DSI International

FMECA Plus

Rethinking the Boundaries of the Traditional FMECA

The **FMECA Plus** capability in ***eXpress*** transcends customary disciplinary barriers, allowing engineers and analysts in different areas of design to integrate the results of their respective efforts. The flexibility of the **FMECA Plus** engine not only fosters non-traditional uses of FMECA-related data, but also adds some simple, yet powerful twists to standard FMECA-based activities.

Item	Failure	Root Failure Mode Causes	Failure Effects			Compensating Provisions	Severity Class	Failure Ratio	Failure Rate	Diagnostic Coverage	
			Local	Next Higher	End Item					Failure Detected	Fault Group Sizes
Fvalve:Valve	Insuffiecient Pressure	Insuffiecient Pressure (Prognostic	Valve Prognostic Limit	Fuel Assy:Fuel Control Failure	Unable to control fuel system						
	Non-Constant Flow (Surging)	Erratic operation (sticky)	Valve Prognostic Limit	Fuel Assy:Fuel Control Failure	Unable to control fuel system						
	Stuck Closed (mechanical/electrical)	Stuck Closed Solenoid Failure	Valve Failure	Fuel Assy:Fuel Control Failure	Unable to control fuel system						
	Stuck open (mechanical/electrical)	Solenoid Failure Stuck open									
Landing Gear	Landing Gear_Failure	Landing Gear_Failure				Degree of Redundancy may provide sufficient paths to allow return to base	Category III - Marginal	6.0000	0.045413	Yes	6
Pilot Control	Pilot Control_Failure	Pilot Control_Failure				Degree of Redundancy may provide sufficient paths to allow return to base	Category III - Marginal	19.0000	0.143808	No	N/A
PWR Relay	PWR Relay_Failure	PWR Relay Failure				Degree of Redundancy may provide sufficient paths to allow return to base	Category III - Marginal	19.0000	0.143808	No	N/A
VCU	ECU BIT Valid Indication failure	VCU:PWR SUPPLY FAIL VCU:DISCRETE OUTPUT VCU:DISCRETE OUTPUT					Category II - Critical	100.0000	5.000000	Yes	2
							Category II - Critical	100.0000	7.000000	Yes	2
	ENG Controller_control Failure	ENG Controller_control I					Category III - Marginal	100.0000	7.300000	Yes	7
								12.1212	0.763636	Yes	2 1
						Degree of Redundancy may provide sufficient paths to allow return to base System can still maintain control but must fly with calculated results using other inputs	Category II - Critical	100.0000	6.300000	Yes	1

*Derived entirely from data in an **eXpress** Diagnostic Study, the **eXpress** Diagnostic FMEA Chart ties together details of the system from Design, Reliability, Test, Diagnostic and Systems Engineering efforts*

Failure Rate	Severity Class	Relative Criticality	Diagnostic Coverage				
			Failure Detected	Fault Isolation			
				Uniquely Isolated	Number of Root FMs in Fault Groups	Fault Groups	Fault Group Sizes (Number of Items)
31.250000	Category I - Catastrophic	31.2500	Yes	No	10	Fault Group # 84	2
31.250000	Category I - Catastrophic	31.2500	Yes	No	10	Fault Group # 84	2
57.300000	Category III - Marginal	28.6500	Yes	No	20	Fault Group # 4	7
31.250000	Category II - Critical	23.4375	Yes	No	4	Fault Group # 89	2
20.833333	Category I - Catastrophic	20.8333	Yes	No	10	Fault Group # 84	2
10.416667	Category I - Catastrophic	10.4167	Yes	No	9	Fault Group # 91	1
10.416667	Category I - Catastrophic	10.4167	No	N/A	N/A	N/A	N/A
10.416667	Category I - Catastrophic	10.4167	Yes	No	10	Fault Group # 84	2
10.416667	Category I - Catastrophic	10.4167	Yes	No	10	Fault Group # 84	2
10.416667	Category I - Catastrophic	10.4167	Yes	No	4	Fault Group # 89	2
10.416667	Category I - Catastrophic	10.4167	Yes	No	10	Fault Group # 84	2
10.416667	Category I - Catastrophic	10.4167	Yes	No	4	Fault Group # 89	2
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 60	1
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 73	1
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 64	1
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 69	1
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 65	1
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 68	1
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 61	1
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 71	1
10.416667	Category II - Critical	7.8125	Yes	Yes	1	Fault Group # 62	1

*This excerpt from an **eXpress** Critical Failure Diagnosis Chart shows the columns that describe the fault detection and isolation that can be achieved for each critical failure.*

Better Leverage – With **FMECA Plus**, the results of different analysis activities can be united in a single arena, allowing analysts from different disciplines to reap the benefits of each other's efforts.

The ***eXpress*** *Critical Failure Diagnosis Chart*, for instance, lists all failures in order of relative criticality, based on Reliability Analysis data. Details from the Test & Diagnostic Engineering efforts are then used to identify the extent to which each failure can be detected and isolated by actual system diagnostics.

A Firmer Foundation – Diagnostic data in each **FMECA Plus** chart is derived directly from diagnostic analysis in ***eXpress***, so analysts can be sure that results are based on the actual system diagnostic design, rather than on speculative best-guesses by individuals not involved in the diagnostic engineering process.

Failure	Item	Severity		Occurrence		Detection		Risk Priority Number (RPN)
		Severity Class	Severity Rating	Failure Rate	Occurrence Rating	Overall Pctg. of Failure Detected	Detection Rating	
			S		O		D	
Bypass_Failure	JET ENGINE	Category I - Catastrophic	10	104.072917	1	0.00	10	100
Stuck Closed (mechanical/electrical)	Fvalve:Valve	Category III - Marginal	4	0.143808	1	0.00	10	40
Stuck open (mechanical/electrical)	Fvalve:Valve	Category III - Marginal	4	0.143808	1	0.00	10	40
Unable to monitor Engine parameters	JET ENGINE	Category II - Critical	7	1769.239583	4	100.00	1	28
Loss of Avionic Processor	ECU	Category II - Critical	7	9.803865	1	71.40	4	28
FAN_Failure	JET ENGINE	Category I - Catastrophic	10	312.218750	2	100.00	1	20
Inner Turbine_Failure	JET ENGINE	Category I - Catastrophic	10	208.145833	2	100.00	1	20
Outer Turbine_Failure	JET ENGINE	Category I - Catastrophic	10	312.218750	2	100.00	1	20
Open monitor cable	Fuel Cable	Category III - Marginal	4	1.225000	1	85.71	3	12
Shorted monitor cable	Fuel Cable	Category III - Marginal	4	0.525000	1	85.71	3	12
Alternator_Failure	JET ENGINE	Category I - Catastrophic	10	104.072917	1	100.00	1	10
Combustion Chamber_Failure	JET ENGINE	Category I - Catastrophic	10	104.072917	1	100.00	1	10
Compressor_Failure	JET ENGINE	Category I - Catastrophic	10	104.072917	1	100.00	1	10
Fan Drive_Failure	JET ENGINE	Category I - Catastrophic	10	104.072917	1	100.00	1	10
Fuel Control_Failure	JET ENGINE	Category I - Catastrophic	10	104.072917	1	100.00	1	10
Starter_Failure	JET ENGINE	Category I - Catastrophic	10	104.072917	1	100.00	1	10
Comm. Interface_Failure	Comm. Interface	Category II - Critical	7	4.000000	1	100.00	1	7

*The **eXpress** Risk Priority Assessment Chart shows the Severity, Occurrence and Detection ratings for each failure. A detailed version of this chart lists the design details upon which these ratings are based.*

More Easily Updated – With **FMECA Plus**, design updates are a breeze. Simply modify the applicable areas of your ***eXpress*** model (importing data, of course, when available), rerun your diagnostic analysis and then regenerate the desired FMECA chart(s). FMECA updates no longer require months-long manual efforts. Invest in your data, not in manpower!

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Rethinking the Boundaries of the Traditional FMECA

Respecting Tradition – FMEAs come in many varieties, with different formats championed by different industries, projects, companies and individuals. Nevertheless, all FMEAs remain variations on a common theme—tracing the effects of failure upon system behavior and identifying specific failure modes that require special attention. Often the best way of respecting tradition is to allow it to be fiddled with. That's why **FMECA Plus** doesn't just allow, but literally *expects* chart content and layout to be customized to satisfy industry, project, company or personal requirements.

Identification Number	Item / Functional Identification (Nomenclature)	Function	Failure Modes	Causes	Mission Phase / Operational Mode	Failure Effects			Failure Detection Method	Compensating Provisions	Severity Class	Remarks
						Local Effects	Next Higher Level	End Effects				
4003	1553 cable network	1553 coupler linkages	Loss of 1553 comm.	1553 cable open 1553 cable shorted	Flight Line and Mission	Unable to control fuel system Loss of Control of fuel system Unable to monitor fuel control system Flight Recorder failure Communication Interface failure		Unable to control fuel system Loss of Control of fuel system Unable to monitor fuel control system Flight Recorder failure Communication Interface failure	Avionic CBIT	Redundancy may allow return to base System can still maintain control but must fly with calculated results using other inputs	Category II - Critical	Mission Abort
4011	Battery											
4012	Comm. Inter											
4013	CP1											
4014	CP2											
4015	CP3											

Identification Number	Item / Functional Identification (Nomenclature)	Function	Failure Modes	Causes	Mission Phase / Operational Mode	Severity Class	Failure Rate Data Source	Failure Effect Probability (beta)	Failure Mode Ratio (alpha)	Item Failure Rate (lambda)	Operating Time (t)	Failure Mode Criticality	Item Criticality	Remarks
4033	JET ENGINE	Propulsion	FAN_Failure	FAN_Failure	Flight Line & Mission	Category I - Catastrophic	Engineering	1	9.375	3330.333333	6.0 hours	312.218700	3330.3333	Mission Critical
4037	JET ENGINE	Propulsion	Outer Turbine_Failure	Outer Turbine_Failure	Flight Line & Mission	Category I - Catastrophic	Engineering	1	9.375	3330.333333	6.0 hours	312.218700	3330.3333	Mission Critical
4036	JET ENGINE	Propulsion	Inner Turbine_Failure	Inner Turbine_Failure	Flight Line & Mission	Category I - Catastrophic	Engineering	1	6.25	3330.333333	6.0 hours	208.145800	3330.3333	Mission Critical
4029	JET ENGINE	Propulsion	Alternator_Failure	Alternator_Failure	Flight Line & Mission	Category I - Catastrophic	Engineering	1	3.125	3330.333333	6.0 hours	104.072900	3330.3333	Mission Critical
4034	JET ENGINE	Propulsion	Fan Drive_Failure	Fan Drive_Failure	Flight Line & Mission	Category I - Catastrophic	Engineering	1	3.125	3330.333333	6.0 hours	104.072900	3330.3333	Mission Critical
4035	JET ENGINE	Propulsion	Fuel Control_Failure	Fuel Control_Failure	Flight Line & Mission	Category I - Catastrophic	Engineering	1	3.125	3330.333333	6.0 hours	104.072900	3330.3333	Mission Critical
4038	JET ENGINE	Propulsion	Starter_Failure	Starter_Failure	Flight Line & Mission	Category I - Catastrophic	Engineering	1	3.125	3330.333333	6.0 hours	104.072900	3330.3333	Mission Critical
4041	ECU	Main On-board Processor	Loss of Avionic Processor	1553 I/O Fail Motherboard failure Cooling Failure Power Supply Failure EEPROM Fail heat sensor failure	Flight Line & Mission	Category II - Critical	Engineering	1	140.0552	7	6.0 hours	9.803900	9.8039	Mission Abort
4040	Pilot Control	Pilot Controls and Displays	Pilot Control_Failure	Pilot Control_Failure	Flight Line & Mission	Category II - Critical	Engineering	1	100	7	6.0 hours	7.000000	7	Mission Critical
4039	Landing Gear	Landing Gear Control and	Landing Gear_Failure	Landing Gear_Failure	Flight Line & Mission	Category II - Critical	Engineering	1	100	5	6.0 hours	5.000000	5	Mission Abort
4013	CP1	1553 Coupler	CP1_Failure	CP1_Failure	Flight Line & Mission	Category II - Critical	Engineering	1	100	4.2	6.0 hours	4.200000	4.2	Mission Abort

The "traditional" worksheet configurations offered within **FMECA Plus** *(such as these formats based on MIL-STD-1629A) can be easily customized both in terms of content and appearance to satisfy an endless variety of analysis needs.*

Personalizing with Attributes – Because columns can be added in **FMECA Plus** for any attribute defined in ***eXpress***, analysts can easily personalize their charts using industry, project or company-specific data (such as LCN numbers, SMR codes, ARINC labels, Manufacturer data, BIT messages, IETM references, or values from other user-defined ***eXpress*** attributes).

Item	Failure	Root Failure Mode Causes	Fault Signature	Diagnostic Coverage		Failure Rate
				Fault Groups	Fault Group Items	
Landing Gear	Landing Gear_Failure	Landing Gear_Failure	Fault Code 2012 (Proc_LGear Bus Comm) Fault Code 2007 (LGear_Proc Bus Comm) Fault Code 2061 (P1-fan outlet pressure) Fault Code 2069 (T1-fan outlet temperature) Fault Code 2067 (S1-fan drive speed) Fault Code 2072 (T4-Inner turbine outlet temperature) Fault Code 2064 (P4-Inner turbine outlet pressure) Fault Code 2062 (P2-Compressor outlet pressure) Fault Code 2070 (T2-Compressor outlet temperature) Fault Code 2068 (S2-fan speed)	Fault Group # 76	CP6 Landing Gear	5.000000
Pilot Control	Pilot Control_Failure	Pilot Control_Failure	Fault Code 2013 (Proc_Pilot Bus Comm) Fault Code 2008 (Pilot_Proc Bus Comm) Fault Code 2061 (P1-fan outlet pressure) Fault Code 2069 (T1-fan outlet temperature) Fault Code 2067 (S1-fan drive speed) Fault Code 2072 (T4-Inner turbine outlet temperature) Fault Code 2064 (P4-Inner turbine outlet pressure) Fault Code 2062 (P2-Compressor outlet pressure) Fault Code 2070 (T2-Compressor outlet temperature) Fault Code 2068 (S2-fan speed)	Fault Group # 74	CP3 Pilot Control	7.000000
PWR Relay	PWR Relay_Failure	PWR Relay Failure	Fault Code 2016 (Pwr Relay test - Alternator) Fault Code 2017 (Pwr Relay test - battery) Fault Code 2061 (P1-fan outlet pressure) Fault Code 2069 (T1-fan outlet temperature) Fault Code 2067 (S1-fan drive speed)	Fault Group # 4	ECU VCU 1553 cable network PWR Relay CP7	7.300000

This excerpt from an ***eXpress*** *Fault Signature Analysis Chart shows columns that list the fault codes that would be reported for each failure, along with the specific items indicted by each fault signature.*

Encouraging Innovation – In addition to its predefined "standard" formats, **FMECA Plus** also supports non-traditional applications of failure-based analysis.

The *eXpress Fault Signature Analysis Chart*, for instance, can be a valuable tool for cross-checking or even influencing the development of operational or embedded diagnostics.

With all this flexibility at your fingertips, it will be hard not to imagine new and unique ways of employing **FMECA Plus** within your own projects.

Additional Plusses

- Data is derived from multiple engineering & analysis disciplines, eliminating redundant effort and reducing program costs and risks
- Use of Model-based data ensures FMECA consistency, repeatability and traceability
- Approach is consistent with SAE J1739, MIL-STD-1629A and other standard FMECA practices
- Innovative use of diagnostic analysis allows the FMEA to aide in the reduction of False Alarms and System Aborts
- **FMECA Plus** results can inform the development of Prognostics (PHM), Embedded Diagnostics, Run-Time Test Executives and IETM-hosted troubleshooting
- Compatible with existing FMECA databases and tools, the powerful import capabilities in ***eXpress*** maximize data reuse
- Easy updates permit FMECA efforts to remain relevant throughout development and operational life cycles
- Results can be easily exported to MS Excel or XML

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