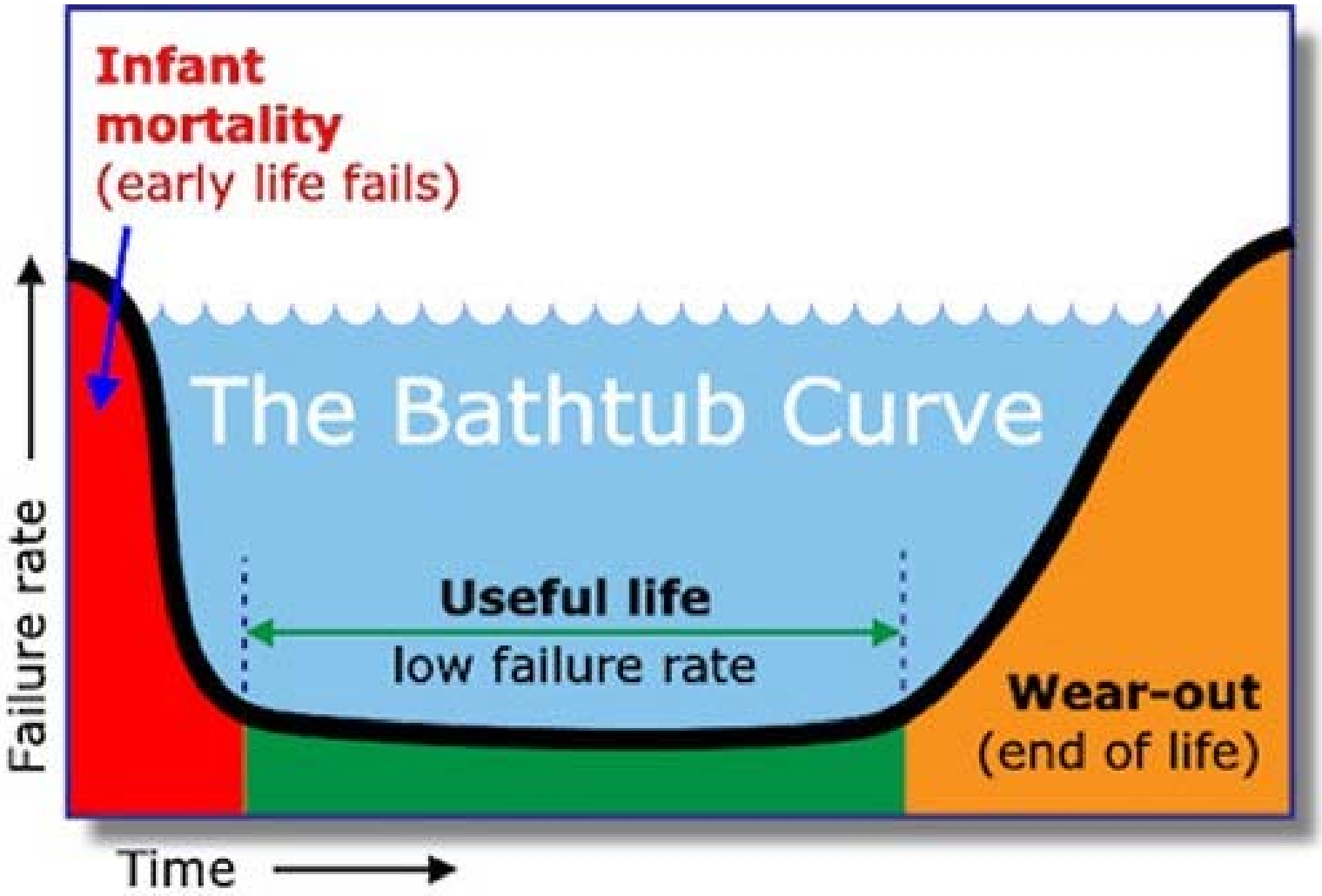
UPWIND SOLUTIONS

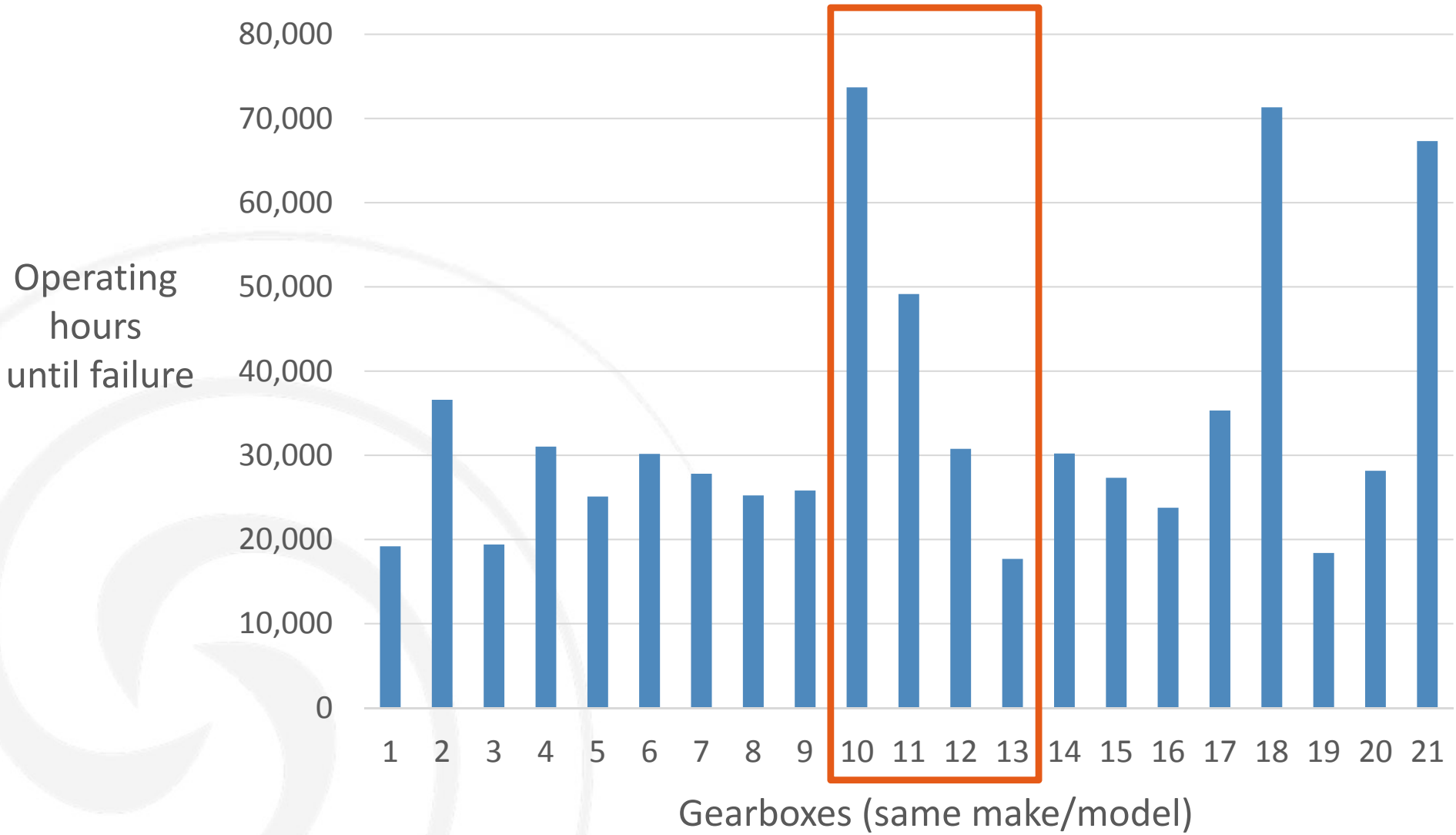
Designing for Wind Turbine Reliability

2015 Wind Energy Systems Engineering Workshop
14 January 2015

In a perfect world…

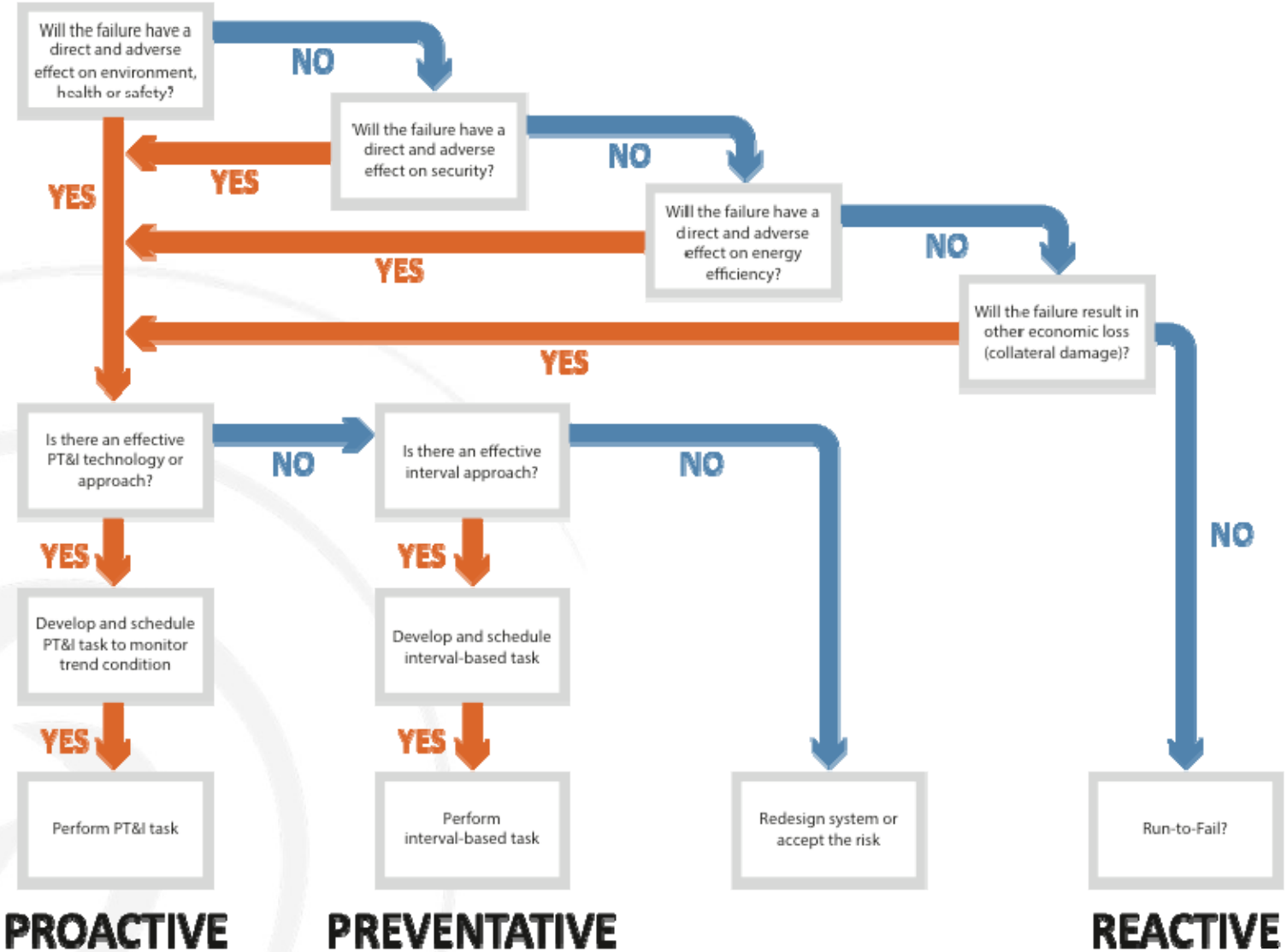


Gearbox life at one wind project



The same gearbox model has a huge life difference: 2, 3.5, 5.5 and 8 years

Reliability Centered Maintenance



Step 1: Describe main functions of a wind turbine

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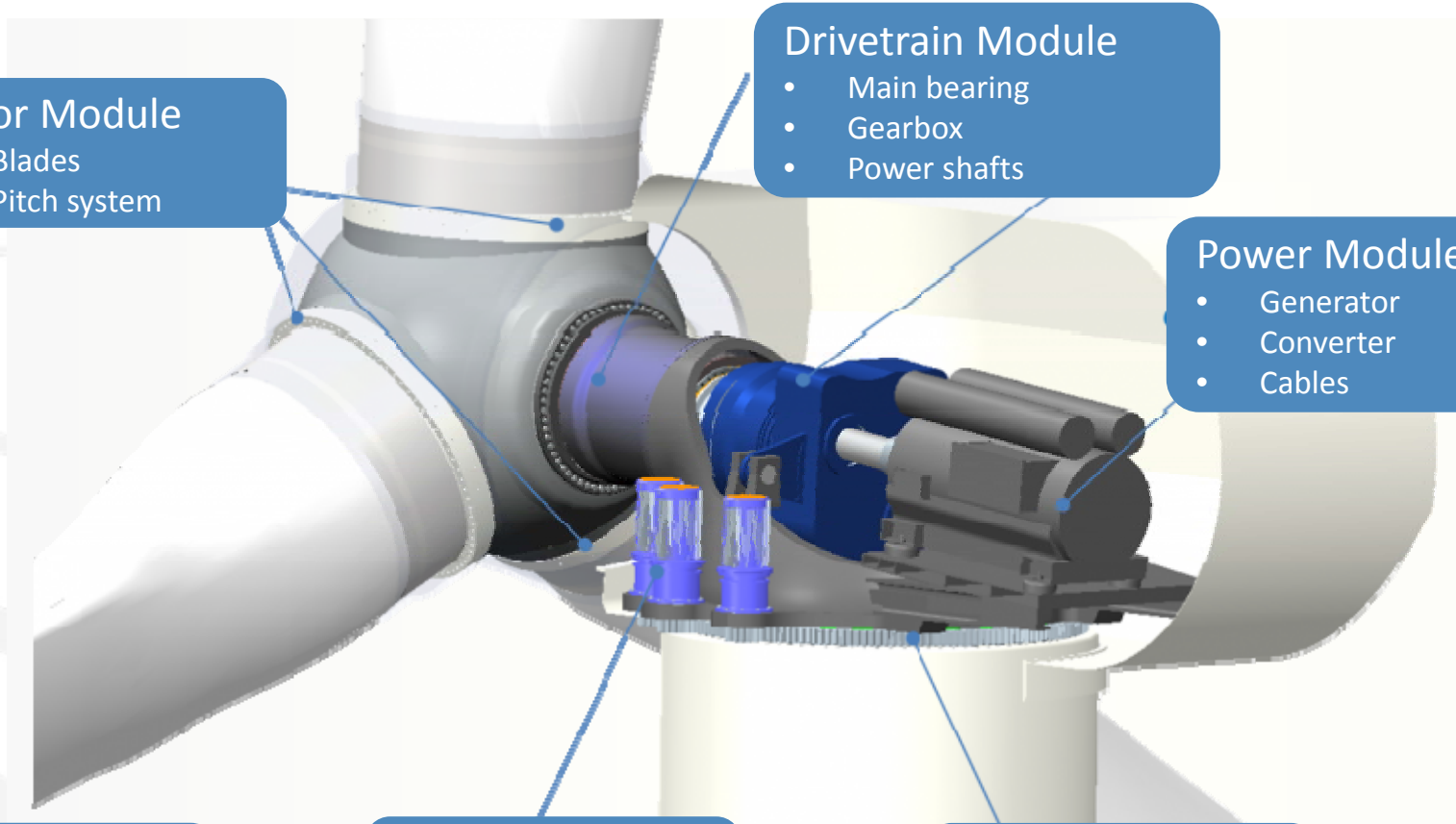
Wind Turbine Nomenclature (Reliawind)



Rotor Module
- Blades
- Pitch system

Drivetrain Module
- Main bearing
- Gearbox
- Power shafts

Power Module
- Generator
- Converter
- Cables

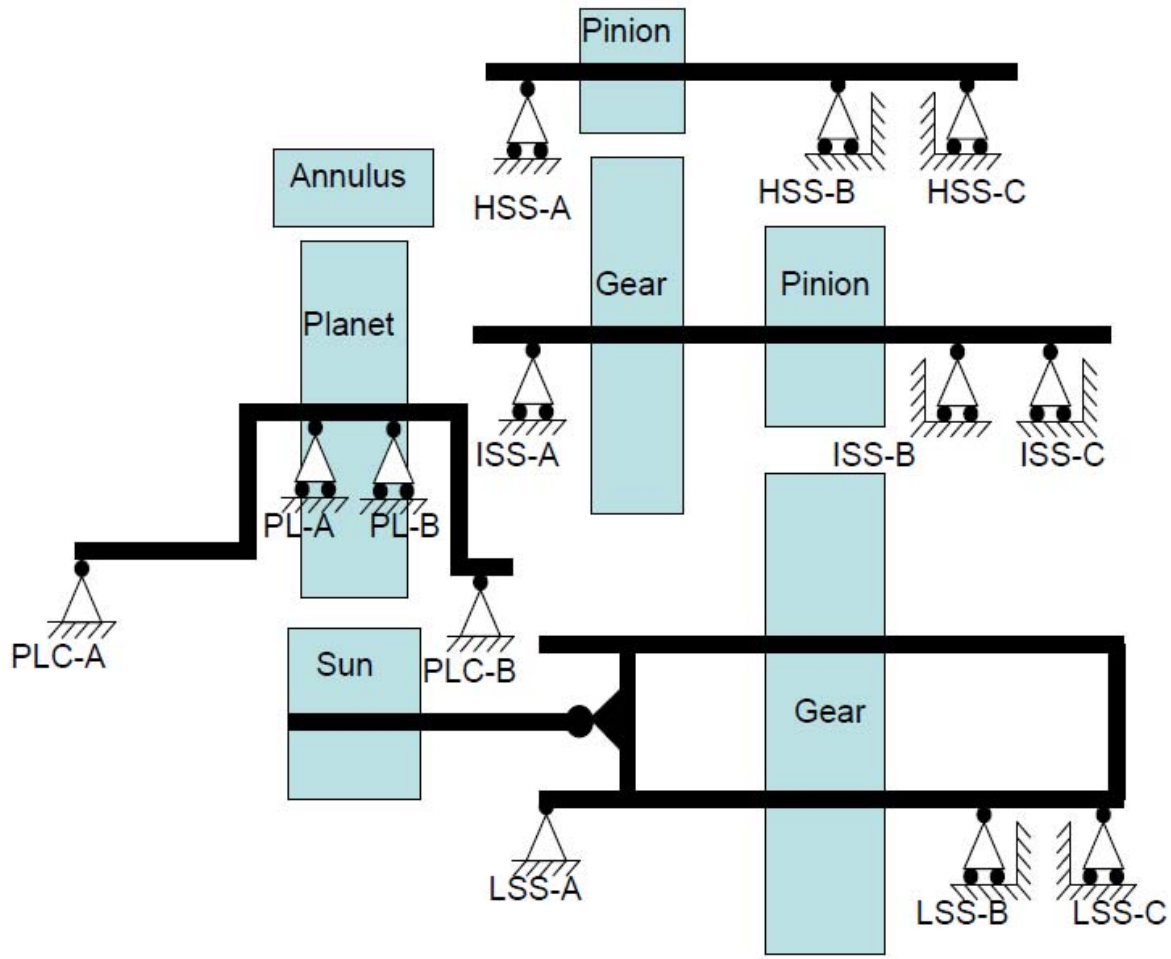
Control & Comms Module
- Controller
- Sensors
- Communications

Nacelle Module
- Yaw system
- Bedplate

Structure Module
- Tower
- Foundation

Step 2: Describe functions of components

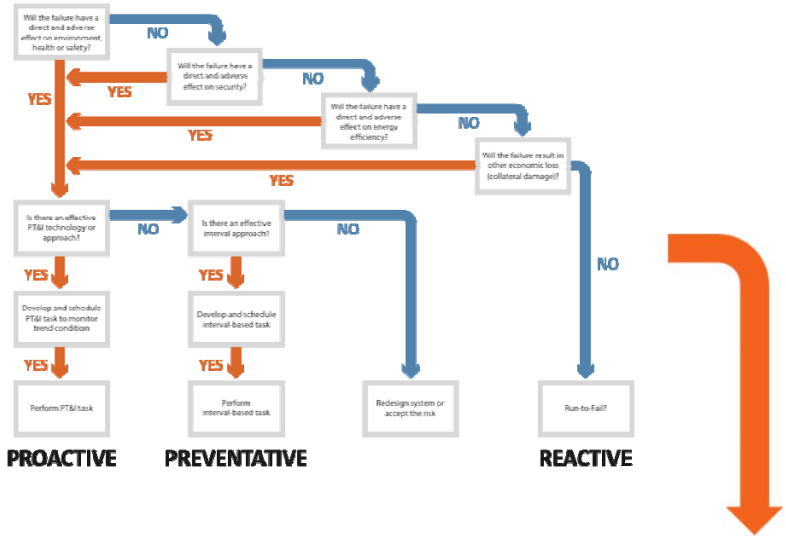
Gearbox Nomenclature (NREL)



Acronym	Definition
PLC	Planet Carrier
PL	Planet
LSS	Low-Speed Shaft
ISS	Intermediate-Speed Shaft
HSS	High-Speed Shaft

Step 3: Define failure mode, importance & strategy

Each function



Function	Failure Mode	Impact	Criticality	Probability	Strategy
Sun gear	Cracked tooth	Weeks - Full gearbox replacement	High	Low	Preventative
Planet gear	Cracked tooth	Weeks - Full gearbox replacement	High	Low	Preventative
HSS Bearing A	Macropitting, cracked race	Days - Uptower bearing replacement	High	High	Proactive
PLC Bearing A	Macropitting, cracked race	Weeks - Full gearbox replacement	High	Very Low	Run to failure

Step 4: Select technology for testing condition

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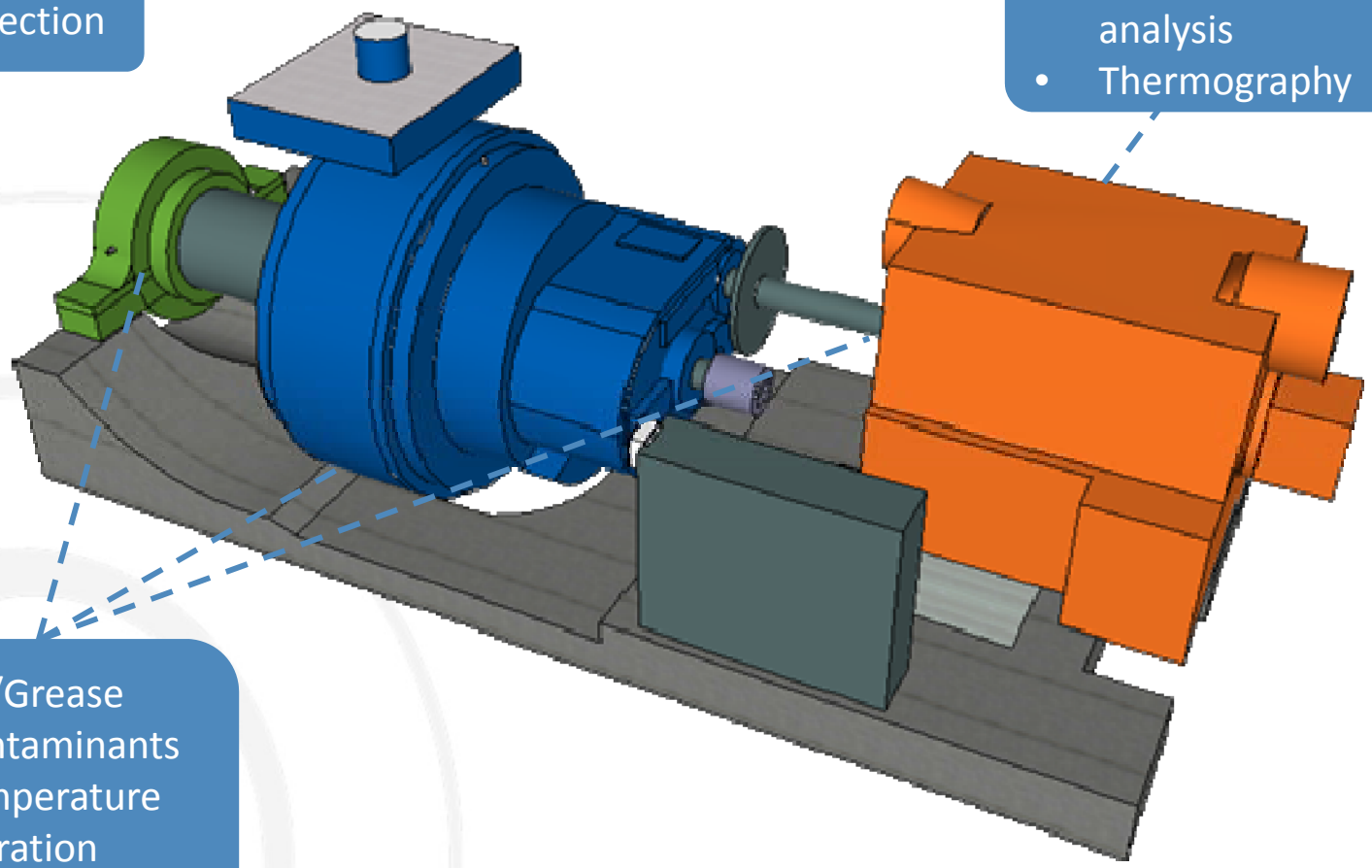
ROTOR MODULE

- Visual inspection

POWER MODULE

- Motor circuit analysis
- Thermography



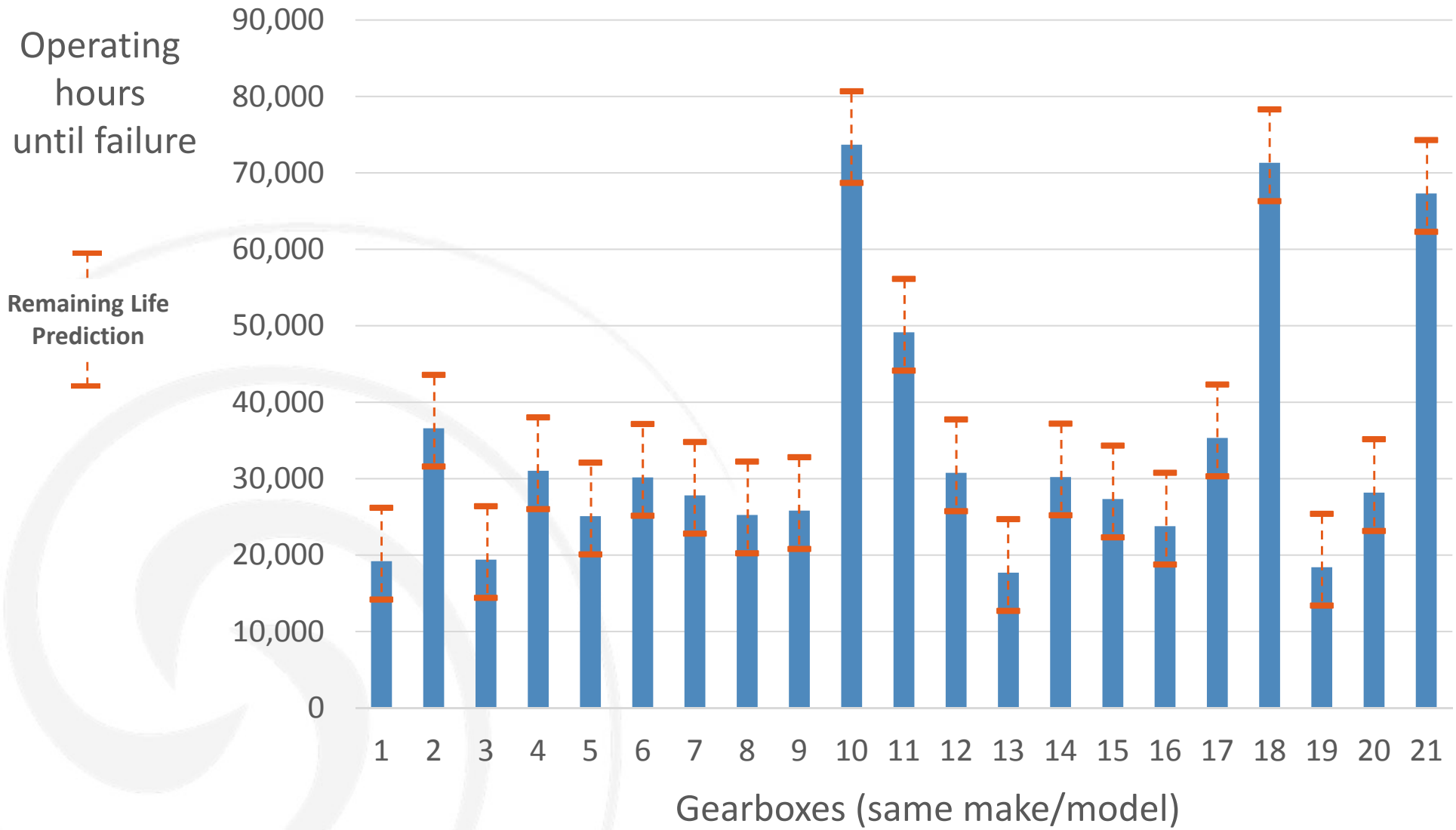
- Oil/Grease Contaminants
- Temperature
- Vibration
- Borescope

DRIVETRAIN MODULE

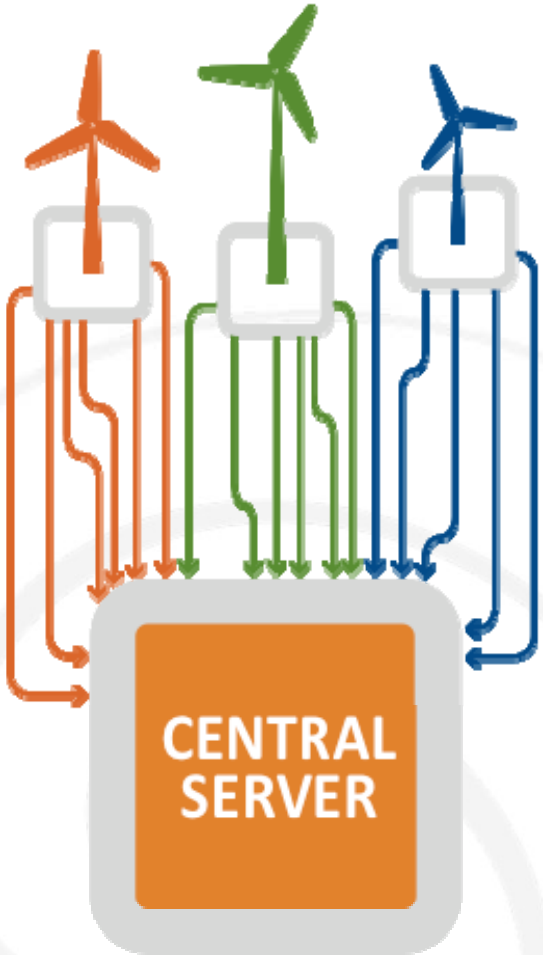
Step 5: Implement RCM program

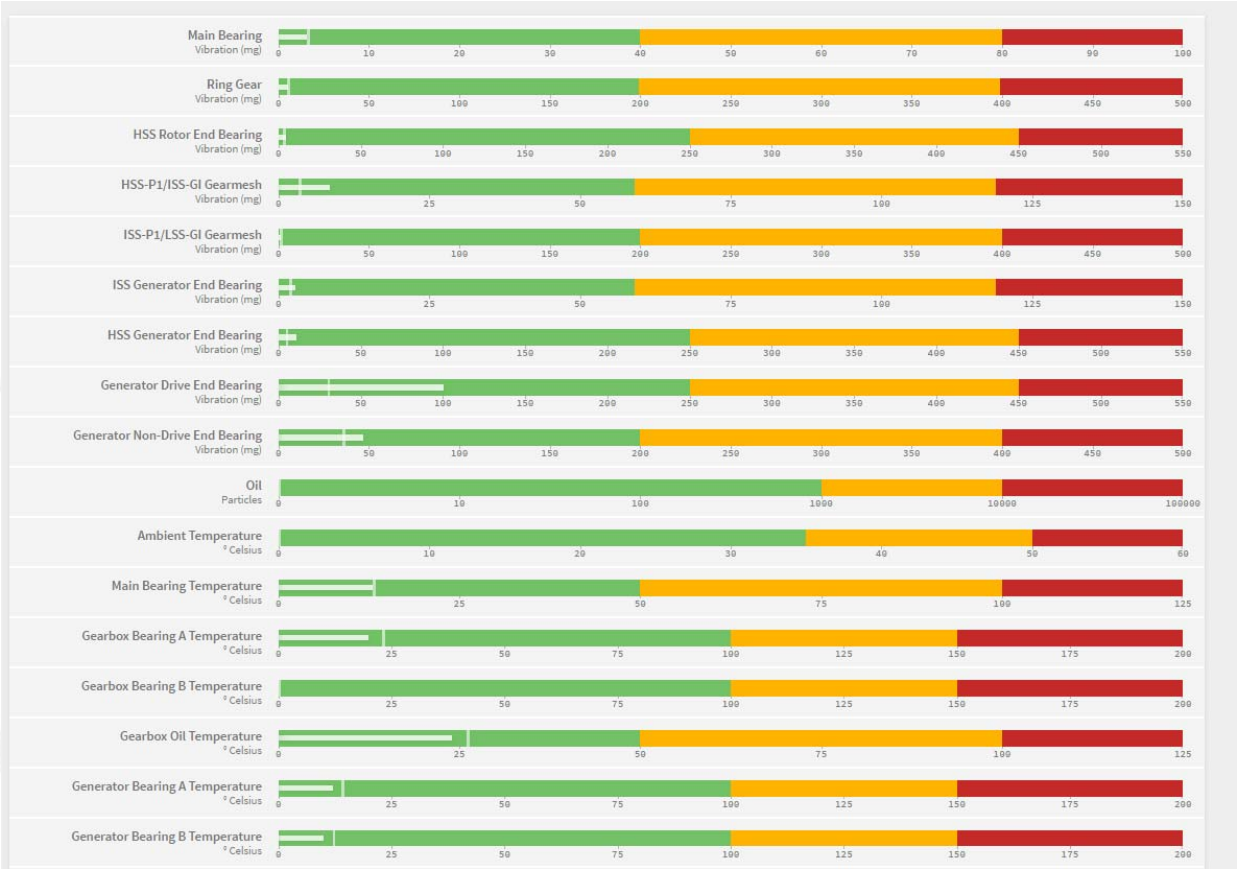
- Secondary or duplicate system? → Run-to-failure
- Predictable bathtub curve failure profile? → Scheduled maintenance
- Critical with random failures? → Monitor & predict

RCM makes random failures predicable



Data challenges with RCM



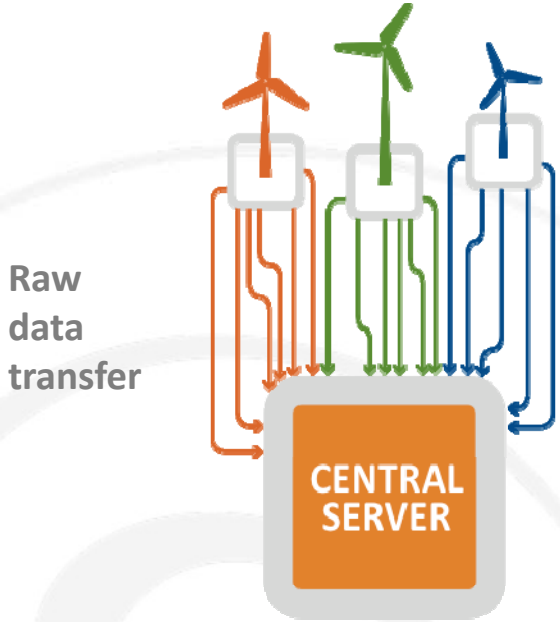


- High speed data streaming to central server
- Requires broad band high speed network (Band width)

→ Many signals to monitor

Select sensors that can post-process

Traditional monitoring systems



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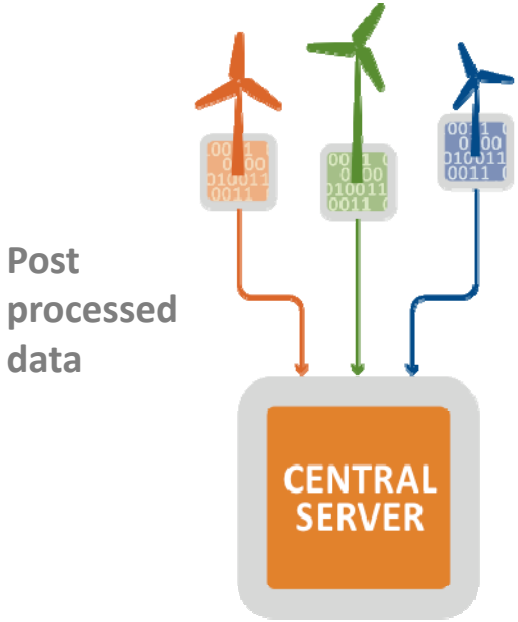
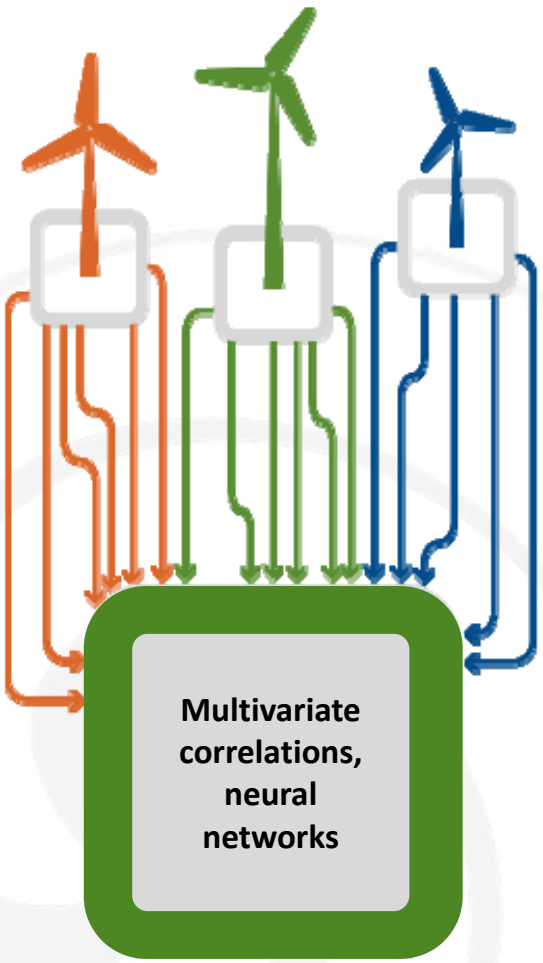
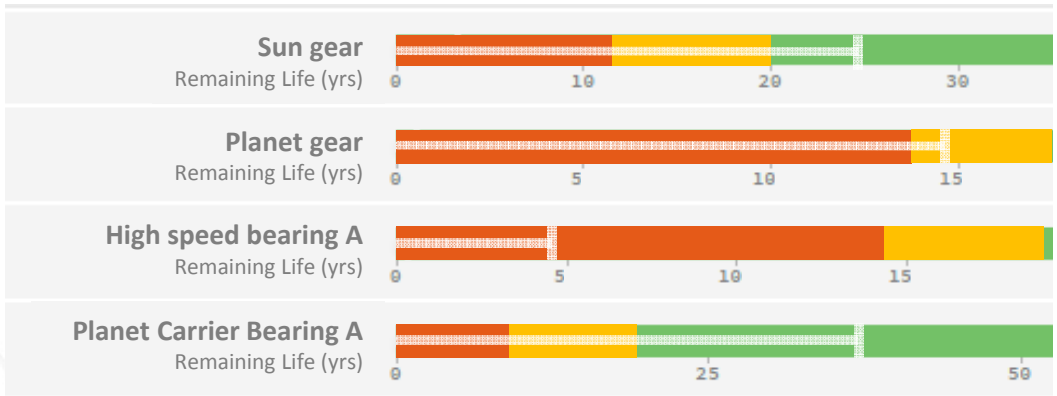
Decentralized monitoring systems



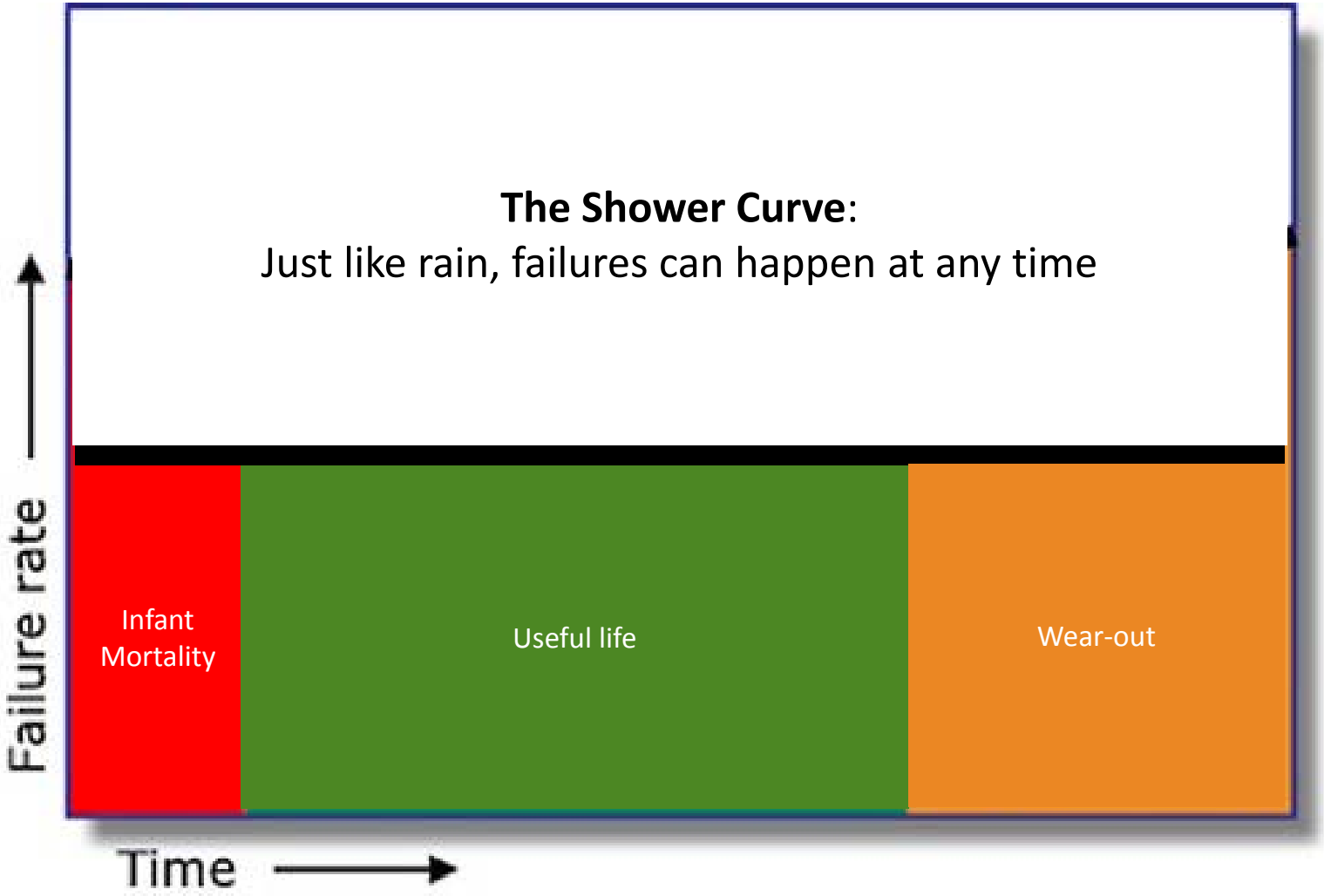
- Post Process data transfer to central server
- Minimal bandwidth for alarming
- Stream data only when necessary for analysis

Use big data techniques to combine many signals





By Component Life Prediction

One signal per component to monitor

Design turbines with reliability measures incorporated