me263 – Project Management and Social Responsibility

Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is a method used to bring out and detail potential defects. It is based on thinking through a potential failure's severity, expected frequency, and likelihood of detection.

A ***Failure Mode and Effects Analysis*** (FMEA) can be performed on a design or a process, and is used to motivate action that will improve design or process robustness. The FMEA highlights weaknesses in the design or process in terms of the user's experience, and is an excellent way to focus ongoing improvement efforts on areas which may the greatest return or represent the greatest concern.

The FMEA Process

The process is very straightforward, and begins by identifying as many of the probable failure modes as possible. This analysis is based on experience, review, and brainstorming, and should, where possible, use actual data. New designs or processes may not have actual historical data to draw upon, but "proxy" data may be available from similar designs or processes.

The next step is to assign a value between 1 and 10 representing the:

- **Severity,**
- **Probability of Occurrence**,
- and **Probability of Detection**

for each of the potential failure modes.

After assigning a value, the three numbers for each failure mode are multiplied together to yield a **Risk Priority Number (RPN)**. The RPN becomes a priority value to rank the failure modes - with the highest number demanding the most urgent improvement attention. Error-proofing, or poka-yoke actions are often an effective response to high RPN's.

FMEA Example

Here is an example of a simplified FMEA for a seat belt installation process at an automobile assembly plant.

FAILURE MODE & EFFECTS ANALYSIS (FMEA) Date: 1/1/2000 Revision: 1.3

Process Name: Left Front Seat Belt Install Process Number: SBT 445

Failure Mode	A) Severity Rate 1-10 10 = Most Severe	B) Probability of Occurance Rate 1-10 10 = Highest Probability	C) Probability of Detection Rate 1 - 10 10 = Lowest Probability	Risk Preference Number (RPN) AxBxC
1) Select Wrong Color Seat Belt	5	4	3	**60**
2) Seat Belt Bolt Not Fully Tightened	9	2	8	**144**
3) Trim Cover Clip Misaligned	2	3	4	**24**

As you can see, three potential failure modes have been identified. Failure mode number two has an RPN of 144, and is therefore the highest priority for process improvement.

FMEA's are often completed as part of a new product launch process. RPN minimum targets may be established to ensure a given level of process capability before shipping product to customers. In that event, it is wise to establish guidelines for assessing the values for Severity, Occurrence, and Detection to make the RPN as objective as possible.

Additional Information

When completing an FMEA, it's important to remember Murphy's Law: "Anything that can go wrong, will go wrong." The FMEA team need to identify all the components, systems, processes and functions that could potentially fail to meet the required level of quality or reliability. The team should not only be able to describe the effects of the failure, but also the possible causes.

The sample shown in Figure 1 can be used as an example when learning how the FMEA works. The team in this case is analyzing the tire component of a car.

Figure 1: FMEA for Car Tire

Function or Process Step	**Failure Type**	**Potential Impact**	**SEV (Severity)**	**Potential Causes**	**OCC (Occurrence)**	**Detection Mode**	**DET (Detection)**	**RPN**
Briefly outline function, step or item being analyzed	Describe what has gone wrong	What is the impact on the key output variables or internal requirements?	How severe is the effect to the customer? **(10 = Most Severe)**	What causes the key input to go wrong?	How frequently is this likely to occur? **(10 = Highest Probability)**	What are the existing controls that either prevent the failure from occurring or detect it should it occur?	How easy is it to detect? **(10 = Lowest Probability)**	Risk priority number
Tire function: support weight of car, traction, comfort	Flat tire	Stops car journey, driver and passengers stranded	10	Puncture	2	Tire checks before journey. While driving, steering pulls to one side, excess noise	3	60

Figure 2: Corrective Actions

Recommended Actions	**Responsibility**	**Target Date**	**Action Taken**	**SEV**	**OCC**	**DET**	**RPN**
What are the actions for reducing the occurrence of the cause or improving the detection?	Who is responsible for the recommended action?	What is the target date for the recommended action?	What were the actions implemented? Now recalculate the RPN to see if the action has reduced the risk.				
Carry spare tire and appropriate tools to change tire	Car owner	From immediate effect	Spare tire and appropriate tools permanently carried in trunk	4	2	3	24

Criteria for Analysis

An FMEA uses three criteria to assess a problem:

- the severity of the effect on the customer,
- how frequently the problem is likely to occur; and,
- how easily the problem can be detected.

FMEA Team Members must set and agree on a ranking between 1 and 10 (1 = low, 10 = high) for the severity, occurrence and detection level for each of the failure modes. Although FMEA is a qualitative process, it is important to use data (if available) to qualify the decisions the team makes regarding these ratings. A further explanation of the ratings is shown in Table 1.

Table 1: Severity, Occurrence and Detection Ratings

	Description	**Low Number**	**High Number**
Severity	Severity ranking encompasses what is important to the industry, company or customers (e.g., safety standards, environment, legal, production continuity, scrap, loss of business, damaged reputation)	Low impact	High impact
Occurrence	Rank the probability of a failure occurring during the expected lifetime of the product or service	Not likely to occur	Inevitable
Detection	Rank the probability of the problem being detected and acted upon before it has happened	Very likely to be detected	Not likely to be detected

After ranking the severity, occurrence and detection levels for each failure mode, the team will be able to calculate a risk priority number (RPN).

The formula for the RPN is: *RPN = severity x occurrence x detection*

In the FMEA in Figure 1, for example, a flat tire severely affects the customer driving the car (rating of 10), but has a low level of occurrence (2) and can be detected fairly easily (3). Therefore, the RPN for this failure mode is 10 x 2 x 3 = 60.

Setting Priorities

Once all the failure modes have been assessed, the team should adjust the FMEA to list failures in descending RPN order. This highlights the areas where corrective actions can be focused. If resources are limited, practitioners must set priorities on the biggest problems first.

There is no definitive RPN threshold to decide which areas should receive the most attention; this depends on many factors, including industry standards, legal or safety requirements, and quality control. However, a starting point for prioritization is to apply the Pareto rule: typically, 80 percent of issues are caused by 20 percent of the potential problems. As a rule of thumb, teams can focus their attention initially on the failures with the top 20 percent of the highest RPN scores.

Applying Corrective Actions

When the priorities have been agreed upon, one of the team's last steps is to generate appropriate corrective actions for reducing the occurrence of failure modes, or at least for improving their detection. The FMEA leader should assign responsibility for these actions and set target completion dates.
Once corrective actions have been completed, the team should meet again to reassess and rescore the severity, probability of occurrence and likelihood of detection for the top failure modes. This will enable them to determine the effectiveness of the corrective actions taken. These assessments may be helpful in case the team decides that it needs to enact new corrective actions.