

Design for reliability-an FMEA study, WP2

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Design for reliability - a FMEA study



Specific objectives of the Study

- Review and harmonize failure data from manufacturers and suppliers
- Harmonize equipment failure rates and failure modes;
- Develop reliability models for Reliability analyses at system, subsystem and components level;
- Perform a Failure Modes, Effects Analysis in order to identify, evaluate and document component failures modes and potential impact on the system and finally to eliminate or mitigate unacceptable effects;
- Identify, design and develop possible fault tolerance mechanisms, such as redundancy or back-up systems to ensure that failure propagation is contained at component level with no impact on the operational turbine availability;
- Provide reliability and maintainability metrics for maintenance optimization.

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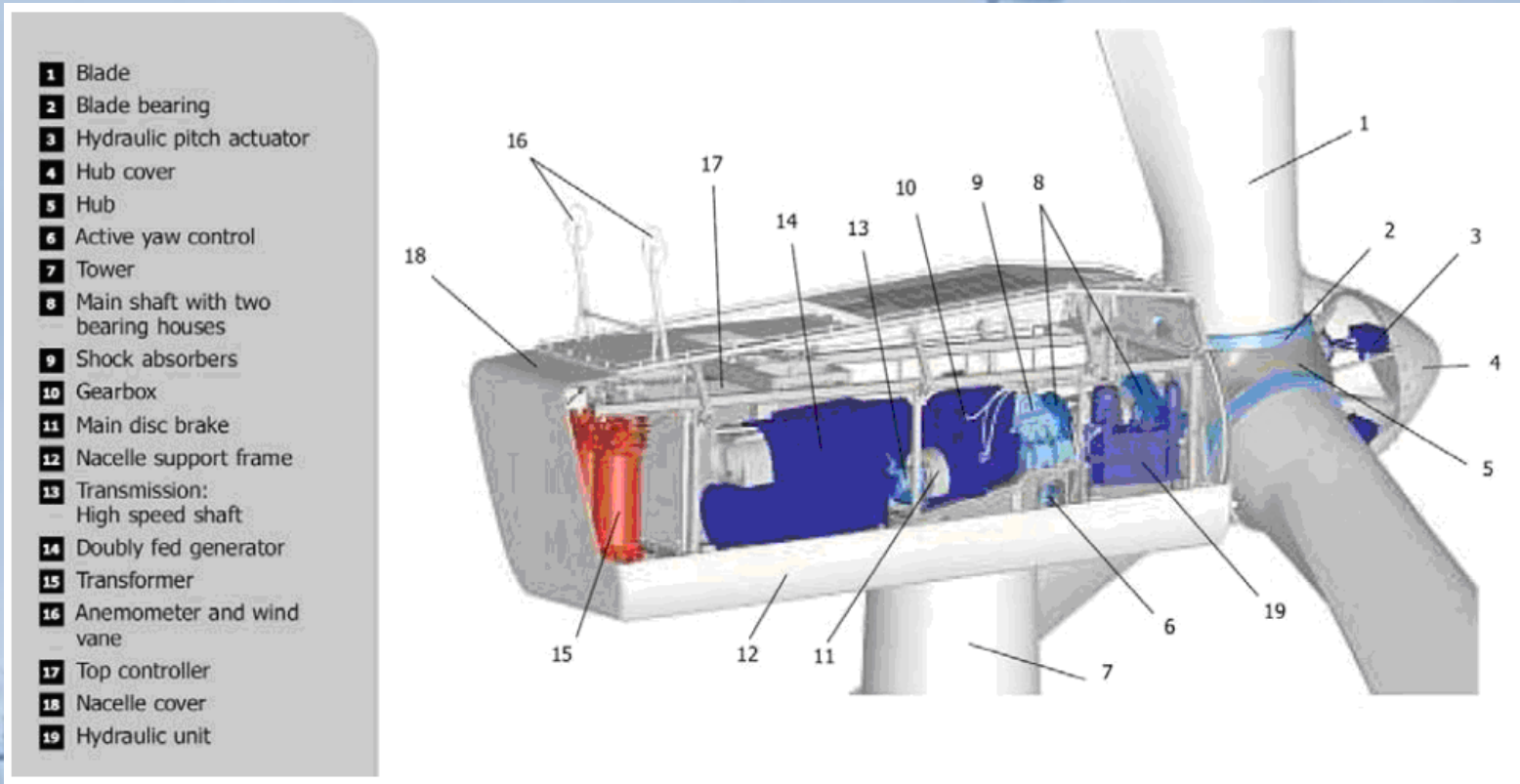


The Design for Reliability Approach

- Define System Hierarchy and Parts for each Assembly
- Create a Reliability Model at System, Subsystem and Component level
- Perform a System Reliability Prediction
- Perform a System Availability Analysis using Functional and Reliability Block Diagrams
- Perform a FMECA (Failure Mode Effects and Criticality Analysis)
- Report the overall Wind Turbine Reliability Characteristics in a harmonised form
- Propose new system Design Guidelines and recommendations to improve the overall reliability and availability

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General Structure for a 2MW Wind Turbine



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WTG Sub-System Reliability Model integration

System Tree

Name	Part Number	Description	System Tree Identifier
WTG	WIND TURBINE	WTG	System
ROTOR MODULE	ROTOR MODULE	Rotor Module	System263
PITCH SYSTEM (HYDRAULIC)	PITCH SYSTEM	HYDRAULIC PITCH SYSTEM	System1484
Hub	HUB	Hub	System1672
BLADES	BLADES	Blades	System283
Extender	WTG80AD	Extender	System1690
Sliprings	SLIPRINGS	Sliprings	System1693
DRIVE TRAIN MODULE	WTG80B	Drive Train Module	System290
Main shaft system	MAIN SHAFT	Main shaft system	System1865
GEARBOX ASSEMBLY	GEARBOX ASSEMBLY	Gearbox Assembly	System297
Nacelle Module	NACELLE MODULE	Nacelle Module	System1766
Yaw	WTG80CA	Yaw	System1767
Nacelle cover	WTG80CD	Nacelle cover	System1822
Nacelle Body Structure	WTG80CE	Nacelle Body Structure	System1845
Nacelle sensors	WTG80CF	Nacelle sensors	System1862
Structural Module	STRUCTURAL MODULE	Structural Module	System1620
Foundation	WTG80DA	Foundation	System1621
Tower	WTG80DB	Tower	System1634
POWER MODULE	POWER MODULE	Power Module	System345
Asynchronous generator	WTG80EB	Doubly-fed asynchronous generator	System1951
2MW doubly-fed converter	WTG80EC	2MW doubly-fed converter	System1924
CONTROL & COMMUNICATION SYSTEM	COMM&CONTROL	Control & Communication System	System1435
CONTROL SYSTEM	WTG80FA	Group of control & communication modules which manages the nor...	System1436
HUMAN & OPERATIONAL SAFETY DEVICES	WTG80FB	Devices which are only involved with the emergency safety stop, ...	System1471
INSTRUMENTATION	WTG80FC	Instrumentation elements monitoring this assembly.	System1482
CONDITION MONITORING SYSTEM	CONDITION MONITORING	Condition Monitoring System	System1396
AUXILIARY EQUIPMENT	AUXILIARY EQUIPMENT	Auxiliary Equipment	System841
WIND FARM SYSTEM	WIND FARM SYSTEM	WIND FARM SYSTEM	System1401
Scada Server System - server #1	WTG80IBA	Scada Server System - server #1	System1402
SCADA Data Base Server - server #2	WTG80IBB	SCADA Data Base Server - server #2	System1411
SCADA Server Rack - WF infrastructure communication	WTG80IBC	SCADA Server Rack - WF infrastructure communication	System1420
SCADA Server Rack - WF external communication	WTG80IBD	SCADA Server Rack - WF external communication	System1422
SCADA Server Rack	WTG80IBE	SCADA Server Rack	System1424
SCADA Server UPS	WTG80IBF	SCADA Server UPS	System1431

Parts Table

Name	Part Number	Part Classifica...	Category	Subcategory	Failure Rate...	Failure Rate, Percentage
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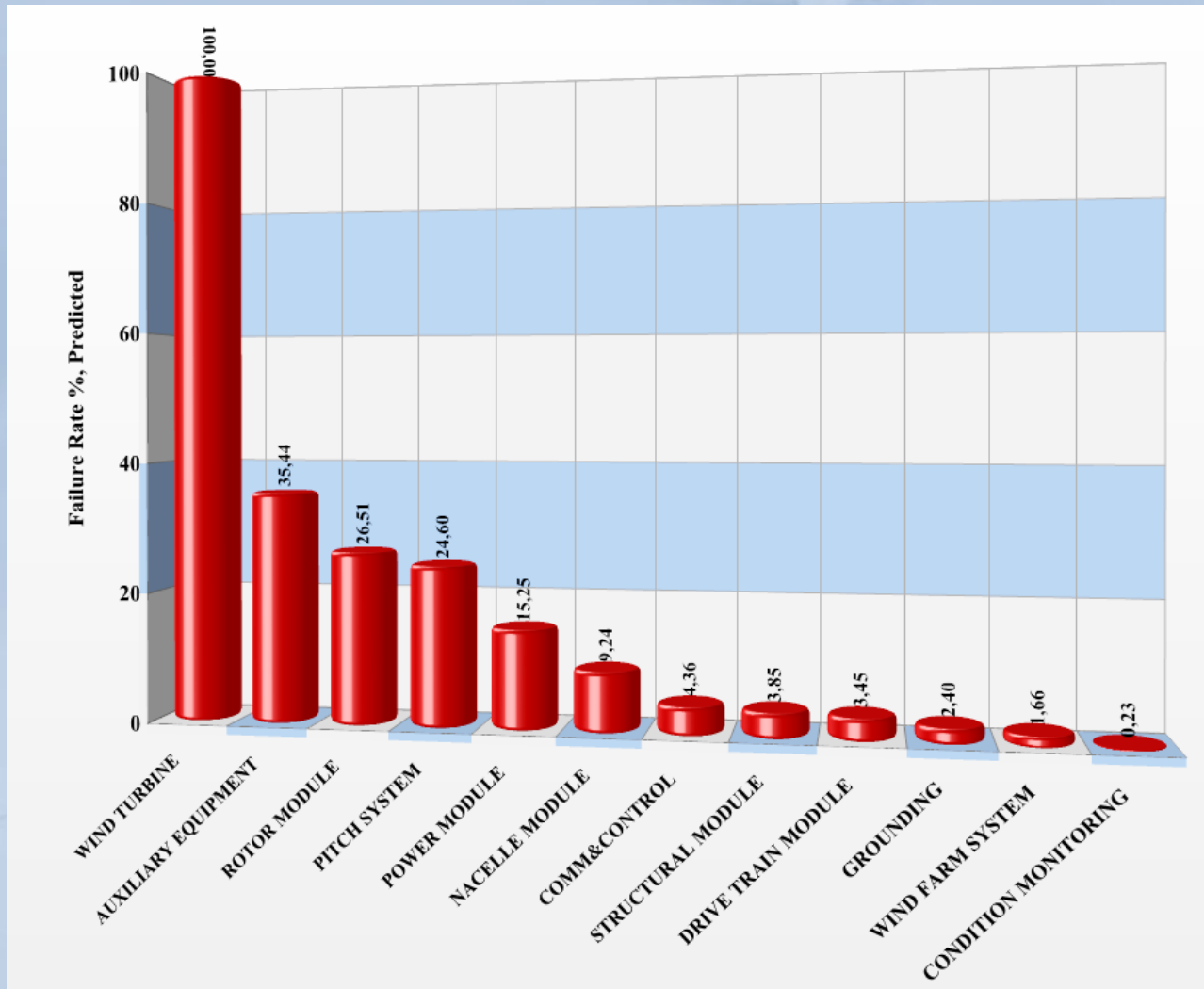
Predicted failure rates and availabilities for the R80 system

Name	Failure Rate %	Availability%
Wind Turbine Generator	100	93,96
Rotor Module	26,51	95,31
Power Module	15,25	99,29
Nacelle Module	9,24	99,92
Control & Communication System	4,36	99,94
Structural Module	3,85	99,72
Drive Train Module	3,45	99,90
Wind Farm System	1,66	99,9964
Condition Monitoring System	0,23	99,9996
All auxiliary Equipments	35,44	99,74

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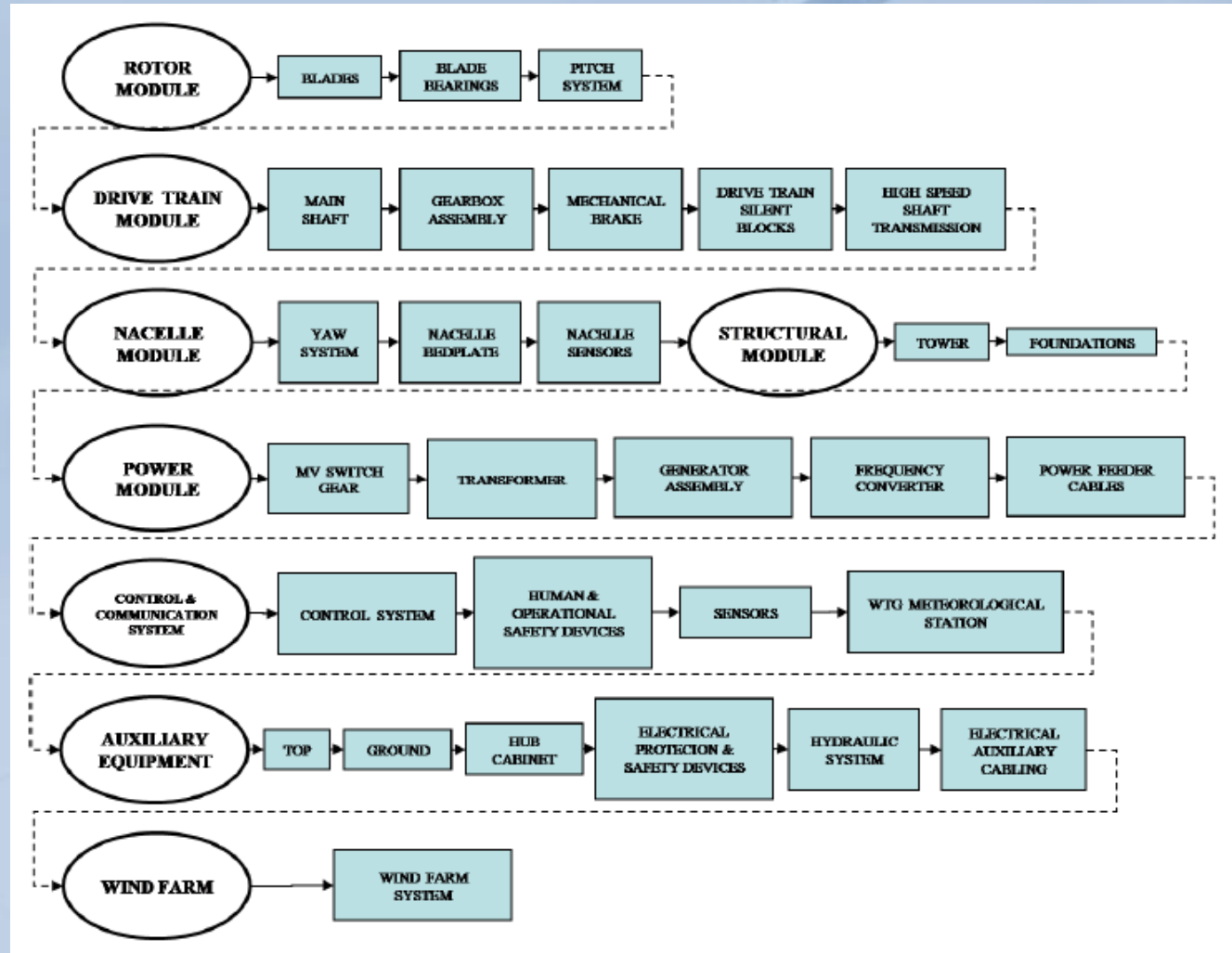


Top Failure Rates for the WTG and main subsystems



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Reliability Block Diagram



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FMECA Procedure

- Complete definition of WTG System at all indenture level including identification of internal and external interface functions, expected performance and failure definitions.
- Construct Functional Block Diagrams.
- Associate each function to components.
- Identify all potential item and interface failure modes including their effects.
- Evaluate each failure mode in terms of local, next and end effects with associated Severity Classification.
- Identify corrective action required to eliminate the failure or reduce the risk.
- Identify failure detection methods and possible compensating provisions for each failure mode.

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Failure Modes Severity Classification

Description	Category	Definition
CATASTROPHIC	I	A failure Mode which causes Death, WTG loss or severe environmental damage
CRITICAL	II	A failure Mode which causes Severe injury, severe occupational illness, major WTG or environmental damage
MARGINAL	III	A failure Mode which causes minor injury, occupational illness, minor WTG and environmental damage, or mission degradation
MINOR	IV	Less than minor injury, occupational illness, or less than minor WTG or environmental damage

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WTG FMECA Worksheet

Relax Architect - [R100 FMECA, Report Output, Report: 'Example of FMECA Report', Data Source File: 'R100 RotorModule Gamesa']

Preview View Window Help

Project Navigator

Relax
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RELIAWIND - FMECA Worksheet

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System Name : R100 Wind Turbine

Item	Item Name	Failure Mode No.	Failure Mode	Local Failure Effect	End Effect	Item Failure Rate	Failure Mode Ratio (%)	Mode Failure Rate (FIT)	Severity Classification	Remarks
HPS-21	RELIEF VALVE	Mode645	LEAKING	Increase pumping time	Different loads on the blades	2,95	5,0	0,1	II - Critical	
		Mode644	PREMATURE OPEN	Increase pumping time	Different loads on the blades					
		Mode643	STUCK CLOSED	Pressure increase	Loss of functionality					
HPS-104	LOGIC ELEMENT	Mode733	STUCK CLOSED	Impossible to move the cylinder	No control of blade position.	5,89	50,0	2,9	II - Critical	
		Mode732	STUCK OPEN	Impossible to move the cylinder	No control of blade position.					
HPS-105	TEMPERATURE SENSOR	Mode647	WRONG SIGNAL	Wrong measurement	Different loads on the blades	5,84	48,0	2,8	II - Critical	
		Mode646	NO SIGNAL	Loss of signal	Different loads on the blades					
HPS-106	ORIFICE Ø 2.25 mm	Mode663	BLOCKED	Speed decreases during emergency	Different loads on the blades	0,30	100,0	0,3	II - Critical	
HPS-107	BUFFER CYLINDER	Mode735	BLOCKED	No high speed during the beginning of emergency	No control of blade position.	0,01	100,0	0,0	II - Critical	
WTG80AAAC	HYDRAULIC CYLINDERS PROTECTIONS	Mode753	No effect	No effect	No effect	0,91	50,0	0,5	IV - Minor	
		Mode754	Loss of protection	Impossible to protect elements	Impossible to protect elements					

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FMECA Results - WTG Criticality Matrix

P_{occ}

A				
B	1		1	
C		8	14	
D	4	17	11	
E	5	2	16	2
	IV Minor	III Marginal	II Critical	I Catastrophic

Severity Classification

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FMECA Results - WTG Criticality Matrix cnt.

- There are two Extremely Unlikely Catastrophic Failures Modes (Level E) which are due to a failure of the Nacelle Body Structure causing the Yaw brake to be unsupported and the Rear Bearing to be locked in the Hub;
- Within the Critical Failure Modes, the 14 Occasional Occurring (Level C) failures are associated with 13 failures that can induce the WTG to stop working and one failure that can have a possible adverse effect on safety and possible WTG collapse due to a loss of over-speed protection. The Critical Reasonably Probable (Level B) failure Mode is associated with a complete failure of the Converter, ie Converter inoperable.
- The remaining Marginal (27) and Minor (10) failure modes are mainly in the Low and Medium Risk areas being characterized by very low severity and probability of occurrence