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APPLICATION OF FMEA IN THE CONTEXT OF ORGANIZATIONS PROVIDING INTEGRAL SERVICES OF LOCAL AND REGIONAL INTEREST IN ROMANIA

Vasile GUSAN, Aurel-Mihail ȚIȚU, Dorin-Vasile DEAC-ȘUTEU

Abstract: *Failure Mode and Effects Analysis, FMEA, is a methodology frequently used in the commercial sector to investigate the numerous causes and repercussions that could result from a failure (defects that cause the object to lose its ability to perform functions). In this research paper, we will investigate why it is useful, as well as how this strategy could be used in the context of integrated services of local and regional importance. Organizations that provide services of local and regional importance will benefit if they can predict potential problems and failures of the management infrastructure. A process FMEA study shows discrepancies that impact product safety and quality.*
Keyword: *FMEA, public sector, process improvement, prevention tool, report procedure, COVID pandemic.*

1. INTRODUCTION

The public sector is currently facing numerous problems that persist to this day. One of the problems that are repeated with an annual recurrence is represented by the snow removal process. Every year, the companies that deal with road snow removal are fined by various state authorities because the snow is not removed following legal and contractual obligations. This aspect can lead over time to the loss of contracts with the public sector, the realization of a reduced profit, and in the event of accidents even to the loss of human lives. Due to these mentioned aspects, the authors considered the problem of de-snowing the roads a serious problem that should be addressed through a scientific methodology. The authors considered that by applying the PFMEA methodology the impact will be significantly reduce of deficiencies following their identification, potential effects and the timely implementation of a plan of measures. This methodology is predominantly applied in the automotive industry.

The PFMEA methodology can be defined in several ways [1]:

- analytical methodology that allows ensuring that potential problems have been taken into account and have been fully verified both in the manufacturing process and in the products
- methodology known as a systematic method used by the team to recognize the evaluation and prevention of errors during the design and planning phases of products and processes
- methodology for analyzing the potential failures of a product or process, with the aim of developing a plan of measures that aims to prevent them as well as increase the quality level of products, work processes and production environments. It starts from the elements, to determine the Cause – Mode – Effect

FMEA is the process of bringing value because the actions that are defined by the team increase the knowledge of a company and are then used as "Lessons learned" for the following similar projects. It is important that when winning a new public sector snow removal project, the manager in charge of the respective project must carry out an FMEA to detect any deficiency or problem that may arise during the

snow removal process. Thus, it will be necessary to create a process FMEA, an PFMEA, in which the snow removal process will be analyzed, together with all the sub-processes related to this process. [2]
FMEA was first introduced in 1940 for military use. [3] FMEA is an acronym for FMEA: Failure Mode and Effect Analysis.

2. FMEA OBJECTIVES AND STAGES OF THE METHODOLOGY

To understand the methodology, it is important to know the specific objectives of the FMEA.

Both FMEA and LEAN have the same main objectives. These consist of identifying, preventing and correcting defects. [4]

FMEA represents and acronym and stands for Failure Mode and Effect Analysis.

LEAN stands for creating more value for your customers with fewer resources. [5]

PFMEA can also be defined as a way to identify probable and possible adverse effects. PFMEA is a methodology that analyzes criticality, having the following clear objectives:

- Early identification of non-conformities
- Discovering weak points in a technical system
- Discovery of some causes of initiation of some malfunctions
- Prevention of potential non-conformities and their causes
- Carrying out corrective actions with the role of removing the causes of defects and the defects themselves
- Establishing an improvement plan in terms of product quality and maintenance
- Risk reduction
- Cost reduction
- Increasing the level of communication between departments and people
- Eliminating potential sources of system, process or design defects before they occur. [6]

Completing the FMEA is done through meetings attended by all the people involved. The person who leads the meeting addresses the questions and completes the answers by correctly evaluating each answer received is a specialist in the application of this methodology, also known as the FMEA moderator. Also, the FMEA moderator will be the one who will be in charge of planning the cyclical meetings and tracking the deadline for the completion of the analysis.

FMEA is a method divided into five sequentially chained steps:

- Data initialization and collection
- Analyze
- Evaluation and decision
- Identification and implementation
- Verification and capitalization

In the first stage, initialization and data collection are carried out. Before creating an FMEA, its product or process that is to be subject to risk analysis must be defined. The next stage consists of establishing a core team that will contribute to the creation of the FMEA. Along with the nomination of the team, the goals to be achieved at the end of the risk analysis will also be established. In order for the deadline to be respected, the moderator is responsible for the periodic planning of the meetings and the creation of the structure and the analysis of potential errors. It is very important, however, to use as data input, the documentation, and statistics of similar projects, for example, the control plan, the maintenance plan, the flow chart, etc.

The second stage is represented by the analysis. In this secondary stage, the requirements that are relevant for a process established based on the data collected in the first stage will be determined. The functions of a considered product, process or component will be identified. In this relationship with the functions, the potential failure modes are highlighted and the critical stages will be highlighted.

The next stage is presented by evaluation and decision. In this stage, the potential defects determined in the previous stage will be highlighted. These are to be evaluated from the point of view of their seriousness. The risk realized by each potential defect will be assessed separately. Depending on each assessed risk, the team will decide whether it is useful or not to introduce actions to reduce or completely eliminate the observed risks.

The next stage is represented as the identification of an action plan and their implementation. In this stage, the team will identify the appropriate actions and how to plan them. The actions that will be established by the team will have to show process parameters, for example: technical sheets, verification instructions, work instructions, adjustment sheet; the sequence of the process, for example: the sequence of operations and work steps; process control: test and supervision plans.

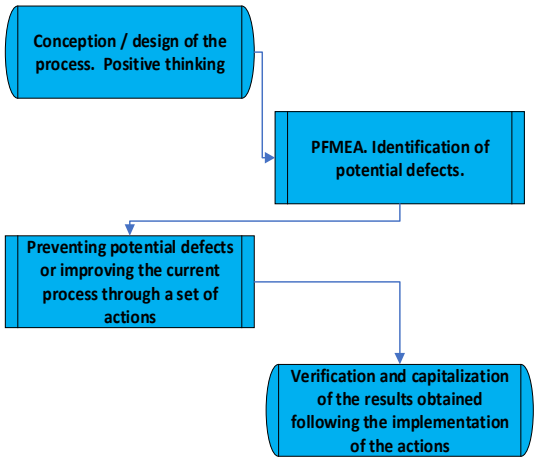

Fig. 1. PFMEA Flow Chart

The next stage is presented as the verification and capitalization of the implemented actions. In this final stage, the objectives that were established in the first stage will be verified. More precisely, the implemented actions will be verified. At this stage, the results of the actions that have been implemented will be continuously checked and a reassessment of risks will take place.

Due to these mentioned aspects, the authors consider that the PFMEA can bring a plus in terms of carrying out the snow removal process efficiently and effectively.

3. TYPES OF EXISTING FMEA

In table 1 it can be seen that there are three types of FMEA, namely:

SFMEA stands for System FMEA Failure Mode and Effect Analysis. This type of FMEA aims to treat the entire system (for example an automobile) and will be created after the concept of a product is established. It can be applied to a system based on the concept of a product. This can be done when the product concept has been finalized.

Table 1

Types of FMEA.

Types of FMEA	Applied to	FMEA is based on	The moment of preparation
System FMEA SFMEA	Product or System (for example a car)	Product concepts	After establishing the product concept
FMEA for Product Design DFMEA	The designed component (for ex. car shock absorber)	Design documents	After the design documents are prepared
FMEA for Process PFMEA	Process or steps of the production process (for example milling)	Development plans of the process	After drawing up the process development plan

The responsible department in charge of carrying out the SFMEA is the development department.

DFMEA stands for Design Failure Mode and Effect Analysis. The design/product FMEA which will deal with the components of a product will analyze the interferences and connections between the components and will be created after drawing up the design documentation. DFMEA will allow the analysis and tracking of products right from the design stage, thus concluding possible or probable defects and what implications they will have on the finished product.

PFMEA represents the process FMEA that will deal with the steps of a production process and that will be created after drawing up a process development plan. PFMEA represents the FMEA methodology, applied to the process. PFMEA is an acronym for Process Failure Mode and Effect Analysis. The PFMEA will allow the validation of certain technologies for making a product, ensuring at the same time it is efficient manufacturing. This can be done when the process flow has been drawn. The department responsible for performing the PFMEA is the production planning department. [7]

Finally, all these three types are individual, but there is the possibility of interaction between them. The root cause could be SFMEA and is found as a defect in DFMEA and as effect in PFMEA.

4. APPLICATION OF THE PFMEA TO THE SNOW REMOVAL PROCESS

The FMEA is theoretically structured in three main fields: the field of effects, the field of defects and the field of causes; the other additional fields that may appear are the so-called auxiliary or helping fields. Each field consists of system elements, functions and erroneous functions. [8]

The method is thus differentiated according to product requirements, production stages and quality measures. [9]

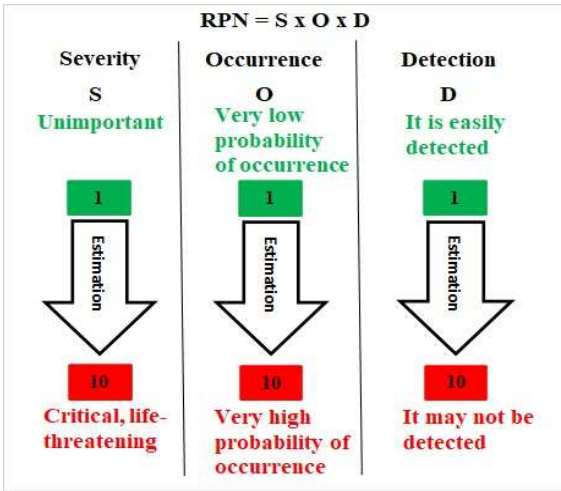

Fig. 2. PFMEA Grading method by estimating indices [1]

It was necessary to apply a qualification depending on the severity of the failure (S), the occurrence of failure (O) and the probability of detecting the failure (D), after which the RPN (Risk Priority Number) will be calculated according to figure number 2. RPN represents the sum of all indices S, O and D. [10]

Thus, the construction of the PFMEA was initiated, which can be seen in table 2. First of all, the authors identified the process on which the authors want to improve, which is the snow removal of the roads. The authors then determined what is the desired function that the process must fulfill, this being the process of removing snow from the road.

After these aspects were determined, it was important to identify failure modes or deficiencies that may appear during this type of process.

FMEA may be considered and individual project tool which can be used. [11]

The authors determined the following failure methods and deficiencies:

- The process of snow removal of the road is not effective
- The process of snow removal of the road is not efficient
- Too many fines are received from various public authorities of the state because the road is not properly cleared of snow
- Faulty communication between the involved team

Next, the authors identified multiple potential effects that could appear following the appearance of the defect or deficiency. The data was gathered by the authors. Thus, for:

- For the deficiency: the process of snow removal of the road is not effective; the authors have identified the following potential effects: roads are covered with snow, accidents may occur between cars, traffic can be blocked
- For the deficiency: the process of snow removal of the road is not efficient; the authors managed to determine the following potential effects: accidents may occur between cars, traffic may be blocked
- For the deficiency: too many fines are received from various public authorities of the state because the road is not properly cleared of snow; the authors have identified the following potential effects: The snow removal companies may not produce profit, low profitability, the loss of future contracts with the authorities in the following years
- For the deficiency: faulty communication of the team involved; the authors determined the following potential effects: delayed reaction of the operations team, roads covered with snow.

For each potential effect, the authors have assigned a qualification in terms of the severity

of the potential effect. Thus, for each potential effect, a qualifier was assigned as follows:

- The roads are covered with snow. This potential effect was assigned grade 8, the severity being quite high. Due to this aspect, multiple cars could remain stuck in the snow, generating, further, multiple situations in which it is necessary to save them
- Accidents may occur between cars. The authors assigned the highest severity rating, namely grade 10. The authors assigned this rating because this aspect could lead to damage to the personal belongings of the participants in the practice or even to the loss of human lives
- Traffic may be blocked. The authors assigned this potential effect a grade of 7, the severity being quite high. Blocking the traffic could lead to many other problems as well as to the dissatisfaction of the participants in the traffic.
- The snow removal companies may not produce profit. The authors assigned this potential effect a score of 6 because the effect is indeed severe, but the company can survive
- Low profitability of snow removal companies. The authors assigned a score of 5 to this potential effect. This is a little less severe than if the snow removal companies do not make a profit at all
- Loss of future contracts with the authorities in the following years. I assigned a grade 7 to this cause because the return of the client facilitates in the future the amortization of the investment and the realization of the profit
- Delayed reaction of the operations team. To this potential effect was assigned a score of 8. In case of a delayed reaction of the snow removal team, entire roads could remain blocked and the snow removal process could be even more difficult.

Next, to each potential effect was assigned a potential cause. Thus, for each potential effect of the deficiency:

- The road snow removal process is not effective, the authors have determined one potential cause: The intervention method of the machines and the reduced frequency to which they pass is reduced as efficiency, the communication method is faulty, the method of preparing the machines for snow removal is not efficient
- The road snow removal process is not efficient, the authors transposed one potential cause: The communication method is faulty, the traffic is not predictable and the snow removal cars have to wait in the line
- Multiple fines are received every year from different state authorities because the road is not cleared properly, the authors have determined one potential cause: No dedicated machines and human resource only for snow removal, the communication method is faulty, the method of preparing the machines for snow removal is not efficient
- Faulty communication of the team involved in the process, the authors transposed one potential cause: The communication method is faulty, no dedicated machines and human resources only for snow removal

For each cause, the authors awarded one qualification depending on the occurrence of these potential causes. The authors also noted the possibility of detecting these problems that can appear promptly.

Next, the authors calculated the RPN index by realizing the product of the three qualifiers. Following the results obtained, the authors considered the fact that the RPN index is very high for each problem detected during the development of the PFMEA. Due to this aspect, the authors considered the punctual application of a set of measures so that the reduction of the RPN index would be facilitated [12]. The highest RPN score must be fixed. [13]

Due to this aspect, the authors considered it appropriate to take specific measures to reduce the occurrence and improve the detectability of potential causes. Thus, the authors determined the following actions that I applied:

- GPS installation on snow removal machines
- Streamlining the transfer of information so that communication is carried out in the shortest possible time between the driver and the operator of the weather station. This measure was taken to reduce the occurrence of faulty communication between the teams involved in this process

- Monitoring and recording calls between the weather station operator and the snow removal machine driver. This measure was determined to detect communication problems more easily between the driver and the weather station operator. If the problems persist, specific measures can be taken based on the evaluation of the calls by the management
- Update the organization plan of the activities to facilitate the standardization of the method of preparing the machines so that the occurrence of the inefficient method of preparing the machines is reduced. It is important that each person involved knows exactly what actions to follow so that the cars are ready in the shortest possible time
- The use of traffic monitoring applications so that the dispatcher informs the driver via GPS were to arrive on the shortest route to avoid traffic congestion. This action will allow the driver to detect blocked and congested routes to avoid them to reach the route that needs to be cleared in the shortest possible time

Table 2

Applied PFMEA to the Snow removal of the road process

Process / product name	FUNCTION of the subassembly / product / process	MODE OF FAILURE / DEFICIENCY	POTENTIAL EFFECT	S	POTENTIAL CAUSE	O	D	Risk Priority Number (RPN)	Action results				
									PROPOSED MEASURES	G	O	D	RPN
Snow removal of the road	The process of snow removal of the road	The process of snow removal of the road is not effective	Roads are covered with snow	8	The intervention method of the machines and the reduced frequency to which they pass is reduced as efficiency	5	10	400	GPS installation on snow removal machines	8	5	1	40
			Accidents may occur between cars.	10	The communication method is faulty	8	10	800	Streamlining the transfer of information so that communication is carried out in the shortest possible time between the driver and the operator of the weather station.	8	1	10	80
									Monitoring and recording calls between the weather station operator and the snow removal machine driver	8	1	2	16
			Traffic may be blocked.	7	The method of preparing the machines for snow removal is not efficient.	4	4	112	Update the organization plan of the activities to facilitate the standardization of the method of preparing the machines	7	2	4	56
		The process of snow removal of the road is not efficient	Accidents may occur between cars.	10	The communication method is faulty	8	8	640	Streamlining the transfer of information so that communication is carried out in the shortest possible time between the driver and the operator of the weather station.	10	1	10	100
									Monitoring and recording calls between the weather station operator and the snow removal machine driver	10	1	2	20
			Traffic may be blocked.	7	The traffic is not predictable and the snow removal cars have to wait in the line	6	10	420	The use of traffic monitoring applications so that the dispatcher informs the driver via GPS where to arrive on the shortest route so as to avoid traffic congestion	7	6	2	84
		Too many fines are received from various public authorities of the state because the road is not properly cleared of snow.	The snow removal companies may not produce profit.	6	No dedicated machines and human resource only for snow removal.	9	9	486	The allocation of additional resources in terms of human resources and the addition of the car fleet	6	1	9	54
			Low profitability.	5	The communication method is faulty	8	8	320	Streamlining the transfer of information so that communication is carried out in the shortest possible time between the driver and the operator of the weather station.	5	1	10	50
									Monitoring and recording calls between the weather station operator and the snow removal machine driver	5	1	2	10
			Loss of future contracts with the authorities in the following years.	7	The method of preparing the machines for snow removal is not efficient.	4	4	112	Update the organization plan of the activities to facilitate the standardization of the method of preparing the machines	7	2	4	56
		Faulty communication between the involved team	Delayed reaction of the operations	8	The communication method is faulty	8	8	512	Streamlining the transfer of information so that communication is carried out in the shortest possible time between the driver and the operator of the weather station.	8	1	10	80
									Monitoring and recording calls between the weather station operator and the snow removal machine driver	8	1	2	16
			Roads are covered with snow	8	No dedicated machines and human resource only for snow removal.	9	9	648	The allocation of additional resources in terms of human resources and the addition of the car fleet	8	1	9	72

- The allocation of additional resources in terms of human resources and the addition of snow removal machines to the fleet. This action will punctually reduce the occurrence of companies having too few resources to manage crises

Following the application of these measures promptly for each potential cause mentioned, new qualifications were offered in terms of occurrence and detectability. The severity rating given initially to the potential effects remained unchanged because the severity of the effects cannot be modified. Based on the new qualifications, the RPN index was recalculated.

It can be observed that following the punctual application of the measures, the Risk Priority Number was reduced to a considerable extent. By means of the PFMEA, the potential causes that facilitate the emergence of the potential effects were treated. By punctually treating the causes that generate the occurrence of negative effects from a process, the authors will significantly reduce their occurrence in the long term, and thus the authors will increase the efficiency and effectiveness of the snow removal process.

5. CONCLUSIONS

The snow removal process in the public sector is particularly complex. It can have negative effects that can even lead to the loss of human lives. Through this scientific work, I demonstrated the fact that a methodology applied predominantly in the automotive field can also be applied in the public sector to determine possibilities for improving the processes carried out.

The paper offers a theoretical perspective regarding FMEA from the point of view of objectives, stages and existing types used. Also, the paper offers a practical example by which FMEA can be applied in any existing sector, bringing multiple benefits.

Applying the PFMEA methodology to the public road snow removal process, the authors identified the deficiencies of this process. By determining the deficiencies, the authors were able to identify the potential effects caused by the deficiency. Next, for each potential effect the authors determined a potential cause. To potential effects were given a qualification in terms of severity, and to potential causes were given qualifications in terms of occurrence and the possibility of detection in case of occurrence. Based on them, an initial Risk Priority Number was calculated. The initial RPN result determined us to take specific measures. Thus, one or more measures were taken on each potential cause so that the occurrence was reduced and the detectability was significantly improved.

Following the application of these measures, both the occurrence and the detectability were reevaluated through the qualifiers, following which the RPN index was recalculated. It was found that the Risk Priority Number was significantly reduced thus offering a significant improvement of the final process from multiple points of view.

Finally, it was demonstrated that FMEA is a methodology for all areas of activity and can be applied in any area bringing numerous improvements.

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APLICAREA ANALIZEI DE RISC DE TIP FMEA IN CONTEXUL ORGANIZATIILOR CARE ASIGURA SERVICII INTEGRATE DE INTERES LOCAL SI REGIONAL IN ROMANIA

Analiza modului de defectare și a efectelor, FMEA, este o metodologie utilizată frecvent în sectorul comercial în scopul de a investiga nenumăratele cauze și repercusiuni care ar putea rezulta dintr-o defecțiune (defecte, din cauza cărora obiectul își pierde capacitatea de a-și îndeplini funcțiile). În această lucrare stiintifica, vom investiga de ce este utilă, precum și modul în care această strategie ar putea fi utilizată în contextul serviciilor integrate de importanță locală și regională. Organizațiile care furnizează servicii de importanță locală și regională vor avea de câștigat dacă reușesc să prezică potențialele probleme și defecțiuni ale infrastructurii de gestionare. Un studiu FMEA al procesului arată discrepanțe care au un impact asupra siguranței și calității produsului.

Vasile GUSAN, Sc.D Student, University Politehnica of Bucharest, Faculty of Industrial Engineering and Robotics, Splaiul Independenţei no. 313, 6th District, Bucharest, Romania, E-mail: vasilegusan@yahoo.ro.

Aurel Mihail ȚÎȚU, Professor, Lucian Blaga University of Sibiu, 10 Victoriei Street, Sibiu, România, E-mail: mihail.titu@ulbsibiu.ro

Dorin-Vasile DEAC-Șuteu, Sc.D Student**,** University Politehnica of Bucharest, Faculty of Industrial Engineering and Robotics, Splaiul Independenţei no. 313, 6th District, Bucharest, Romania, E-mail: fam.deac@gmail.com.