p–ISSN: 2723 - 6609 e-ISSN: 2745-5254
Vol. 5, No. 8 August 2024 http://jist.publikasiindonesia.id/

# Suroboyo Bus Operational Risk Management System Using the Fmea (Failure Mode Effect Analysis) Method

**Mustar Ichsandi**
Institut Teknologi Sepuluh Nopember, Indonesia
Email: mustarichsandi@gmail.com
*Correspondence

**Keywords:** suroboyo bus operations, public transportation, fmea (failure mode and effect analysis).

**ABSTRACT**

Suroboyo Bus Operational Risk Management System Using Fmea Method (Failure Mode Effect Analysis). Suroboyo Bus currently has several operational risks so efficient risk management planning is needed. The risk management planning mechanism used is Failure Mode and Effect Analysis (FMEA) with the hope of identifying the risks inherent in the operational business process of Suroboyo Bus. It can be seen from the survey results that 35% of the public want to add routes and 25% of the public want to add fleets. From the results of risk identification, 18 causes of the highest operational risks were obtained, including Driver absence, Minor damage or disruption to tyres, Major damage or disruption to facilities inside, Minor damage or disruption to facilities inside the bus, Traffic congestion around the bus stop, No plastic bottle checks, Damage or incomplete bus spare parts that were missed from the checking process, No helper at the passenger gathering point, Accidents on the way to the bus stop, Bus accidents, Major damage or disruption to the engine, Major damage or disruption to tyres, Unprinted receipts (out of stock), Unvalidated receipts, Lost receipts, Gears not in P position when parking at the Pool, No bus spare part checking process, accidents by cleaning staff, so SOPs, regulations, and budget policies are needed.

## Introduction

Surabaya, as a metropolitan city, has a major role in economic activities for the surrounding buffer cities. Based on BPS data (2019), the population of Surabaya City in 2018 was 3,094,732 people and continues to increase every year (Arviana, 2024). The flow of population mobilization from the surrounding buffer zone often causes congestion, especially due to the surge in the use of private vehicles during peak hours. The number of private vehicles in Surabaya in 2018 reached 5,015,001 vehicles (Dobrović & Furjan, 2020). Therefore, the use of public transportation based on travel management is needed.

The existing condition of public transportation in Surabaya is also considered less than optimal due to the lack of availability of public transportation. Based on research on

public transportation in the city of Surabaya, there is a gap between performance and passenger expectations regarding the quality of public transportation services in Surabaya (Gong, Gu, Chen, & Wang, 2020). Therefore, the city of Surabaya needs adequate public transportation facilities to support the increasing mobility of the population.

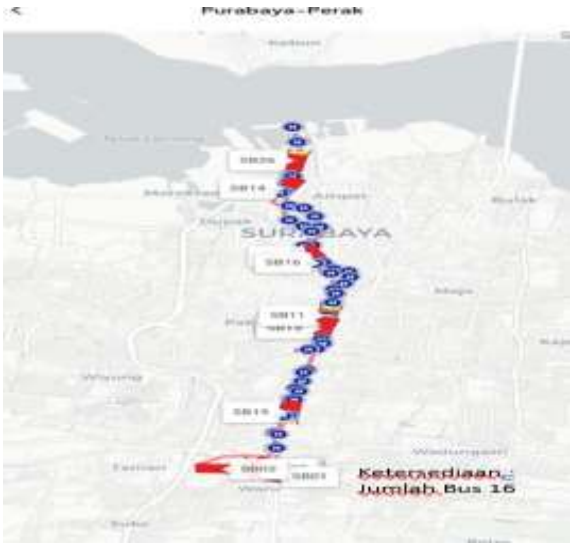


**Figure 1 Bus Availability Through Application**

With these problems, the Surabaya City Government is trying to provide public transportation services, namely Suroboyo Bus (Dudjak & Martinović, 2020). This service is expected to be able to increase public interest in returning to using public transportation. Suroboyo Bus was inaugurated in April 2018 and currently serves three routes, namely the North-South Corridor (Surabaya Terminal – Jl. Rajawali), the West-East Corridor (Jl. Mayjen Jonosewojo – ITS Roundabout), and Gunung Anyar-MERR.


**Figure 2 Surabaya Transportation Network**

Suroboyo Bus uses 26 units of low-floor maxi buses and 2 units of double-decker buses. In 2024, the number of Suroboyo Bus has increased to 28 units with more than 200 employees consisting of drivers, prima/pram, mechanics, cleaning personnel, and other support personnel. Suroboyo Bus operating hours are from 06.00 to 22.00 (Priyawati, Rokhmah, & Utomo, 2022).

Apart from being a public transportation service, Suroboyo Bus has also become one of the leading breakthroughs in the field of public transportation in the city of Surabaya which has been recognized at the international level (Priyawati et al., 2022). Therefore, quality improvement must continue to be carried out so that Suroboyo Bus can continue to serve the people of Surabaya sustainably (Priyawati et al., 2022). One way to improve the quality of services to all relevant stakeholders is to review the risks that have existed and have the potential to arise so that a handling plan can be formulated. The goal is to be able to manage obstacles in realizing the goals of implementing the Suroboyo Bus (Irawan, Muzid, Susanti, & Setiawan, 2018).

In the daily operational activities of Suroboyo Bus, there are always risks that arise such as vehicle damage, passenger safety, worker indiscipline, complaints from the community, and so on. Examples are delays or crew absences due to the indiscipline of human resources, damage to the bus body both interior and exterior, work accidents due to inadequate facilities, ticket forgery, and non-accommodating passengers (Simanjuntak, Siagian, Prasetyo, Rozak, & Purba, 2022).

Risk can be interpreted as the possibility of adverse events that interfere with the achievement of goals (Cahyani, Dewi, Suryadi, & Listartha, 2021). Risks that arise in operational activities can cause Suroboyo Bus's operational reputation to decline. If not handled properly, this can lead to a bigger and systemic problem, namely the failure to achieve the main goal of the Suroboyo Bus program. Therefore, it is necessary to prepare a comprehensive risk management plan to be able to identify, measure, map, prioritize, and develop alternative risk management in a structured and systematic manner.

## Research Methods

### Risk Identification

Risk identification is carried out by recording all risks that may occur by the context that has been determined in the previous subchapter accompanied by risk categorization and recording the causes and consequences of risks. Risk causes can be categorized into:

1. Operational environmental factors that include all external conditions that affect Suroboyo Bus's operational activities. For example: the accuracy of the arrival of the Suroboyo Bus, and the accommodating of passengers.
2. Economic factors that include all conditions of expenditure activities and income from Suroboyo Bus operational costs
3. Social factors include all conditions of the number of workers who are accommodated by the Surabaya City Transportation Agency in the field of BLUD UPTD PTU because they are affected by the Suroboyo Bus route.

### Data Collection Techniques

1. Data Primer

Primary data is in the form of data on potential hazards related to technical risks through the results of interviews and the distribution of questionnaires with several staff in pre-selected projects related to the risk of work accidents. The results of the interviews were conducted to find out the risk of work accidents that may occur in the projects reviewed.

2. Data Seconds

The secondary data used is risk identification data, pictures of Suroboyo bus routes, management systems and occupational safety obtained directly from the public transportation management.

**Research Steps**

1. Risk Identification

It is carried out through literature studies, observation interviews in the field, and the distribution of questionnaires that will be included in the questionnaire form.

2. Risk Analysis

Estimating the occurrence of a risk and the impact of that risk. The steps taken are:

1. Questionnaire Deployment of Risk Identification
2. Interview
3. Risk Assessment and its impact will occur through the FMEA (Failure Mode and Effect Analysis) method.
4. The Most Dominant Cause of Risk with the Domino Method

**Risk Response**

This step is used to determine the extent of the response to a risk that occurs.

Types of risk responses:

1. Risk Avoidance
2. Accepting Risk
3. Delegate and
4. Reduce risk

**Data Analysis**

The problem discussed uses the FMEA (Failure Mode and Effect Analysis) method. The following is the process of conducting data analysis:

a. Risk Process Identification describes project activities starting from the work to be carried out so that work accident risk analysis can be carried out.

b. FMEA (Failure Mode and Effect Analysis) The stages of the process carried out are:

   1. Identify functions in Project activities
   2. Identify the Failure Mode process
   3. Identify project failures
   4. Identify the cause of the risk failure that occurs
   5. Determine the risk rating that occurs
   6. Proposed improvements

Based on the data processing research discussed using the Process Failure Mode and Effect Analysis (PFMEA) Method. Determine the level of interest at risk (RPN) by calculating the RPN value as follows:

**RPN = *probability x severity x detection***

The result of the value of the greatest risk interest or the most critical RPN will be used as input for the stages of the Domino method.

## Results and Discussion

### Likelihood Estimation for Every Suroboyo Bus Operational Risk

In the risk assessment process, it is necessary to have an estimate of the likelihood in this research is needed as one of the inputs of the FMEA method which will be used as a method of operational risk management of Suroboyo Bus which describes the level of how often an operational risk occurs in Suroboyo Bus operational activities daily (Munaroh, Amrozi, & Nurdian, 2021).

The likelihood estimation method for each risk used in this research can be categorized into two main categories, namely objective calculation where the likelihood calculation is made based on Suroboyo Bus operational data that has been collected in Chapter IV; and subjective calculation where the probability level of a risk is determined based on expert judgement from stakeholders related to these operational risks.

Data has been collected for expert judgement from Suroboyo Bus stakeholders, including:

1. Person in Charge of Personnel
2. Person in Charge of Repair and Maintenance
3. Person in Charge of Application and Social Branding
4. Person in Charge of Suroboyo Bus Operational Planning

### Likelihood Assessment of the Person in Charge of Suroboyo Bus Operational Planner

In the following case, an interview was conducted with the expert judgment person in charge of personnel regarding the problems and obstacles of Suroboyo Bus related to human resources. The following was conveyed about the Bus Operational Likelihood Scale questionnaire based on the assessment of *Expert Judgment* in the field of Suroboyo Bus personnel:

**Table 1**
**Rekapitulasi Skala Likelihood Operasional Bus**

| BUS OPERATIONS | | | | | | |
|---|---|---|---|---|---|---|
| No | Variable | ASSESSMENT SCALE | | | | |
| | | *Rare* | *Unlikely* | *Possible* | *Likely* | *Almost certain* |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Average bus accident per month | ✓ | | | | |
| 2 | Average minor bus accidents per month | | ✓ | | | |
| 3 | Average employee serious accidents per month | ✓ | | | | |
| 4 | Average minor accidents of employees per month | ✓ | | | | |
| 5 | Average buses do not operate due to protests | | ✓ | | | |
| 6 | Passenger Waiting Time More Than 10 Minutes | | | | | ✓ |

In the following case, an interview was conducted with *the expert judgment* person in charge of personnel regarding the problems and obstacles of Suroboyo Bus related to human resources (Fitriyan & Syairudin, 2016).

**Recapitulation of Likelihood Maintenance and Damage Scale**

In the following case, an interview was conducted with *the expert judgment* person in charge of bus maintenance and repair regarding the problems and obstacles of the Suroboyo Bus related to repairs, maintenance and obstacles to supporting bus operations (Simanjuntak et al., 2022). The following was conveyed about the Bus Operational Likelihood Scale questionnaire based on the assessment of Expert Judgment in the field of bus repair and maintenance:

**Table 2**
**Recapitulation of Likelihood Maintenance and Damage Scale**

| **MAINTENANCE AND REPAIR** | | | | | | |
|---|---|---|---|---|---|---|
| No | Variable | ASSESSMENT SCALE | | | | |
| | | *Rare* | *Unlikely* | *Possible* | *Likely* | *Almost certain* |

| | | | | | |
|---|---|---|---|---|---|
| 1 | Spare parts are unavailability every month | | | ✓ | |
| 2 | Bus Body Damage | | | | ✓ |
| 3 | Bus Tire Damage | | | ✓ | |
| 4 | Engine Breakdown | | | ✓ | |
| 5 | Suspension damage | | | | ✓ |

**Recapitulation of the Likelihood Social Branding and Service Scale**

In the following case, an interview was conducted with *the expert judgment* person in charge of social branding and services regarding the problems and obstacles of Suroboyo Bus related to the service and branding obstacles built by Suroboyo Bus. The following is conveyed about the Bus Operational Likelihood Scale questionnaire based on an assessment from *Expert Judgment* in the field of Social Branding and maintenance:

**Table 3**
**Recapitulation of the Likelihood Social Branding and Service Scale**

| SOCIAL BRANDING AND SERVICE | | | | | | |
|---|---|---|---|---|---|---|
| No | Variable | ASSESSMENT SCALE | | | | |
| | | *Rare* | *Unlikely* | *Possible* | *Likely* | *Almost certain* |
| 1 | Server crashes on the application | | ✓ | | | |
| 2 | Complaints Through Social Media | | | | | ✓ |
| 3 | Ticket digital printing error | | | | ✓ | |
| 4 | Passengers' Direct Complaints on Bus Services | | | | ✓ | |
| 5 | Passenger Accident | ✓ | | | | |

**Estimated Severity for each risk**

The severity estimation process in this research is needed as one of the inputs of the FMEA method which will be used as a method of operational risk management of Suroboyo Bus which describes the severity related to the impact of an operational risk if the operational risk occurs in the operational activities of Suroboyo Bus (Siregar, 2023).

In the first stage, the severity estimation method for each risk used in this research was obtained through Suroboyo Bus operational data and based on *expert judgement* from

relevant *stakeholders* of the operational risk. The following is a recapitulation table of the categorization of operational risks of Suroboyo Bus based on the type of severity determination.

Data has been collected for *expert judgement* from Suroboyo Bus stakeholders, including:

1. Person in Charge of Personnel
2. Person in Charge of Repair and Maintenance
3. Person in Charge of Application and Social Branding
4. Person in Charge of Suroboyo Bus Operational Planning

**Efforts to improve service quality**

The formulation of quality improvement strategies is carried out by description analysis. The purpose of the description itself is to provide an overview of the object being studied through the data or samples that have been collected (Sugiono, 2009). The existing conditions and expectations of users then need to be supported by concepts or regulations related to the three variables above in formulating a strategy so that the formulated strategy is by the applicable provisions and principles. In providing better public transportation services, in addition to regulators as policymakers, operators are also needed as actors who provide services directly to the community. Therefore, the strategy formulated needs to be made from two sides, namely regulators and operators. To make the analysis easier, tabulation is carried out related to existing conditions, user expectations, concepts or regulations as follows.

**Table 4**

| Variabel | Current Conditions | User Expectations | Concepts and Regulations | Strategi |
|---|---|---|---|---|
| Waiting time | • Average passenger wait time 8.5 minutes<br>• The fastest time a passenger ever spends waiting is 6 minutes and the longest time that passengers have spent is 60 minutes | The waiting time spent by passengers to decompose the Suroboyo Bus for each trip is not much different | Waiting time at the time peak is 10 minutes at most during peak hours and 8 minutes at non-peak hours. The determination of peak and non-peak times is adjusted to the conditions of each region. (Permenhub No.98 Year 2013) | Regulator :<br>• Determining the magnitude<br>• *Headway* Fits with peak and non-peak time conditions.<br><br>This affects the waiting time spent by passengers, the headway is directly proportional to the waiting time.<br><br>Operator :<br>• Improve the services offered by paying attention to the amount of |

| Variabel | Current Conditions | User Expectations | Concepts and Regulations | Strategi |
|---|---|---|---|---|
| | | | | waiting time.<br>• Conducting regular monitoring of implementasi kebijakan penetapan *headway* and the maximum waiting time limit for Suroboyo Bus public transportation<br>1. Developing *a reward* system for Suroboyo Bus operators<br>2. Providing optimal service in terms of waiting time<br>• Integrate waiting time information for each fleet at each stop and terminal location on the application system Tracker |
| Availability of modes (units) | 1. The number of modes has a permit of 28 units<br>2. The number of modes operating on weekdays (Monday-Sunday) is 11-17 units. | Optimalisasi jumlah unit Suroboyo Bus | Assistive devices or transports are always available whenever the object being transported needs it, regardless of time and place (Miro, 2005).<br><br>Then according to the National Research Council (1999), service providers must have the | Regulator :<br>1. Assess the number of vehicle needs that operate per day so that the number of vehicles can be used optimally<br>2. Operator :<br>Integrating information on the type of fleet operating with the Tracker application |

| Variabel | Current Conditions | User Expectations | Concepts and Regulations | Strategi |
|---|---|---|---|---|
| | | | value of responsiveness, which is related to the willingness or readiness of service providers to provide services and accuracy of service time.<br><br>In Permenhub No.98 of 2013 It is stated that the number of operating armadas is at least 90% | system Optimizing the function of BLUD UPTD PTU and overcoming problems related to service transportation performance. |
| Information | 1. Service information can be obtained through transportation agencies, bus stops, bus stops, and Tracker applications.<br>2. Transportation service information at bus stops is more complete than the information listed at the bus stop or the Tracker application.<br>Some bus stops | • Transportation service information is displayed in full on each media<br>• Availability of information on arrival time and transportation | The quality of service can be seen from several perspectives, one of which is *Information*, which is related to the ease of obtaining information about transportation services. (Litman, 2019)<br><br>Then according to the National Research Council in Basuki (2007), the quality of transportation services can also be seen through the Communication factor, which is related to the ability to communicate in providing information. | Regulator<br>• Completing service information that does not yet exist or is inadequate on transportation, bus stops, bus stops, and Tracker applications<br>• Integrate the location information of the operating transportation with the Tracker application system<br>• Operator :<br>Completing service information at the transportation agency |

| Variabel | Current Conditions | User Expectations | Concepts and Regulations | Strategi |
|---|---|---|---|---|
| | have not been equipped with service route information or have been equipped but the condition is damaged and cannot be read<br>• Information on the arrival time of transportation is not yet available | | | |

**Effective Risk Management to Support the Sustainability of Suroboyo Bus Operations**

The risk management process begins with risk management planning. Risk management planning is carried out by experienced judgment in several fields to find out all kinds of existing operational risks of Suroboyo Bus. Surveys and interviews were conducted with experienced judges to find out the risks that exist in Suroboyo Bus. After knowing the risks, the next step is to identify the risks that exist and classify them based on the frequency or how often they arise and the impact of the risks. Furthermore, an assessment of the risk scale, high, moderate and low was carried out based on the Recapitulation of the Risk Mapping Index for Suroboyo Bus Operational Risk. After knowing the risk mapping index table, risks can be mitigated based on the highest to lowest risk scale. The following is the risk management flow:

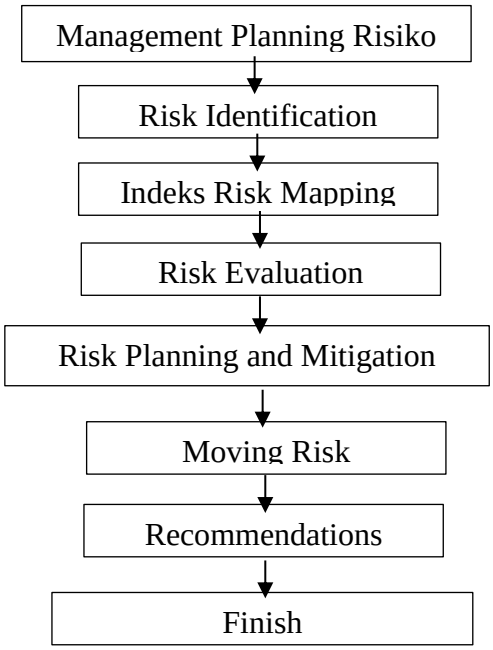


**Figure 3 Risk Management Flow**

**Risk Management Planning**

The risk analysis process includes the stages of estimating severity and likelihood objectively by using historical data from parameters related to Suroboyo Bus operational activities; and subjectively by using validated and verified literature reviews on Suroboyo Bus stakeholders. Based on the severity and likelihood values, the risk value can be obtained according to the calculation formula that has been submitted. The risk evaluation process begins by sorting risks descendingly, starting from the risk with the highest risk value, namely the absence of a driver, to the risk with the lowest risk value. Then the results of the calculation of the risk value can be categorized into three different risk categories based on the level of risk appetite and the division of risk mapping areas, namely high risk, mediocre risk, and low risk.

**Risk Identification**

After planning how the risk management system will be implemented, the next step is to carry out the risk identification process. This can be done by understanding in advance what risks may occur when a project is carried out. Identification can be done by analyzing the problem from the source it comes from. In addition, identification can also be done by checking the risk list based on experience from previous projects. This can expand team thinking and be able to more effectively identify risks optimally. Experience is very valuable and can help the risk identification process run more optimally.

**Risk Evaluation**

Once a risk has been identified, the next step is to evaluate the risk based on the probability of the event as well as the potential losses involved. Not all risks are created equal. Some risks are potentially easier to occur than others. In addition, the cost of risk

can be quite varied. By conducting an evaluation, you can find out how much impact the risk will have on the business you manage.

**Mitigation Plan**

Mitigation is a way or plan that is prepared to reduce the impact of unexpected events. You must be able to minimize losses that may have to be borne due to a certain risk. Several ways can be applied, namely risk sharing, risk transfer, risk avoidance and risk reduction. Each mitigation technique can be the most effective tool to reduce the impact of risk. In planning, mitigation techniques will approach each event to be able to take appropriate actions to maximize the impact of risks that may occur.

**Moving Risk**

If the risk is not able to be handled internally by the company, then the risk should be transferred to a party who may be able to help handle the risk. The party in question who can help handle risk is the insurance company. You can rely on the party if the risks that may occur are related to unexpected events such as theft, fire, damage and so on. The insurance company will help you to minimize losses that may become a burden on the company in handling these risks.

**Management Implications**

Implications are everything that has been produced as a result of the policy formulation process. So it can be interpreted that implications are the consequences and consequences that arise with certain policies or activities that are implemented. In this study, the Surabaya city government enacted a policy to provide public transportation in the form of the Suroboyo Bus. However, this is not done optimally so it has an impact on the community in the form of people not being accommodated in several areas in Surabaya to use public transportation services.

## Conclusion

Based on the research that has been conducted, several important conclusions have been obtained regarding the operation of the Suroboyo Bus. First, the survey results show that 35% of people want additional routes because some areas in Surabaya are not traversed by the Suroboyo Bus. In addition, 25% of the public proposed an additional bus fleet, because many passengers were not properly accommodated by the current services.

Furthermore, through the process of identifying and analyzing risk variables, 18 significant risk variables were found that had the potential to affect Suroboyo Bus operations. Some of them are driver absence, damage or interference with tyres, and severe or minor damage to facilities on the bus such as seats, glass, safety equipment, monitors, and audio. In addition, traffic congestion around bus stops, the absence of checking plastic bottles, and the incompleteness of bus spare parts that are missed from the checking process are also included in the significant risk variables. Other risks include the absence of helpers at the gathering point, accidents experienced by passengers when heading to the bus stop, to bus accidents that hit or hit other vehicles or objects. Some other technical risks are heavy damage to the engine and tyres, problems with receipts such as receipts not being printed or missing, and gear conditions that are not in a safe

position when parking in the Pool. Cleaner accidents are also one of the risks that need to be considered. In risk analysis using the RPN FMEA method, the risk priority level is calculated by multiplying the Severity (S), Occurrence (O), and Detection (D) indices obtained from the analysis of failure modes and effects. The results of the calculation show that the driver's absence has the highest risk priority level with a risk value of 25, which has a significant impact on the non-accommodating of passengers.

## Bibliography

Arviana, Delfi. (2024). Optimalisasi Produktivitas dan Manajemen Risiko pada Sistem Produksi Aleta Leather Menggunakan Metode House of Risk. *Jurnal Teknologi Dan Manajemen Industri Terapan*, *3*(2), 160–170.

Cahyani, Desi Dwi, Dewi, Luh Putu Windy Puspita, Suryadi, Kadek Dika Rama, & Listartha, I. Made Edy. (2021). Analisis Kerentanan Website SMP Negeri 3 Semarapura Menggunakan Metode Pengujian Rate Limiting dan OWASP. *INSERT: Information System and Emerging Technology Journal*, *2*(2), 106–112.

Dobrović, Željko, & Furjan, Martina Tomičić. (2020). SWOT analysis in the strategic planning process-Meta-modelling approach. *2020 IEEE 10th International Conference on Intelligent Systems (IS)*, 574–579. IEEE.

Dudjak, Mario, & Martinović, Goran. (2020). An API-first methodology for designing a microservice-based Backend as a Service platform. *Information Technology and Control*, *49*(2), 206–223.

Fitriyan, Rama, & Syairudin, B. (2016). Analisis risiko kerusakan peralatan dengan menggunakan metode fmea untuk meningkatkankinerja pemeliharaan prediktif pada pembangkit listrik. *Prosiding Seminar Nasional Manajemen Teknologi XXV. Program Studi MMT-ITS*.

Gong, Yifei, Gu, Feng, Chen, Kengbin, & Wang, Fei. (2020). The Architecture of Micro-services and the Separation of Frond-end and Back-end Applied in a Campus Information System. *2020 IEEE International Conference on Advances in Electrical Engineering and Computer Applications (AEECA)*, 321–324. IEEE.

Irawan, Yudie, Muzid, Syafiul, Susanti, Nanik, & Setiawan, Rhoedy. (2018). System Testing using Black Box Testing Equivalence Partitioning (Case Study at Garbage Bank Management Information System on Karya Sentosa). *The 1st International Conference on Computer Science and Engineering Technology Universitas Muria Kudus*.

Munaroh, Lailatul, Amrozi, Yusuf, & Nurdian, Risky Agung. (2021). Pengukuran Risiko Keamanan Aset TI Menggunakan Metode FMEA dan Standar ISO/IEC 27001: 2013. *Technomedia Journal*, *5*(2 Februari), 167–181.

Priyawati, Diah, Rokhmah, Siti, & Utomo, Ihsan Cahyo. (2022). Website vulnerability testing and analysis of website application using OWASP. *International Journal of Computer and Information System (IJCIS)*, *3*(3), 142–147.

Simanjuntak, Indra Jadi, Siagian, Rizky Torang, Prasetyo, Rendra, Rozak, Nanda Fathur, & Purba, Humiras Hardi. (2022). Manajemen Risiko Pada Proyek Konstruksi Jembatan: Kajian Literatur Sistematis. *Jurnal Teknologi Dan Manajemen*, *20*(1), 59–76.

Siregar, Tamzid Tarmizi. (2023). Pemanfaatan Manajemen Sistem Transportasi Umum. *Laporan Kerja Praktek Mahasiswa Teknik*, *1*(6).