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# Improving Reliability of Service Operation Using FMEA: Review and New Opportunity for Investigations

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**Abstract.** Despite its growing contribution to the global economy, investigation on the application status of service FMEA study to support realization of reliable service operation is very limited in literature. Motivated by such situation, the paper presented an initial survey on the status and research gaps in developing and applying FMEA in service sectors. Systematic preliminary survey using specific criteria are undertaken. Our study indicated that development and application of service FMEA are partially addressing the characteristics of service operations and it is still applied into the good deed and profit oriented operations. Opportunities for further investigation pertaining to advancement of its decision supporting tool for service risk appraisal, its modification to cope with sustainability related requirements and application of service FMEA in not for profit oriented operations are presented as new avenues for further investigation

## 1. Introduction

In line with growing contribution service sector to the global GDP nowadays, maintaining reliable service operation is undoubtedly important for sustaining world economy [1]. Failed service provision will yield into customers' dissatisfaction and incur service quality loss. In industrial practice, practitioners using service FMEA as means to assess reliability by identify the service failure modes, appraise the risk of faulty service occurrences and finding solutions to remedy or prevent its re-occurrence in future. Due to its beneficial effects, application of FMEA methodology is widely spreading in various service operation fields. However, in spite of its versatility in its application, studies discussing opportunities intended to improve reliability by using FMEA in the literature such as the studies of [2], [3], [4] and [5] are mostly still focusing on improving product design and manufacturing process related - reliability and paying very little attention on service operation reliability.

Motivated by scarcity on the availability on references on improving reliability of service operation, this study is intended to review and proposed new perspectives on improving reliability of service



operations by using Service FMEA approach by extending to the study of [6] based on time period of 2011 onward. The goal of this study are as follows, first we intend to consolidate contemporary papers pertaining to the application of service FMEA in service operations, second; to classify service FMEA papers based on criteria such as advancement of the methodology in service risk appraisal, application of service FMEA in supply chain context, modification of FMEA, and its integration with other engineering tools. Third, to investigate the most important ideas based on the service FMEA survey and proposed new prospects on service FMEA studies for further investigations.

## 2. Research Methodology

In an attempt to reach our research goal, literature survey is conducted. Studies pertaining to service FMEA in the field of quality and reliability management in various publisher databases between time span 2011 onward is accomplished. The papers pertaining to the FMEA in service operations are retrieved from various journals publishers such as Elsevier Science Direct, Emerald, Taylor and Francis, IGI Global Publishers, Springer, Hindawi, Sage, and Directory of Open Access Journals (DOAJ), Cambridge University press and Wiley Interscience. Only periodicals written in English are retrieved. The keyword “FMEA”, “FMECA” and “service FMEA” and “Service FMECA” are used to consult the aforementioned literature database. Reference classification criteria used in literature search are service failure risk reprioritization methodology, supply chain FMEA and integration of service FMEA with other engineering methodology are used for categorizing service FMEA literature. The result of our initial literature survey then classified into various classification criteria as depicted in Table 1, Table 2, and Table 3.

**Table1. SERVICE FMEA REFERENCES ON ADVANCING SERVICE FAILURE RISK REPRIORITIZATION METHODOLOGY**

Service FMEA Aspect	Methodological basis	References	Service Area	Application
<b>Failure Risk Reprioritization</b>	1-10 Ordinal Scale	[7]		Knowledge Management
	AHP (Analytical Hierachy Process)	[8]		Healthcare
	Decomposition Theory	[9]		Trade Service
	Bayesian Network Causal Model	[10]		Healthcare
	Fuzzy Logic	[11]		Healthcare
	Fuzzy Rule and Bayesian Network	[12]		Security
	Cloud Theory	[13]		Maintenance
	Logarithmic scale	[14]		Healthcare
	Cost Oriented Fuzzy Theory, GRA and Profitability Theory	[15]		Healthcare
	2-Tuple Linguistic Representation Model and GRA	[16]		Healthcare
	Grey Relational Analysis	[17]		Healthcare
	Data Envelopment Analysis	[18]		Tourism Service

**Table2.** Classification Of Supply Chain FMEA Studies And Its Application Settings

Supply Chain Scope	FMEA	References	Methodology	Application Setting
Failure Re prioritization	Risk	[19]	Fuzzy AHP and Fuzzy TOPSIS	Manufacturing Supply Chain
		[20]	MICMAC Method	Food supply Chain
		[21]	Bayesian Belief Networks	Aerospace Mfg Supply Chain
		[22]	Bow-Tie Diagram and Fuzzy Inference system	Manufacturing Supply Chain
Risk Mitigation		[23]	MICMAC	Horticultural Supply Chain
		[24]	Grey Theory and Digraph Approach	Electronics Supply Chain

**Table3.** Integration Of Service Fmea With Other Engineering Improvement Tool

Integration of Quality Tools into Service FMEA	References	Application Area	Application Context
FMEA-IDEFO	[25]	Healthcare Service	Companywide
FMEA-Control Chart	[26]	Manufacturing	Companywide
FMEA-QFD	[27]	Healthcare	Organizational wide
FMEA-SWOT Analysis	[28]	Gas Distribution Service	Company wide
	[29]	Manufacturing	Companywide
FMEA and Design of Experiments	[30]	Manufacturing	Companywide
FMEA and Non Homogeneous Poisson Process	[31]	Maintenance	Companywide
FMEA and Process Activity Mapping	[32]	Manufacturing	Companywide

In spite of the fact that service FMEA studies is continuously growing and becoming more versatile, driven by the escalation of global disastrous events [33], the Inseparability, Heterogeneity, Intangibility and Perishability (IHIP) characteristics of service operations [34] and the rising of the grey and black swan type risk events' occurrences [35], in our point of view, much unanswered questions are still waiting for further investigations. Considering that enhancement and application of service FMEA is having a vast scope, we only limit our ideas into the few aspects which covering enhancement of FMEA's Risk Appraisal, Modification of Service FMEA, Application to Non Profit Oriented Service and integration with other engineering tools. Some new research opportunities for advancing and expanding application of service FMEA studies are discussed in brief in the followings.

### 3. New Opportunities of FMEA Studies in Service Operations

*3.1. Advancement of Failure Risk Assessment, Its Root Causes Re-prioritization, and Mitigation in Service Operations.*

#### *3.1.1. Prioritizing Root Causes of Failure for Risk Re prioritization*

In an attempt to determine appropriate risk-based risk recovery measures, determination of root causes of the service failure occurrences is important. Contrary to the abundance of methodology to rank

failure risk criticality in FMEA, the existence of methodology to prioritise root cause of failure occurrence is very limited in literature. Extending on the work of [36] and [37] in appraising the weight of failure root causes and ranking their hierarchy using other type of multi criteria decision making methodology and probability theory is a potential research direction.

### *3.1.2. Revision of the failure risk Evaluation by considering failure time occurrence and Interdependencies of Failure Event occurrences*

In FMEA methodology, the magnitude of the risk is measured by its RPN. Due its simplicity, the use of RPN based on the multiplication among FMEA indexes on failure occurrence scale, detectability and severity using 1-10 ordinal like scale is very versatile. However, it has limitation such as ignorant to the failure time occurrence, which in real situations may escalate loss over time. Furthermore, although many studies have been proposed to improve determination on the component of probability of failure occurrences in FMEA as exemplified by [38], and [39], their previous works is based on the idea that probability of failure occurrences is independent among others. In real situation, however, the occurrence of failure modes is sometimes dependent among others. Reformulation of failure risk assessment quantitatively by considering dependencies among others is important and to our knowledge, never been investigated in previous Service FMEA studies.

### *3.1.3. Development of FMEA Method as Risk Distribution Tools in Supply Chain Application Framework*

In supply chain risk assessment framework, quantifying the magnitude of the SCM risk is only half way to battle the risk. In an attempt to mitigate the adverse effect of risk event occurrences in supply chain context, decision makers must also consider the affected parties due to the risk exposure, which may endanger sustainability of multiple tiers in SCM framework. While many studies focus on appraising the magnitude of the risk by using many advanced mathematical tools such as Graph Theory, endeavour to design capability of FMEA as risk distribution tool for risk distribution to the affected parties in the supply chain context is vacant in references.

### *3.1.4. Modification of FMEA for Waste Appraisal Tool in Maintenance as Service Supporting Operation.*

Driven by sustainability issues nowadays, currently global manufacturers face the challenge of creating green and sustainable manufacturing practice [40]. Sustainable manufacturing demands the efficient resource utilization and minimization of any activities which do not add value. From this point of view, application of lean manufacturing principle into maintenance is obviously relevant in supporting sustainable manufacturing as the goal of lean philosophy is on curbing the root cause of resource wastage. Nevertheless, studies which discuss on the advancement of maintenance methodology such as [41] indicate to the escape on the focus of developing maintenance model based on lean principle. Narrowing down the gaps, opportunities in this directions may commence by development of modified service FMEA model dealing with reprioritization of maintenance waste, which to our knowledge, is never been investigated in previous service FMEA references.

## *3.2. Application of Service FMEA in Not for Profit Oriented Operations.*

According to the study of [42], the escalation of global disastrous events is coming at an alarming rate. In order to cope with above situation, designing a reliable service recovery operations is believe to be able to mitigate the negative impact of disastrous events occurrence. In this situation, investigation of the utilisation of FMEA as Risk Appraisal tool in disaster recovery actions can be basis for a start. An opportunity in this direction for instance is the modification of Service FMEA to appraisal the criticality of customers' needs in humanitarian situation. Another opportunity to apply FMEA in not for profit oriented operations is in the area of educational service provision in a supply chain framework. An investigation of [43] indicated that attention of previous studies in supply chain

operations are almost neglect to pay attention on investigation of risk appraisal in educational service supply chain settings.

### 3.2. Integrating Service Life Cycle Analysis and Anticipatory Failure Determination Engineering Tools in Designing Predictive Service FMEA Model

In an attempt to enhance capability of FMEA, many studies integrating it with other engineering tools has already been proposed as given in table 4. Nevertheless, above mentioned studies are not sufficient since those still uncover limitation of service FMEA in dealing with service defectiveness at second and sub sequent limitation. And also, the birth of grey and black swan risk event types indicated to the need to design a predictive oriented model beyond the utilization of integrated FMEA and NHPP model such as the work [31]. In this regards, integration of service FMEA with Service Life Cycle Analysis and Anticipatory Failure Determination (AFD) methodology can be chosen as an opportunity for further studies.

## 4. Conclusions

In this paper, a preliminary survey and classification scheme of current service FMEA studies from current periodical - type references using specific criteria are proposed. In spite of the facts that applications of service FMEA is continuously growing and becoming more advanced, driven by nowadays business situations getting more complex due to uncertainties and characteristics of the service process itself, many challenges are still awaiting. In our paper, some directions of investigating service FMEA for future studies are proposed. Obviously, by using a very limited literature, it is clear that this study is not an exhaustive investigation and future research could reiterate our initial findings by using more databases. Furthermore, discussions on opportunities for development of service FMEA model could include some issues such as its application in virtual settings, its integration with performance measurement tools, inclusion of people's belief in apprising the criticality of defective services and establishment of time -considering multi criteria decision support model for service failure risk appraisal.

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