Failure Modes and Effects Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA)

A method used to identify potential design or process problems

Analysis technique examines effects of lower level failures.

Identifies where corrective actions (also called compensating provisions) are needed to

- reduce the likelihood of the problem occurring, and
- mitigate the risk, if problem does occur.

FMEA Background and History

* A part of US Military Procedure(MIL-P-1629) entitled “Procedures for Performing a Failure Mode, Effects and Criticality Analysis” in 1949
* A reliability evaluation technique used 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.
* Similar **SAE J1739** is a prevalent FMEA standard in the automotive industry.

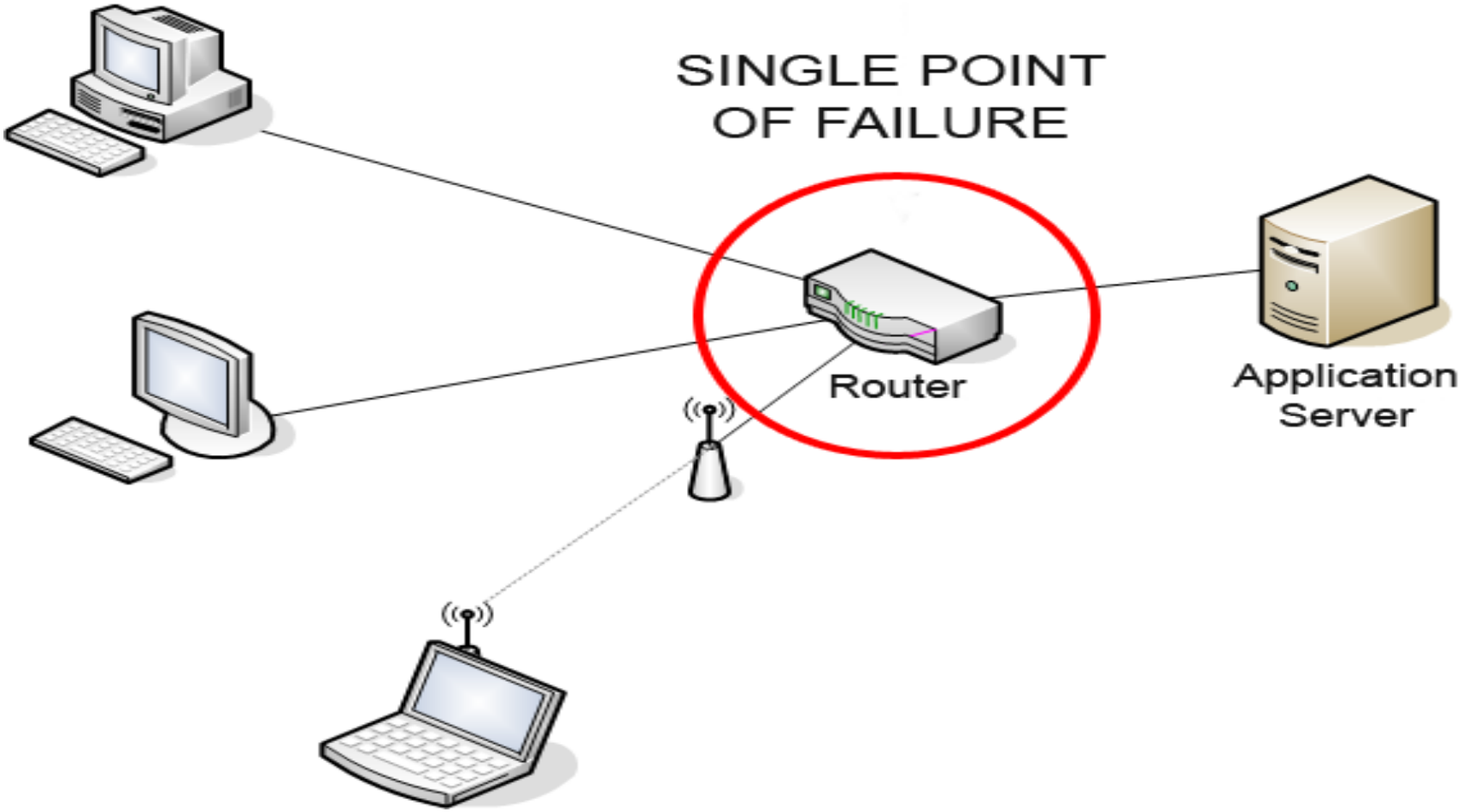
Application of FMEA in Industry

* FMEA Project teams made up of experts from design, engineering, manufacturing, quality, procurement etc assigned to review the concept, design, process or system

* The FMEA team determines the effect of each failure and identifies single failure points that are critical.

* Team determines and rank each failure according to failure effect probability and criticality, to assign importance.

Example: SPOF



Design failure modes effects analysis (DFMEA)

Recognises potential failures of a ***design*** before occurrence.

Establishes the cause of potential failures

Evaluates effects and **severity** of effect resulting from the failure

Assesses **how often** and when failures might occur

Manufacturing Process FMEA (PFMEA)

Identify and evaluate the potential failure of a ***process*** and its effect

Decide on actions which could eliminate or reduce the occurrence of failure, or improve likelihood of detection

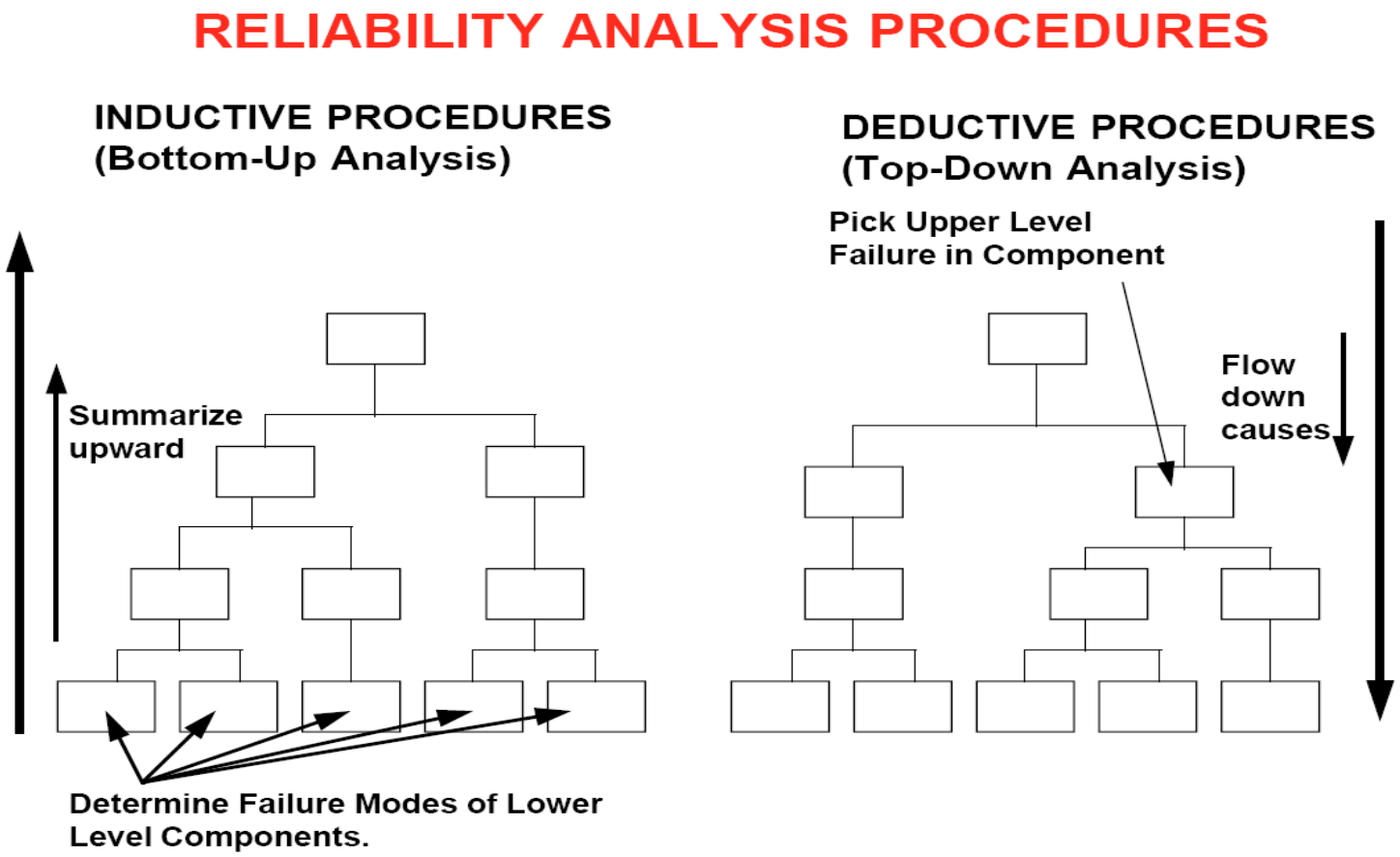
Document the process

Monitor changes to process-incorporated to avoid potential failures

Why is FMEA Important?

* FMEA provides a basis for identifying root causes of failure and developing corrective actions
* The FMEA establishes reliability and safety of critical components
* It facilitates investigation of alternatives at several design stages
* Provides a foundation for maintainability, safety or testability analyses
* A Pro-active engineering quality method for design and processing
* Facilitates to identify and counter weak points
* Works in the conception phase of all kinds of products and processes
* Easy to use, even for a non-specialist, as this is a structured approach

Block Diagrams of two approaches: Bottom-Up vs Top-Down



The FMEA Analysis Process:

1) Define the system

2) Identify and list the potential failures

3) List possible causes or mechanisms

4) List the potential effects of the failure

5) Rate the likelihood of occurrence (O)

6) Estimate potential severity (S)

7) Assess detection (D)

8) Calculate Risk Priority Number (RPN)

9) Feed results back into design process

10) Implement corrective action or Redesign. Repeat analysis to determine effectiveness of the actions

Examples of Some Failure Modes

Acoustic noise
Binding
Buckling
Burning
Corrosion
Cracking
Creep
Deflection/Deformation
Delamination
Electrical short
Erosion
Fracture
Intermittent Operation
Leaks
Wobble
Misalignment
Open Circuit
Oxidation
Radiation Damage
Resonance
Ringing
Sagging
Seizure
Staining
Fatigue
Stripping
Surge
Thermal Expansion
Tensile/Compressive material Failure
Unstable Unbalanced
UV Deterioration
Vibrations
Wear

Examples of potential effects of the failure

Noise

Odor

Fire

Erratic performance

Critical Structural Failure

Non-critical Structural Failure

Excessive vibration

Fit problems

Durability issues

Other Quality or functional problems…

Estimate potential Severity (S), Rate the likelihood of Occurrence (O), Assess Detection difficulty(D)

Severity is a numerical, subjective estimate of severity

- Can also be construed as how severe the customer or end user will perceive the failure effect

Occurrence is a numerical subjective estimate of the likelyhood that the cause, if it occurs, will produce the failure mode and its particular effect.

Detection (Detection difficulty) is a numerical, subjective estimate of the effectiveness of the controls used to prevent or detect the cause or failure mode. Detection should occur before the failure affects the finished product.

Example of Ranking: Severity (S)

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

Example of Ranking: Occurrence (O)

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

Example of Ranking : Detection (Detection difficulty) (D)

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

Risk Priority Number (RPN)

Provides a qualitative numerical estimate of design risk. Nonlinear in risk, numbers are relative for a given evaluation process. To review carefully to determine critical items in the system

RPN is defined as the product of the three independently assessed factors:

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

where

Severity = (S), Occurrence = (O),

and Detection (Detection difficulty) = (D).

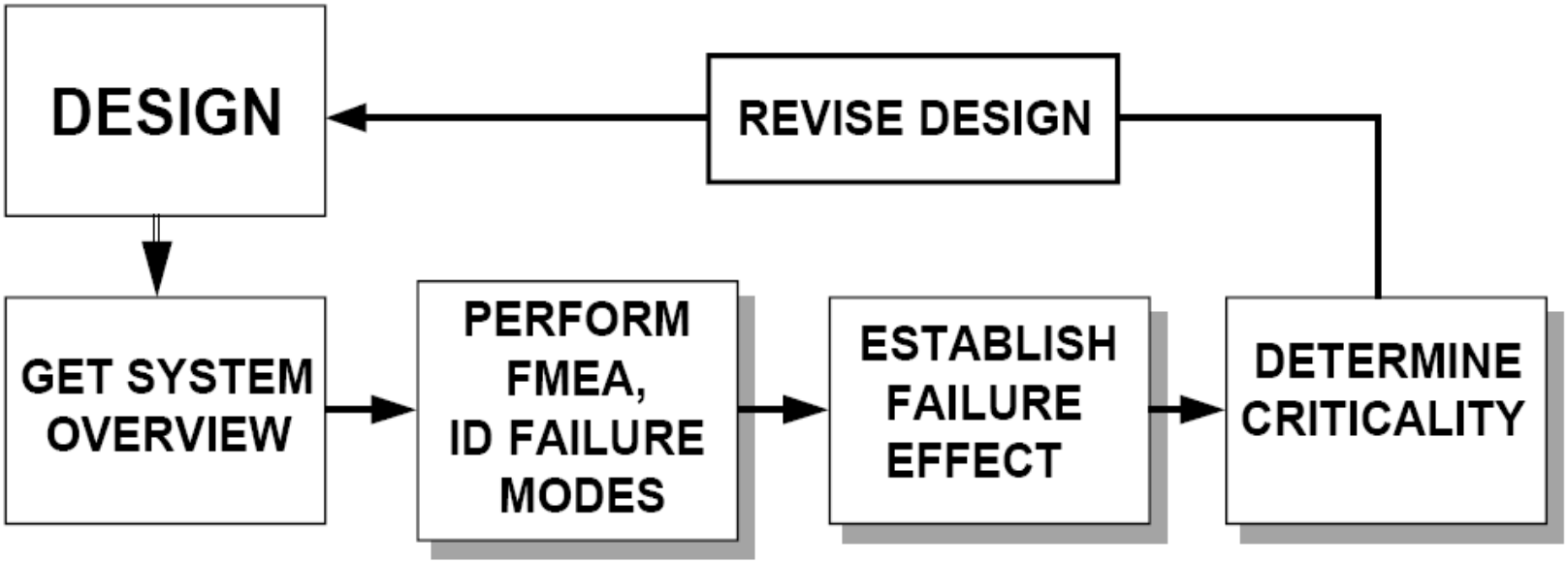
Feed results back into design process

Corrective actions developed on a priority basis

Assign Responsibility for Implementation of corrective action

Scheduling of corrective action items is key to product development and improvement

Implementation into Design Process Methodology



Example: FMEA Template for Design and Development

Product Name: _____ ___ System ___ Subsystem Name: _____ ___ Component			Devel. Team: _____ _____				Page No. _____ of _____ FMEA Number _____ Date: _____		
Part # & Functions	Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Causes/ Mechanism(s) of Failure	Occurrence (O)	Current Design Controls/ Tests	Detection (D)	Recommended Actions	RPN