# Shopping Center Escalator Maintenance Process Using Business Process Re-Engineering Approach

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## Abstract

Escalator maintenance for public facilities needs attention because it can cause time, cost, and safety losses for escalator users. This study aims to design an electronic maintenance system, supported by Internet of Things (IoT) and Relational Database. Business Process Re-engineering (BPR) method is carried out to improve processes and through business simulation processes using iGrafx software. The design of information systems is arranged in several stages, making an entity relationship diagrams (ERD), use case diagrams, relational tables, and data flow diagrams (DFD). four maintenance options that result in different maintenance. The combination of information system, CMMS and sensor scenarios resulted in the best improvement rate of 23.65%.

## Keywords
Shopping Center, Business Process Re-engineering, iGrafx, Information System

## 1. Introduction
Indonesian Central Statistics Agency, in 2020 has a population of 270.20 million people with various needs, to accommodate these needs, Shopping center is one of solution. (Indonesian Central Statistics Agency, 2020). To explore the shopping center, several vertical transportations are provided such as escalators, elevators, and stairs. The escalator is used because it is easy to use, so it can create a positive attitude for visitors to be enthusiastic to explore shopping centers, and it is also the most efficient transportation because it can accommodate many people between floors (Zaman, 2020)

To maintain optimal performance at the shopping center facilities, it is necessary to maintain facilities through maintenance activities. Maintenance is also important in accordance with the rules that have been determined by the government, it was said that when compared to escalators to elevators, it has 10 times the dysfunction per unit (Construction Competency and Training Center, 2006). The main factor is negligence in maintenance, inspection, and operation, which can cause speed conditions to suddenly stop, the direction of the escalator to suddenly change, and the handrail suddenly unable to function optimally (Amillia & Basir, 2018).

### 1.1 Objectives
Designing an electronic maintenance monitoring system on the escalator, supported by Relational Database and Internet of Things (IoT) technology, with Business Process Engineering method and information systems.

## 2. Literature Review
Business Process Re-engineering (BPR) is a principal re-planning and a fundamental re-conceptualize processes of a business to achieve better performance and improvement of key indicators, such as expenses, time, and convenience (Caeldries et al., 1994). BPR is also defined as a management of strategy for business with focuses on analyzing and concepting new design for material and information workflows and processes within a structure. This technique recommends the old system need to be readjusted with a new system so it can be more innovative and effective (Dachyar & Christy, 2014). BPR aims to achieve dramatic increases in company performance measures using the latest information technology (IT) to fundamentally and radically redesign business processes (Dachyar & Pertiwi, 2020).

According to Bhaskar (2018), BPR framework has six phases. In the first stage, top management must recognize and understand what they want and why they want it. In the second stage, a vision is needed to get the business going in the right direction. The third stage relates to benchmarking, where current processes and activities are evaluated to identify areas of focus of attention. The fourth stage is related to the transformation in a feasibility study is carried out. The work is assessed to measure the resources needed and the changing scope from the transformation carried out. The fifth stage concerns the implementation of the BPR project. The sixth step is about monitor and evaluate the whole project performance to know areas that need modification. There are several methods of construct BPR, such as task reduction, task arrangement, and technology integration (Ferretti & Schiavone, 2016).

Maintenance is a combination of activities such as technical, administrative, and managerial activities, maintenance aims to maintain the value of assets. Maintenance process include concept planning, communication, financial planning, and operations to achieve reliability, availability, productivity and market value (Dachyar et al., 2018). In addition, another definition of maintenance is the process of ensuring the system is in good performance. Some of the benefits of right maintenance management are increased safety issues, efficiency, cost optimization, and increased integration, better management and so on. (Isnaini Janipha et al., 2018).

As part of a commercial building, not only focusing on time efficiency and visitor safety, maintenance is also useful for reducing costs, in addition to focusing on escalators or other machines, building maintenance is important because as the building ages, various problems will arise that need to be maintained through performance. maintenance. The initial strategy that can be done is to know the characteristics of the building, some things that need to be known are the age of the building, the use of the building, where the building is located, the size and height of the building and the structure to calculate the cost of further maintenance (Uzoamaka & Emoh, 2018).

Over the years, escalator maintenance has evolved through several types of maintenance, including preventive, breakdown, usage-based, task-based, and condition-based maintenance. New maintenance method with data driven approach, this maintenance leverages technologies such as Cloud Computing, Big Data, and Machine Learning, which are useful for enterprises and escalator passengers. This has the potential to change the Escalator Industry as a whole, especially in the areas of quality, escalator maintenance, and product development. (Smith, 2015). This was also conveyed by Lai et al (2019) regarding maintenance with IoT which has the potential to reduce costs due to damaged machines and need replacement, then forecasting, processing, planning data for decision making, digital data, real time and effectiveness & transparency.

## 3. Methods

This study has five major stages. The first stage, the study of literature was carried out to formulate the background, problems, and objectives of this research. In the second stage, conducted interviews with experts to collect and understand the current process of escalator maintenance in the shopping center. The third stage, the current process is modeled and simulated with iGrafx software. The four stages, conduct an assessment of the results to find problems and weaknesses from the current model, interviews were also conducted to understand the voice of customers (VOC) regarding escalator maintenance in shopping centers. In the fifth stage, the current problem is aligned with the VOC to produce a recommended solution. iGrafx software can be used to model and simulate three scenarios, which is a design of classified solutions. The best scenario to implement are obtained from the comparation of each scenario results with the as-process result.

## 4. Data Collection

Data collection is carried out by conducted interviews to get the overall process, then be mapped into a flow process chart (FPC) as the basis for make business process model. FPC is used to show step by step of the whole process use symbols that indicate the type of activity. From the FPC, the overall processes can be categorized into 15 operation processes, 3 movement processes, 23 inspection processes, and 3 delay processes. The time of each process is known by conducted interviews with stakeholders. The time of each process will be shown in Table 1 below.

Table 1. Escalator Maintenance Process Time

| No | Process | Fastest Time | Longest Time | No | Process | Fastest Time | Longest Time |
|---|---|---|---|---|---|---|---|
| 1 | Schedule maintenance activities for the escalator unit | 10 | 20 | 24 | Step Chain Condition Check | | |
| 2 | Send to chief engineer | 2 | 3 | | a. Check the condition of the plate chain | 10 | 15 |
| 3 | Wait for chief engineer's schedule approval | 10 | 20 | | b. Check Roller Axle Condition | 10 | 15 |
| 4 | Report to operations | 10 | 20 | 25 | Check Machine Room Condition | 5 | 10 |
| 5 | Wait for operational schedule approval | 10 | 20 | 26 | Check the Traction of the Escalator Machine | | |
| 6 | Wait for confirmation of the presence of the PIC engineer according to schedule | 5 | 8 | | a. Check Engine Traction Condition Conditions | 10 | 15 |
| 7 | Go to the work tool room according to schedule | 5 | 8 | | b. Check the Condition of the Oil Seal | 5 | 10 |
| 8 | Ensure the condition of work tools is complete and good for preventive use | 15 | 30 | | c. Perform Operational Checks | 10 | 15 |
| 9 | Move to the destination escalator | 5 | 8 | 27 | Magnetic Brake Condition Checks | 10 | 15 |
| 10 | Turn on the Escalator | 5 | 10 | 28 | Check Driving Chain & Follower Conditions | 10 | 15 |
| 11 | Check the visual condition for any abnormality during operation | 10 | 15 | 29 | Control Panel Condition Check | 10 | 15 |
| 12 | Check for noise or abnormal sound from the machine during operation | 10 | 15 | 30 | Automatic Start Stop Condition Check | 10 | 15 |
| 13 | Turn off the escalator | 5 | 10 | 31 | Check the Condition of the Econo Drive System | 10 | 15 |
| 14 | Open the landing cover | 2 | 5 | 32 | Check the Condition of Handrail Lighting | 5 | 10 |
| 15 | Escalator running test | 5 | 10 | 33 | Check the Condition of Monitoring System | 5 | 10 |
| 16 | Check the condition of Comb | 5 | 10 | 34 | Turn on the escalator | 5 | 10 |
| 17 | Emergency Stop & Key SW test | 3 | 5 | 35 | Check the visual condition for any abnormality during operation | 10 | 15 |
| 18 | Check Handrail Guard & Switch | 5 | 10 | 36 | Check for noise or abnormal sound from the machine during operation | 10 | 15 |
| 19 | Visual check on the Step/ Palette | 10 | 15 | 37 | Turn off the escalator | 5 | 10 |
| 20 | Check on the Roller Step | 10 | 15 | 38 | Fill out the job report form | 8 | 15 |
| 21 | Check Demarcation or line step | 10 | 15 | 39 | Check work tools and adjusting to records | 8 | 15 |
| 22 | Check Handrail Driving Equipment | | | 40 | Check and tidy up accompanying technical documents | 5 | 10 |
| | a. Check the Condition of the Drive Roller | 5 | 10 | 41 | Move to the work tool room and accompanying technical documents | 10 | 17 |
| | b. Check the Condition of the Pressure Roller | 5 | 10 | 42 | Arrange work report documents onto shelves in the right order | 5 | 10 |

| No | Process | Fastest Time | Longest Time | No | Process | Fastest Time | Longest Time |
|---|---|---|---|---|---|---|---|
| | c. Check the Condition of the Drive Wheel | 5 | 10 | 43 | Send photo and video reports to related parties via WhatsApp | 5 | 12 |
| | d. Check Guide Roller Condition | 5 | 10 | 44 | Put work tools | 2 | 5 |
| | e. Check Condition of Chain Drive R/L | 5 | 10 | | | | |
| | f. Check the Condition of the R/L Chain Sprocket | 5 | 10 | | | | |
| 23 | Check the Condition of Skirt Guard & Switch | 5 | 10 | | | | |

## 5. Results and Discussion

The escalator maintenance process was created used Business Process Model Notation (BPMN) to represent the overall business process. The As-Is model consists of three lanes: maintenance preparation, maintenance implementation, and post maintenance implementation.

### 5.1 Current Escalator Maintenance Process (As-Is)

The overall current escalator maintenance process consists of 44 processes. The preparation of maintenance process will be shown in figure 1, the maintenance implementation process will be shown in Figure 2, and the post-maintenance implementation process will be shown in Figure 6, subprocess this will be represented in figure 3- figure 5. The simulation is also validated with the face and event validity methods to see whether the model has been made appropriate and describes the actual process.

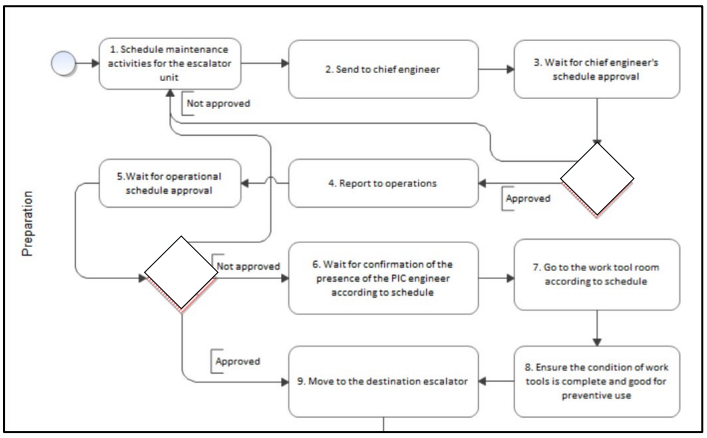


Figure 1. Current Maintenance Preparation Process (As-Is)

In the current maintenance preparation process, the preparation conditions are carried out manually and repeatedly, this is with the support of WhatsApp as a platform for communicating so it takes a long time

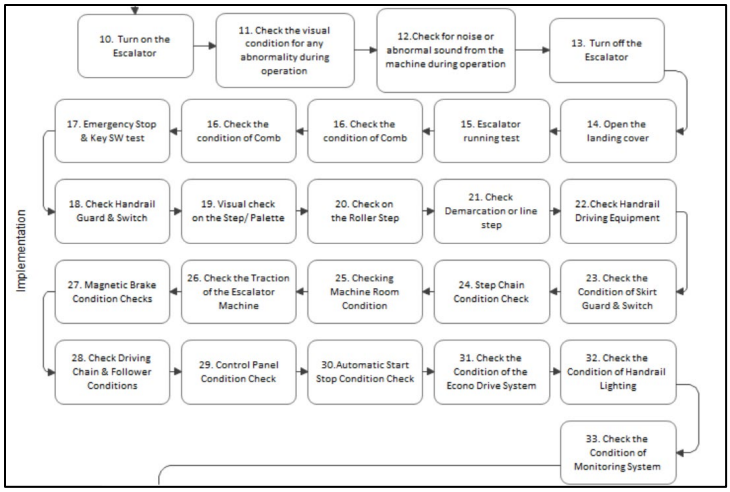


Figure 2. Current Maintenance Process (As-Is)

In the current maintenance process, maintenance is carried out manually to identify noise and speed based on the opinion of the technician, this not only has a bad impact on performance but also takes a long time.

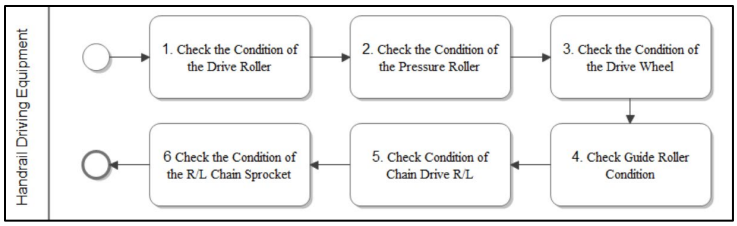


Figure 3. Current Handrail Driving Equipment Sub Process (As-Is)

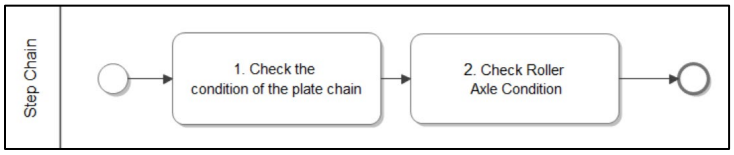


Figure 4. Current Step Chain Sub Process (As-Is)

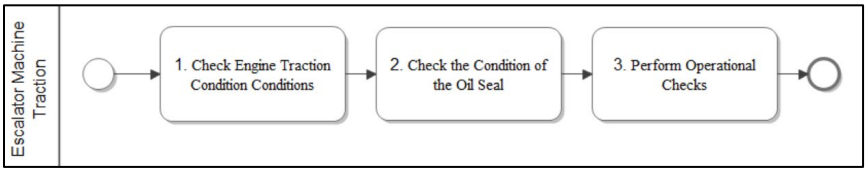


Figure 5. Current Engine Traction Sub Process (As-Is)

The process that has a sub-process is only the implementation maintenance process, in this process some parts of the escalator require more detailed maintenance, such as maintenance on the handrail (Figure 3), step chain (figure 4) and Engine traction (figure 5)

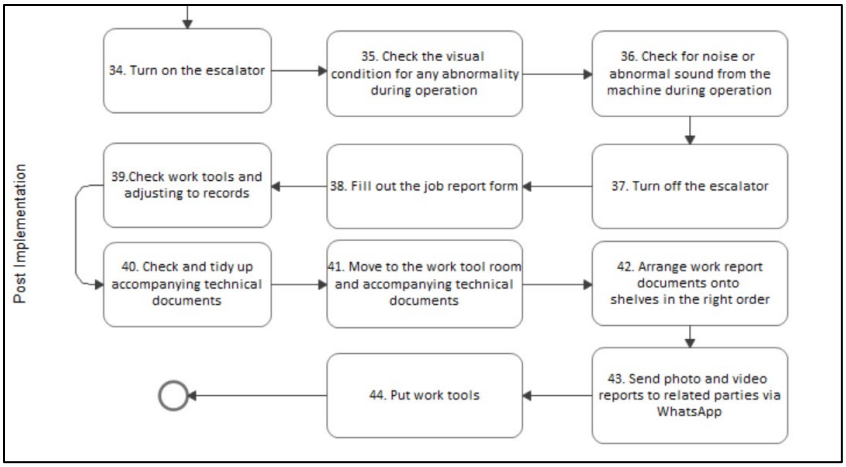


Figure 6. Current Post Maintenance Implementation Process (As-Is)

In the Current Post Maintenance Implementation Process, the results of maintenance in the form of reports are written on paper stored in the room, this can have the risk of files being damaged, lost and taking time to be sent to various related parties.

Overall, the average cycle time is 643.8 minutes and the service with the largest cycle time is 237,6 minutes. The result of As-is simulation will be shown in Table 2 below.

Table 2. Escalator Maintenance Process Simulation Result

| Process | Avg. Cycle Time (minutes) |
|---|---|
| Overall Process | 643,8 |
| Maintenance Preparation | 225,6 |
| Maintenance Implementation | 237,6 |
| Post Maintenance Implementation | 207,6 |

### 5.2 Analysis of Current Process and Designing Solutions

From current model simulation, improvements were made to the process by identifying processes that took a long time and based on current problems from interviews and observations. Then, several problems were found in the overall escalator maintenance process as follows:

• The preparation process related to schedule, information flow and communication is done manually with the help of WhatsApp and is not integrated with each other and across related divisions.
• The process of work reports is done manually on worksheets that are collected in one particular room.
• The process of identify problems during the maintenance process, such as noise identification, is still manual according to the opinion of the technician in charge

Escalator maintenance process analysis is carried out used the voice of customers (VOC) method. VOC is divided into two types of drivers, data and information and processes. Data and information indicate reports regarding escalator monitoring, while the process indicates the stages or processes carried out on escalator during preparation to post maintenance. Then, solutions were made by looking at the relationship between problems and final outputs (goal) from VOC (See Table 3).

Table 3. Escalator Maintenance Goal-Problem-Solution

| Goal | Problem | Solution |
|---|---|---|
| Efficiency | The process of submitted manual information so that it takes extra time because it must go through many platforms and stages | Officers can send uploaded information to various interested parties directly through the system immediately |
| | Decision-making and approval processes that take extra time because they must go through many platforms and stages | Through the database, all data related to maintenance actions and communications will be directly informed in real-time and recorded in historical maintenance data. |
| Responsive | Unresponsiveness of certain departments in handling certain conditions experienced by escalators | |
| Completeness | There is no unity of information and data to support the maintenance process | |

### 5.3 Escalator Maintenance Monitoring To-Be Process

Based on the best practice offered, four scenarios for the improvement of the escalator maintenance process were developed. Scenarios W, X and Y have different system implementation strategies, while scenario Z is a combination of these systems. The details of the repair scenarios that will be carried out will be shown in Table 4 below.

Table 4. Escalator Maintenance Process Improvement Scenarios

| Scenario | CMMS | RFID | Sensor |
|---|---|---|---|
| W | ✓ | | |
| X | ✓ | ✓ | |
| Y | ✓ | | ✓ |
| Z | ✓ | ✓ | ✓ |

In scenario W the escalator maintenance process is implemented with a Computerized Maintenance Management System (CMMS). The implementation of CMMS encourages the existence of a computerized system that is integrated with each other. This is very much needed to streamline time and facilitate communication with various relevant stakeholders. Currently escalator maintenance only uses WhatsApp as a communication platform and paper documents that are written and stored manually.

In scenario X the escalator maintenance process is implemented with a combination of CMMS and RFID. CMMS encourages the existence of a computerized system that is integrated with each other, the benefits are the same as in scenario W. Then, RFID can record real time performance and be stored as historical data so that it can support further maintenance processes. This is because the current performance of the escalator maintenance during maintenance checks during the inactive escalator period will be different from the performance of the escalator currently being used by the user, so real time performance insight is also needed for such a period.

In scenario Y, CMMS and Sensor are implemented. The existence of a CMMS implementation encourages a computerized system that is integrated with each other, with the same benefits as scenarios 1 and 2. Then, the Sensor can identify performance in real time and store it to become historical data related to noise and escalator speed, so that it can support a more efficient maintenance process. further.
This is implemented because when the maintenance check is still in the form of a manual utilizing the senses of the technician in charge, such as hearing and vision without a supporting device, there is often the potential for differences between one technician and another technician to cause conflicts that are resolved without an agreed reference. .

Scenario Z is the overall combination of the technologies in the previous scenario, so the benefits are the same, the difference is the placement. In the preparation process, CMMS is implemented, then the implementation process is implemented with RFID and sensors, and after implementation, CMMS and sensors are implemented.

The most suitable scenario to be implemented in the maintenance of the shopping center escalator, the research target is scenario Y, namely the combination of CMMS with sensors has a reduced time of 491.4 minutes or decreased by

23.67%, not only reduces time but also answers the problem of standard determination. noise during the maintenance process.

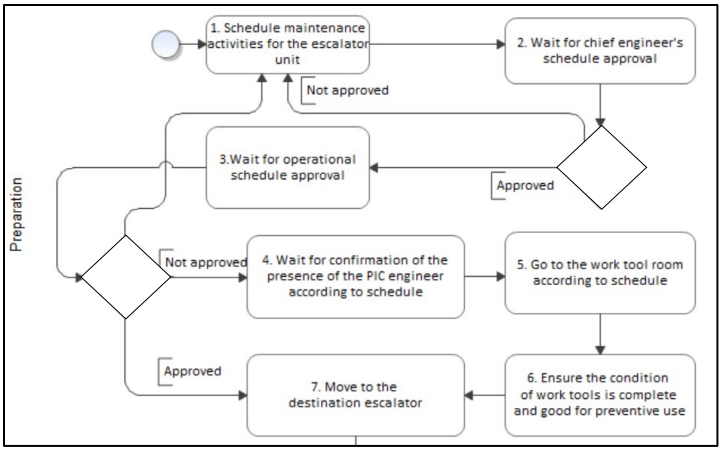


Figure 7. Scenario Y To be Maintenance Preparation Monitoring Process

In scenario Y (Figure 7) To be Maintenance Preparation Monitoring Process, preparation is carried out with the help of Computerized Maintenance Management System (CMMS), with CMMS, the scheduling process, information and confirmation can be carried out on the same platform, there is no need to send repeated information and make preparation time efficient.

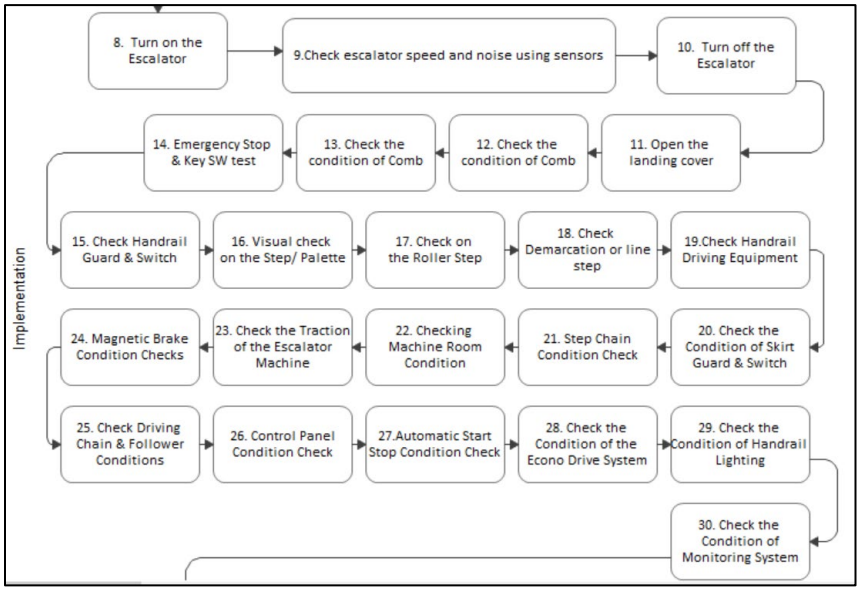


Figure 8. Scenario Y To be Maintenance implementation Monitoring Process.

In Scenario Y (Figure 8) To be Maintenance implementation Monitoring Process, the manual maintenance process is assisted by sensors to identify noise and speed on the escalator, this can help determine performance accuracy and time efficiency

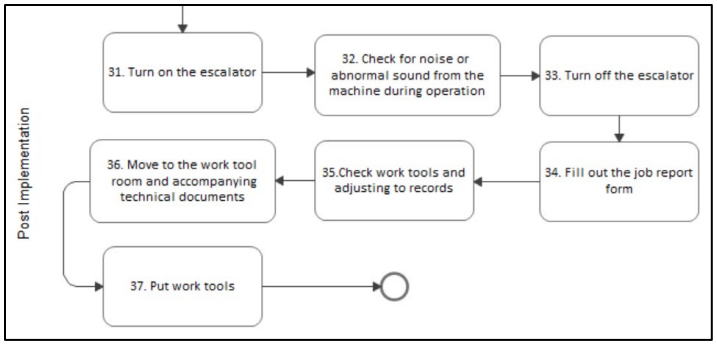


Figure 9. Scenario Y To be Post Maintenance implementation Monitoring Process.

In Scenario Y (Figure 9) To be Post Maintenance implementation Monitoring Process, the escalator performance report process is carried out on the CMMS platform so that it can be accessed by all related parties and is safe from file loss and damage.

Table 5 below shows the result of the scenario Y model simulation. The average cycle time for each service has been decreased because of the implementation of new systems mentioned before. The average cycle time for the overall process was reduced to 491,4 minutes.

Table 5. Scenario Y Escalator Maintenance Process Simulation Result

| Process | Avg. Cycle (minutes) |
|---|---|
| Overall Process | 491,4 |
| Maintenance Preparation | 45 |
| Maintenance Implementation | 27,6 |
| Post Maintenance Implementation | 23,4 |

After conducting the simulation, the result of each scenario proposed was compared with the As-Is model to calculate the efficiency process from the reduction of average cycle time from each scenario. The comparison of efficiency processes from scenario W, X, Y and X will be shown in Table 6 below.

Table 6. Time Reduction Result

| As-Is Process Average Cycle Time (minutes) | Scenario | To-Be Process Average Cycle Time (minutes) | Efficiency (%) |
|---|---|---|---|
| 643,8 | W | 532,8 | 17,24% |
| | X | 507 | 21 |
| | Y | 491,4 | 23,67% |
| | Z | 489,6 | 23,95% |

## 6. Conclusion

With the Business Process Engineering approach through the iGrafx simulation process, the researchers succeeded in designing an electronic maintenance monitoring system on the escalator, supported using Relational Database and Internet of Things (IoT) Technology, divided into 4 scenarios with all of them supported by a relational database, namely scenario W Implementation of Computerized Maintenance Management System (CMMS), Scenario X is Combination of CMMS with RFID Application, then Scenario Y is combination of CMMS with sensors, then Scenario Z is combination of CMMS, with RFID and sensors and the Scenario with the least time reduction. scenario W with an overall time reduction of 17.24%. While the best scenario with the most time reduction is scenario Z with a total efficiency of 23.95%. The most suitable scenario to be implemented in the maintenance of the shopping center escalator, the research target is scenario Y, namely the combination of CMMS with sensors has a reduced time of

491.4 minutes or decreased by 23.67%, not only reduces time but also answers the problem of standard determination. noise during the maintenance process.

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## Biography

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