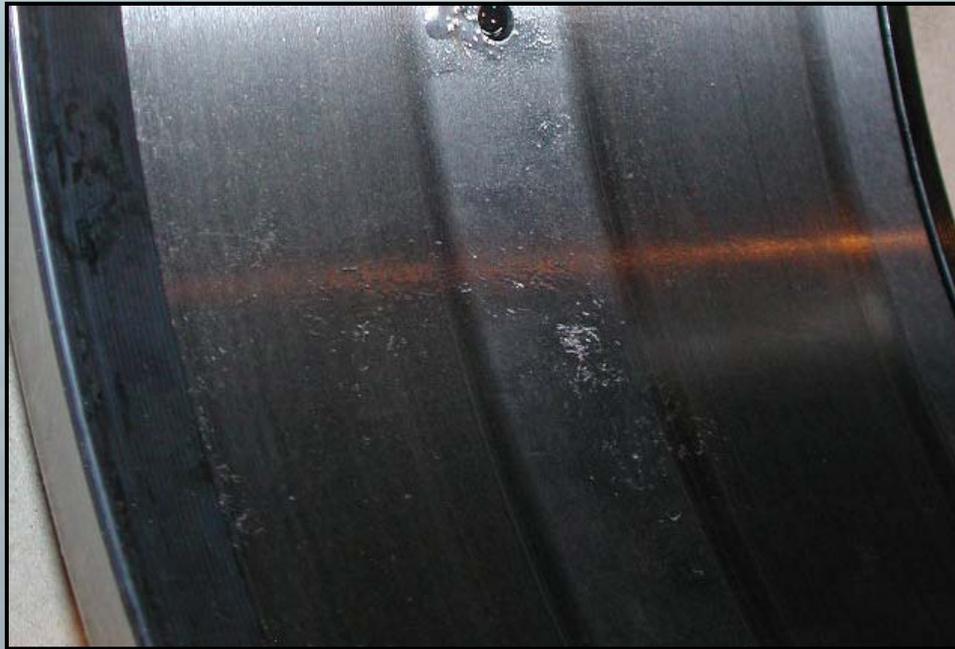
**IR Inner Race OD**

# 4300 Pictures



**2R Inner Race OD**

# 4300 Pictures



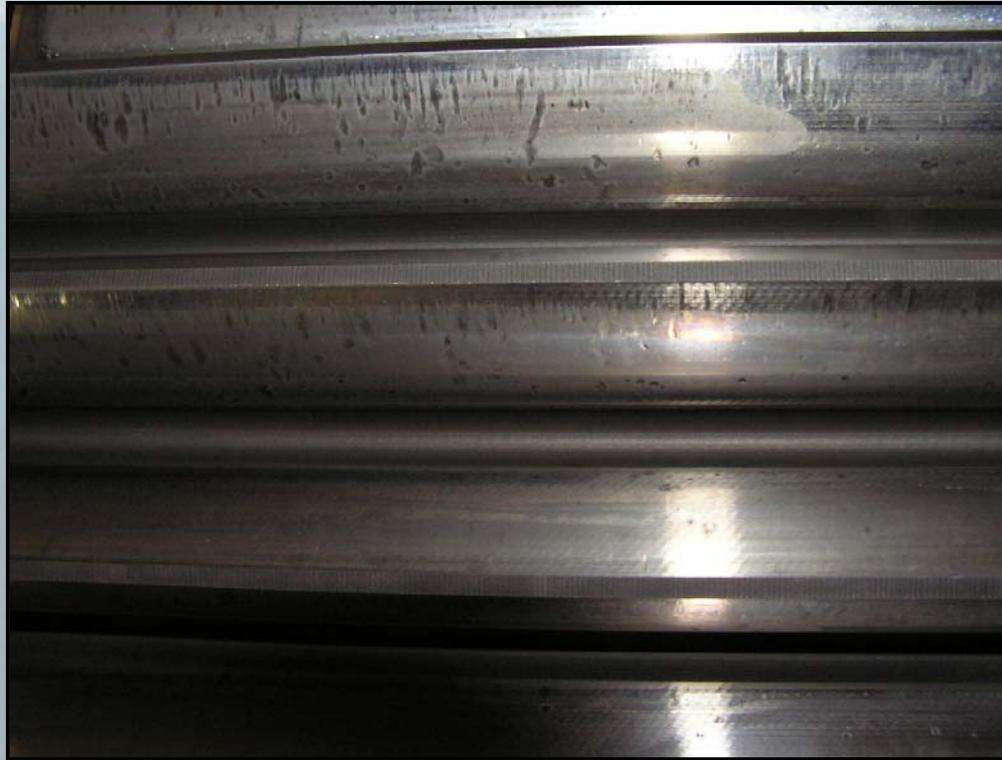
**2G Outer Race OD**

# EH55G21S

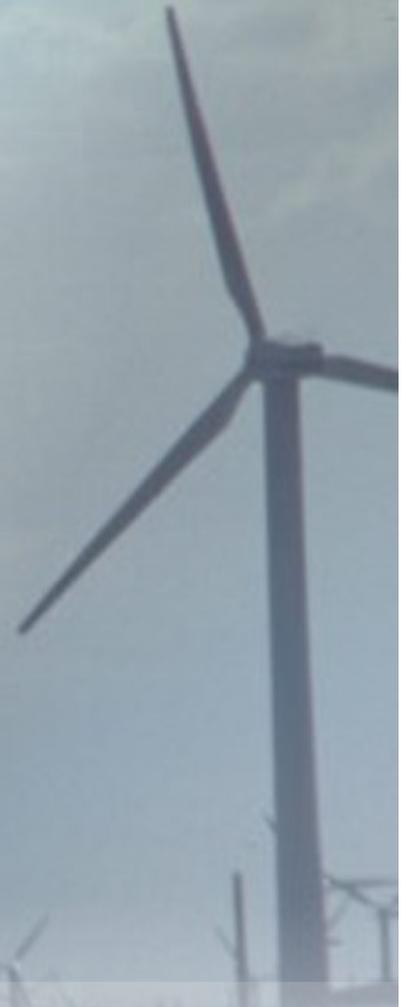


**Inter-race Plant Bearing**

# EH55G21S



Plant Gear



# EH552G21S

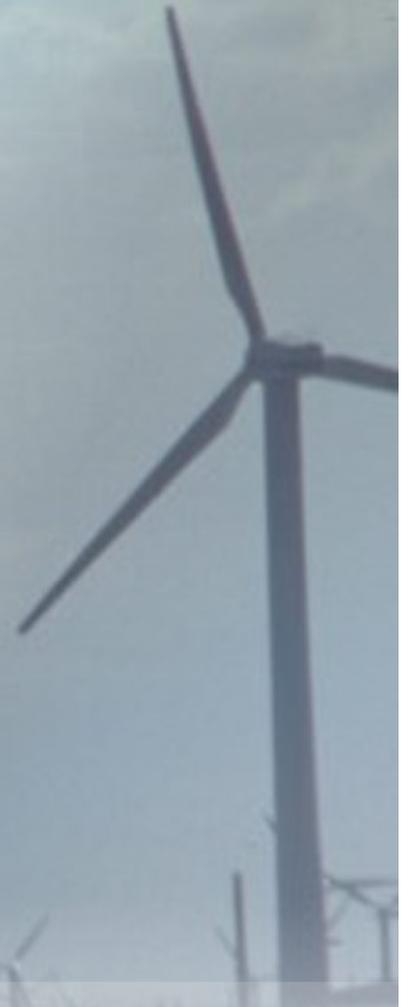


**Inter-race Plant Bearing**

# EH552G21S



Planet Gear



# EH552G21S



**Planet Gear**

# EH552G21S



Ring Gear

# Condition Assessment

- **Oil Sample Analysis – Every 6 months**
- **Filter Inspection**
- **Magnet Sweep**

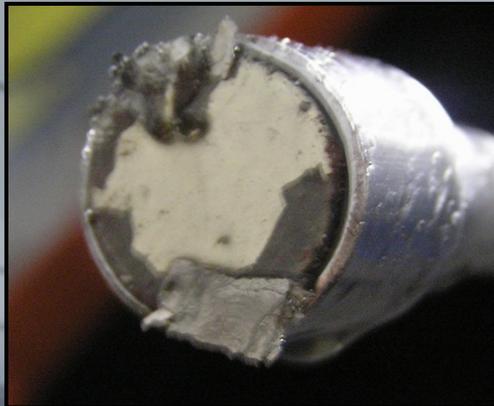


# Flender PEAC 4300 Inspections



Filter inspection

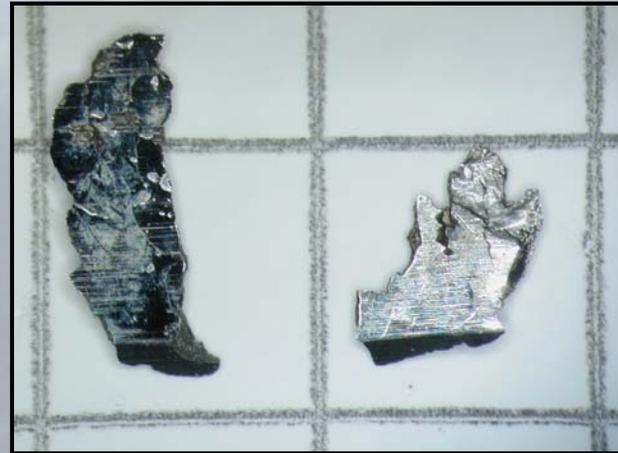
# Metal removed from Sump



# Flender PEAC 4300 Inspections



Filter debris



Spalling chips from  
inner race of planet  
bearing

# Flender PEAC 4300 Inspections



Filter debris



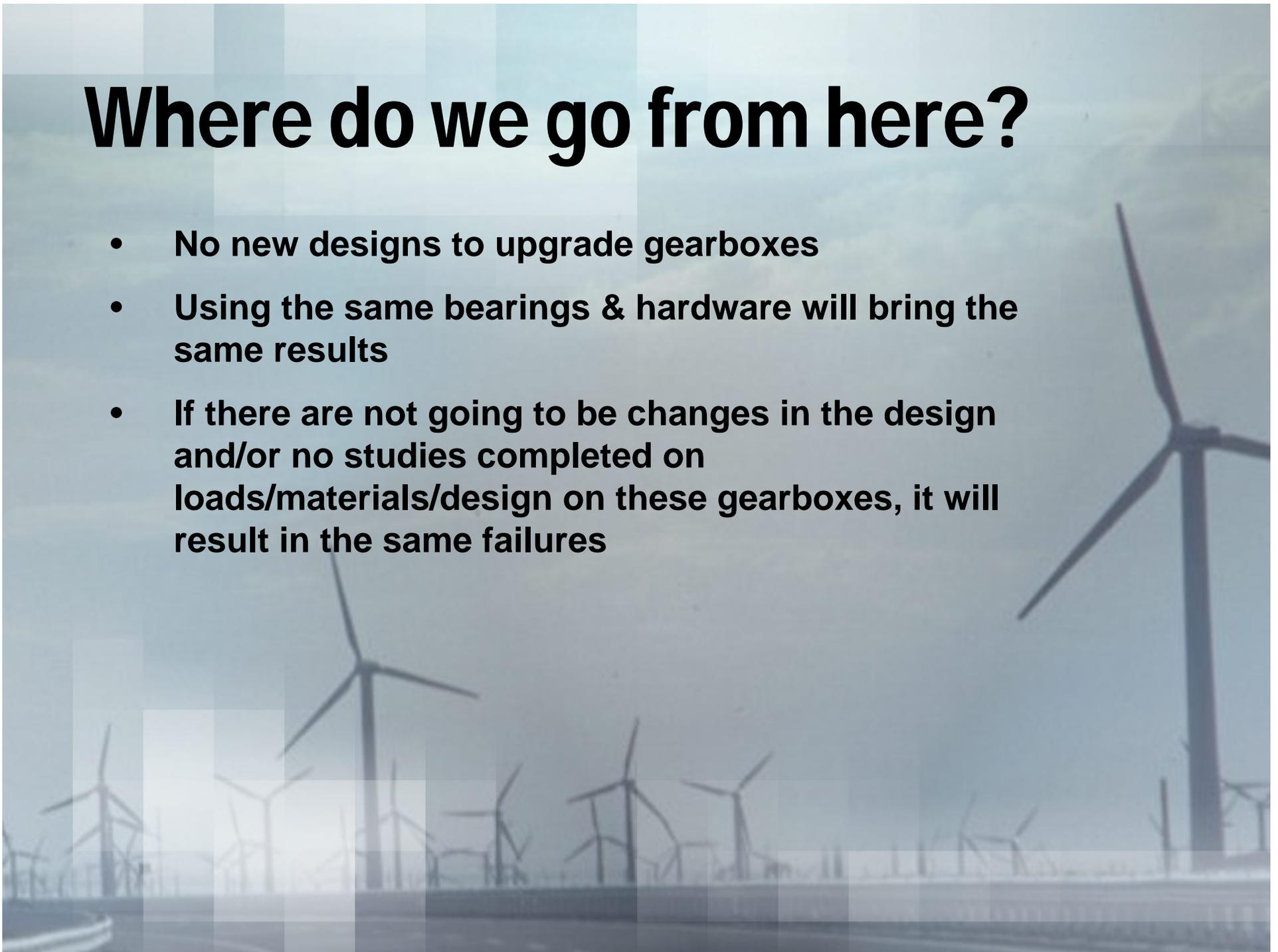
Filter Debris

# Helical Section - Flender PEAC 4300



# Where do we go from here?

- **No new designs to upgrade gearboxes**
- **Using the same bearings & hardware will bring the same results**
- **If there are not going to be changes in the design and/or no studies completed on loads/materials/design on these gearboxes, it will result in the same failures**



# Operator's Needs

- **NREL/Sandia Labs to study these loads on these mid size turbines**
- **Manufacturers and vendors – give load calculations and devise criteria for NREL to study**
- **Work with NREL/Manufacturers, Vendors and Engineers to produce a reliable product and retro fit**
- **Use this data as a platform for larger turbines**