


Failure Mode and Effects Analysis (FMEA)

Reference:
Potential Failure Mode and Effects Analysis Reference Manual, Obtained from Automotive Industry Action Group (AIAG), 1995. Copy may be obtained via www.aiag.org (see GM, FORD, and Chrysler Quality Documents)


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FMEA

- **Defined:** FMEA is a systematic tool for identifying:
 - effects or consequences of a potential product or process failure.
 - methods to eliminate or reduce the chance of a failure occurring.
- FMEA generates a *living document* that can be used to anticipate and prevent failures from occurring. (note: documents should be updated regularly.)
- **Some History of FMEA** - formal applications began in Aerospace industry (mid 1960s) now widely used in Automotive Industry.


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Proactive FMEA - When to Use

- FMEA is most effective when it occurs before a design is released rather than "after the fact".
 - focus should be on *failure prevention not detection*.
- As such, FMEA is often a standard process used in the development of new products.

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Two Types of FMEA

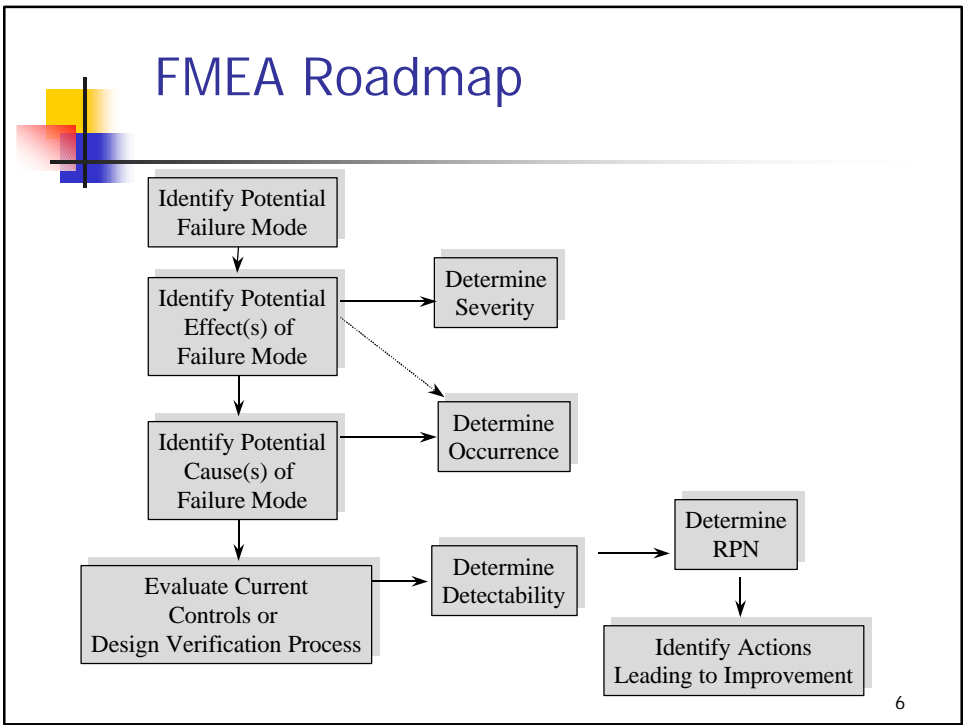
- Design FMEA - examines the functions of a component, subsystem or main system.
 - Potential Failures: incorrect material choice, inappropriate specifications.
 - Example: Air Bag (excessive air bag inflator force).
- Process FMEA - examines the processes used to make a component, subsystem, or main system.
 - Potential Failures: operator assembling part incorrectly, excess variation in process resulting in out-spec products.
 - Example: Air Bag Assembly Process (operator may not install air bag properly on assembly line such that it may not engage during impact).

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FMEA Terminology (Car Door Example of a Design FMEA) -

- Basic and Secondary Functions - verb~noun descriptions of what product (process) does.
 - Basic Function: ingress to and egress from vehicle
 - Secondary functions - protect occupant from noise
- Failure Mode - physical description of a failure.
 - noise enters at door-to-roof interface
- Failure Effects - impact of failure on people, equipment
 - driver dissatisfaction.
- Failure Cause - refers to cause of the failure.
 - insufficient door seal.

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FMEA Variables

(see Ch. 14 for more detailed rankings)

Severity is a rating corresponding to the seriousness of an effect of a potential failure mode. (scale: 1-10. 1: no effect on output, 5: moderate effect, 8: serious effect, 10: hazardous effect)

Occurrence is a rating corresponding to the rate at which a first level cause and its resultant failure mode will occur over the design life of the system, over the design life of the product, or before any additional process controls are applied. (scale: 1-10. 1: failure unlikely, 5: occasional failure, 8: high # of failures likely, 10: failures certain)

Detection is a rating corresponding to the likelihood that the detection methods or current controls will detect the potential failure mode before the product is released for production for design, or for process before it leaves the production facility. (scale: 1-10. 1: will detect failure, 5: might detect failure, 10: almost certain not to detect failures)

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Risk Priority Number (RPN)

The RPN identifies the greatest areas of concern. It comprises the assessment of the:

- (1) Severity rating,
- (2) Occurrence rating, and
- (3) detection rating for a potential failure mode.

$$\text{RPN} = \text{Severity Rating} \times \text{Occurrence Rating} \times \text{Detection Rating}$$

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Corrective actions should be taken if:

- The severity is 9 or 10 (potentially hazardous failures), OR.
- Severity rating x Occurrence rating is high, OR.
- High RPN (severity x occurrence x detection).
- No absolute rules for what is a high RPN number. Rather, FMEA often are viewed on relative scale (i.e., highest RPN addressed first).

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Classification of Critical Characteristics

- Companies often identify special product characteristics with an appropriate symbol on the FMEA worksheet.
- These special critical characteristics are typically items which affect regulatory compliance, such as items which should be given warning to consumers or **special** process controls.

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Conducting FMEA

- Prior to conducting an FMEA, it is often useful to:
 - perform a functional analysis, and
 - generate FMEA cause-and-effect diagrams.

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1. Functional Analysis

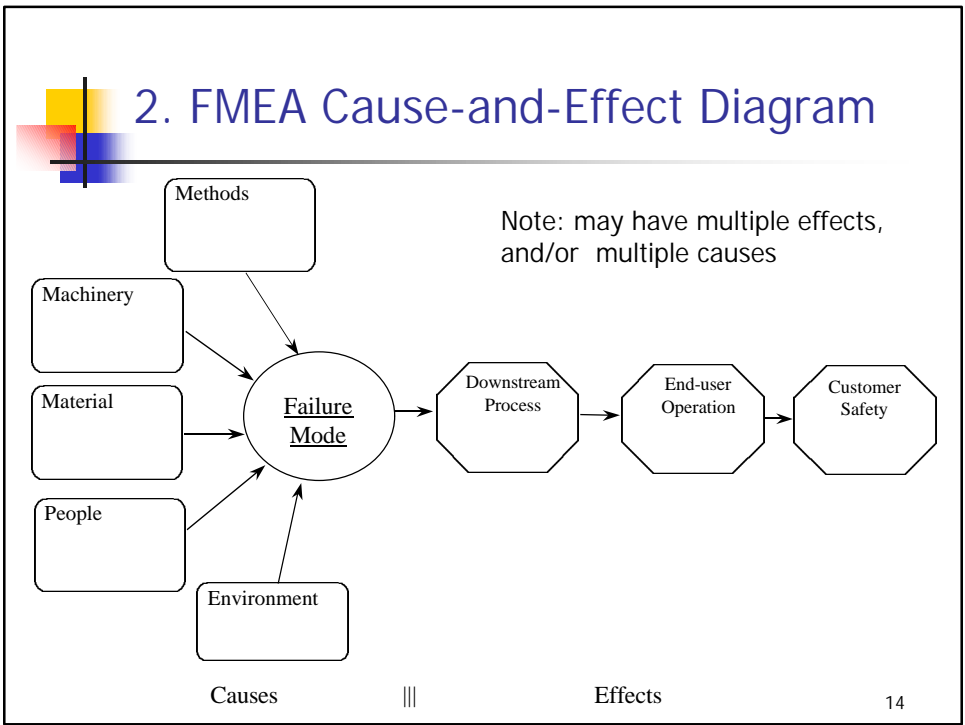
- Identify the *basic* and *secondary* function(s) of products or processes using verb-noun relationships.
- *Basic functions*: specific functions which a product or process is designed to do.
 - moustrap example: basic function is to **Kill-Mouse or Catch-Mouse**.
- Secondary functions: all other functions which are subordinate to the basic function (e.g., close trap).
- Example: Seat Belt
Identify Basic and Secondary Functions:

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Identifying Failure Modes

- After functional analysis, failure modes are typically just the inability to perform a function.
- Describe failure modes for car door:
 - Basic function: ingress / egress vehicle
 - Failure mode: door does not open, door sticks, door does not open wide enough
 - Secondary Function: protect occupant from noise
 - Failure Mode: door does not seal, door header leaks

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Example: Worksheet for Air Bag

Part or Process Name Automotive Passenger Air Bag System					Suppliers & Plants Affected						
Design/ Mfg Responsibility					Model Date						
Other Areas Involved					Engineering Change Level						
Process Operation, Product Function or Purpose	Potential Failure Mode	Potential Effect(s) of Failure	S E V C	P C A U S E S O F F A I L U R E	O C C U R R E N T C O N T R O L S E V A L U A T I O N M E T H O D	D E T	S * O	R P N	Recommended Action(s)		
Inflate Air Bag	Bag Does Not Open on impact	Injure passenger	8	*	Sensor is not functioning properly	2	light to notify that system is malfunctioning	6	16	96	Add Redundant Sensor to monitor impact
Restrain Passenger	Occupant Unable to Withstand Inflation Force	Injure Lightweight Passenger	8	*	passenger not wearing seat belt	4	none	10	32	320	1) install switch which deactivates air bag system unless seat belt is worn 2) consumer education of air bag system potential failures
		Bruise passenger in crash	3		force regulator not working	2	repeatability tests in lab	3	6	18	

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Continuous Improvement

- Last Columns of FMEA worksheet are used to identify improvement plan.
 - Recommend action
 - Identify responsibility to complete action.
 - Identify target dates to complete action.
 - List action taken and reassess RPN.

- FMEA also uses a Measure - Analyze - Improve - Control Cycle.

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