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Improvement of Lean methodology with FMEA

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ABSTRACT

Considering the degree of competition between companies in the world, advantages in competition will be won by those companies who focus on performance improvement, customer satisfaction, reducing the costs. In this way, lean production strategies can help us to identify and eliminate non value added resources. FMEA technique is applied to analyze the possible failures, in order to raise the safety factor and consequently costumer satisfaction.

Considering the weak and strong points of each of these methods, and the synergy between them, simultaneous implementation of these two, leads to much better results comparing to their separate implementation. In this paper, we focus on implementing them together too; in a way that not also their specific abilities will not be lost, but also raise the overall performance of the organization. In the following, these two methods are compared from different aspects. Later, we combine their operational phases and represent flowchart.

KEYWORDS

Lean, FMEA, Value, Muda, Failure prevention, Reliability, Risk

1. Introduction

Considering the degree of competition between companies in the world, advantages in competition will be won by those companies who focus on performance improvement, customer satisfaction, reducing the costs and increasing the efficiency, and overlay try to purify their organizations and processes. In this way, production strategies and lean thinking can help us to identify and eliminate non value added resources. Besides, issues like competition, increase in expectations, changes in requirements, and alterations in technology, leads to more responsibility for producers on removing products deficiencies and deviation in processes. Otherwise, companies will lose their market share,

due to costumer dissatisfaction. In order to do so, today companies use tools called FMEA[1]. Lean thinking is not an analytical method, yet implementing its operational principles and applications, can lead to changes in organizational culture, increase in efficiency and proficiency and better customer relationship. In order to avoid any kind of failures in production and development processes, and also estimating the problems and finding the most economic way to stop them, we use FMEA or prevention strategies. Today, companies need powerful methods for their business, in order to survive and promote their place in international competitions. In this article, we try to integrate two famous methods and represent a new methodology based on this integration. We hope this works, lead to satisfying the needs of today's companies [1, 2, 3].

2. Failure modes and effects analysis

In production and service businesses, issues like increase in customer expectations, growth in technology, and participation in international markets, leads to more competition between producers. So, producers are going after growing the quality of their products/ services and reducing any kind of deficiency in them. Today, companies use FMEA. Using these tools, we can identify potential failure modes in system, processes, products and services, and then prioritize all potential them and then define and deicide some actions in order to prevent or decrease the possibility of these failures and finally we document this process (which eventually supply us with a good source for future problems). [1]

FMEA technique is applied to analyze the possible failures, in order to raise the safety factor and consequently costumer satisfaction. One of the main differences between FMEA and other quality methods is that FMEA is an active method, while other methods are passive (are based on reaction): when failures occur, other methods define some reactions; but reactions have lots of costs and

[1] Failure mode and effects analysis

resources. FMEA tries to estimate the potential problems and their risks and then decide upon actions leading to reduce or eliminate this risk. This kind of preventive act is an action against what could happen in the future. it is obvious that determining about preventive actions, which happens in early phases of development, needs lower cost and time comparing to reactions[1,4].

Figure 1 and table 2, shows the FMEA implementation process. As you can see, after initial planning, a new design is represented. Then it must be decided whether it has enough reliability or not? In order to answer this question, all potential failure modes in our design are identified and their importance will be estimated. if their effects is more than an acceptable limit, some actions will be proposed to reduce the risk; this way we can be sue that our products and process have proper reliability. it is important to mention that FMEA can not act alone, but they must be used along with some other problem solving tools.

3. Lean thinking

Lean thinking is a strategy at management level. Its aim is to identify and eliminate the Muda (waste), in order to decrease the costs and increase productivity and organizational excellence; this strategy has roots in continuous improvement philosophy (Kaizen) which first emerged in Japanese manufacturing community in the form of Lean manufacturing. This philosophy was born at the time when some people hesitated whether concepts like mass production , production processes based on batch and queue , waiting lines , inventory volume , etc are evidences of value adding production or not and consequently ranked these as non value added concepts (NVA) and brought up Lean production which concentrates on concepts like : make to order (pull systems), zero defects, team work, cellular manufacturing, continuous improvement and flow of information. They did their best to eliminate Muda's and NVA's (figure 1). [5, 6]

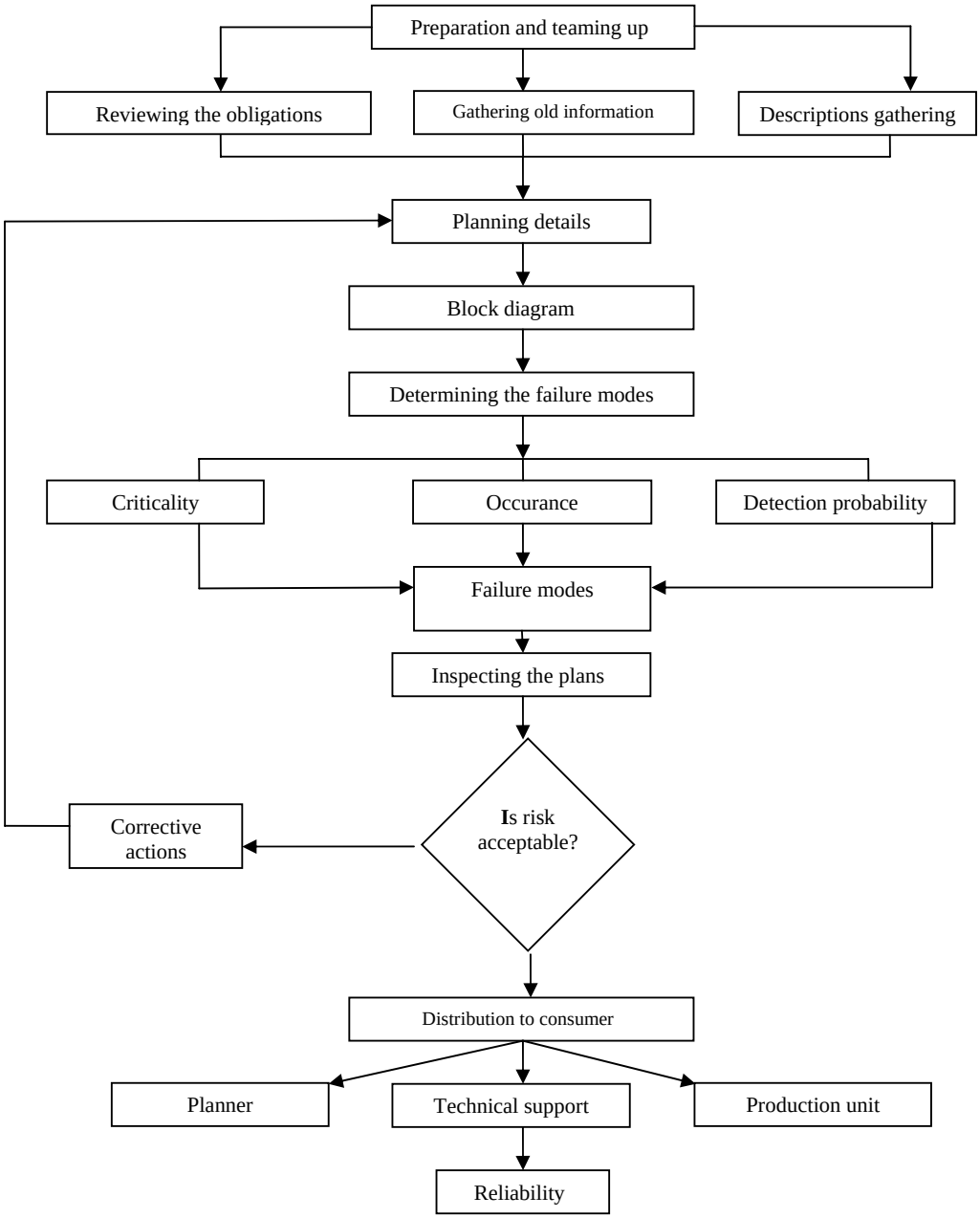


Figure 1: FMEA algorithm

Lean manufacturing is called Lean because in comparing with mass production, anything is used at a leaner degree. Applying Lean manufacturing reduces the amount of human resource, production area,

equipment (constant capital in total), engineering resources and production time, up to half. Also required inventory will be half, defects will be less, and production will be produced with greater diversity.

Key lean manufacturing principles include:

- Waste and Muda elimination and minimization.
- Continuous flow of parts in lower volumes.
- Pull processing (i.e. products are pulled from the consumer end, not pushed from the production end).

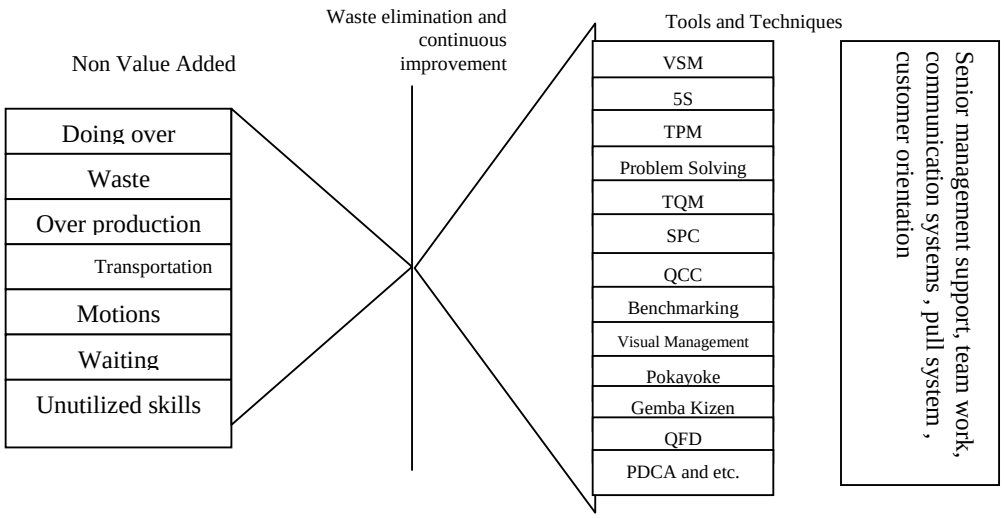


Figure 2: Lean manufacturing philosophy

Muda is one of the principles of Lean manufacturing and means anything that is wasteful, just consumes resources and doesn't add value. In other words, Muda increases the costs of services / products without adding value to it. Taiichi Ohno identified seven types of Wastes (Muda): [7]

- Defects
- Overproduction
- Transportation
- Waiting
- Doing over
- Waste motions
- Overprocessing
- Unutilized skills

Later Womack and Jones introduced "Lean thinking" as a new and more detailed approach toward lean manufacturing. They focused on five core concepts (called VVFPP) and then represent a "value stream" (figure 2). [4] These concepts are as followings:

1. Value specification: Specify value in the customer’s point of view
2. Eliminate waste and involve and empower employees
3. Identifying the value stream: by sketching a visual scheme of the value stream along the chain of value.
4. Make value flow at the pull of the customer so he can pull the expected value from producer.
5. Perfection: continuously improve in the pursuit of perfection in order to establish the value stream.

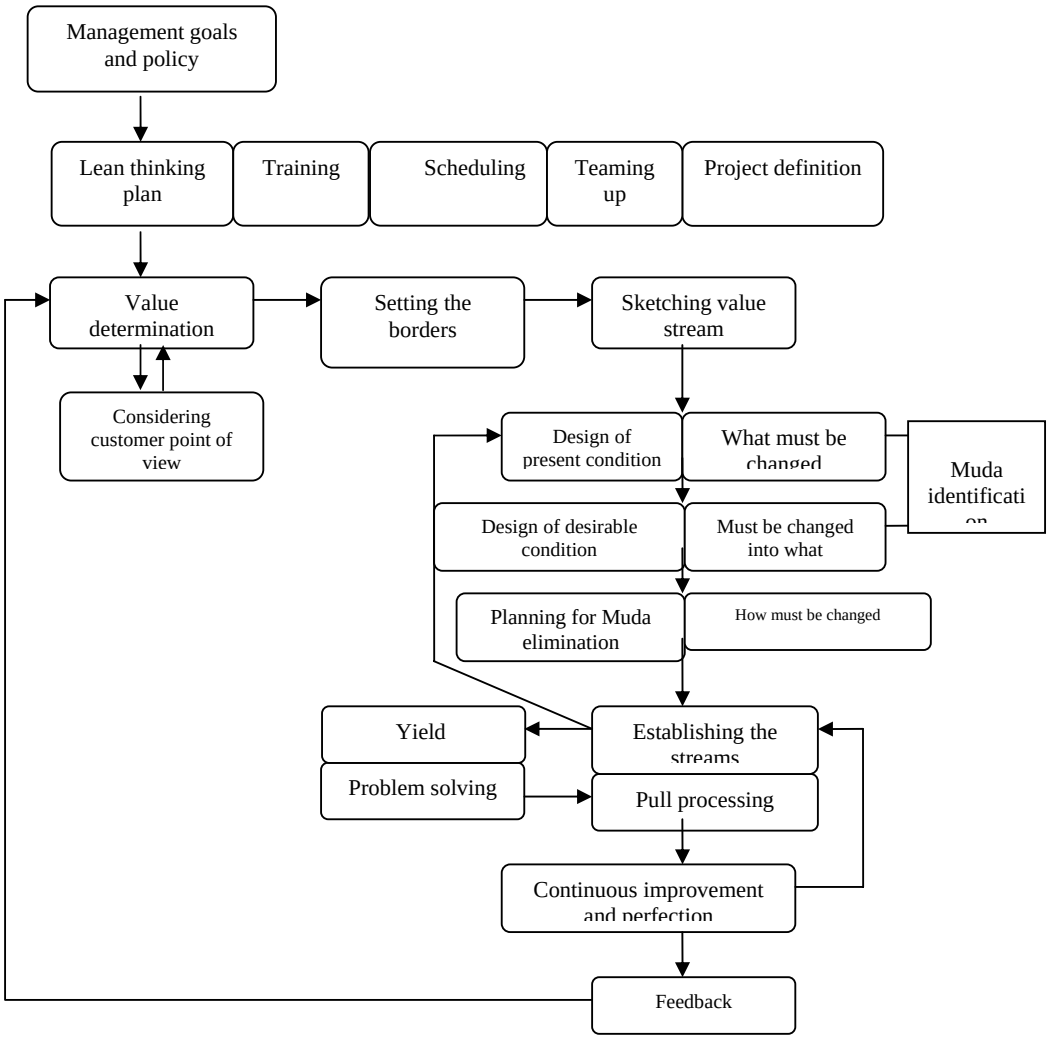


Figure 3: lean manufacturing process

4. Comparing lean manufacturing and FMEA

Considering the specifications and characteristics of FMEA and Lean manufacturing (lean thinking), these two techniques has been compared and the results are in table 1.

Table 1: comparing lean thinking and FMEA

No		***Lean***	***FMEA***
1	History	1950's – Toyota Co.	Aerospace industry – 1950's
2	Aim	Establishing value stream – eliminating Muda's and waste – maximizing value stream – flexibility in operations	Decrease in costs – increase in reliability – costumer satisfaction – increase in market share
3	methodology	Semi structured VVFPP – identifying waste resources and then eliminating them	Failure mode and effects analysis
4	Focus on	Muda identification and elimination – costumer value stream – job standardization – waste identification and elimination	Identifying potential failure modes and their effects
5	theory	Waste elimination	Failure prevention
6	Operational area	Production system – quality – human resources – repair and maintenance – engineering	(Process – design – system – service) – system – sub system -
7	Key success factors	Planning – contribution of senior management – team work – Lean principles training -	Team work – team skill – exact implementation of suggestions
8	Tools and key techniques	less setup and installation time – less production cycle – less waste – less breakdown – layout optimization – continuous improvement (Kaizen)- 5S – pull systems – cellular manufacturing – persistent test – statistical tools (poka yoke) – visual management	Tree diagram – quality engineering – risk priority number – market studies – QFD techniques - test
9	What are the benefits?	Savings due to less Muda – less wastes and less doing over	More safety – faster introduction to market – improvement of organization image – less deficiency costs – controllability - propagation of team work culture in company
10	Hypothesis	Eliminating wastes will lead to better operation – lots of small changes is better than a few big analysis	If less resources are dedicated to FMEA ,cost is reduced – if the defects aren't comprehended , costumer satisfaction will be less
11	Concept of value	Principles for improving the process / Muda and waste resources removal	Principles for improving the equipment accuracy (faultless equipment)
12	Required infrastructure	Senior management support / standardization of operations / communication system / team work / problem solving process	Training / customers and interested parties communication system / team members specialized skills

13	discipline and regularity characteristics	Key Muda's and operational priorities recognition / quality improvement and decreasing the costs / decreasing the requirements of processes / concentrating on "make to order" systems (based on customer opinions and requirements / visual management techniques and other similar approaches in order to improve the working conditions	Concentrating on customer requirements / recognizing and prioritizing the potential failures / equipment correction and improvement / taking the suggestions seriously
14	Control on	Process value stream	Performance (process – product)
15	Decision making	Based on quality improvement techniques	Based on failure prevention
16	flaws and limitations	The subject under study is not accurate / not enough training for Lean projects / limitations of equipments in order to decide strategic and operational priorities / lack of equipment for resolving the bottlenecks	Not considering all the failure modes / not separating the failures , (not considering their impact on each other) / weak and unrealistic documentation
17	Do not consider	Motivation and morale among personnel using Lean principles	NVA 's
18	Initial results	Less process time	Less time – failure prevention
19	Project picking criteria	High waste resources – low profitability – lack of flexibility – customer dissatisfaction – lack of efficiency and effectiveness	High risk – high defects – low quality – high costs – costumer dissatisfaction – lack of efficiency – lack of reliability
20	slogan	Supply as much as you need it , and when you need it (not more , not sooner)	Act beforehand , instead of react after an incident

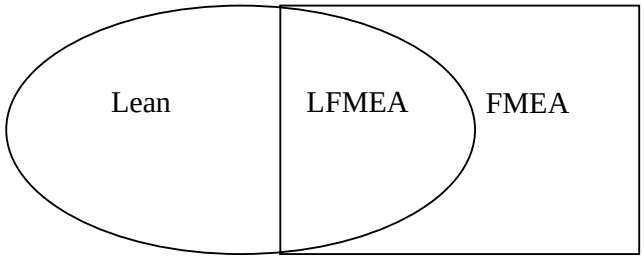
5. The Synergy between FMEA and Lean thinking

Examining the similarities and differences between FMEA and Lean manufacturing (see table 1) shows close relationship between these two; similar goals and objectives, and concentration on minimizing the defects. The potentials and abilities of each of these two strategies make it difficult to choose, utilize and order. But if we understand the weak points of each technique, we can fill the gap with proper tools and principles from other one (i.e.: the strong points of one strategy make up for the weak points of the

other one). So, we expect to see some synergy by combining and joining the potentials and strong points of the two methodologies.

Based on what we mentioned before about combination of Lean and FMEA, which was discussed here under the definition of a new methodology called LFMEA, it is necessary to redefine concepts like quality and costumer.

"Quality" in this new method (LFMEA), is the value added (costumer viewpoint) and faultless and improved process (organization viewpoint). "costumer" is anyone who could be affected by the consequents of potential faults ; whether he/she is out of organization or in it ; whether he really want to purchase or not .



Figur4: integration approach lean, FMEA

6. Proposed Methodology, LFMEA

Implementing Lean thinking and FMEA together in an organization, results in a synergy; it means that each of these two methods helps and supports the other one. FMEA leads to more speed, more power and better implementation of Lean thinking; and Lean thinking, in return, leads to less operational costs and maximizing the efficiency. Such a synergy needs a proper background.

The principles of lean manufacturing show that it can identify and eliminate Mudas; yet, there is no guaranty that the organization will not face any other Muda in future. Also, there is no proof that whether eliminating some Mudas leads us into trouble in the future or not. So there is always the possibility that if we alter or delete a Muda (which maybe is not completely a Muda), the organization will encounter lots of trouble and crisis in future. If we could somehow study and examine the effects of eliminating a certain waste and consider all of it aspects, we can decide more confidently and only

eliminate a waste which has no bad effect by doing so. In this way, better results will be produced with less possible cost of elimination. FMEA eliminates anything that cause defects in products and problems in processes, but doesn't have a proper outlook toward failures and process; Lean thinking can equip FMEA with a good vision and mention new failures by defining the concept of Muda. FMEA, in return, helps Lean method with a better analysis of the effects of eliminating Mudas. So Analysis phase of FMEA must be changed a little: FMEA must analyze non-Muda cases with a usual viewpoint, and use a wider outlook when analyzing Mudas. For example if eliminating a Muda, doesn't have a negative impact on other production elements, it is considered as a delectable one; but if problems occur as a result of certain elimination, it won't be deleted.

7. The objectives of the proposed methodology

Our proposed methodology, LFMEA, has the main goal of "maximizing the (added) value for interested parties. The complete list of objectives is as follows:

- Organization without losses and defects.
- Faultless processes.
- 100 % marketable products.
- Minimum waste resources and Muda.
- Higher efficiency and effectivity.
- Maximum rate of added value.
- Continuous improvement and gaining competitive advantage.
- Decreasing irrelevant costs (inefficient reforms).
- More flexibility, speed and accuracy in production process.
- Decreasing the repair and maintenance costs.
- Complete satisfaction of organization and customer.

8. The process of the proposed methodology

The aim of an integrated methodology is producing reliable products, increasing the customer satisfaction and eliminating non value added causes; in this way the organization's cost will not increase, but the profit will be more. In order to reach these aims these two techniques have to be integrated (Lean thinking and FMEA) and a proper sequence of their tools and operational phases must be planned, so as much benefit as possible from combining these two techniques is gained. Figure 5 presents the proposed algorithm which shows the sequence of operations in this methodology. In this new technique all necessities including planning, field studies, etc will be done first to determine the organizational strategies for solving the future problem. In next stage, various tools are used to realize what is considered as "value" for the organization and what makes it a value. After answering the questions, Mudas must be identified according to Lean principles. All of these deficiency cases and non value added resources will be then prioritized and will be eliminated or corrected later in future phases. High priority defects and NVA's will be eliminated by three units: production, technical support and planning. In this way, production reliability will be increased and the role of value added resources will be more prominent. In order to save the time, FMEA documentations can always be used.

9. Conclusion

Lean and FMEA techniques are very effective in solving various problems that organizations are dealing with. Each of them has some capabilities which could be used in certain parts of an organization. The aim of this article is to combine these two techniques in order to expand their application and face the new challenges of today's organizations. In this way they will gain more advantages in competitions.

These methods have some weak and strong points; but it is possible to cover the weak points of one method with strong points of the other. The results of integrated implementation of these methods was better than separate implementation of them and also solved some problems that none of these two could solved separately. All of these evidences show that a comprehensive technique (which is a combination of these two) could be effectively utilized by today's organizations in order to win competitions and challenges. In order to reach these aims, these two techniques must be integrated (Lean thinking and FMEA) and a proper sequence of their tools and operational phases has to planned, so we can gain as much benefit as possible from combining them. in order to fulfill these goals, has been presented the proposed algorithm which shows the sequence of operations in this methodology.

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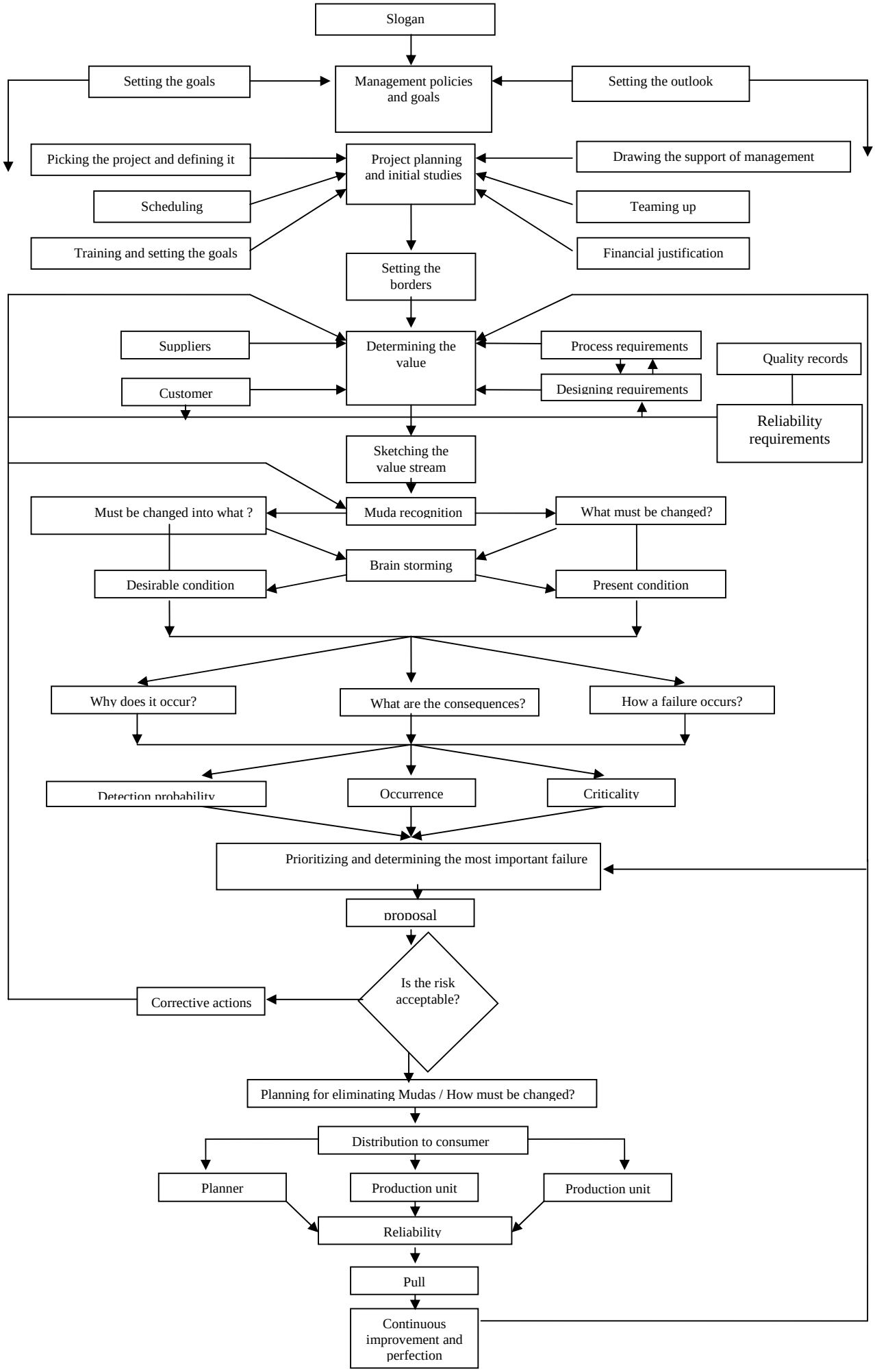

Figure 5: proposed algorithm

Table 2: FMEA phases

Levels	Planning	Block diagram	Failure modes analysis	Correction	Investigation
Goals	Project definition / planning/ borders setting	Identifying related operations	Failure mode and effects analysis / picking the right strategy for prioritization	Failure prioritization / looking after high priority failures / suggestions / prioritizing the suggestions	Performing the suggestions in correction phase
Key requirements , key questions , key tools	-Why do we perform FMEA? -Who must contribute in such a project? -Which parts will be affected? -Who is in charge? -Do all failures have been investigated? -What is the criterion for scoring? *** Forming a leading committee/ gathering the specification / gathering previous specification / identifying the requirements / identifying critical quality factors / compiling an executive strategy / training / allocating the responsibilities / pog model	-What is expected from this plan in order to satisfy the customer? -What are the related operations? -Is there any plan with only one function? -What are the other functions which we expect from uni-function plans? -What are the other functions that must be done by this plan , in order to satisfy the customer?	-How does a failure happen? -Why does a failure happens? -What are the effects of a failure occurrence? -How is the criticality of these effects? -How often does a failure or its effects occur? -What is the possibility of a failure been detected before being accessed by the customer? **** -Market studies -patterning studies -quality yield studies -guarantee period reports -customer complaints -related journals -information analysis	-What should be done in order to avoid potential failures and its effects? -What should be done in order to reduce the criticality and potential consequences? -What should be done in order to identify the problems after being accessed by the costumer? -What should be done in order to warn the customer when a problem has been occurred and has risky effects? -Brain storming -Flow chart -Parto diagrams -Formal group techniques -Tree analysis	-Preventing potential failures -Reducing failure detection -Installing warning systems -Process correction by production unit -Planning correction by planning engineer -Repair and maintenance by technical support unit
output	Information related to beginning of project	Summarized list of operations and functions in a process , plan , system , service	Failures , reasons , effects , criticality , detection probability	Final plan of equipment	Corrected plan or process
result	FMEA planning	Identifying the best operations that will lead to customer satisfaction	Presenting all potential failure modes in previous phase operations	Choosing potential failures in order to analyze and make improvement suggestions	reliability