Estimating the Benefits of CM for Wind Turbines

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PUGET SOUND ENERGY
The Energy To Do Great Things

Overview

- What drives the decision to install CM equipment?
- How can the costs and benefits be estimated?
- Who makes the decision and what do they need to know?
- Why are we sitting on the fence?

CM Perspective

For Engineering

- Predict reliability
- Prevent consequential damage
- Understand equipment loading
- Understand equipment failure modes
- Warranty claim substantiation
- Evaluate design improvements

For Asset Management

- Keep equipment running ($)
- Minimize costs of failures ($)
- Minimize downtime if failures do occur ($)

Making the Case

- Probability that failure will occur
  - These are *unexpected* failures
- Probability that failure can be predicted
  - Reliably detected and trended
- Probability of consequential damage
  - If no additional measures are taken
- Avoided cost
  - From eliminating consequential damage
- Cost to implement
  - Purchase, install, integrate, deploy

$$(P_f)\ (P_p)\ (P_c)\ (\Delta\$_{cost}) - \$_{Implement}$$

Consequential Damage

Premature surface fatigue of HSS bearing

Up-tower replacement

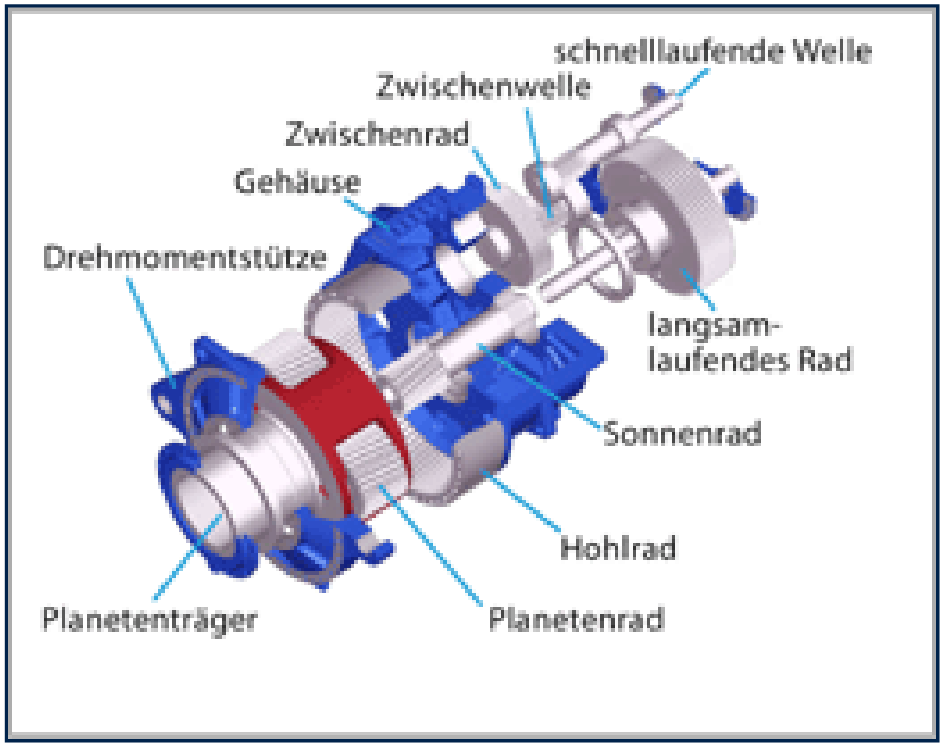
Debris infiltrates planet bearings

Bring in the crane

Additional debris damages gear teeth

Major rebuild

Mesh jams and case cracks



Example – Hydro Generator

- Failure mode: stator winding failure
- CM candidate: partial discharge monitoring
  - Probability of failure: Low
  - Probability of prediction: High
  - Probability of consequential damage: High
  - Avoided cost: $1M+
  - Cost to implement: $30K

(.2) (.8) (.9) ($1000k) - $30k = $114k

Long downtime for critical asset, expensive rebuild as opposed to clean and re-wedge

Example – Wind Turbine Gearbox

- Failure mode: High-speed shaft bearing
- CM candidate: vibration monitoring
  - Probability of failure: High
  - Probability of prediction: Medium*
  - Probability of consequential damage: Medium
  - Avoided cost: $400k
  - Cost to implement: $8K

(.8) (.5) (.5) ($400k) - $8k = $72k

Complete rebuild and crane rental,
as opposed to uptower HSS replacement

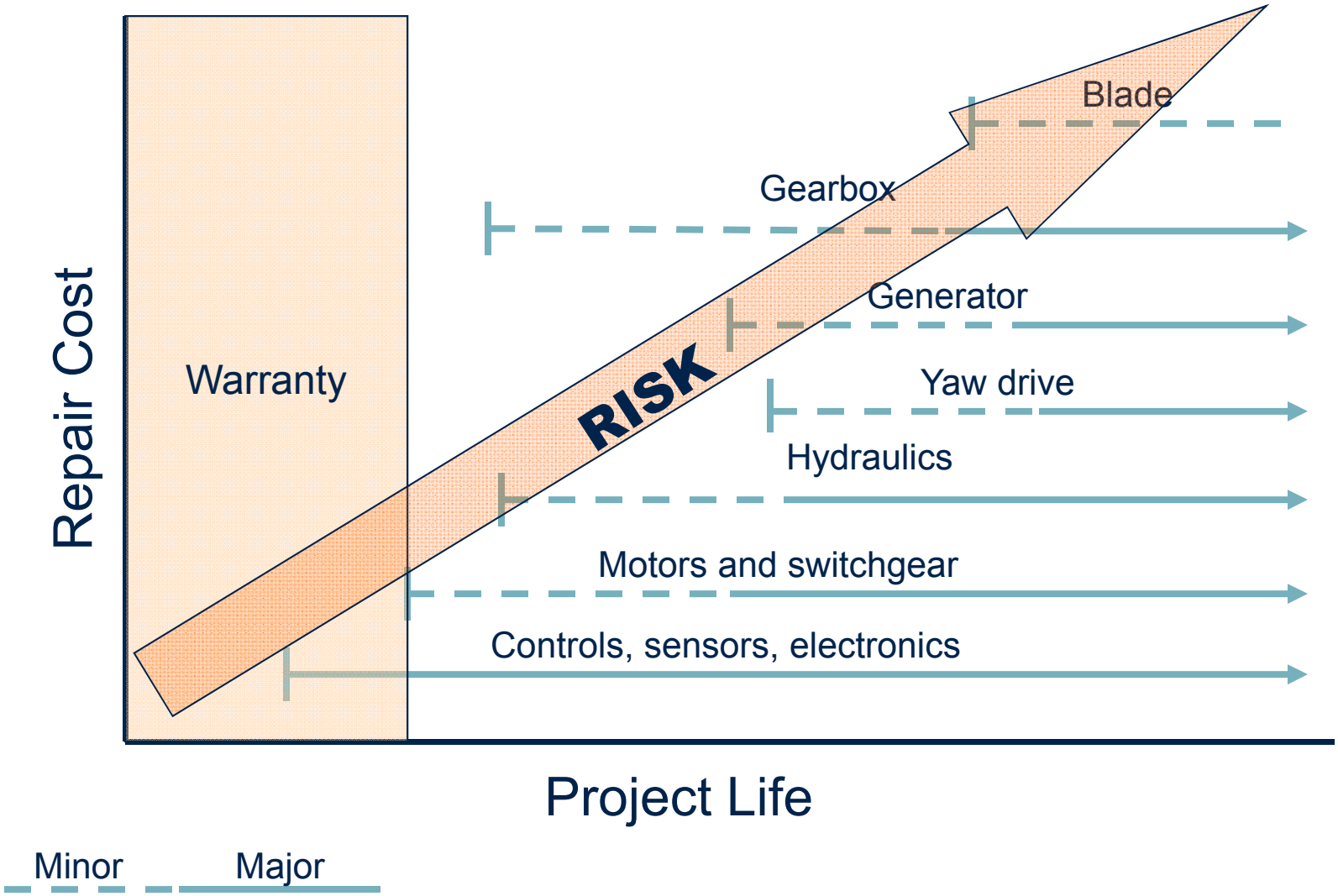
Example – Wind Turbine Gearbox

- Failure mode: Planetary bearing
- CM candidate: vibration monitoring
  - Probability of failure: Medium
  - Probability of prediction: Low
  - Probability of consequential damage: Medium*
  - Avoided cost: $100k
  - Cost to implement: $8K

(.5) (.2) (.5) ($100k) - $8k = -$6k

Requires a complete rebuild in any event; possibly avoid a cracked gearcase

Failure Risk (Industry Average)



Summary

Justification is case dependent

Don't overstate your case!

Factors will change with time

Equipment ages and experience grows

Evidence erodes denial

Get it in the operations budget

Start early and revisit as necessary ....

or get it with the equipment purchase ....

or consider adding to end-of-warranty

inspection process

High Water at Snoqualmie