FMEA and FMECA

Source

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FMEA and FMECA Information

FMEA - If you are wanting to find out more about Failure Mode and Effects Analysis (**FMEA**) or **FMECA**, then you have come to the right place.

Our goal is to provide **useful resources** for reliability engineers, quality engineers, design engineers, or anyone else who may be interested in learning more about FMEA or FMECA.

This site will provide you with a good **introduction to FMEA / FMECA**. Spend a few minutes looking around our site to find out just what a FMEA is, a little bit about the different types(Concept, Design, and Process), some of the benefits from this type of analysis, and much more. We also have **FMEA examples** and helpful presentations, books and reference guides, plus some good information on **FMEA software**, and links to some of the major software vendors.

What is a FMEA?

Failure Mode and Effects Analysis (FMEA) or **FMECA** is an analysis technique which facilitates the identification of potential problems in the design or process by examining the effects of lower level failures. Recommended actions or compensating provisions are made to reduce the likelihood of the problem occurring, and mitigate the risk, if in fact, it does occur.

The FMEA team determines, by failure mode analysis, the effect of each failure and identifies single failure points that are critical. It may also rank each failure according to the criticality of a failure effect and its probability of occurring. The **FMECA** is the result of two steps:

- Failure Mode and Effect Analysis (FMEA)
- Criticality Analysis (CA).

FMECA is just **FMEA** with Criticality Analysis. There are many different flavors of FMEA. There are Conceptual or Functional FMEAs, Design FMEAs, and Process FMEAs. Sometimes during a design FMEA the analysis will look at a combination of functions and hardware. Sometimes it will include just hardware, and sometimes the analyst will take a detailed look at the system down to a piece-part level, especially when critical functions or hardware are involved.

Here is a list of some of the more common FMEA acronyms:

FMECA - Failure Mode, Effects, and Criticality Analysis.
FMEA - Failure Mode and Effects Analysis.
CFMEA – Concept FMEA
DFMEA – Design FMEA
PFMEA – Process FMEA

Here is a list of some of the more common FMEA Definitions:

Mil-Std-1629A Related FMEA Definitions

Compensating Provision: Actions available or that can be taken to negate or reduce the effect of a failure on a system.
Criticality: a measure of the frequency of occurrence of an effect. May be based on qualitative judgment or may be based on failure rate data
Detection Method: The method by which a failure can be discovered by the system operator under normal system operation or by a maintenance crew carrying out a specific diagnostic action.
End Effect: The consequence a failure mode has upon the operation, function or status at the highest indenture level.
Failure Cause: The physical or chemical processes, design defects, quality defects, part misapplication or other processes which are the basic reason for failure or which can initiate the physical process by

which deterioration proceeds to failure. **(Past)**

Failure Effect: The consequence of a failure mode has upon the operation, function or status of a system or equipment. **(Future)**

Failure Mode: The way in which a failure is observed, describes the way the failure occurs, and its impact on equipment operation. **(Present)**

Indenture Levels: The levels which identify or describe the relative complexity of an assembly or function.

Local Effect: The consequence a failure mode has on the operation, function or status of the specific item being analyzed.

Mission Phase Operational Mode: The statement of the mission phase and mode of operation of the system or equipment in which the failure occurs.

Next Higher Level Effect: The consequence a failure mode has on the operation, functions, or status of the items in the next higher indenture level above the specific item begin analyzed.

Severity: Considers the worst possible consequence of a failure classified by the degree of injury, property damage, system damage and mission loss that could occur (**Mil-Std-1629A FMECA severities**).

Mil-Std-1629 FMEA / FMECA

Severity Levels

Category I - Catastrophic: A failure which may cause death or weapon system loss (i.e., aircraft, tank, missile, ship, etc...)

Category II - Critical: A failure which may cause severe injury, major property damage, or major system damage which will result in mission loss.

Category III - Marginal: A failure which may cause minor injury, minor property damage, or minor system damage which will result in delay or loss of availability or mission degradation.

Category IV - Minor: A failure not serious enough to cause injury, property damage or system damage, but which will result in unscheduled maintenance or repair.

Single Point Failure: The failure of an item which can result in the failure of the system and is not compensated for by redundancy or alternative operational procedure.

Other Related FMEA Definitions

Risk Priority Number (RPN) - Provides an alternate evaluation approach to Criticality Analysis. The risk priority number provides a qualitative numerical estimate of design risk. RPN is defined as the product of three independently assessed factors: Severity(S), Occurrence (O) and Detection (D).

RPN = (S) * (O) * (D)

Severity (S) - Severity is a numerical subjective estimate of how severe the customer (next user) or end user will perceive the EFFECT of a failure.

Effect	Criteria: Severity of the Effect	Ranking
Hazardous - without warning	Very high severity ranking when a potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation without warning.	10
Hazardous - with warning	Very high severity ranking when a potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation with warning.	9
Very High	Vehicle / item inoperable, with loss of primary function.	8
High	Vehicle / item operable, but at reduced level of performance. Customer dissatisfied.	7
Moderate	Vehicle / item operable, but Comfort/Convenience item(s) inoperable. Customer experiences discomfort.	6
Low	Vehicle / item operable, but Comfort/Convenience item(s) operable at reduced level of performance. Customer experiences some dissatisfaction.	5
Very Low	Fit & Finish/Squeak & Rattle item does not conform. Defect noticed by most customers.	4
Minor	Fit & Finish/Squeak & Rattle item does not conform. Defect noticed by average customer.	3
Very Minor	Fit & Finish/Squeak & Rattle item does not conform. Defect noticed by discriminating customer.	2
None	No Effect.	1

Occurrence (O) - Occurrence or sometimes termed LIKELIHOOD, is a numerical subjective estimate of the LIKELIHOOD that the cause, if it occurs, will produce the failure mode and its particular effect.

Probability of Failure	Possible Failure Rates	Ranking
Very High: Failure is almost inevitable	>= 1 in 2	10
	1 in 3	9
High: Repeated failures	1 in 8	8
	1 in 20	7
Moderate: Occasional failures	1 in 80	6
	1 in 400	5
	1 in 2,000	4
Low: Relatively few failures	1 in 15,000	3
	1 in 150,000	2
Remote: Failure is unlikely.	<= 1 in 1,500,000	1

Detection (D) - Detection is sometimes termed EFFECTIVENESS. It is a numerical subjective estimate of the effectiveness of the controls to prevent or detect the cause or failure mode before the failure reaches the customer. The assumption is that the cause has occurred.

Detection	Criteria: Likelihood of Detection by Design Control	Ranking
Absolute Uncertainty	Design Control will not and/or can not detect a potential cause/mechanism and subsequent failure mode; or there is no Design Control.	10
Very Remote	Very remote chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.	9
Remote	Remote chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.	8
Very Low	Very low chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.	7
Low	Low chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.	6
Moderate	Moderate chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.	5
Moderately High	Moderately high chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.	4
High	High chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.	3
Very High	Very high chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.	2
Almost Certain	Design Control will almost certainly detect a potential cause/mechanism and subsequent failure mode.	1

Here is a list of some of the FMEA tips and advices:

- **The FMEA / FMECA should begin as early as possible**

  This allows the analyst to affect the design before it is set in stone. If you start early, as recommended, expect to have to redo portions of your FMEA as the design is modified.
- **FMEAs take a lot of time to complete**

  Don't let this scare you and prevent you from performing an FMEA. A product recall can be very costly, time consuming, and cause severe damage to your company's reputation. A FMEA, done properly, can help prevent something like this from occurring.
- **FMEAs require considerable knowledge of system operation**

  This is true. FMEAs do require considerable knowledge of system operation, and it will be necessary to have extensive discussions with Software and Hardware Design Engineering, System Engineering, and other disciplines to gather the information that you need.
- **Spend time developing ground rules with your customer**

  It is very important to spend time, upfront, developing ground rules with your customer. This will help to prevent misunderstandings in terms of the scope of the analysis, report formats for deliverables, definitions, and other related issues.
- **Design FMEA Advice**

  Start early in the process. Complete the design FMEA by the preliminary drawings are done, and before any tooling is initiated.
- **Process FMEA Advice**

  Start as soon as basic manufacturing methods have been discussed. Be sure and complete the process FMEA prior to finalizing production plans and releasing for production.

Why is FMEA / FMECA Important?

There are a number of reasons why this analysis technique is so valuable. Here are just a few:

- FMEA provides a basis for identifying root failure causes and developing effective corrective actions
- The FMEA identifies reliability/safety critical components
- It facilitates investigation of design alternatives at all stages of the design
- Provides a foundation for other maintainability, safety, testability, and logistics analyses

FMEA / FMECA Background and History

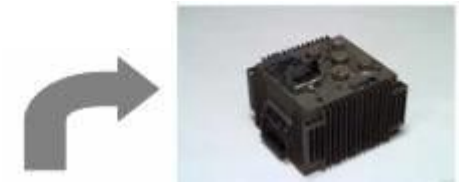
- An offshoot of Military Procedure MIL-P-1629, titled Procedures for Performing a Failure Mode, Effects and Criticality Analysis, dated November 9, 1949.
- Used as a reliability evaluation technique to determine the effect of system and equipment failures. Failures were classified according to their impact on mission success and personnel/equipment safety.
- Formally developed and applied by NASA in the 1960's to improve and verify reliability of space program hardware.

- The procedures called out in **MIL-STD-1629A** are the most widely accepted methods throughout the military and commercial industry.
- **SAE J1739** is a prevalent FMEA standard in the automotive industry.

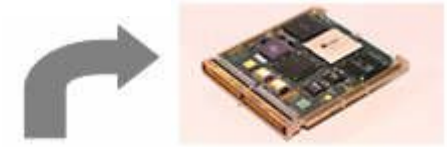
FMEA and FMECA

How to do a FMEA?

What are the effects of box failures on the system?



What are the effects of board failures on the box?



What are the effects of part failures on the board?

The above example is a bottoms-up approach to a Design FMEA, but a tops-down approach could also be used.

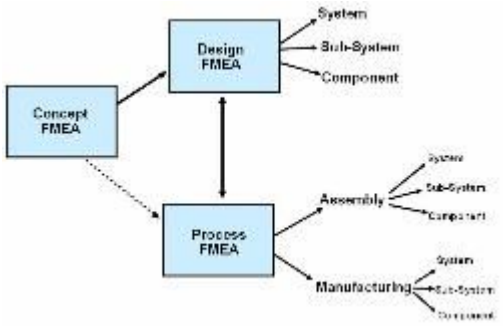
Facts and Tips About FMECA:

- FMECAs should begin as early as possible. This allows the analyst to affect the design before it is set in stone. If you start early, as you should, expect to have to redo portions as the design matures.
- FMECAs take a lot of time to complete.
- FMECAs require considerable knowledge of system operation necessitating extensive discussions with software/hardware Design Engineering and System Engineering.
- Spend time developing ground rules with your customer up front.

The FMECA Analysis Process:

1) Define the system
2) Define ground rules and assumptions
3) Construct system block diagrams
4) Identify failure modes
5) Analyze failure effects / causes
6) Feed results back into design process
7) Classify failure effects by severity
8) Perform criticality calculations
9) Rank failure mode criticality
10) Determine critical items
11) Feed results back into design process
12) Identify means of failure detection, isolation and compensating provisions
13) Document the analysis. Summarize uncorrectable design areas, identify special controls necessary to mitigate risk.
14) Make recommendations
15) Follow up on corrective action implementation / effectiveness

FMEA / FMECA Types



CONCEPT FMEA (CFMEA)

- The Concept FMEA is used to analyze concepts in the early stages before hardware is defined (most often at system and subsystem)
- It focuses on potential failure modes associated with the proposed functions of a concept proposal
- This type of FMEA includes the interaction of multiple systems and interaction between the elements of a system at the concept stages.

DESIGN FMEA (DFMEA)

- The Design FMEA is used to analyze products before they are released to production.
- It focuses on potential failure modes of products caused by design deficiencies.
- Design FMEAs are normally done at three levels – system, subsystem, and component levels
- This type of FMEA is used to analyze hardware, functions or a combination

PROCESS FMEA (PFMEA)

- The Process FMEA is normally used to analyze manufacturing and assembly processes at the system, subsystem or component levels.
- This type of FMEA focuses on potential failure modes of the process that are caused by manufacturing or assembly process deficiencies.

FMEA / FMECA Benefits

This page describes some of the benefits that can be derived by performing various types of FMEA / FMECA

FMEA / FMECA - General Benefits:

- Prevention Planning
- Identifies change requirements
- Cost reduction
- Increased throughput
- Decreased waste
- Decreased warranty costs
- Reduce non-value added operations

Concept FMEA:

- Helps select the optimum concept alternatives, or determine changes to design specifications
- Identifies potential failure modes caused by interactions within the concept
- Increases the likelihood all potential effects of a proposed concept's failure modes are considered.
- Identifies system level testing requirements
- Helps determine if hardware system redundancy may be required within a design proposal

Design FMEA:

- Aids in the objective evaluation of design requirements and design alternatives
- Aids in the initial design for manufacturing and assembly requirements
- Increases the probability that potential failure modes and their effects have been considered in the design/development process
- Provides additional information to help plan thorough and efficient test programs.
- Develops a list of potential failure modes ranked according to their effect on the customer. Establishes a priority system for design improvements.
- Provides an open issue format for recommending and tracking risk reducing actions.
- Provides future reference to aid in analyzing field concerns.

Process FMEA:

- Identifies potential product related process failure modes.
- Assesses the potential customer effects of the failures.

- Identifies the potential manufacturing or assembly process causes and identifies process variables on which to focus controls or monitoring.
- Develops a ranked list of potential failure modes, establishing a priority system for corrective action considerations.
- Documents the results of the manufacturing or assembly process.
- Identifies process deficiencies
- Identifies confirmed critical characteristics and/or significant characteristics
- Identifies operator safety concerns
- Feeds information on design changes required and manufacturing feasibility back to the designers.

Failure Mode and Effect Analysis

Date: 8 Nov 2006

Project: **Simple Flashlight Example**
Function/System: **Flashlight**
Phase/Mode: **Normal Operation**
Assembly Name: **Flashlight**

Reference Drawing: **FL164578-1**
Assembly RD: **1**

Ref Des	Name & Function	FMI	Failure Mode	Local Effect	Next Higher Effect	Sev.	End Effect	Detection Method Compensating Provisions Remarks	Failure Cause	RD	Item Causing
1	Flashlight - No Data	FAAA	constant flashlight output			1	constant flashlight output	Comp / Prov: None Det. Method: None Remarks: None	Stuck closed	1A2	Switch
		FAAB	flashlight output dim			3	flashlight output dim	Comp / Prov: None Det. Method: None Remarks: None	dim light	1A1	Bulb
									poor contact	1A3	Contact
									low power	1A4	Battery
		FAAC	flashlight sometimes will not turn on			3	flashlight sometimes will not turn on	Comp / Prov: None Det. Method: None Remarks: None	intermittent	1A2	Switch
									intermittent	1A3	Contact
		FAAD	no flashlight output			2	no flashlight output	Comp / Prov: None Det. Method: None Remarks: None	no light	1A1	Bulb
									Stuck open	1A2	Switch
									no contact	1A3	Contact
									no power	1A4	Battery

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Ref Des	Name & Function	FMI	Failure Mode	Local Effect	Next Higher Effect	Sev.	End Effect	Detection Method Compensating Provisions Remarks	Failure Cause	RD	Item Causing
1A1	Bulb - Provides the light source for the flashlight	FAAA	dim light		flashlight output dim	3	flashlight output dim	Comp / Prov: None Det. Method: None Remarks: None			
		FAAB	no light		no flashlight output	2	no flashlight output	Comp / Prov: None Det. Method: None Remarks: None			
1A2	Switch - Turns flashlight on or off	FAAA	intermittent		flashlight sometimes will not turn on	3	flashlight sometimes will not turn on	Comp / Prov: None Det. Method: None Remarks: None			
		FAAB	Stuck closed		constant flashlight output	1	constant flashlight output	Comp / Prov: None Det. Method: None Remarks: None			
		FAAC	Stuck open		no flashlight output	2	no flashlight output	Comp / Prov: None Det. Method: None Remarks: None			
1A3	Contact - No Data	FAAA	intermittent		flashlight sometimes will not turn on	3	flashlight sometimes will not turn on	Comp / Prov: None Det. Method: None Remarks: None			
		FAAB	no contact		no flashlight output	2	no flashlight output	Comp / Prov: None Det. Method: None Remarks: None			
		FAAC	poor contact		flashlight output dim	3	flashlight output dim	Comp / Prov: None Det. Method: None Remarks: None			
1A4	Battery - Provides the power source for the flashlight	FAAA	low power		flashlight output dim	3	flashlight output dim	Comp / Prov: None Det. Method: None Remarks: None			
		FAAB	no power		no flashlight output	2	no flashlight output	Comp / Prov: None Det. Method: None Remarks: None			