GL Garrad Hassan

Empirical analysis of wind turbine reliability

Michael Wilkinson – EWEA 2011: Improving Turbine Reliability Side Event - Brussels March 2011

Summary of Reliawind Field Study

Main project work packages:

- Field data reliability analysis
- Design for reliability
- Algorithms for condition monitoring
- Proof of concept

Field Study Aim:

- Identify critical failure modes at the component, sub-system and system scale within wind turbines based on the analysis of long term operational data

ReliaWind

Summary of Reliawind Field Study

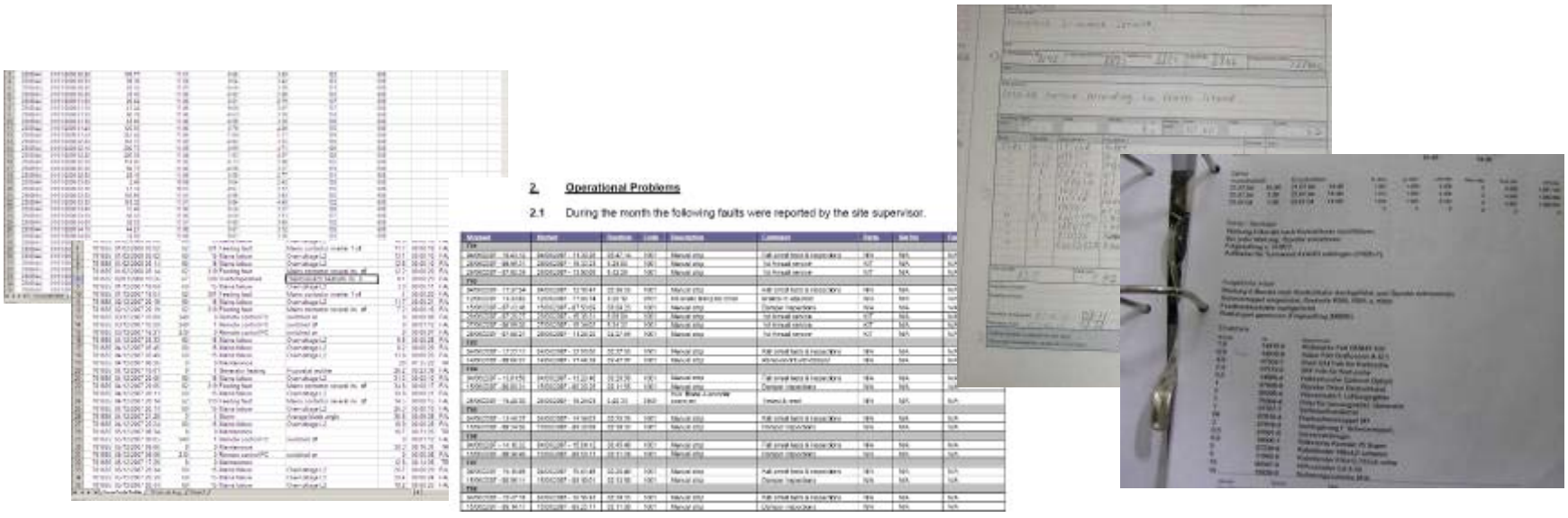
Method:

- Collation of Data
- Data processing and quality control
- Derivation of reliability profiles
- Documentation

ReliaWind

Collection of Data Available from a Wind Farm

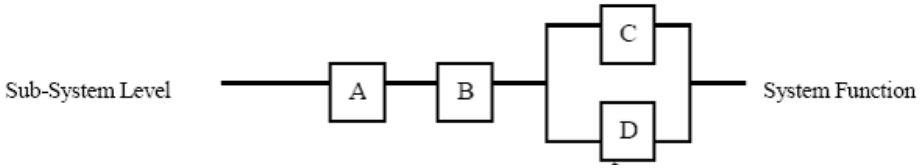
- 10 minute average turbine and substation SCADA databases
- Fault logs per turbine and substation
- Service records & work orders
- Monthly operational reports compiled by the operator and or manufacturer



Common Formats & Method

Turbine taxonomy

A common approach to describe wind turbines from different manufacturers



Rotor Module

Common Formats & Method

Turbine taxonomy

A common approach to describe wind turbines from different manufacturers

WTG		
	WIND TURBINE GENERATOR	
ROTOR MODULE		
	PITCH SYSTEM	
		PITCH HYDRAULIC SUBSYSTEM
		BLADE PITCH ACTUATORS
		ROTATING JOINT
		POSITION SENSOR (BALLUFF)
		BLADE LOCKING SYSTEM
	HUB	
	BLADES	
		TC
	BLADE BEARINGS	
		GENERAL BLADE BEARINGS
		LUBRICATION SYSTEM
	HUB COVER	
DRIVE TRAIN MODULE		
	MAIN SHAFT	
		MAIN SHAFT
	GEARBOX ASSEMBLY	
		GEARBOX
		TORQUE ARMS
		GEARBOX COOLING SYSTEM
		GEARBOX LUBRICATION SYSTEM
		GEARBOX SENSORS
	MECHANICAL BRAKE	
		MECHANICAL BRAKE HYDRAULIC SUBSYSTEM
		BRAKE CALLIPERS
		BRAKE DISC
		BRAKE PADS
		THERMISTOR
		SUPPORT PLATE
	DRIVE TRAIN SILENT BLOCKS	
	HIGH SPEED SHAFT TRANSMISSION	
		COUPLING
NACELLE MODULE		
	YAW SYSTEM	

Common Formats & Method

Definition of downtime event

A common approach to describe and classify a failure

- Duration ≥ 1 hour
- The event required at least a manual restart

- Category 1: manual restart
- Category 2: minor repair
- Category 3: major repair
- Category 4: major replacement

Common Formats & Method

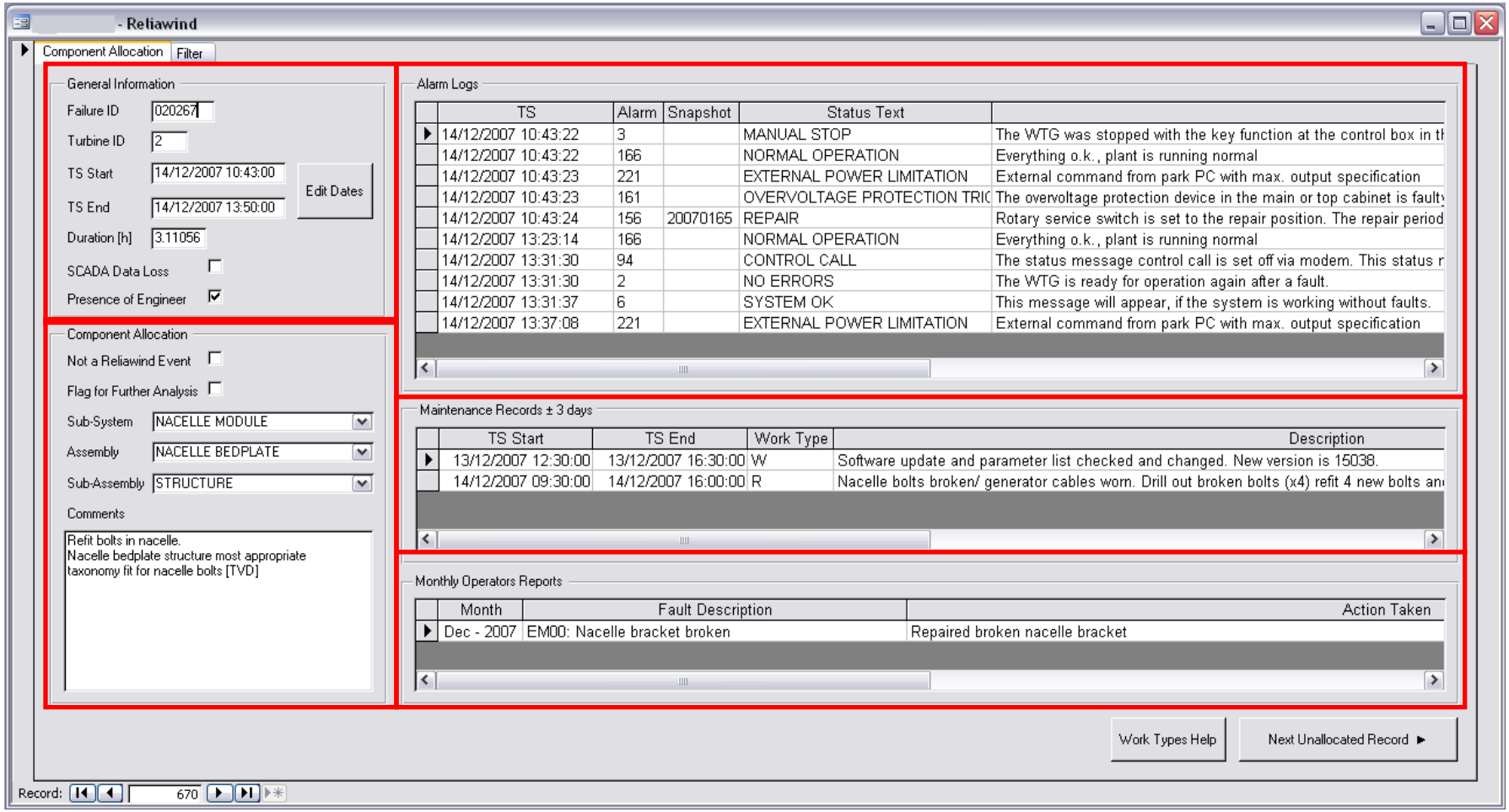
Database

A common method to store downtime events and their origin

TABLE 1 EVENTS

Wind Farm	Turbine ID	Date & Time of Event	Time to Repair TTR (hours)	Actual Repair Time ART (hours)	Sub-System	Assembly	Sub-Assembly	Part	Failure Mode	Root Cause	Maintenance Category	Severity Category	Additional information
A	1	2008-04-01 11:28:01	54.2	N/A	Drive train	Gearbox assembly	Gearbox	N/A	N/A	N/A	4	3	N/A
A	23	2008-04-24 01:56:11	168.4	3.5	Rotor	Pitch system	N/A	N/A	N/A	N/A	3	2	N/A
B	2	2008-04-25 08:43:24	2.5	1	Power	Generator assembly	Generator	Stator phase b winding	Open	Over current	1	1	Series defect
…	…	…	…	…	…	…	…	…	…	…	…		…

Component Allocation – database interface tool



Results

Data sources:

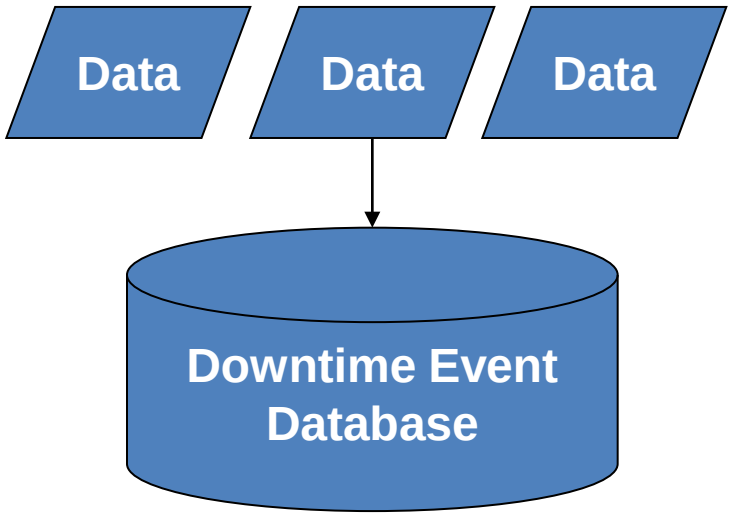
- Manufacturers – Consortium members
- Owners & Operators – Users' Working Group

Database composition:

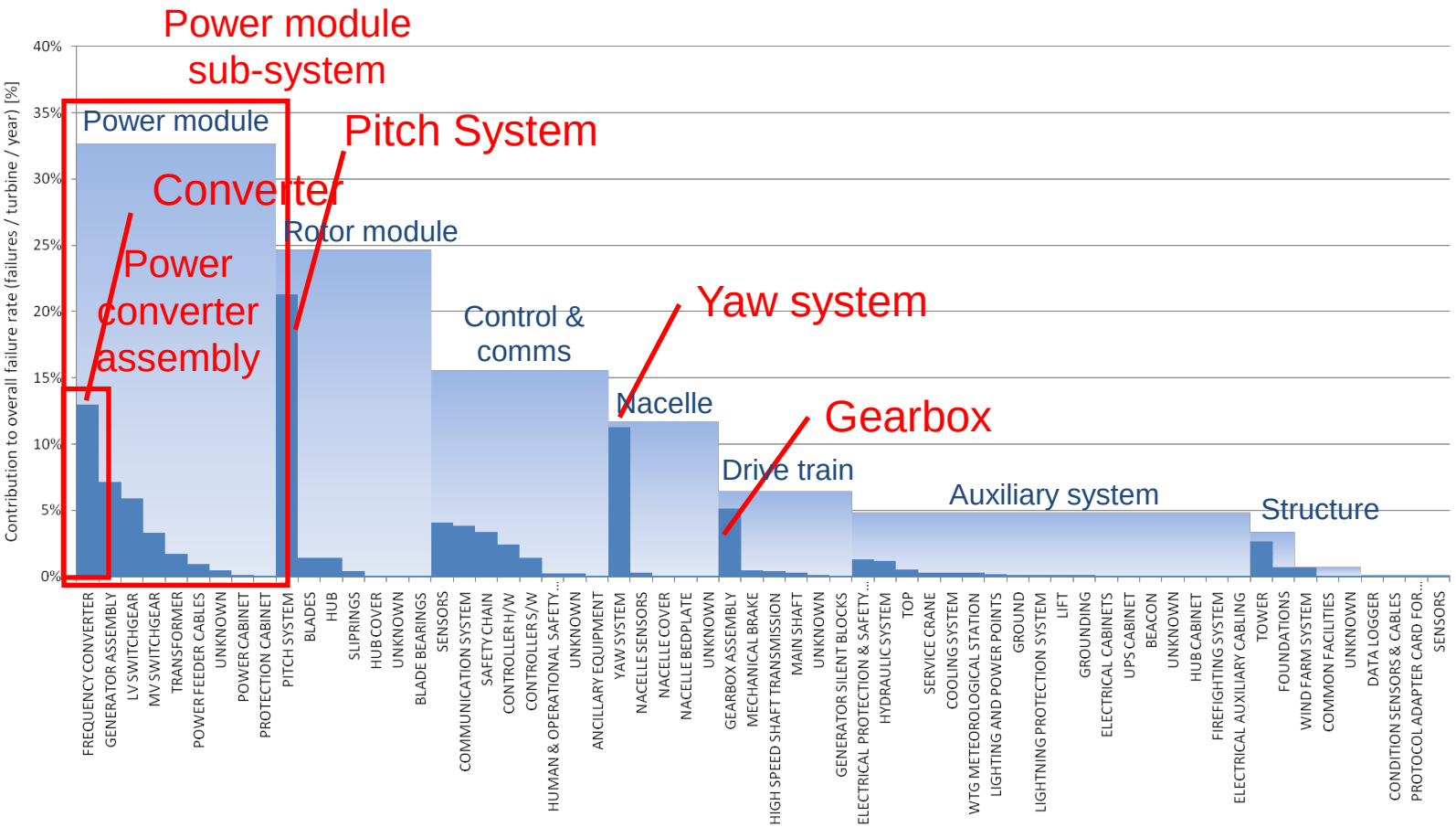
- 4 turbine manufacturers
- Pitch regulated, variable speed turbines

Database size:

- ~ 35,000 downtime events
- ~ 350 turbines
- ~ 450 wind-farm months



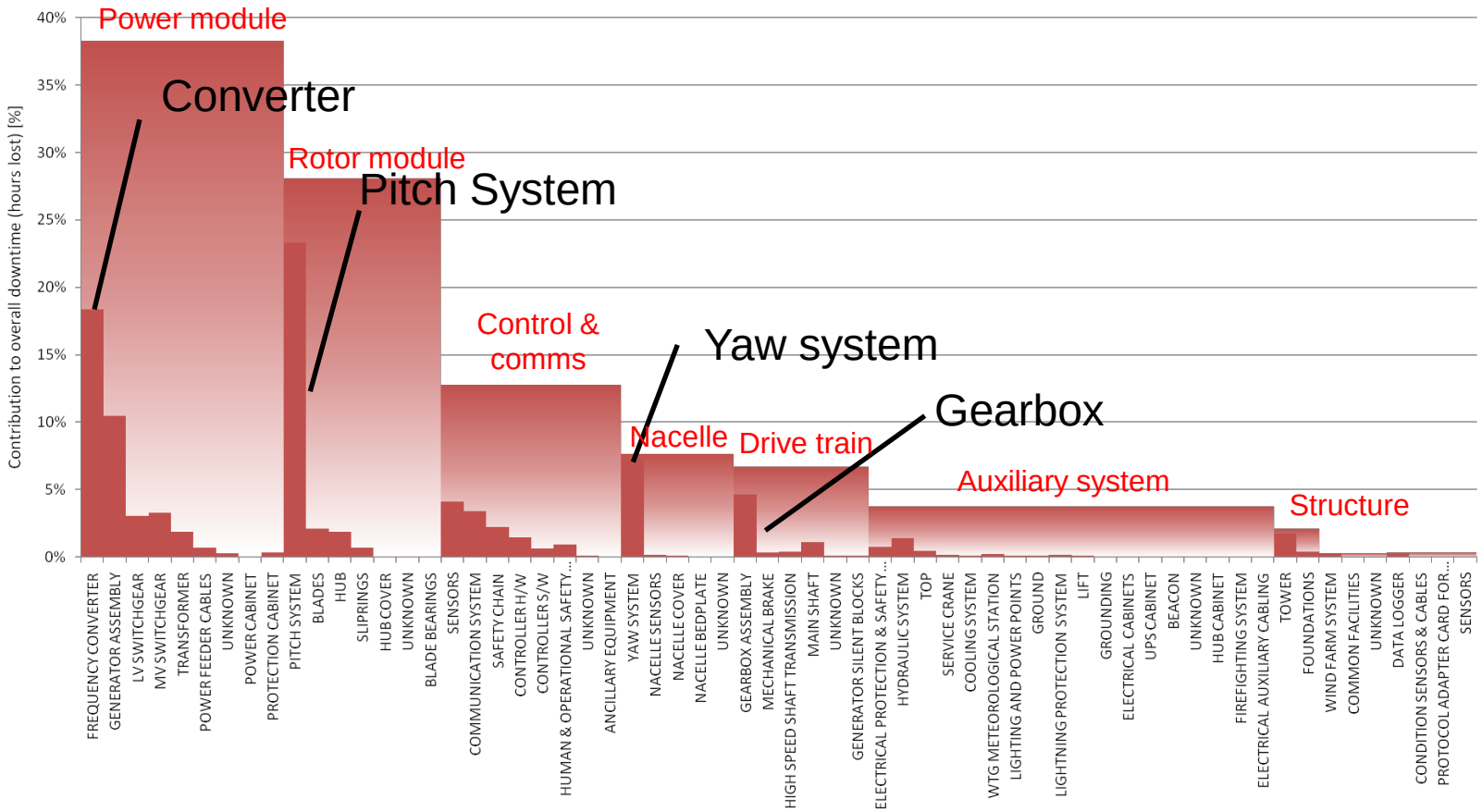
Results – Failure Rate (all downtime events)



Percentage contribution to overall failure rate

Data source: turbines from multiple manufacturers

Results – Downtime (all downtime events)



Percentage contribution to overall failure rate

Data source: turbines from multiple manufacturers

Conclusions

- Exhaustive downtime event database compiled
  - ~35,000 downtime events
  - ~350 turbines

- Results indicate significant parts of the turbine:
  - Power electronics
  - Pitch system

- Standardisation [Deliverable D 6.7]:
  - Taxonomy – common description of turbine
  - Definitions of downtime events
  - Methods for storing downtime events

Acknowledgements

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More results

09:00 – 10:30 Wednesday 16th March Reliability Session

Further information

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