Design for reliability-an FMEA study, WP2

EWEA2011 Reliawind side event
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EC Contract number 212 966 - FP7-ENERGY-2007-1-RTD

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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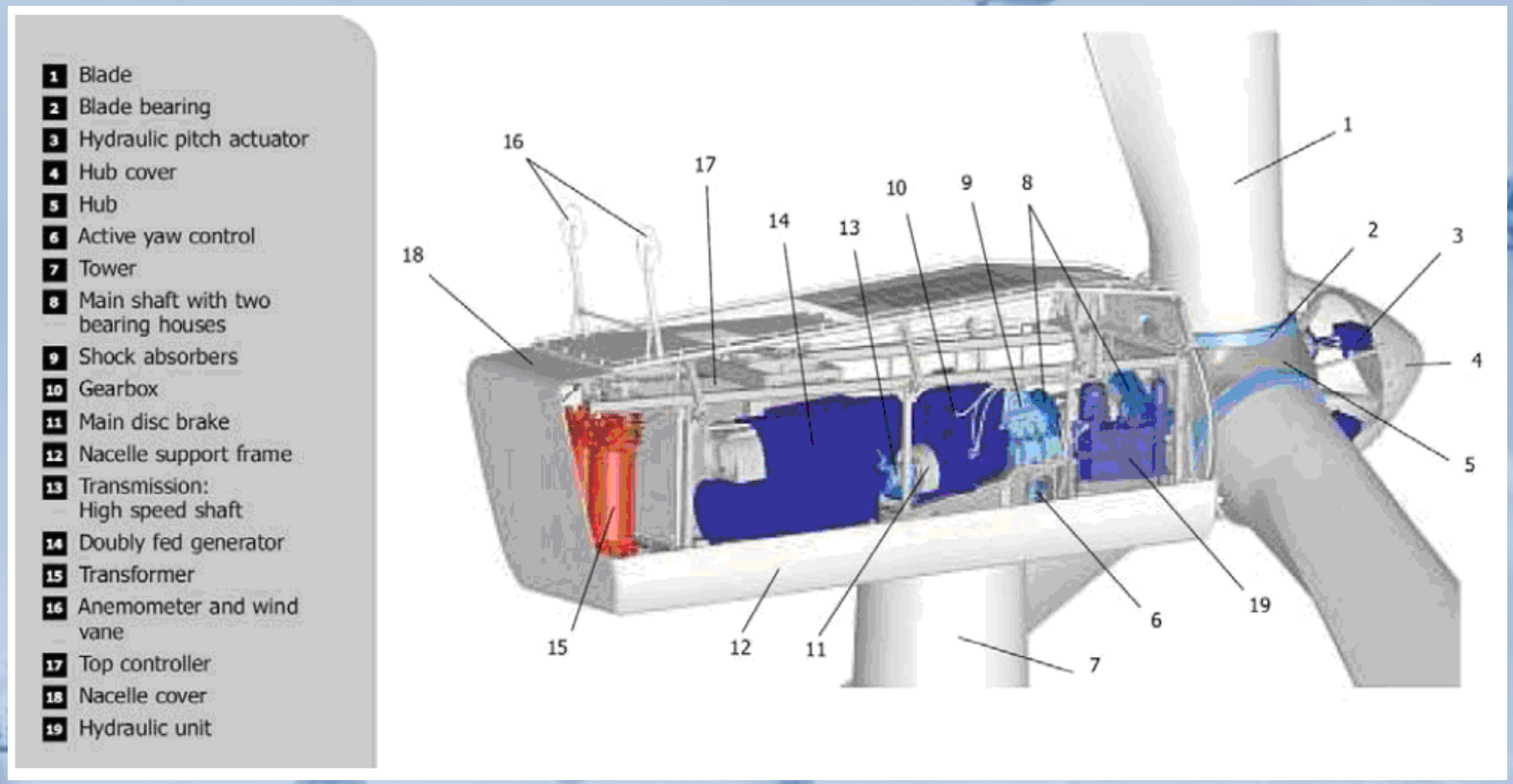
General Structure for a 2MW Wind Turbine



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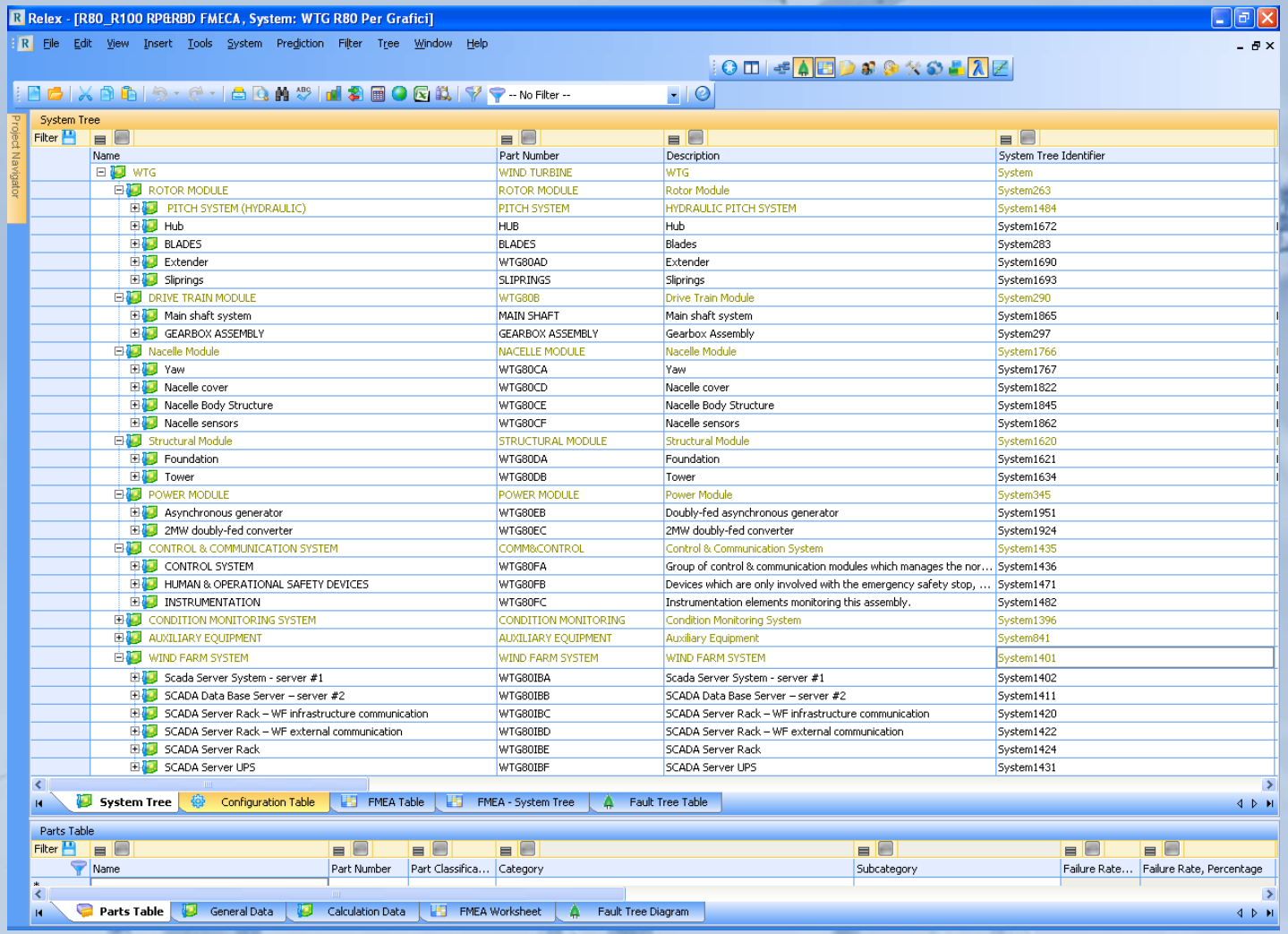
WTG Sub-System Reliability Model integration



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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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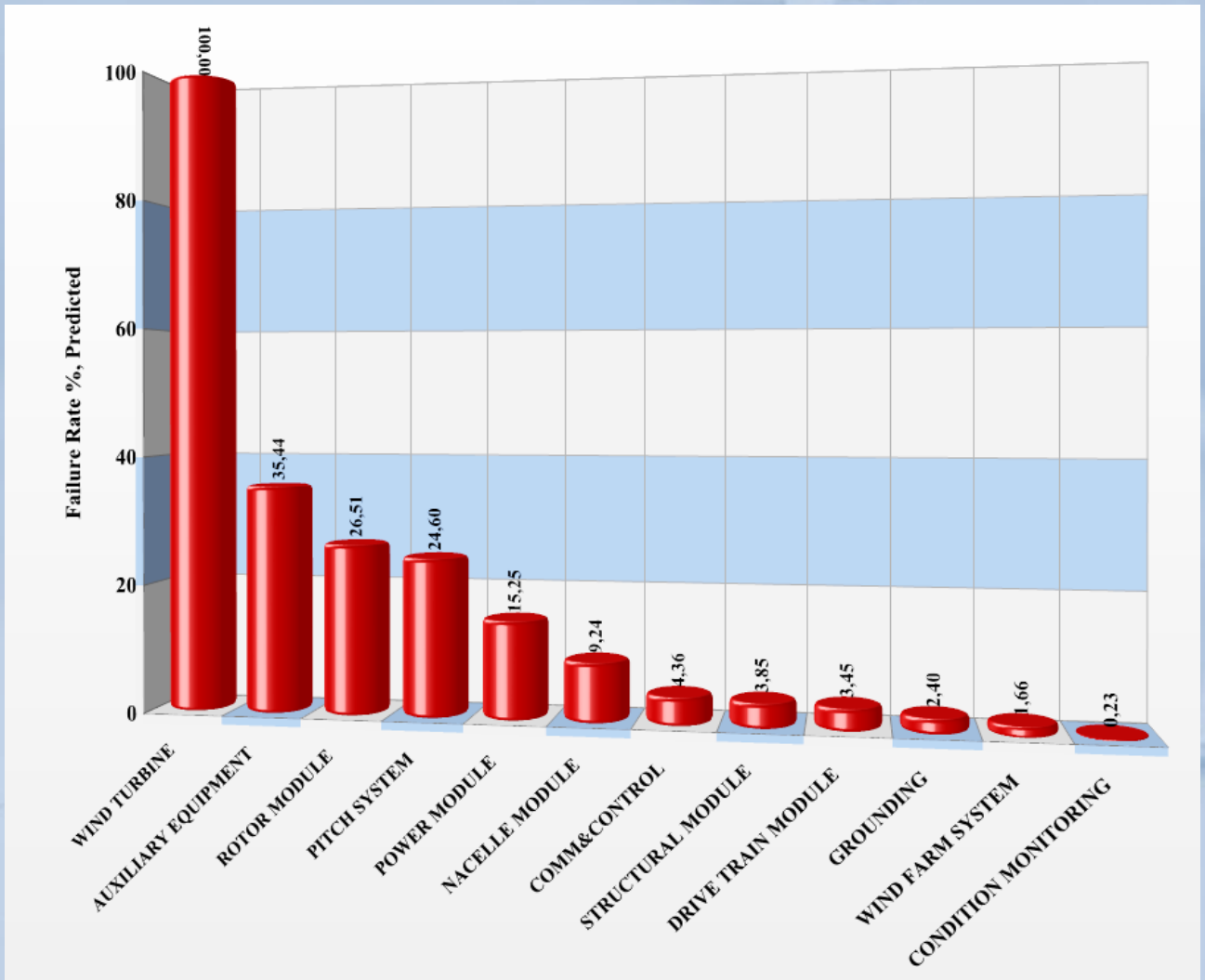
Top Failure Rates for the WTG and main subsystems



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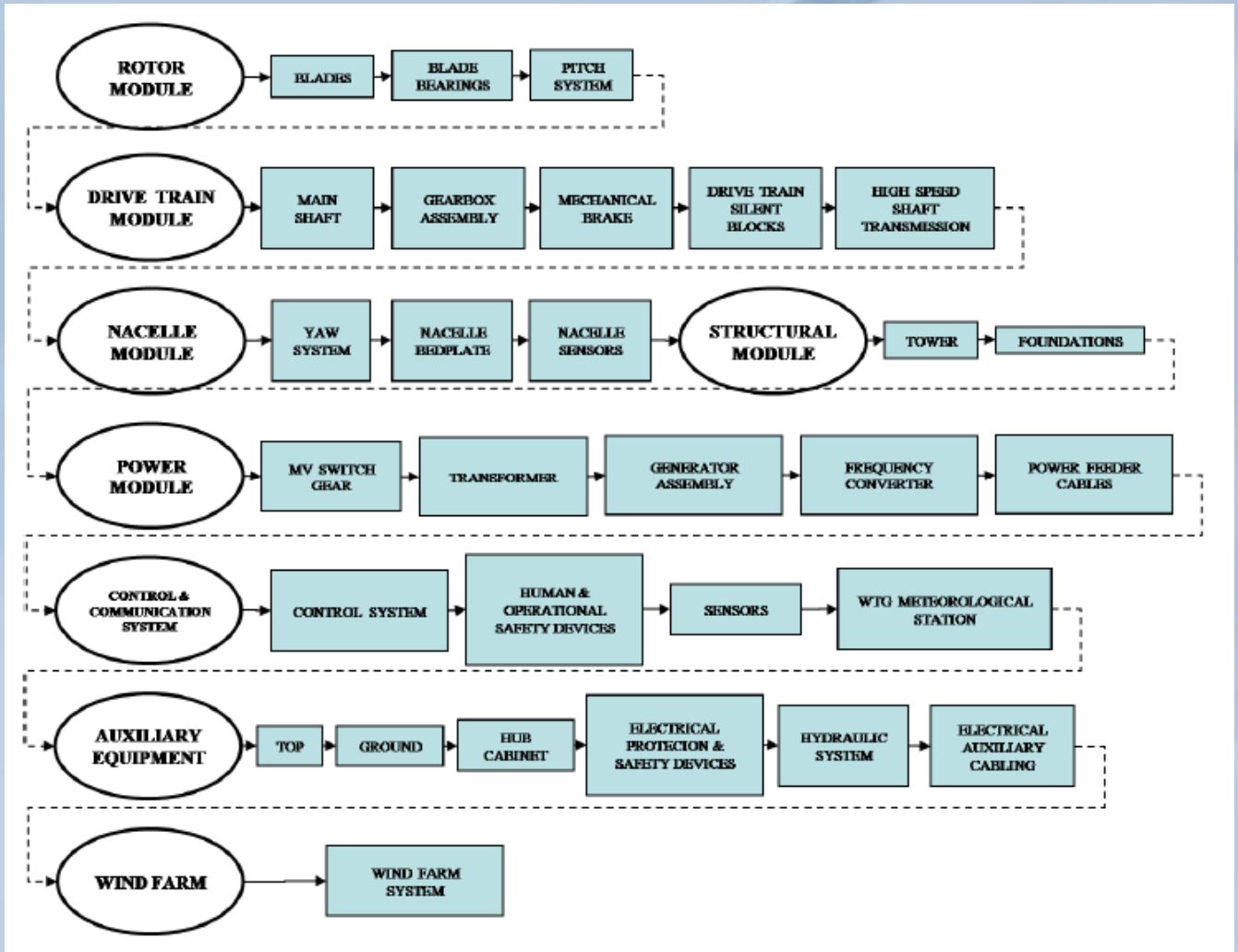
Reliability Block Diagram



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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

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

Preview View Window Help

Relex Italia Srl

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		80,0	2,4	II - Critical	
		Mode643	STUCK CLOSED	Pressure increase	Loss of functionality		15,0	0,4	III - Marginal	
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.		50,0	2,9	II - Critical	
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		52,0	3,0	II - Critical	
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		50,0	0,5	III - Marginal	

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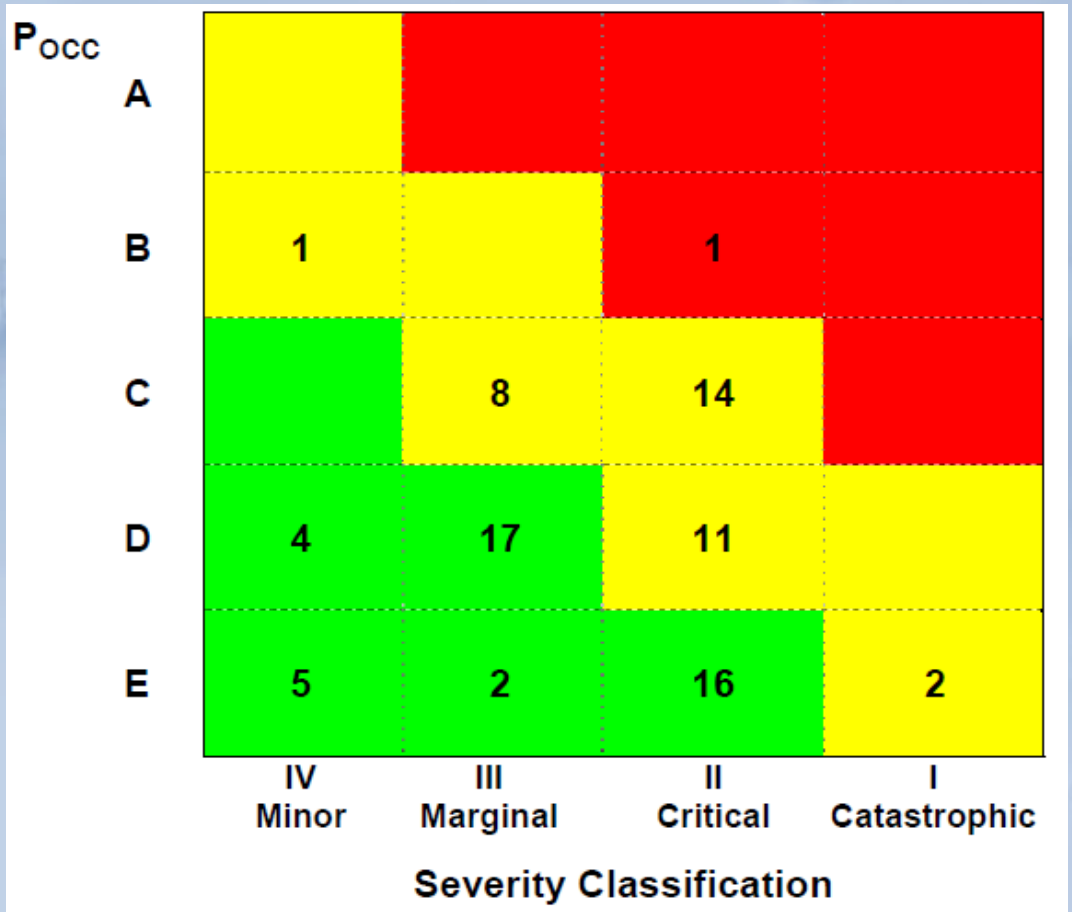
FMECA Results - WTG Criticality Matrix



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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