



Problem Analysis in Sub-Assembly Department Using Empathize Design Thinking and Failure Mode Effects Analysis: A Case Study of PT X

Fernando Septa Andrian^{1,a)}, Novenda Kartika Putrianto^{1,b)}

Author Affiliations

*¹Program Studi Teknik Industri, Fakultas Sains dan Teknologi, Universitas Ma Chung
Jalan Villa Puncak Tidar N-01 Malang, Indonesia, 65151*

Author Emails

*a) fernandoseptaa@gmail.com**

b) novenda@msn.com

Received 11 April 2023 / Revised 05 May 2023 / Accepted 27 May 2023 / Published 06 June 2023

Abstract. PT X is a company that engages in the production of large vehicles, particularly buses. The company currently has a sub-assembly department responsible for providing support materials used in the production process. Within the sub-assembly department, there are several constraints that affect the ongoing production process. These hindrances can lead to various losses for the company. Therefore, a study is being conducted to identify and understand the obstacles present in the sub-assembly department. The problem identification process employs the empathize stage of design thinking, aiming to determine the importance of each problem. To achieve this, a ranking system known as Failure Mode Effects and Analysis is being utilized. The results indicate the existence of six problems within the sub-assembly department. Following the prioritization process, it was determined that the primary issue revolves around inadequate administrative procedures. Based on these findings, an evaluation is planned for the company, specifically focusing on the sub-assembly department. The objective is to promptly address these problems and prevent any significant impacts on the company. This abstract emphasizes the importance of identifying departmental issues and prioritizing immediate solutions.

Keywords: Design thinking; Emphatize; Failure mode effects and analysis; Sub-assembly

1. Introduction

The development of public transportation through road networks is progressing rapidly. Public transportation on roads plays a significant role in facilitating people's movement from one place to another. Modes of public transportation such as buses and trains are considered highly effective for both short and relatively long distances (Fadila, 2021).

One industry that supports the advancement and growth of land transportation is vehicle body manufacturing companies, also known as karoseri companies. These companies specialize in producing the frame or body of a vehicle, which is then combined with the chassis. In the past, karoseri companies primarily manufactured passenger vehicles based on cargo vehicles. However, as time has progressed, they are now capable of producing larger-scale passenger vehicles, including minibuses and large buses. The process of manufacturing minibuses or large

buses at a karoseri company begins with the ordering process, managed by the sales department, and then proceeds to the production process. The quality of production is influenced by the efficiency of the production process and supporting operations.

Within the production facility, the body welding division, commonly referred to as the panelling division, plays a crucial role in the manufacturing process. This process necessitates the use of various materials, including raw materials and semi-finished components. Some materials are produced in-house by the company, specifically in the press shop department and the sub-assembly department. The distribution of materials from these departments is facilitated by the courier department, which acts as an intermediary and distributes products to the workstations or stalls. However, on occasion, this distribution process encounters challenges such as missing items after production and delays in providing and distributing goods to the workstations, resulting in temporary disruptions to production and subsequent delays.

To address these issues, this study will be conducted to identify the causes of challenges in the sub-assembly department, the individuals involved in the sub-assembly department, and the operational system within that department. This analysis will be based on field observations and assessments of each user in the sub-assembly department, utilizing the empathize design thinking method and prioritizing problem areas through failure mode effects and analysis so as to avoid failure (Carlson, 2014).

2. Methods

This study employs the design thinking method, specifically the empathize stage, to process the gathered data, which helps identify the issues present in the sub-assembly department. The empathize method involves adopting an empathetic approach to understand the users' perspectives in operating the system (Dam, 2022). Furthermore, interviews are conducted to learn about the challenges users face without putting them in a defensive position. Upon completing the empathize stage, the next step involves ranking the identified challenges based on observations from the empathize stage using the failure mode effects and analysis method to determine urgent issues that require attention.

2.1. Analysis of Empathize Design Thinking

Empathize serves as the initial stage in the design thinking method, aiming to comprehend user needs (Kelley & Brown, 2018). During the empathize stage, the design team gathers information about the target users, analyzing their experiences, emotions, and situations (Widodo & Wahyuni, 2021). The team positions themselves as users to accurately pinpoint problem areas and devise appropriate solutions. This stage employs interview and observation methods.

Observations during the empathize stage encompass various parties directly involved in the production and distribution processes, including:

- a. Head of the frame and panelling department
- b. Head of the sub-assembly department
- c. Administrative staff of the sub-assembly department
- d. Courier of the sub-assembly department
- e. Operator of the sub-assembly department
- f. Operators from related departments

In addition to observing the work systems executed by the involved parties, this study also observes the production process, its underlying foundations, and the steps involved. Furthermore, observations are made regarding the work system of the administrative staff, the associated processes, and the individuals participating in those processes.

Following the observations made within the sub-assembly department, interviews are conducted with all users involved in the production and administration processes to obtain detailed information about the issues and challenges encountered in the sub-assembly department. The interview stage employs explorative interviews as a tool within the empathize

design thinking approach. The following list in table 1 presents the questions posed during the interview process:

Table 1 *Explorative Interview Questions*

No	Questions
1	What happens if the routine production process is not based on forecasting?
2	If the forecast is inaccurate and the product becomes deadstock, what steps are taken to address this issue?
3	If the production process requires material A but it is unavailable, and the product needs to be produced urgently, what steps are taken?
4	If goods are taken without accompanying withdrawal notes, what risks may arise and how severe are these issues?
5	How can the habit of taking goods without notes be changed, and who should be involved in addressing this issue?
6	How can the issue of taking goods without going through a courier be resolved?
7	Who is most affected within the department if there is missing production inventory?
8	What are the most noticeable impacts if production inventory goes missing?
9	Why doesn't the sub-assembly department have historical data for tracking incoming and outgoing goods?
10	What are the consequences if the department lacks complete data regarding the availability of goods in the field?
11	Why do administrative staff struggle to have complete data regarding the summary of available goods in the field?

2.2. Failure Mode Effects and Analysis (FMEA)

The Failure Mode Effects and Analysis (FMEA) analysis is utilized to determine, identify, and address known failures in a system, design, or process based on issues, errors, and similar factors before all processes are completed (Stamatis, 1995). FMEA is commonly employed to prioritize improvement efforts (Casadai, 2007).

When conducting the FMEA analysis, it begins with identifying potential failures that may occur in each process, determining their occurrence frequency, and identifying control systems (Anggi, 2018). Each of these three steps is assigned points based on the Severity, Occurrence, and Detection (SOD) indicators. These points are then used to calculate the Risk Priority Number (RPN) using a formula, resulting in a rating (Puspitasari et al., 2017). By evaluating the calculated rating, the priority of the issues becomes evident by multiplying the RPN by its highest value. A higher RPN value indicates a more critical problem, while a lower RPN value suggests a less severe issue (Cahyabuana & Pribadi, 2014).

The data used for ranking is obtained from the consolidation of previous interviews and observations. The weighting values employed in the Failure Mode Effects and Analysis method are derived from an adaptation of prior research, tailored through discussions with relevant stakeholders in the company, particularly the sub-assembly department. The following are the values associated with Severity, Occurrence, and Detection:

1. Severity

The severity rating assesses the level of severity of the consequences resulting from the analyzed potential failures. A higher value indicates a more significant impact. Table 2 is the explanations for the severity values (Widianti & Firdaus, 2015).

Table 2 *Severity Indicators*

Severity	Description	Rank
Dangerous Without Warning	System Failures Cause Extremely Harmful Effects	10
Dangerous With Warning	System Failures Cause Harmful Effects	9

Severity	Description	Rank
Very High	System not Working	8
High	System Operates but Can't Fully Executed	7
Medium	System Can Safely Operates but Degradation Performance	6
Low	Experience a Gradual Decline in Performance	5
Very Low	Small Effects on System Performance	4
Small	Little Effects on System Performance	3
Very Small	Negligible Effects on System Performance	2
No Effect	No Effects	1

2. Occurrence

The occurrence rating is an assessment of the likelihood of frequent failure occurrences. The higher the value, the more frequently failures are likely to occur. Table 3 is an explanation of the occurrence values (Hidayat, 2017).

Table 3 Occurance Indicators

Occurance	Description	Rank
Very High	Failure is Inevitable	10
		9
High	Failure Happen Often	8
		7
Medium	Failure that Occur Sometimes, but Not in Large Portions	6
		5
Low	Only for Specific Failure	4
Very Low	Failure Almost Identifiable	3
Almost Not Happen	Failure Almost Not Happen	2
		1

3. Detection

Detection rating is an assessment of the capability of a failure detection control system. The higher the value, the less likely the failure will be detected. Table 4 is an explanation of the detection values (Widiyanti & Firdaus, 2015).

Table 4 Detection Indicators

Detection	Description	Rank
Uncertain	Checking Always be Unable to Detect Potential Failure Mechanism	10
Very Small	Checking has Possibility to be Able Detect Potential Causes or Mechanism Failure	9
Small	Checking has Possibility of Remote to be Able Detect Potential Causes or Mechanism Failure	8
Very Low	Checking has Very Low Probabilty of being Able to Detect Potential Causes of Failure	7
Low	Checking has Low Probabilty of being Able to Detect Potential Causes of Failure	6
Medium	Checking has Medium Probability of being Able to Detect Potential Causes of Failure	5
Medium High	Checking has Medium High Probability of being Able to Detect Potential Causes of Failure	4
High	Checking has High Probability of being Able to Detect Potential Causes of Failure	3

Detection	Description	Rank
Very High	Checking has Very High Probability of being Able to Detect Potential Causes of Failure	2
Almost Certain	Cheking Always Detect Potential Causes or Mechanism Failure	1

Next, the three assessments will be multiplied to calculate the rankings using the Risk Priority Number (RPN) values.

$$RPN = Severity * Occurrence * Detection$$

After calculating the RPN, the obtained RPN values will be sorted from highest to lowest. The higher the value, the more complex the problem is, and immediate control measures should be taken. According to Nuchpho et al. (2014), the RPN values are divided into three categories (table 5):

Table 5 Risk Priority Numbers Indicators

Risk Priority Number	Risk Level
≥200	High
100-199	Medium
1-99	Low

3. Results and Discussion

3.1. The Result of Emphatize Design Thinking

After going through the observation phase of the production system, this study proceeded to observe the issues occurring in the sub-assembly department and all the involved parts within the department. In the production phase, issues were identified regarding demand forecasting for goods, both through work orders (SPK) and ongoing trends. This is mainly due to the possibility of changes in work order schedules caused by various factors in the field, resulting in unexpected stock of sub-assembly department products. Another problem arises with trend-based forecasting, as it involves producing goods based on trends with the intention of creating stock. If the trend suddenly changes, the manufactured goods can become deadstock in the department with an uncertain usability timeframe. Furthermore, when it comes to preparing consumable materials, the department lacks information on the available stock in the warehouse or other departments. This can lead to delays in the production process if the required stock is unavailable and cannot be replaced with alternative materials.

Moving on to the data compilation phase in the administrative staff, there is a problem arising from the lack of historical data. As a result, the administrative staff has to start from scratch to compile the data. However, not all the necessary data is available, and relying solely on the requested work order notes from the operators does not represent all the materials present in the field. Even during the compilation process, there are still significant data gaps that do not align with the field conditions.

The questions provided in Table 6 serve as a means to gather information that could not be obtained through independent field observations. Table 6 is the answers to the given set of questions:

Table 6 The Answer of Explorative Interview

No	Answer
1	If the production process deviates from the forecast, delays or work accumulation are highly likely to occur. This is because the products from the sub-assembly department are typically packaged and must be executed according to the required specifications.

No	<i>Answer</i>
2	When a product becomes deadstock, the usual course of action is to wait and see if it can be utilized in the next forecast. If not, certain specifications may allow for reuse with certain additions. However, for specific specifications, the product is either designated as deadstock or occasionally used by the Repair department.
3	When production requires a specific material that is out of stock, the department head will discuss with relevant staff members on how to best address the situation. It may involve using temporary materials or, if not possible, delaying the work and sourcing the needed materials.
4	The act of taking goods without proper documentation poses significant risks. Without validation of who took the goods and for what purpose, serious consequences can arise. This often leads to a blame game, as the creator feels they have made the product, while the production floor claims not to have received it. Consequently, additional time and costs are incurred in reproducing the goods and arranging overtime pay for the operators.
5	To address the issue of unauthorized goods retrieval, all users involved, including the creators, operators/couriers responsible for collecting the goods, administrative staff for generating documents, and department heads for approval, must be engaged. These individuals need to be educated about the importance of reminding each other when retrieving goods.
6	To prevent unauthorized retrievals, a mapping should be established to determine which goods should be distributed via couriers and which should not. Education should be provided on when couriers should distribute goods. However, in urgent cases where operators must retrieve goods independently, they must inform the couriers that the goods have been collected.
7	If goods go missing, the production operator is significantly affected. They must procure the goods again, adjust the production schedule, and extend working hours. Additionally, department heads are impacted as the production process is hindered due to the lack of production materials.
8	The consequences of missing goods result in altered work schedules, which in turn affect production floor schedules. Operators also face extended working hours, while administrative staff must work extra hours to prepare the necessary work order documents in case of material shortages.
9	
10	The sub-assembly department lacks comprehensive data on incoming and outgoing goods due to the absence of prior recording practices. Besides the lack of documentation, there is no supporting system in place to facilitate such record-keeping.
11	The impact of not having records for incoming and outgoing goods is evident during stock audits, as everything must start anew. Operators and staff members must manually record all products on the field, including both stock and non-stock items.
	The administrative staff faces difficulties in recording due to time constraints. They are burdened with daily tasks that cannot be neglected, necessitating additional human resources dedicated to data collection and updating information on goods in the field.

3.2. Recapitulation of Issues Based on Observations and Interviews

The recapitulation combines the constraints identified through independent observations and the findings from interviews conducted with relevant parties in the sub-assembly department. It is possible that there may be differences between the previously identified discoveries, which can be attributed to variations in terminology between observation results and interviews. The following table 7 is a recapitulation of the problems encountered in the sub-assembly department.

Table 7 The Recapitulation

No	The Problems
1	Production processes in the sub-assembly department are carried out based on demand or forecasts using Work Orders called SPK. However, if there are sudden changes in the SPK due to on-site issues, it can slightly hinder the production process in the sub-assembly department.
2	The handling of deadstock products has not been fully addressed due to variations in specifications for certain non-universal products.
3	Synchronization among schedules, material usage, and the availability of production materials must be aligned to ensure the smooth and continuous flow of the production process in the sub-assembly department.
4	Every outgoing item must be accompanied by a printed note prepared by the administrative staff and approved with the signature of the department head. This ensures that each outgoing item is official, approved, and acknowledged by the relevant staff members.
5	Adjustments are necessary regarding the users responsible for retrieving finished goods, as it is related to the accountability of production operators and couriers. Loss of finished goods can significantly impede the overall production process.
6	The administrative staff lacks human resources dedicated to managing and updating data according to the available information in the field. Due to their heavy workload, they often do not have time to make adjustments to field data, resulting in a lack of recapitulation data and historical records from the field.

3.3. Analisis Failure Mode Effects and Analysis (FMEA)

The FMEA analysis is conducted to determine the prioritized order of issues that need immediate attention in the sub-assembly department. The FMEA table is populated based on the recapitulation from the previous subsection, while the severity, occurrence, and detection assessment indicators are adjusted according to the predetermined indicators.

Table 8 FMEA Analysis

No	Process Description	Potential Failure Mode	Potential Effects of Failure	SEV	Potential Cause of Failure	OCC	Failure Control	DET	RPN	Action
1	Production Process	Worksheet SPK Changes	1. The Production Schedule has Change 2. Reprocurement	5	1. There's A Change in Worksheet SPK Schedule 2. Bus Hasn't	4	Checking Repeatedly about The Latest SPK	4	80	Allocate Sub-Assembly Product for Subsequent

			Materials is Required 3.If Spesificatio n Change, Then it Will be Stock		Been Complete d in Previous Departem ent		Workshe et			Produc tion
2	Post-productio n process	Differen t Product Spesific ation	1. Create Deadstock for Multiple Item Spesificatio n 2. Inventory Fulfillment dor An Indenfinite Time	5	1. SPK Workshe et Changes 2. Human Error	5	More Attentio n to the Design Launche d by The Engineer ing Departm ent	4	100	Re-Checki ng Each Produc t to Be Made
3	Productio n time	Shortag e of Product ion Material s	1. Production Will be Late 2. Other Departmen t Also Become Waiting for Each Other	6	1. Operator Pay Less Attention to the Readiness of Productio n Materials 2. Stock Not Available	4	Operator Must Ensure About the Readines s and Complet eness of Their Workpla ces	3	72	Create Materi al Request before Run Out, So not Hampe r the Produc tion Process
4	Dispensin g Good Result (Pick-Up Notes)	Pick Up Notes Tardine ss	1. Allows Loss of Goods 2. Outgoing Goods Data Become Imprecise	5	1. Operator Underesti mates Notes (Habbitua l Factors) 2. Rush Need Goods	5	Operator and Couriers Should Always Remind Each Other to Bring Pick-Up Notes	3	75	Provid e Educati on and Warnin g to Operat or and Courier to Always Use Notes When Picking Up Goods
5	Dispensin g Good Result (User)	Differen t User When Picking	1. Misunderst anding Between Creator and	5	1. Goods Not Distribute d	5	Adjusme nt to Job Descripti on dan	3	75	Creatin g Deliver y Tracks,

		Up Goods	Courier 2. Distribution Process Doesn't Go Through Path		Immediately 2. Special Order		Distribution Time			So Goods Always Distributed Through by 1 Lane
6	Administration process	Shortage of Human Resources	1. Distribution Data Always Late 2. Must Repeat Logging	6	1. Shortage of HR Personal who Focus on These Field 2. There's A Job Can't Be Left Behind	4	Collecting Data Based on Newest Data By Operator Input	5	120	Adding HR Personal Who Just Focus Managing The Update Data

Based on the FMEA analysis, the prioritized order of issues in the sub-assembly department is as follows:

1. Administrative Process: The problem arises from a lack of human resources focused on updating specific data, resulting in a lack of real-time data availability in the department's system.
2. Post-Production Process: The problem arises from product specification changes or operator errors in manufacturing a product.
3. Production Process: The problem occurs due to changes in the work order sequence on the production floor, leading to delays or waiting time in production.
4. Issuance of Output Items in the Form of Reports: The problem arises because each outgoing item is not accompanied by a real-time issuance report, leading to inaccurate and imprecise recording of outgoing and incoming item data.
5. Issuance of Output Items to Users: The problem arises from the distribution not following a consistent path, resulting in miscommunication and additional working time to meet demand requirements.
6. Production Time: The problem occurs due to operators' lack of preparation regarding production material readiness, leading to production waiting time as they need to prepare the required products to continue the production process.

4. Conclusions

Based on the conducted study in Company X's sub-assembly department, several challenges have been identified along with the factors contributing to these issues. These problems have been prioritized based on their urgency for the company to address. The identified sequence of issues faced by the company includes administrative processes, post-production processes, production processes, the issuance of reports for output items, the issuance of output items to users, and production time. These issues have resulted in delays and the loss of production parts. Further study is required to explore the implementation of advanced solutions to address these urgent issues and assess their impact on the company.

References

- Anggi. (2018). FMEA adalah: Pengertian dan cara menerapkannya di dalam manajemen perusahaan. Retrieved February 10, 2023, from <https://accurate.id/marketing-manajemen/fmea-adalah/>
- Cahyabuana, B. D., & Pribadi, A. (2014). Konsistensi penggunaan metode FMEA (Failure Mode Effects and Analysis) terhadap penilaian resiko teknologi informasi (Studi kasus: Bank XYZ). *ITS Repository*, 1-9. <https://repository.its.ac.id/287/1/5211100011-paperpdf.pdf>
- Carlson, C. S. (2014, January). Understanding and applying the fundamentals of FMEAs. In *Annual Reliability and Maintainability Symposium* (Vol. 10, pp. 1-35).
- Casadei, D., Serra, G., & Tani, K. (2000). Implementation of a direct control algorithm for induction motors based on discrete space vector modulation. *IEEE transactions on power electronics*, 15(4), 769-777.
- Dam, R. F. (2022). The five stages in the design thinking process. Retrieved February 11, 2023, from <https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process>.
- Fadila, R. (2021). *Perkembangan transportasi bus di Indonesia*. Retrieved February 11, 2023, from <https://www.kompasiana.com/raihanfadilamedia/619a07f206310e47d3718722/perkembangan-transportasi-bus-di-indonesia>
- Hidayat, N. F. (2017). *Usulan peningkatan kualitas dan minimasi cacat pada produk Thread Protector diameter 4" dengan metode Six Sigma di PT. Plasindo Elok* [Unpublished Undergraduate Thesis]. Universitas Esa Unggul.
- Kelley, D., & Brown, T. (2018). An introduction to Design Thinking. Institute of Design at Stanford.
- Nuchpho, P., Nansaarn, S., & Pongpullponsak, A. (2014, March). Risk Assessment in the organization by using FMEA Innovation: A Literature Review. In *Proceedings of the 7th International Conference on Educational Reform (ICER 2014). Innovations and Good Practices in Education: Global Perspectives* (pp. 781-789).
- Susanto, A.H. & Purnomo, P., 2022. Perancangan Strategi Pemasaran dan Peningkatan Kualitas Produk Pakan Burung pada IKM Sinar Mas Malang dengan Metode SWOT dan FMEA. *Jurnal Sains dan Aplikasi Keilmuan Teknik Industri (SAKTI)*, 2(1), 19-26. <https://doi.org/10.33479/jtiumc.v2i1.21>
- Stamatis, D. H. (1995). *Failure mode and effect analysis: FMEA from theory to execution*. Milwaukee: ASQC Quality.
- Puspitasari, N.B., Arianie, G.P., & Wicaksono, P.A. (2017). Analisis Identifikasi Masalah Menggunakan Metode Failure Mode and Effect Analysis (FMEA) dan Risk Priority Number (RPN) pada Sub-Assembly Line (Studi Kasus: PT. Toyota Motor Manufacturing Indonesia). *Jurnal Teknik Industri (J@ti Undip)*, 1(12), 77-84.
- Tanu, Y., & Purnomo, P. (2021). Manajemen Risiko Perencanaan Optimalisasi Pembangunan Jembatan Utama PT Wijaya Karya dengan Metode Failure Mode and Effects Analysis. *Jurnal Sains dan Aplikasi Keilmuan Teknik Industri (SAKTI)*, 1(2), 63-70. <https://doi.org/10.33479/jtiumc.v1i2.9>
- Widianti, T., & Firdaus, H. (2015). Failure mode and effect analysis (FMEA) sebagai tindakan pencegahan pada kegagalan pengujian. 10th Annual Meeting on Testing and Quality 2015, 131-147.
- Widodo, A.C., & Wahyuni, W.G. (2021). Penerapan Metode Pendekatan Design Thinking dalam Rancangan Ide Bisnis Kalografi. *Jurnal Automata*, 2(2).

