FMEA

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Failure mode effect analysis (FMEA)

This is a tool developed in the field of quality management which systematically tries to imagine different ways in which a system might fail and then puts in place contingency plans for avoiding it or minimizing the risks s associated with it. Originally developed in the 1950s as military systems became more complex the technique has been refined and extended and now forms an important part of project planning for a variety of innovations in fields as diverse as construction and healthcare. It is sometimes called FMECA where the 'C' refers to criticality – of the many ways in which the system could fail which are the critical ones? Identifying these and providing contingency plans for dealing with them is the primary design task.

FMEA is essentially a brainstorming exercise in which teams with particular knowledge and perspectives explore in systematic fashion the possibilities of a system failing. Typically there are five stages in an FMEA:

- Identifying failure modes – what could go wrong?
- Identifying root causes of these failures – why would the failure happen?
- Identifying failure effects – what would the consequences of these failures be?
- Identifying and prioritizing criticality – which failure modes are most significant?
- Developing ways to deal with these failure modes – designing them out, designing fail-safe options, identifying contingency plans, etc.

FMEA is a powerful design tool when creating a new product, service or process but it can also provide valuable systematic knowledge around continuous improvement as the organization acquires experience of the innovation in use.

The process of carrying out an FMEA is as follows.

1   Assemble a team representing different perspectives of the project – for example marketing (to represent customer/user needs), engineering, manufacturing, software, etc. They need to be diverse enough to think through the different angles of the proposed new product/service or process.

2   Agree on the boundaries of the FMEA – essentially define what is the process/product or service which will be examined. In processes this can often be done using a flow chart, in products a product map and in services a user journey.

3   Using a simple matrix, put the stages of the process, the elements of the product or the steps on the service journey in the first column. Let's take the example of a customer in a restaurant ordering a meal. The service journey might look as follows:

Stages in journey
Seat customer
Give menu and return in five minutes to take order

Stages in journey
Take order and pass to kitchen
Collect order from kitchen after food is ready
Serve customer
Return after time delay to clear plates and prepare bill
Present bill and take payment
Present change, receipt, etc and escort customer out

There are many additional stages we could add but let's keep it simple for this example.

4   For each of these then fill in a second column which looks at all the possible ways failure could take place – failure modes.

Stages in journey	
Seat customer	Fail to seat customer
Give menu and return in five minutes to take order	Fail to give menu Fail to return at all Fail to return in specified time period
Take order and pass to kitchen	Fail to pass to kitchen
Collect order from kitchen after food is ready	Fail to collect order
Serve customer	Fail to serve customer
Return after time delay to clear plates and prepare bill	Fail to return Return to clear plates but fail to prepare bill
Present bill and take payment	Fail to present bill Fail to take payment
Present change, receipt, etc and escort customer out	Fail to present change/receipt Fail to escort customer out

Once again there are many other ways in which things can go wrong – part of the brainstorming with the team is to imagine worst-case scenarios where anything and everything that can go wrong is recorded. Role-play and simulation are useful tools in this stage.

5   For each failure mode add a third column which looks at the consequences of that failure happening.

Stages in journey	Failure mode	Consequences

Seat customer	Fail to seat customer	Customer gets annoyed, may leave
Give menu and return in five minutes to take order	Fail to give menu Fail to return at all Fail to return in specified time period	Customer gets annoyed, may leave Table is occupied but non-productive = opportunity cost
Take order and pass to kitchen	Fail to pass to kitchen	Customer gets annoyed, may leave
Collect order from kitchen after food is ready	Fail to collect order	Food gets cold Customer gets annoyed, may leave Wasted food, wasted effort in kitchen, opportunity cost since table is occupied but not earning money
Serve customer	Fail to serve customer	As above
Return after time delay to clear plates and prepare bill	Fail to return Return to clear plates but fail to prepare bill	Customer may get annoyed and complain or even leave Food has been consumed so all the waste above plus customer may refuse to pay Customer may walk out without paying
Present bill and take payment	Fail to present bill Fail to take payment	As above
Present change, receipt, etc and escort customer out	Fail to present change/receipt Fail to escort customer out	As above plus no tip!!!!

6   In the next column put a figure to indicate the severity or impact of that failure happening, typically on a scale of 1 (= minor impact) to 10 (= major impact)

Stages in journey	Failure mode	Consequences	Severity of impact

Seat customer	Fail to seat customer	Customer gets annoyed, may leave	5
Give menu and return in five minutes to take order	Fail to give menu Fail to return at all Fail to return in specified time period	Customer gets annoyed, may leave Table is occupied but non-productive = opportunity cost	5
Etc	Etc	Etc	Etc

7   In the next column list the potential causes (ideally the root cause) which might cause that failure to happen. (tools like a fishbone diagram can be helpful here)

Stages in journey	Failure mode	Consequences	Severity of impact	Potential causes
Seat customer	Fail to seat customer	Customer gets annoyed, may leave	5	Overcrowded restaurant. No clear queuing or priority system Too many customers for each waiter to deal with
Give menu and return in five minutes to take order	Fail to give menu Fail to return at all Fail to return in specified time period	Customer gets annoyed, may leave Table is occupied but non-productive = opportunity cost	5	Lack of training Too busy – result of wrong waiter to customer ratio
Etc.	Etc	Etc	Etc	Etc

8   For each failure add another column which indicates the likely frequency of occurrence – again using a simple scale. For example 1 (= very rarely) through to 10 (= inevitable)

Stages in journey	Failure mode	Consequences	Severity of impact	Potential causes	Likely frequency of occurrence
Seat customer	Fail to seat customer	Customer gets annoyed, may leave	5	Overcrowded restaurant. No clear queuing or	7

Stages in journey	Failure mode	Consequences	Severity of impact	Potential causes	Likely frequency of occurrence
				priority system Too many customers for each waiter to deal with	
Give menu and return in five minutes to take order	Fail to give menu Fail to return at all Fail to return in specified time period	Customer gets annoyed, may leave Table is occupied but non-productive = opportunity cost	5	Lack of training Too busy – result of wrong waiter to customer ratio	5
Etc.	Etc	Etc	Etc	Etc	Etc

9   For each failure mode add another column in which you identify how that fault might be detected (process control) and if it occurs how to deal with it to minimize the impact.

Stages in journey	Failure mode	Consequences	Severity of impact	Potential causes	Likely frequency of occurrence	Process controls/ recovery actions
Seat customer	Fail to seat customer	Customer gets annoyed, may leave	5	Overcrowded restaurant. No clear queuing or priority system Too many customers for each waiter to deal with	7	Monitor number of customers and install queuing system. Head waiter to oversee booking and balance allocation to tables Reduce waiter/customer ratio
Give menu and return in five minutes to take order	Fail to give menu Fail to return at all Fail to return in specified time period	Customer gets annoyed, may leave Table is occupied but non-productive = opportunity cost	5	Lack of training Too busy – result of wrong waiter to customer ratio	5	Etc

Stages in journey	Failure mode	Consequences	Severity of impact	Potential causes	Likely frequency of occurrence
Etc.	Etc	Etc	Etc	Etc	Etc
Seat customer	Fail to seat customer	Customer gets annoyed, may leave	5	Overcrowded restaurant. No clear queuing or priority system Too many customers for each waiter to deal with	7
Give menu and return in five minutes to take order	Fail to give menu Fail to return at all Fail to return in specified time period	Customer gets annoyed, may leave Table is occupied but non-productive = opportunity cost	5	Lack of training Too busy – result of wrong waiter to customer ratio	5
Etc.	Etc	Etc	Etc	Etc	Etc

There are other columns which can be added – for example how easy is the error to detect? How early in the process can it be detected? Will the controls be sufficient to detect it? And so on – the point is to think through thoroughly, using the different perspectives in the team, all the ways in which things might go wrong and then to build in ways of minimizing or eliminating these problems.

The above example is for a service journey but we can see the same pattern working in process innovation. In product innovation this FMEA activity can lead to redesign and improvement of features – and also help to generate the 'troubleshooting' section which often appears in the user manual accompanying the product.

For more on FMEA see http://asq.org/learn-about-quality/process-analysis-tools/overview/fmea.html
Other related tools include cause-and-effect diagrams (fishbone charts) and poke-yoke mistake proofing.