International Journal of Advancements in Mechanical and Aeronautical Engineering– IJAMAE
Volume 2 : Issue 2 [ISSN : 2372-4153]
Publication Date: 19 October, 2015

MBSA in Early Development FOK Issues

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***Abstract*— Problem solving is a fundamental element with essential skill in semiconductor industries. Without a proper problem solving analysis, the solution would be ineffective, and sometimes leads to painful consequences. This paper will describe the significance of model based solver application (MBSA) approach in early development of, first of kind (FOK) equipment and problem solving on chronic issues.**

***Keywords*—*problem solving*, MBSA, problem definition, semiconductor, first of kind, FMEA.**

I. Introduction

The problem solving model (PSM) is an important tool for solving a problem. The key element would be to understand and define the problem statement clearly to achieve the ultimate goal. The paper discuss about a case study in semiconductor environment, where issue popped up during the design phase.

Failure mode effect analysis (FMEA) is a design tool that mitigates risks during the design phase before they occur. Ideally, the FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product services (Hassan et al., 2010). Many semiconductor industries use the current FMEA techniques, but this approach has many opportunities for optimization. According to Rhee and Ishii (2003), one of the FMEA elements, known as risk, is measured in terms of the risk priority number (RPN) of a product, which is rated based on occurrences, severity, and detection difficulty. Measuring severity and detection difficulty is subjective and has no universal scale. The RPN is also a product of ordinal variables making this measure inappropriate (Figure 1).

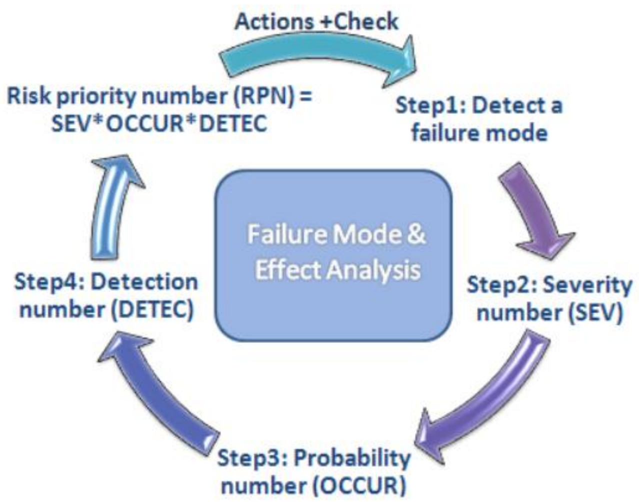

Figure 1: FMEA Process Flow

The paper will also describe on a case study of a FOK tool which was developed and seeing a critical issue for it to be sustained for production use (Table 1).

Table 1: FMEA (rev0) on AT process

Unit/Process Flow Step	Equip/Process Failure Mode	Effect	SE	Cause of Failure	OC	Current Control	DET	Current Containment	DET	RPN	RPN	Risk
AT	AT movement	AT sway intermittently	9	unknown	10	not applicable	6	fine tuning the sensor and controller	6	540	540	Med

There cause of the failure is unknown and the control is not applicable for the moment. The paper also shares how MBSA-FMEA can help to achieve a control solution via proactive FMEA.

A. *Proactive FMEA*

Proactive FMEA enables the opportunity to identify the problems and solutions ahead especially for that new design equipment in industries. The extension of the MBSA to the FMEA is demonstrated using case studies set in real industry environment. In the case study, the results of the model directly contribute to company performance by eliminating the chronic and complex problems. This step ears the confidence and credibility of the stake holders. Thus the result and recommendation are not challenged, and the management supports the pursuit of idea improvement. The model is shared in a generalized manner so that the technique of methodology can be applied beyond the semiconductor industry.

B. *Case Study Research*

Yin (2003) mentioned that the research aim involves "how" and "why" questions and that the use of case studies should be the preferred research strategy. Whetten (1989) pointed out that during the theory. Model development process, logic replaces data as basis of evolution. In this case, the "why" that underlies the reconstituted "What's: and "how's" must be explained. Case study research is suitable for simulating the developed model and justifies the workability of the theory and solving the problem.

Runeson and Host (2009) explained the research findings are obtained through in depth analyses of cases. Meanwhile, Meredith (1998) describes when and how to use the case studies in model development. The case study method is a specific field research method. Field studies investigate problem as they occur without any significant intervention of the researchers. Becker (1970) explained that a case study refers to a detailed analysis of an individual case, assuming that "one can properly acquire knowledge of the problem from intensive exploration of a case study."

C. *MBSA*

The problem solving model is intrinsically difficult to use when resolving chronic or complex problems. One of the key inputs to problem solving is using an MBSA, which allow engineers to easily rectify issues with full blown or permanent fixes. If the model is accurate and use friendly across wide range of scenarios, then the fixes to chronic problem will be accurate. Otherwise, using this model can lead to wrong decision or solutions that can sometime be expensive, result in continues high losses, and weaken equipment behavior. These potential effects justify the need to develop, design and apply MBSA methodology, which can accurately identify the root cause and fix the problems to ensure that factories operate smoothly and without any complex or walking wounded issues. Below figure 2 describes the MBSA model flow to achieve an optimal solution.

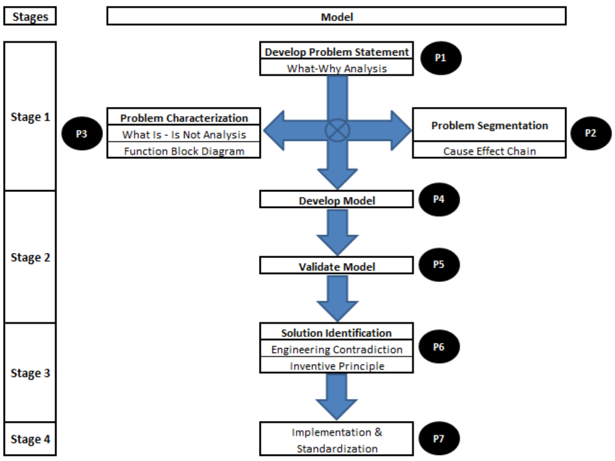

Figure 2: MBSA

Highly accurate MBSA can augment equipment stability by addressing the limitation of current problem solving methods. For complex problem that cannot be solved or fixed permanently, the response from the MBSA can be used, as depicted via case studies. The MBSA can demonstrate a powerful result for real industry issues with accurate fixes. A case study on FOK tool and its problem will discussed in next section, and how MBSA and FMEA enables the potential upcoming issues and fix the chronic issue permanently.

II. Problem Statement

The equipment selected for the case study has sufficient complexity to demonstrate the concept and effectiveness of the MBSA. The confidentiality of the equipment supplier and the specific equipment model is maintained in the process. The case study is related to FOK tool known as automated traveler (AT). AT is one of the module types which operate as traveler from one station to another to travel the goods. It is being operated by a controller and reader of magnetic tape. The key problem statement here is the AT module sways along the way while it travel from station to station (Figure 3). So a task force team has been formed to investigate and work on the solution via MBSA-FMEA model.

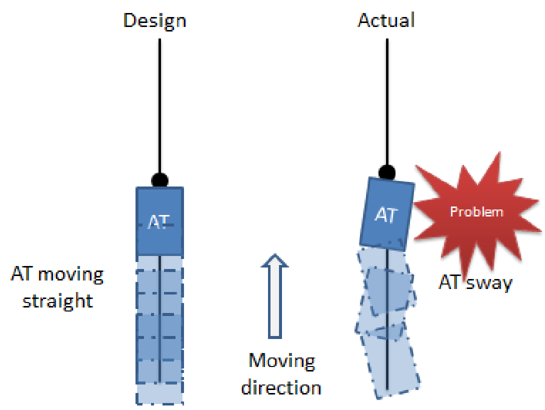

Figure 3: AT movement design vs actual

In stage 1, the problem statement is reviewed to achieve a clear picture of the issue. A What-Why analysis (Figure 4) is being performed to understand the importance of solving the problem and the obstacles that hinder the problem resolution.

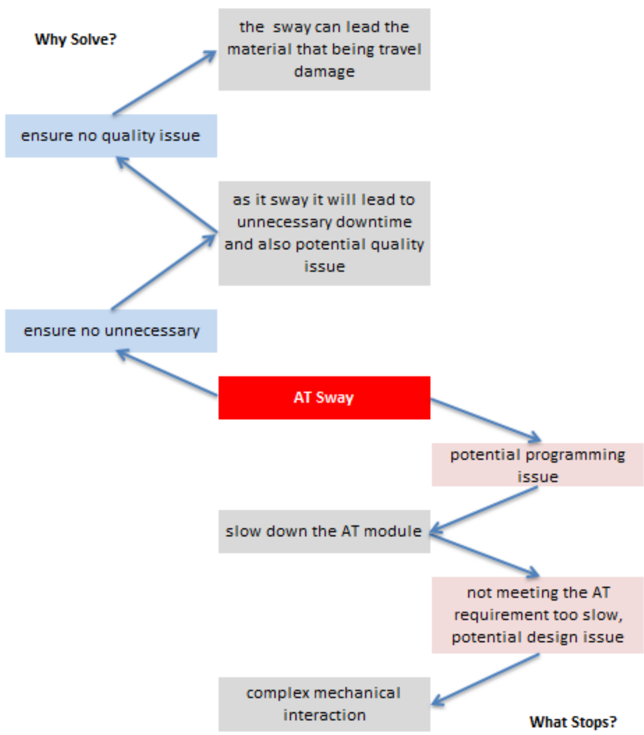

Figure 4: What – Why Analysis

The next step is problem segmentation analysis thorough the cause effect chain (CEC), which is aimed at understanding the whys and identifying the potential key disadvantages of the AT sway issue. Problem characterization as a subset of problem definition is performed through Is and Is Not problem analysis (Table 1) and the function block diagram to understand the connection and interaction between the components of the equipment related to issue.

Table 2: Is-Is Not AT Problem Analysis

	Is	Is Not	Remarks
What	sway	no sway	under slow moving speed no sway observed
What	carry >200kg	carry <100kg	less weight able to work fine
Where	factory floor	supplier lab floor	
Where			
When	since start up		
When			
Others	sensor height to far	sensor close to magnetic	

As shown in figure 6, the team identifies the potential excessive and insufficient connection between the components for further experimentation through hypothesis development for the issue regeneration.

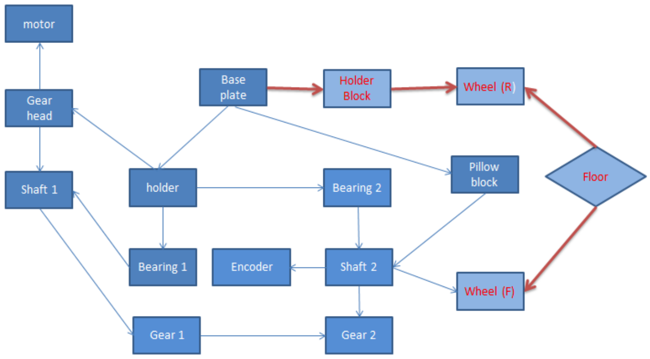

Figure 6: Function Block Diagram

In stage 2, the model is developed based on the hypothesis and validated to identify the actual root cause. The validation indicates the excessive action on rear wheel and insufficient connection between controller to encoder lead to motor and sensor signal loop back with AT module leads to sway issue.

Stage 3 involves the engineering contradiction and solution space, which has 40 potential inventive principles.

IF the rear wheel is free flow (ease of operation) THEN gives a freedom of movement while making turning (adaptability) BUT it will lead to AT module sway (stability)

ON the basis of the above IF, THEN and BUT statement, we arrive at 39 contradiction parameters. Table 3: shows the 40 potential inventive principles.

Table 3: 40 Inventive Principles

Improving Feature ↓ / Worsening Feature →		1 Weight of moving object	2 Weight of stationary object	3 Length of moving object	4 Length of stationary object	5 Area of moving object	6 Area of stationary object	7 Volume of moving object	8 Volume of stationary object	9 Speed	10 Force (Intensity)	11 Stress or pressure	12 Shape	13 Stability of the object's composition	14 Strength	15 Duration of action of moving object	16	17
1	Weight of moving object	+		15, 8, 29,34		29, 17, 38, 34		29, 2, 40, 28		2, 8, 15, 38	8, 10, 18, 37	10, 36, 37, 40	10, 14, 35, 40	1, 35, 19, 39	28, 27, 18,	5, 34, 31, 35		6, 29, 4, 38
2	Weight of stationary object		+		10, 1, 29, 35		35, 30, 13,		5, 35, 14, 2		8, 10, 19, 35	13, 29, 10, 18	13, 10, 29, 14	26, 39, 1,	28, 2, 10, 27		2, 27, 19, 6	28, 19, 32, 22
3	Length of moving object	8, 15, 29, 34		+		15, 17, 4		7, 17, 4, 35		13, 4, 8	17, 10, 4	1, 8, 35	1, 8, 10, 29	1, 8, 15, 34	8, 35, 29, 34	19		10, 15, 19
4	Length of stationary object		35, 28,		+		17, 7, 10, 40		35, 8, 2,14		28, 10	1, 14, 35	13, 14, 15, 7	39, 37, 35	15, 14, 28, 26		1, 10, 35	3, 35, 38, 18
5	Area of moving object	2, 17, 29, 4		14, 15, 18, 4		+		7, 14, 17, 4		29, 30, 4,	19, 30, 35, 2	10, 15, 36, 28	5, 34, 29, 4	11, 2, 13, 39	3, 15, 40, 14	6, 3		2, 15, 16
6	Area of stationary object		30, 2, 14, 18		26, 7, 9, 39		+				1, 18, 35, 36	10, 15, 36, 37		2, 38	40		2, 10, 19, 30	35, 39, 38
7	Volume of moving object	2, 26, 29, 40		1, 7, 4, 35		1, 7, 4, 17		+		29, 4, 38, 34	15, 35, 36, 37	6, 35, 36, 37	1, 15, 29, 4	28, 10, 1, 39	9, 14, 15, 7	6, 35, 4		34, 39, 10,
8	Volume of stationary object		35, 10, 19, 14	19, 14	35, 8, 2, 14				+		2, 18, 37	24, 35	7, 2, 35	34, 28,	9, 14, 17, 15		35, 34, 38	35, 6, 4
9	Speed	2, 28, 13, 38		13, 14, 8		29, 30, 34		7, 29, 34		+	13, 28, 15, 19	6, 18, 38, 40	35, 15, 18, 34	28, 33, 1,	8, 3, 26, 14	3, 19, 35, 5		28, 30,
10	Force (Intensity)	8, 1, 37, 18	18, 13, 1, 28	17, 19, 9, 36	28, 10	19, 10, 15	1, 18, 36, 37	15, 9, 12, 37	2, 36, 18, 37	13, 28, 15, 12	+	18, 21, 11	10, 35, 40, 34	35, 10, 21	35, 10, 14, 27	19, 2		35, 10, 21
11	Stress or pressure	10, 36, 37, 40	13, 29, 10, 18	35, 10, 36	35, 1, 14, 16	10, 15, 36, 28	10, 15, 36, 37	6, 35, 10	35, 24	6, 35, 36	36, 35, 21	+	35, 4, 15, 10	35, 33, 2,	9, 18, 3, 40	19, 3, 27		35, 39, 19,
12	Shape	8, 10, 29, 40	15, 10, 26, 3	29, 34, 5,	13, 14, 10, 7	5, 34, 4, 10		14, 4, 15, 22	7, 2, 35	35, 15, 34, 18	35, 10, 37, 40	34, 15, 10, 14	+	33, 1, 18, 4	30, 14, 10, 40	14, 26, 9, 25		22, 14, 19, 32
13	Stability of the object's composition	21, 35, 2, 39	26, 39, 1,	13, 15, 1, 28	37	2, 11, 13	39	28, 10, 19, 39	34, 28,	33, 15, 28, 18	10, 35, 21, 16	2, 35, 40	22, 1, 18, 4	+	17, 9, 15	13, 27, 10, 35	39, 3, 35, 23	35, 1, 32
14	Strength	1, 8, 40, 15	40, 26,	1, 15, 8, 35	15, 14, 28, 26	3, 34, 40, 29	9, 40, 28	10, 15, 14, 7	9, 14, 17, 15	8, 13, 26, 14	10, 18, 3, 14	10, 3, 18, 40	10, 30, 35, 40	13, 17, 35	+	27, 3, 26		30, 10, 40
15	Duration of action of moving object	19, 5, 34, 31		2, 19, 9		3, 17, 19		10, 2, 19, 30		3, 35, 5	19, 2, 16	19, 3, 27	14, 26, 28, 25	13, 3, 35	27, 3, 10	+		19, 35, 39
16	Duration of action by stationary object		6, 27, 19, 16		1, 40, 35				35, 34, 38					39, 3, 35, 23			+	19, 18, 36, 40

Principle 3 of the local quality proposes to change an objects structure from uniform to non-uniform, and also principle 35 of parameter change which enables degree of flexibility. The technical team designed a proof of concept (POC) by adding a spring at rear wheel act as absorber to the uneven floor condition. The value on the controller has been optimized further to meet the optimum value for the AT module (Figure 7).

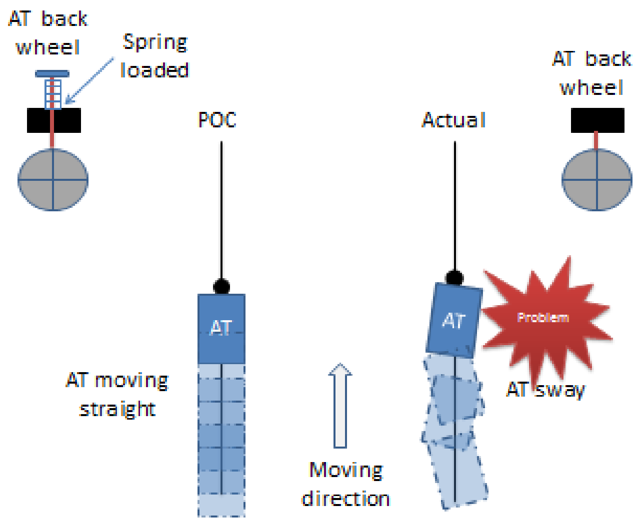

Figure 7: POC Design Validation (Solution)

This concludes the MBSA validation with different scopes of analysis has shown a promising result. The approach with and without MBSA to solve the FOK issue has shown a tremendous differences, mainly getting to the actual root cause and solve the problem in timely manner.

The MBSA is used to explore the actual problem statement, as well as to have an in –depth problem segmentation and characterizations. Table 4 shows the comparison between the approaches with and without the MBSA and the corresponding effects.

Table 4: With and Without MBSA

Without MBSA	With MBSA
NO PSM - trial - error, insight	New PSM - MBSA
no model	every stage has its own model reference
NO fool proof solution - problem reoccurance	Fool proof solution- no reoccurance
solutions are considered by comparison practical system with and without success	solutions are created based on model diagram, and inventive principles
no structured leads to long lead time	simplified < 2 weeks
knowledge based to make a decision	data based decision making
minimized quality impact	Eliminate quality impact

note: PSM - problem solving model

Table 4 also concludes that the MBSA enables a detailed root cause analysis, which can derive a foolproof solution. The MBSA adopts a clustered pattern instead of a trial-and-error or insight pattern to facilitate solution derivation. The MBSA can further be extended to risk management in semiconductor manufacturing. The main focus is on improving and addressing the potential gaps in the FMEA. This focus would help ensure that the FMEA is equipped with a control solution for each potential issue. Table 5, demonstrated a proactive FMEA and ensures the low RPN value is being achieved with control solution.

Table 5: FMEA (rev1) on AT process

Unit/Process Flow Step	Equip/Process Failure Mode	Effect	SE	Cause of Failure	OC	Current Control	DET	Current Containment	DET	RPN	RPN	Risk
AT	AT movement	AT sway intermittently	9	access interaction between the back wheel holder and base plate towards the floor	10	introduce spring loaded mechanism between the back wheel holder and base plate	1	fine tuning the sensor and controller	6	90	540	Low

Most PSMs do not have an in-depth or structured model for the problem space. This deficiency results in a method that only contains the problem fora short period. As time passes, the problem is bound to occur again. Thus, any problem that is being solved must have a permanent corresponding solution to avoid its recurrence. The case study in this paper involves neither foolproof solutions nor a chronic issue without available solutions.

In summary, this pioneering MBSA in early design and development stage has given a light and clear in depth FMEA analysis. The MBSA is derived from observations of proposed business practices. The model integrates all processes, thereby providing a structured PSM for cross-industry explorations. The MBSA is an enhancement of the integration of various models and knowledge within the PSMs.

III. Conclusion

This research presents a structured and systematic approach for developing a PSM that can be effectively used to identify the real root causes of problems and develop foolproof solutions. This research uses the literature as basis to discover the concept for the new PSM and to develop, verify, and validate the developed model through case studies. The challenges lie in the development of the model to ensure its robustness and feasibility toward real-world issues with different mechanisms.

Over 80 publications on operational excellence and PSM-related papers are included in the literature review process. On the basis of this review, we conclude that developing a structured PSM that is feasible for manufacturing industries is more important than developing a theoretical advanced PSM. Considering the findings presented in this paper, we also conclude that the integration of the clustering model into the problem definition (problem statement, problem characterization, and problem segmentation) and model development/validation (Is–Is Not) results in the derivation of a good solution (through the TRIZ inventive principle). The most significant attributes of the MBSA is the fundamental focus on the PSM, which involves problem definition using what–why analysis, problem segmentation, and problem characterization for in-depth problem analysis. The MBSA is comprehensively detailed at each stage for a strong fundamental understanding of the problem definition. Following the model development and validation stage, the focus shifts on the analysis of the major root cause of a problem through the recreation of the issue using hypothesis building. Through an engineering contradiction, detailed inventive solutions are listed for optimum solution prioritization. The model helps reduce the time spent on solving a problem and identifying the actual root cause of the problem. Through the case studies, we prove that the MBSA is applicable in highly complex equipment problems for it leads to the generation of control and foolproof solutions.

This case study also proves that the MBSA-FMEA offers significant advantages to industry experts. The improved result of the MBSA-FMEA leads to the rapid development of a solution, the analysis for which requires only a short period. In addition, industry experts can easily understand this model because of the structured procedure that facilitates the PSM. The MBSA can eliminate the conventional time-consuming practice of using the trial-and-error model. Meanwhile, the outcome of the MBSA is valuable for solving problems and avoiding their recurrence, sustaining equipment stability, and ensuring that no quality issues are repeated. In other words, the MBSA can also be a guide for further enhancing the effectiveness of industry experts in problem solving.

In summary, the MBSA is proved to be capable of providing a structured and systematic way of solving a problem with corresponding criteria under different circumstances. The MBSA is also useful in coping with the business strategies formed by top management. The three key objectives of the research are clearly achieved. This model can also be effectively used to address any engineering problems and increase the competency level of technical experts. The organization that implements this model can easily solve problems in a timely manner, successfully mitigate prospective quality issues using the model, develop a training plan to address the identified needs, and deliver appropriate training for targeted skills. The ultimate aim is to maximize the problem-solving skills and effectiveness of the organization through the deployment of the MBSA to employees.

Acknowledgment

This paper was prepared with the aid of solving one of the critical industry problem and knowledge sharing purpose. I would like to thank Dr. Beth Yam for her guidance and patience in the internal review and approval process, which allowed this paper to be published without violating the company policies on intellectual property. I wish to express my sincere appreciation for my academic advisor, Assoc. Prof. Dr. Shahrul Kamaruddin, and second academic Prof Dr. Ishak whom patiently guided us and provided us with valuable feedback. I am especially grateful to my fellow peer partners on solving this problem, Tze Keong and Shamsol.

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