

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

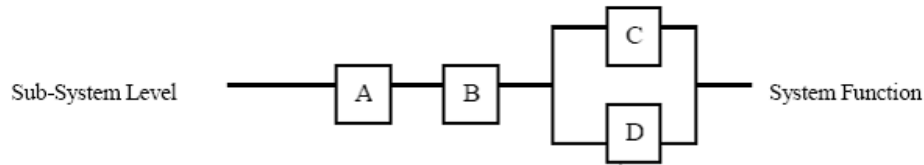


ReliaWind

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 \geq 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

Component Allocation – database interface tool

- Reliwind
_ □ ×

▶ Component Allocation Filter

General Information

Failure ID

Turbine ID

TS Start Edit Dates

TS End

Duration [h]

SCADA Data Loss

Presence of Engineer

Component Allocation

Not a Reliwind Event

Flag for Further Analysis

Sub-System

Assembly

Sub-Assembly

Comments

Refit bolts in nacelle.
Nacelle bedplate structure most appropriate taxonomy fit for nacelle bolts [TVD]

Alarm Logs

TS	Alarm	Snapshot	Status Text	
▶ 14/12/2007 10:43:22	3		MANUAL STOP	The WTG was stopped with the key function at the control box in t
14/12/2007 10:43:22	166		NORMAL OPERATION	Everything o.k., plant is running normal
14/12/2007 10:43:23	221		EXTERNAL POWER LIMITATION	External command from park PC with max. output specification
14/12/2007 10:43:23	161		OVERVOLTAGE PROTECTION TRIC	The overvoltage protection device in the main or top cabinet is faulty
14/12/2007 10:43:24	156	20070165	REPAIR	Rotary service switch is set to the repair position. The repair period
14/12/2007 13:23:14	166		NORMAL OPERATION	Everything o.k., plant is running normal
14/12/2007 13:31:30	94		CONTROL CALL	The status message control call is set off via modem. This status r
14/12/2007 13:31:30	2		NO ERRORS	The WTG is ready for operation again after a fault.
14/12/2007 13:31:37	6		SYSTEM OK	This message will appear, if the system is working without faults.
14/12/2007 13:37:08	221		EXTERNAL POWER LIMITATION	External command from park PC with max. output specification

Maintenance Records ± 3 days

TS Start	TS End	Work Type	Description
▶ 13/12/2007 12:30:00	13/12/2007 16:30:00	W	Software update and parameter list checked and changed. New version is 15038.
14/12/2007 09:30:00	14/12/2007 16:00:00	R	Nacelle bolts broken/ generator cables worn. Drill out broken bolts (x4) refit 4 new bolts and

Monthly Operators Reports

Month	Fault Description	Action Taken
▶ Dec - 2007	EM00: Nacelle bracket broken	Repaired broken nacelle bracket

Work Types Help Next Unallocated Record ▶

Record: ⏪ ⏩ ▶ ⏪ ⏩

Results

Data sources:

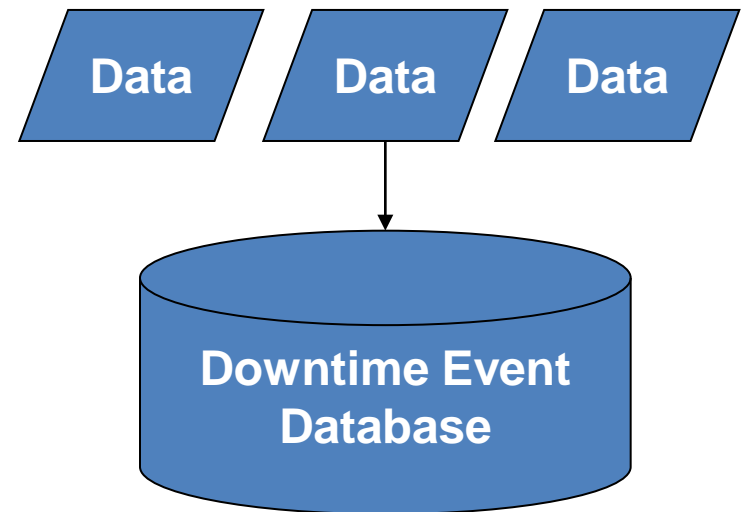
- Manufacturers – Consortium members
- Owners & Operators – Users' Working Group

Database composition:

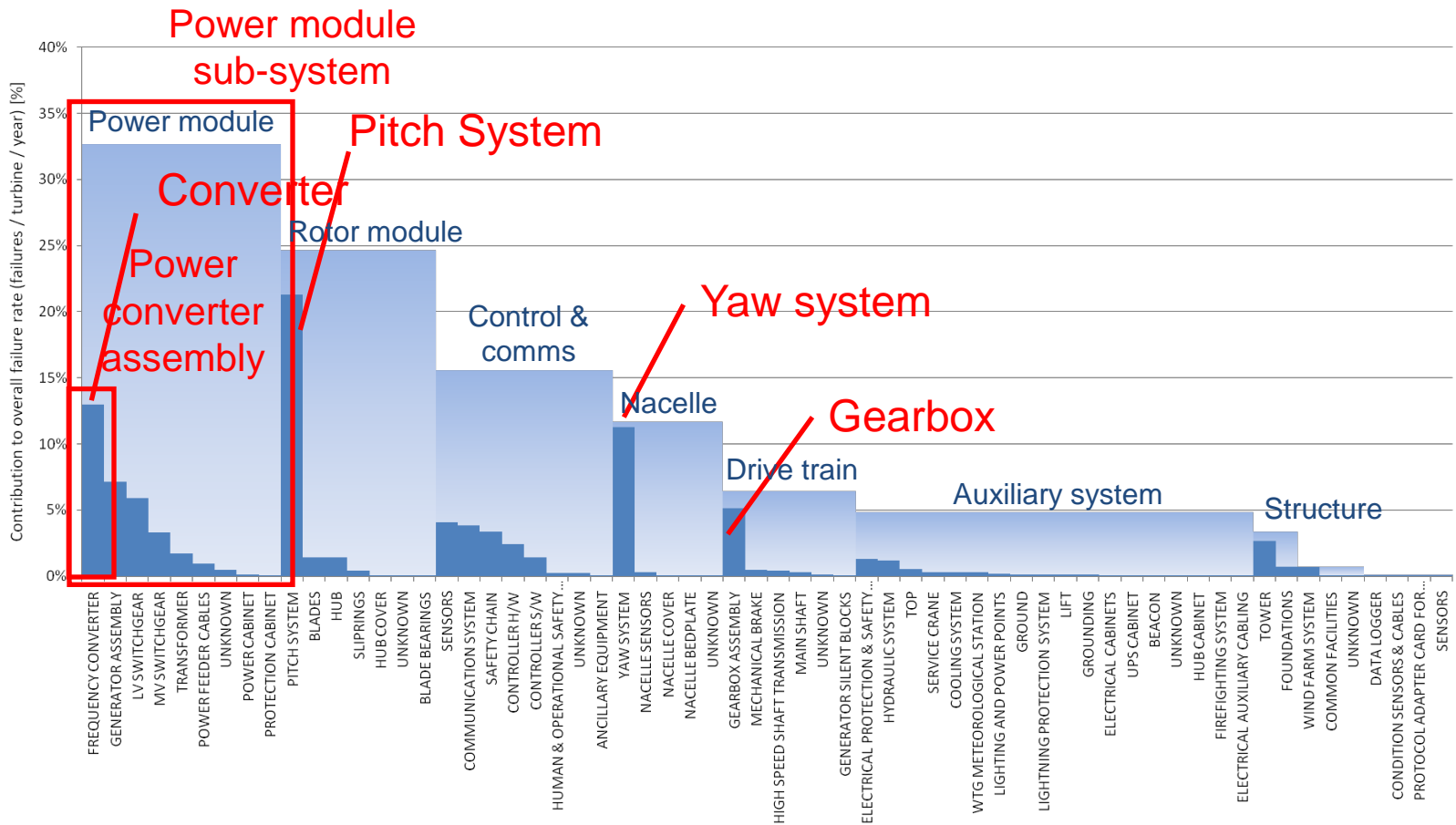
- 4 turbine manufacturers
- Pitch regulated, variable speed turbines

Database size:

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

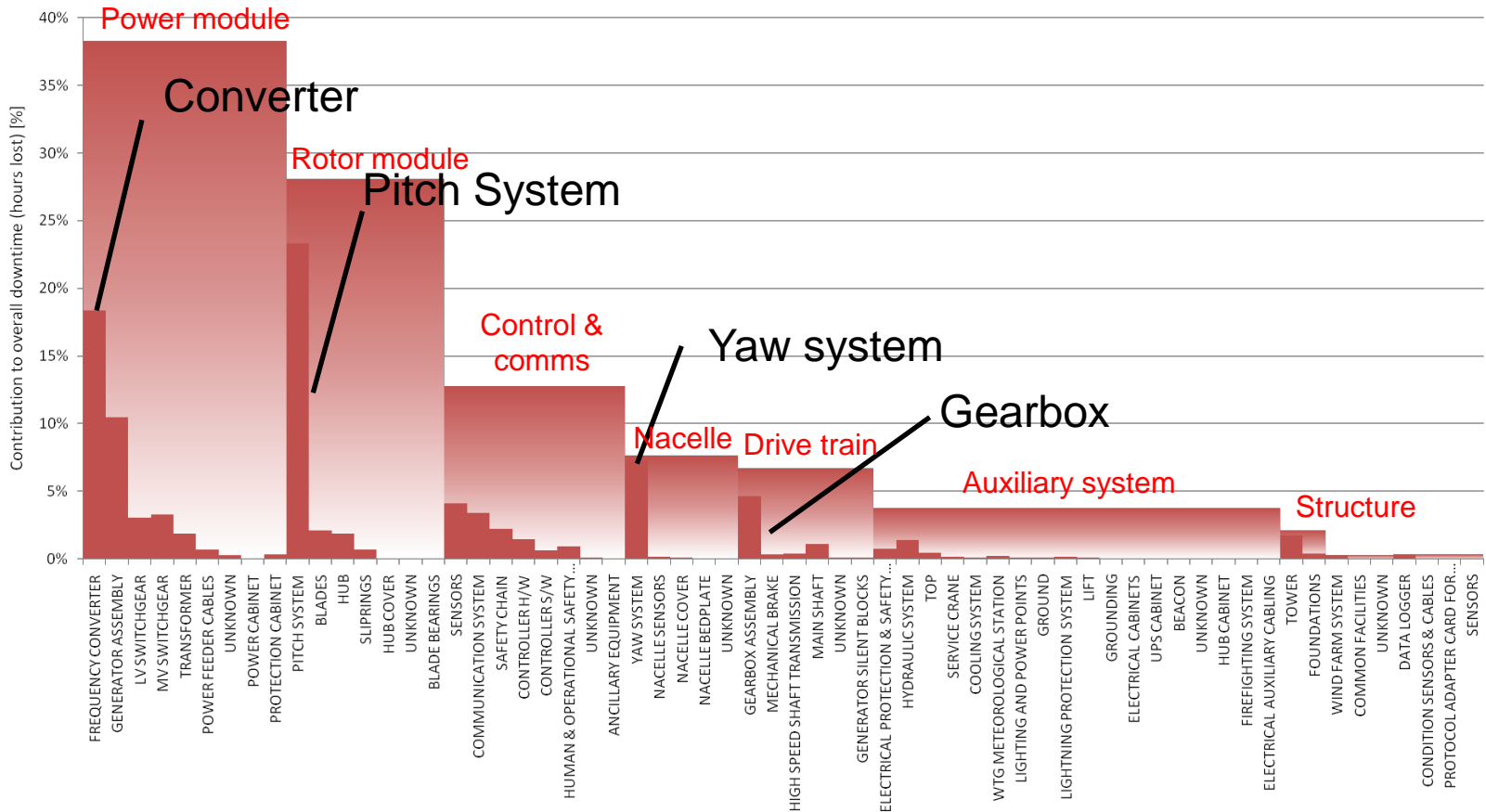


Results – Failure Rate (all downtime events)



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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