IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Special Issue-15, May 2019 E-ISSN: 2347-2693

A Mathematical Model toAssessFailure due to Longer Lead Times in SMEs in IT Sector

Aditya Pai H[1*], Prakash Behera[2], Chimaya Dash[3], Piyush Kumar Pareek[4]

[1]Department of Computer Science and Engineering, K.S. Institute of Technology, Bengaluru and Research Scholar, VTU Belgaum, Bengaluru, India
[2,3]Dept. of CSE, Claret College, Jalahalli, Bengaluru and Research Scholar, JJTU, Rajasthan, India
[4]Department of Computer Science and Engineering, EWIT, Bengaluru, India

DOI: https://doi.org/10.26438/ijcse/v7si15.304308 | Available online at: www.ijcseonline.org

***Abstract*—**The Small and Medium Enterprises (SMEs) uses a lead time to complete the work in the estimated time period. The longer lead time is the fault in which the SMEs take longer time period to complete the work. The reason for this discussed in this paper which are termed to be as 'waste' phenomenon. This phenomenon can be assessed using failure mode effective analysis (FMEA). The paper discusses on the causes behind the wastes using the survey and analysis of the responses from the survey. Then the failure modes identification using FMEA, followed by the mathematical model to assess the failures.

***Keywords*—**SMEs, FMEA, Lead Time, Waste.

I. INTRODUCTION

The Lead Time is the term used in the manufacturing sector for the production of the automobiles, machines etc. The term signifies the time difference between placing of the order by the customer to the delivery. The lead time plays the crucial role in outpacing the organization with the competitors, in order to avoid stocks being exhausted, to keep market flexible in terms of shifts, to meet the target date easily and enhancing the cash income with improved orders.

Although the implementation of lead time has shown improvement in the organization. It has its own disadvantages as incapable of meeting the lead time leads to the 'longer' lead time, leading to bottlenecks during the deployment. Some of the problems with longer lead time are:

1. During delivery or the transfer of work from one team to another team. If a team takes longer time to complete it will have affect to the process of activities to the next team.
2. The longer lead time makes difficult to standardize the process
3. In the developers environment if there is poor availability of the environment provisioning to develop the code then it leads to the longer lead time.
4. The manual software deployment of the code requires more time especially in the larger projects. Hence it is necessary to deploy automatic software deployment techniqueinstead of manual.
5. The manual software testing is more time consuming and has proven to be error-prone and expensive process especially for the larger organization. Hence there is a need in the automated testing of software, without which there will be longer lead time.

II. LITERATURE SURVEY

According to EetuKupiainena, Mika V. Mantyla and JuhaItkonen [1] - The paper aims in knowing the causes and effects in agile development for different software metrics. The paper signifies that using of these metric is similar to that of the traditional approach which results in the sprints in the agile approach becoming necessary to detect the errors and fixing it [9][10].

According to Brian Fitzgerald, Klaas-Jan Stol, Ryan O'Sullivan, and Donal O'Brien [2] – The paper examines the way the agile development process works in the controlled environment. The author signifies the approach by keeping the strategy for the product for the period of 3 months where the numerous backlogs are being identified and prioritized which are then taken up during the scrums. Then after the end of every scrums the clients are being approached for the feedback.

From the paper authored by Robert Imreh and Mahesh S. Raisinghani [3] – The objective of the research was to study the quality aspects of when the agile development is being used and its impact towards the organization. The author signifies the method in while the software is being developed where every work is being documented and the same is being negotiated with the client for any changes in the exiting

document. The outcome of the study is that with usage of the agile development the process of software development can be standardized.

According to SandhyaTarwani and Anuradha Chug [4] - The point of this methodical writing audit: - Various Agile strategies for better software upkeep; Comparison of cascade demonstrate and nimble philosophy; the change from cascade model to dexterous techniques; various devices accessible for Agile approaches; Summarize the quality and shortcomings of Agile Methodologies. In the wake of watching the confirmations from the exploration ponders, it was seen that by presenting light-footed software development procedures there has been a constant improvement in the field of software development.

TaghiJavdaniGandomani, HazuraZulzalil, AbulAzimAbdGhani and Abu Bakar MD Sultan [5] states the similarities in two types of the development methods – agile and open source. The author explains it with the help of the case study. As a result the author finds out that there are two similarities they are the team goals approach in both the methods are the same and secondly the development in both are incremental in nature.

From the paper authored by JarosławBerłowskia, PatrykChruściela, MarcinKasprzyka, IwonaKonanieca, Marian Jureczko [6] – The explanation given by the author is in the testing method used in the medium sized agile approach. Where the author explains that by using scrum it is necessary to get into the testing process. Here in the agile method there are two types of testing being used one being flow of analysis method and the second one is the testing documents.

According to S. Harichandan, N. Panda and A.A. Acharya [7] – The paper fundamentally signifies the testing process by undergoing the scrum conditions. The author explains that there are two mythologies beings used one is unit and integrated. It is necessary to collect the software requirements at an early stage. The code is adaptable to change and also the testing process exhibits quality aspects of the software.

According to AthulJayaram [8] – The paper explains how the Lean Six Sigma (LSS) can be profitable to the organization in reducing the wastes especially in the industries that are smart – Industry 4.0, where the machines are associated with the sensors. That is in the operational aspects. The LSS ensures that there are no wastes in the production and as much as possible there has to be data recovery. Industry 4.0 and IIoT plays important role in efficiency of the product in quicker rate, also in more productive and efficient way.

III. RESEARCH OBJECTIVES

The research work being carried out has the following research objectives listed below:

1. To conduct the survey in Small and Medium Level Enterprises in order to understand the factors behind longer lead time.
2. To understand the potential cause and effects of the longer lead time using failure mode effective analysis.
3. Creating a mathematical model for minimizing the potential failure modes.

IV. METHODOLOGY

The Figure 1 below shows the step by step process for assessing the longer lead times causes and effects and coming up with the solution by creating a mathematical model.

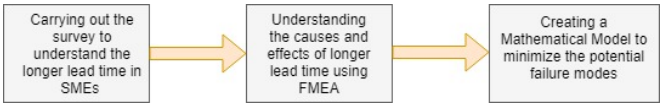

Figure 1. Research Methodology for assessing failure due to longer lead times in SMEs

V. RESULTS AND DISCUSSIONS

The paper is divided into various stages, initially through the survey longer lead time in the SMEs is analyzed for 243 respondents. The following Table 1 shows the descriptive statistics of survey respondents. The minimum statistic taken here is 1 and maximum is 5 in the scale of 1 to 5. The table also describes mean, standard deviation, variance, skewness and kurtosis. The formula for

The formula for standard deviation is

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{N - 1}} \quad (1)$$

Where,

x_i	i^{th} observation
$\bar{x}$	mean of the observations
N	number of nonmissing observations

The formula for variance is

$$s^2 = \frac{\Sigma\ (x_i - \bar{x})^2}{N-1} = \frac{\Sigma\ \ x_i^2 - (N \times \bar{x})^2 / N}{N-1}$$

(2)

Where,

x_i	i^{th} observation
$\bar{x}$	mean of the observations
N	number of nonmissing observations

The formula for skewness is

$$b_1 = \frac{N}{(N-1)(N-2)}\ \ \Sigma\ \left[\frac{x_i - \bar{x}}{s}\right]^3 \quad (3)$$

Where,

x_i	i^{th} observation
$\bar{x}$	mean of the observations
N	number of nonmissing observations
s	standard deviation of the sample

The formula for kurtosis is

$$b_2 = \frac{N(N+1)}{(N-1)(N-2)(N-3)}\ \ \Sigma\ \left[\frac{x_i - \bar{x}}{s}\right]^4 \ -\ \frac{3(N-1)^2}{(N-2)(N-3)} \quad (4)$$

Where,

x_i	i^{th} observation
$\bar{x}$	mean of the observations
N	number of nonmissing observations
s	standard deviation of the sample

Table 1. Descriptive Statistics of the survey responses

Descriptive Statistics										
Research Questions	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	*Statistic*	*Statistic*	*Statistic*	*Statistic*	*Statistic*	*Statistic*	*Standard Error*	*Statistic*	*Standard Error*
Pleaseindicate the type ofcompany	243	1	5	3.48	1.478	2.185	-.235	.156	-1.572	.311
Please indicate approximate number of employees	243	1	5	2.71	1.140	1.299	.863	.156	-.258	.311
Please indicate thenumber of workingshift per day	243	1	3	1.79	.726	.528	.336	.156	-1.051	.311
Please indicate approximate annual turnover ofyour company	243	1	5	2.16	1.265	1.601	.921	.156	-.201	.311
Please indicate average annual growth in turnover	243	1	5	3.21	1.411	1.991	-.183	.156	-1.238	.311

In the next step, the causes and effects from the potential failure is done. This is done by ranking the failures according to severity rate, how many times it is repeated and number of times it is being detected. Table 2 describes the listing of failures done by FMEA.

Table 2. List of the Potential Failures

Potential Failures	Description
FL01	Delay in the specifying the requirements from the clients
FL02	Listing of the requirements which are actual and that which are addressed are different
FL03	Total number of defects found and that which has been rectified
FL04	The planned number of coding and testing is less during implementation stage
FL05	Number of end user participation to the required project is less

Based on the listed failures ranking is done as shown in the Table 3.

Table 3. Ranking of the different types of Failure

Type of Failure	Description	Ranking
Very High Ranking	The overall system function causes the system to produce very high failure rate without any warning and causing highest damage to the system	5
High Ranking	The overall system function causes the system to produce high failure rate with warning with possibility of high damage to the system	4
Medium Ranking	The overall system function causes the system to produce medium failure rate with possibility of medium damage to the system	3
Low Ranking	The overall system function causes the system to produce low failure rate with minor damage to the system	2
No Ranking	Least failure to Nil Failure	1

Now based on these rankings the ranking is done based on severity rate, repeated failure occurrences and number of failure being detected.

Table 4. Ranking of the Potential Failures on severity, repeated occurrences, detection rate

Potential Failures	The Severity of the Failure (A)	Repeated Occurrences of the Failure (B)	Number of times the Failure being detected (C)
FL01	4	2	3
FL02	4	2	2
FL03	5	3	1
FL04	4	4	2
FL05	5	5	2

Based on the above Table 4, the risk index of the failure is being calculated to give the solution to the potential failures being detected which is shown using the formula

$$\text{Risk Index Rate} = A \times B \times C \quad (5)$$

The above mathematical equation assess the potential failures and based on which the action will be taken. Table 5 shows the Risk Index Rate for the potential Failures

Table 5. Risk Index Rate for the Potential Failures

Potential Failures	The Severity of the Failure (A)	Repeated Occurrences of the Failure (B)	Number of times the Failure being detected (C)	Risk Index Rate
FL01	4	2	3	24
FL02	4	2	2	16
FL03	5	3	1	15
FL04	4	4	2	32
FL05	5	5	2	50

Now based on the Table 5, Table 6 shows the prioritization of the potential failures and the ranking is done accordingly, which shows that FL05 is being more riskiest and FL03 being the least in the risk ranking.

Table 6. Ranking for the Risk Index Rate for the Potential Failures

Potential Failures	The Severity of the Failure (A)	Repeated Occurrences of the Failure (B)	Number of times the Failure being detected (C)	Risk Index Rate	Ranking of Failures
FL05	5	5	2	50	Rank 1
FL04	4	4	2	32	Rank 2
FL01	4	2	3	24	Rank 3
FL02	4	2	2	16	Rank 4
FL03	5	3	1	15	Rank 5

From the analysis of Table 6, it is clearly evident that the ranking of the failures based on risks are FL05, FL04, FL01, FL02 and FL03 respectively. Based on which the solution is given

Table 7. Suggestions to eliminate the necessary failures

Problems	SuggestedActions
Delay in the specifying the requirements from the clients	Increase the number of end user participants like clients, developers, testing teams etc. It is their contribution which gives the idea behind the actual working of the software
Listing of the requirements which are actual and that which are addressed are different	This failure is ranked second hence it is necessary to go with the plan with actual number of codes being developed and to be tested being executed properly by total team participation among the developers and the
Total number of defects found and that which has been rectified	Delay in specifying the requirement collections leads to incompletion of the project. Here the role of the business analysts is pivotal in deciding and defining the
The planned number of coding and testing is less during implementation stage	The listing of the requirement mentioned in the actual requirement collection phase should be the same in the further implementation. The project manager plays important role to see that the team of designers, developers are going as per plan.
Number of end user participation to the required project is less	The tester has to fix the bugs effectively and efficiently.

VI. CONCLUSION

The conclusion of the paper is that with the failure mode effective analysis we could be able to identify the possibility of the different failure modes and how it has affected the system in what way. Then with risk index rate we could categorize those risks in the priority way with which the nature of the problem could be understood. Following this the suggestions of the different failures could be given based on the nature of the impact of the failure due to risk. As a future work the proposal of the risk elimination can be done at every stage of the software process regardless of the software process being agile or waterfall method.

REFERENCES

[1] Kupiainen, E., Mäntylä M. V., Itkonen J., "*Utilizing Metrics in Agile and Lean Software Development - A Systematic Literature Review of Industrial Studies*", Information and Software Technology, **2015**.

[2] Brian Fitzgerald, Klaas-Jan Stol, Ryan O'Sullivan, and Donal O'Brien, "*Scaling agile strategies to managed situations: an industry contextual investigation*", ICSE '13 Proceedings of the International Conference on Software Engineering, pp. **863-872, 2013.**

[3] Robert Imreh , Mahesh S. Raisinghani , *"Impact of Agile Software Development on Quality inside Information Technology Organizations"*, Vol. **2,** No. **10,** ISSN **2079-8407**, Journal of Emerging Trends in Computing and Information Science, October **2011**,

[4] Sandhya Tarwani, Anuradha Chug, "*Agile Methodologies In Software Maintenance:A Systematic Review*", Informatica, Vol. **40**, No **4**, 2016.

[5] Taghi Javdani Gandomani, HazuraZulzalil, Abdul Azim Abdul Ghani, Abu BakarMd Sultan, *"A Systematic Literature Review on connection between agile strategies and Open Source Software Development technique"*, International survey on PCs and software (IRECOS), Vol. **7**, Iss. 4, pp. **1602-1607**, **2012**.

[6] Jarosław Berłowskiaet.al., *"Profoundly Automated Agile Testing Process: An Industrial Case Study"*, e-Informatica Software Engineering Journal, Vol.**10**, Iss.**1**, **2016**.

[7] S. Harichandan , N. Panda , A.A. Acharya, *"Scrum Testing With Backlog Management in Agile Development Environment"*, International Journal of Computer Sciences and Engineering, Vol. **2** , Iss**3** , pp. **187-192**, **Mar2014**.

[8] AthulJayaram, "*Lean Six Sigma Approach for Global Supply Chain Management utilizing Industry 4.0 and IIoT*", Second International Conference on Contemporary Computing and Informatics (IC3I), pp. **89– 94**, **2016**.

[9] N. Abbas, A. M. Gravell, and G. B. Wills. *"The impact of organization, project and governance variables on software quality and project success",* In Proceedings Agile Conference, AGILE, pp. 77–86, Orlando,FL, **2010**.

[10] D. J. Anderson. *"Stretching agile to fit cmmi level 3-the story of creating msf for cmmi process improvement at microsoft corporation."* In Agile Conference Proceedings - IEEE, pp. **193–201**, **2005**.

Authors Profile

Mr. Aditya Pai H received the BE degree in Computer Science and Engineering in VTU, Belgaum in 2009 and pursued his masters MS degree in Information Technology and Management Manipal University, Manipal in 2012. He is currently pursuing PhD degree in Computer Science and Engineering under VTU, Belgaum at East West Institute of Technology Research Centre, Bengaluru. He has 7 years of teaching experience. Currently working as Assistant Professor in Department of Computer Science and Engineering, K.S. Institute of Technology, Bengaluru. He has two books being published in Lambert Publishing, Germany. He is also the member of ISTE. His research area is Software Engineering.

Mr. Prakash Beherais currently working as assistant professor in St. Claret College. Also pursuing his PhD degree in Computer Science and Engineering in JJTU University in Rajasthan. His Area of Specialization is Software Engineering.

Mr. Chinmaya Dashis currently working as assistant professor in St. Claret College. Also pursuing his PhD degree in Computer Science and Engineering in JJTU University in Rajasthan. His Area of Specialization is Software Engineering.

*Dr.*Piyush Kumar Pareek is a Ph.D (2016)in Computer Science Engineering from Jain University , Bengaluru , M. Tech (2012) from Dayanand Sagar College of Engineering , Bengaluru & B.E (2010) from Basaveshwar Engineering College , Bagalkote , Author has over 8+ Years of Academic Experience , He is author or co-author of over 53 international journal papers or conference proceedings, He has Four Books published in Lambert Publications , Germany. He is BOS Member – Alumni – ISE - of Basaveshwar Engineering College, Bagalkote, He is PhD Alumni Convener of Jain University, Bengaluru. He is Recognized Research Supervisor in Computer Science & Engineering (VTU0817401), Visvesvaraya Technological University, Balagavi . He is currently serving in department of Computer Science & Engineering at East West Group of Institutions, Bengaluru. His Interested areas of Research are Software Engineering, Computer Networks & Machine Learning. He is Editorial Board Member & Reviewer of International Journal of Advanced Research in Computer Science & Technology (IJARCST), Brittany, FRANCE. Reviewer of International journal of Engineering Research and Technology ESRSA Publications (IJERT), INDIA , International journal of Computer Science Research and Technology (IJCSRT), INDIA, Inter Science Research Network (IRNET), Bhubaneswar, INDIA, International Journal of Computer Science and Informatics (IJCSI), Bhubaneswar, INDIA, International Journal of Engineering, Sciences and Management (IJESM), U.P, INDIA., International Journal of Scientific & Technology Research (IJSTR), Paris, FRANCE, Journal of Theoretical and Applied Computer Science (JTACS), Szczecin, Poland, International Journal of Advanced Research in Computer Science & Technology (IJARCST), INDIA, Journal of Harmonized Research in Engineering, INDIA.,IASTER's International Research Journals , INDIA, IJMAS Journals , Bhopal , INDIA, RR Journals ,INDIA , Reviewer of IRD INDIA & STEM Journals , INDIA

