PREVENTIVE MAINTENANCE OF MEDIUM SPEED ELECTRIC TRAIN SYSTEM

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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A report submitted in fulfilment for the requirements for the degree of Bachelor of Mechanical Engineering

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DECLARATION

I declare that this project report entitled 'Preventive Maintenance of Medium Speed Electric Train System' is the result of my own work except as cited in the references.

Signature : .....

Name of Supervisor : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature :……..

Name of Supervisor : Assoc. Prof. Dr. Mohd Azman Bin Abdullah

Date :……..

DEDICATION

To my beloved family, respected supervisor, lecturers and friends,

Thank you for everything and I love you all.

ABSTRACT

In the developed country, commuter rail transportation has a higher demand than other transportation. It is because of the good service and it easy to use. However, the maintenance issues that occur in the train is one of the challenges that the company has to face it. These kinds of situation can cause the uncomfortable to the passengers and the drivers during their journey. In other to make sure the railway service is to be reliable and safe the apparatus must be maintained in great working control and standard maintenance is the basic fixing to accomplish this. The study of the maintenance issues and the actions taken are making as prepared to make sure the process of maintenance can be settled smoothly. The research was focused in the local commuter rail express company in the duration of nine months. Eight commuter rail has been analyses which are commuter rail Express 101, Express 102, Express 103, Express 104, Express 105, Express 106, Express 107 and Express 108. The maintenance routine is recorded by technician into the daily report. The data will show the type of the maintenance issue on which express train, when it occurs and also the attachment. The interview session has been done with the technician manager of the company when doing the site visit. The important of interview session is to understand with deeper the objectives of this research. Other than that, the main goal of this site visit is to know the level severity of the maintenance issues and to learn how the operation of the train.

ABSTRAK

Di negara maju, pengangkutan kereta api komuter mempunyai permintaan yang lebih tinggi daripada kenderaan lain. Ini adalah kerana perkhidmatannya yang baik dan mudah digunakan. Walau bagaimanapun, isu penyelenggaraan yang berlaku di dalam kereta api adalah salah satu cabaran yang dihadapi oleh syarikat. Keadaan seperti ini boleh menyebabkan tidak selesa kepada penumpang dan pemandu semasa perjalanan mereka. Oleh it, untuk memastikan perkhidmatan keretapi boleh dipercayai dan selamat, peralatan mesti dikekalkan dalam kawalan kerja yang baik dan penyelenggaraan standard adalah penetapan asas untuk mencapai tahap terbaik. Kajian tentang isu-isu penyelenggaraan dan tindakan yang diambil adalah membuat persiapan untuk memastikan proses penyelenggaraan dapat diselesaikan dengan lancar. Penyelidikan ini ditumpukan pada syarikat ekspres kereta api komuter setempat dalam tempoh sembilan bulan. Lapan kereta api komuter telah dianalisis yang merupakan rel kereta api Express 101, Express 102, Express 103, Express 104, Express 105, Express 106, Express 107 dan Express 108. Rutin penyelenggaraan direkodkan oleh juruteknik ke dalam laporan harian. Data akan menunjukkan jenis isu penyelenggaraan di sekian kereta api, apabila ia berlaku dan juga lampiran. Sesi temuduga telah dilakukan dengan pengurus juruteknik syarikat semasa melakukan lawatan tapak. Perkara yang penting dalam sesi wawancara adalah memahami dengan lebih mendalam objektif kajian ini. Selain itu, matlamat utama lawatan tapak ini adalah untuk mengetahui tahap keterujaan isu penyelenggaraan dan untuk mengetahui bagaimana operasi kereta api.

ACKNOWLEDGEMENTS

First of all, gratefulness of thanks Allah for His continuous blessing, which make this work become easier and can be completed in time.

Secondly, I would like to express my deepest appreciation to those who have provided me the encouragement to complete this Final Year Project Report. A special thank goes to my project supervisor, Associate Professor Dr. Mohd Azman Bin Abdullah for his contribution, guidance, critics and comments during my progress in completing this project. His professional views and valuable opinions allow me to make the appropriate solutions on the problems that I had encountered during the most critical stages of my work. The knowledge and tips given are valuable to my career.

Thirdly, I would like to express my heartfelt appreciation to my family and friends for their continuous advice, motivation and criticism. With their support and assistance, this project cam finish as expected. Last but not least, I would like to express my gratitude to all the parties that involved at various occasions, for their patience towards me for making me wiser.

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LIST OF ABBREVIATIONS

ERL	Express Rail Link
O&M	Operation and Maintenance
Sdn. Bhd	Sendirian Berhad
MRT	Mass Rail Transit
LRT	Light Rail Transit
KTM	Keretapi Tanah Melayu
KLIA	Kuala Lumpur International Airport
DDU	Driver Display Unit
MCB	Motor Circuit Breaker
BCU	Brake Control Unit
EB	Emergency Brake
APC	Automatic Power Control
EP	Electric Panel

LIST OF SYMBOLS

&	=	And

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CHAPTER 1

INTRODUCTION

1.1 Background

Railroads are combined of complex mechanical and electrical frameworks and there are a huge number of moving parts. In other to make sure the railway service is to be reliable and safe the apparatus must be maintained in great working control and standard maintenance is the basic fixing to accomplish this. Despite the fact that maintenance is costly, it will turn out to be increasingly costly to supplant the failing equipment since the maintenance has been ignored.

Rolling stock is the most important maintenance part of the railway framework and it is the most unsafe if maintenance is ignored. Reliability is the most important point to keep the railway activity success and maintenance should be the main priority to make sure safety and reliability is continuing.

In Malaysia, Express Rail Link (ERL) maintains the safety of rail operations with the highest priority. Operation and Maintenance (O&M) subsidiary, ERL Maintenance Support Sdn. Bhd has a 24-hour skilled workforce to ensure the rail system is in excellent condition and reliable. The train collectively records more than 66 million miles so far, with an average of 6,500 trips made each month. It is worth noting that ERL has successfully made a canceled trip, due to unforeseen circumstances, with an average of two or less in a month.

Strict compliance with maintenance schedules ensures the train is in the top position and supports the Reliability of Train Service. Distance traveled daily is monitored to determine the type of scheduled maintenance. The maintenance work is very important to ensure the train services are safe and reliable for thousands of passengers traveling with this train every day.

1.2 Objectives

The objectives of this research are first to analyse the routine maintenances and problems that occur on the train. Second, to study the action taken for maintenances in the future.

1.3 Problems statements

On the train, there are many types of maintenances issues and problems occur. These kinds of situation can cause the uncomfortable to the passengers and the drivers during their journey. It can be seen that the problems can influenced the rate of the passengers. The study of the maintenance issues or problems and the actions taken are making as prepared to make sure the process of maintenance can be settled smoothly. Furthermore, the most important of this study is to provide good experienced to the passengers on the train.

1.4 Scope

In order to accomplish the objectives, the main scope of work for this project is to study the most critical problems and maintenances issues that occur at the local train. These problem and maintenance issues occur on the local train in Malaysia.

1.5 Thesis Outline

There are five chapters that contain in this report. Chapter 1 covered the introduction, chapter 2 discussed about literature review, chapter 3 explained the methodology, chapter 4 show the results and discussion and the conclusion and recommendation reviewed in chapter 5.

1.5.1 Chapter 1: Introduction

In this chapter the background study, objectives, problem statement, scope of the study and thesis outline are explained briefly relating to the project.

1.5.2 Chapter 2: Literature review

The literature review of this report is discussed in the second chapter. Many journals, articles or any other issues from the old research related to this project are reviewed deeply.

1.5.3 Chapter 3: Methodology

The project methods are discussed in this part. Begin with the general methodology that shows the steps of research regarding to the project. Then the flowchart also included in the general methodology.

1.5.4 Chapter 4: Result and Discussion

From the data and the graph, the result of the maintenance issues can be analysed briefly. From the pattern of the graph, it showed the higher rate of maintenance issues of the train. Then, the problems are discussed deeply in this chapter.

1.5.5 Chapter 5: Conclusion and Recommendation

For this chapter, it concluded the entire thesis briefly from each chapter and the recommendations also included in this part in other to propose for further research.

CHAPTER 2

LITERATURE REVIEW

21 Introduction

This chapter discussed about the preventive maintenance of medium speed electric train system. The sources include journals, articles, report, book and websites. The sources are used as guideline to complete this study by using the related information, ideas and knowledge obtained from it. In this study, theories related to the train maintenance are discussed. Besides, the history of the early development of the train and the applications of maintenance are also discussed. The type of investigation approach also discussed in this chapter.

Railways are comprised of complex mechanical and electrical frameworks and there are a huge number of moving parts. To make sure that a railway is solid and safe, the equipment must be kept in good working order and regular maintenance is the fundamental fixing to accomplish this. Rail transport has expanded in the course of the most recent decade and it is probably going to additionally increment as traveler and freight transportation move from street and air to rail, because of rising vitality costs, congestion of roads and sky, and the interest to diminish discharges (Stenstrom, 2014).

Benefits for transportation alludes to the sum and kind of movement that individuals will pick under specific conditions and factors, for example, costs and administration quality. There has been expanded considerably with respect the way to quantify the effects of administration quality on movement request and how to foresee the

effects of particular administration quality changes toward transport. In particular, public transportation has been becoming more important for environmental goals. With growing competition, it is expected that service quality will have an increasing impact on the public transport demand. Improvements of service quality can help smoothen the operation and make transit a more attractive travel option.

22 Development of the train.

In 1767 Richard Reynolds made an arrangement of rails for moving coal at Coalbrookdale. These were initially wood however change to iron rails. In 1801 the principal Act of Parliament was passed for the making of a railway, despite the fact that at this point it was a horse pulled trucks on rails. Small, scattered railroad advancement proceeded, and yet, the steam motor was developing. In 1801 Trevithic invented a steam driven train which kept running on streets, and 1813 William Hedly fabricated Puffing Billy for use in mines, pursued a year later by George Stephenson's motor.

In 1821 Stephenson assembled the Stockton to Darlington railroad utilizing iron rails and steam power with the point of breaking the monopoly of the canal owners. The underlying arrangement had been for horses to supply the energy, however Stephenson pushed for steam. The significance of this has been misrepresented, as despite everything it stayed slow. The first run through a railway utilized a true steam train running on rails was the Liverpool to Manchester rail route in 1830. This is most likely the genuine milestone in rail, and reflected the course of the ground breaking Bridgewater Canal. In fact, the owner of the canal had restricted the railroad to ensure his investment. The Liverpool to Manchester railroad gave the administration outline to later advancement, a permanent staff and perceiving the capability of passenger travel. For sure, until the 1850s railroads made more from passengers than cargo.

During the 1830s canal organizations, tested by new railroads, cut costs and generally kept their business. As railroads were once in a while associated they were generally used for local freight and passengers. In any case, industrialists soon realized that railroads could make a clear profit, and in 1835 – 37, and 1844 – 48 there was such a blast in the production of rail lines that 'railway mania' was said to have cleared the nation. In this later period, there were 10,000 acts making railroads. Obviously, this madness empowered the making of lines which were nonviable and in rivalry with each other. The government largely adopted a laissez-faire mentality however intervened to attempt and stop accidents and perilous rivalry. They also passed a law in 1844 requesting third class travel to be on at least one train a day and the Gauge Act of 1846 to ensure the trains kept running on a similar kind of rails (Wikipedia, 2018).

23 Rail Transport in Malaysia.

Rail transport in Malaysia involves heavy rail (including commuter rail), light rapid transit (LRT), mass rapid transit (MRT), monorail, airport rail link and a funicular railway line. Heavy rail is mostly used for intercity passenger and cargo transport as well as some urban public transport, while rapid transit is used for intercity urban public transport. There are two airport rail link services connecting Kuala Lumpur with the Kuala Lumpur International Airport and Subang Airport. The sole monorail line in the nation is likewise utilized for public transport in Kuala Lumpur, while the main funicular railroad line is in Penang. The railroad organize covers the vast majority of the 11 states in Peninsular Malaysia. In East Malaysia, just the territory of Sabah has railroads. There are several type rail transport in Malaysia.

2.3.1 Keretapi Tanah Melayu (KTM)

The intercity railroad network in Peninsular Malaysia consists of two primary lines. The KTM West Coast Line between Singapore and Padang Besar, Perlis while KTM East Coast Line between Gemas in Negeri Sembilan and Tumpat in Kelantan. There are few branch lines between Kuala Lumpur and Port Klang, Batu Junction and Batu Caves, Bukit Mertajam and Butterworth, Tapah Road and Teluk Intan, Kempas and Tanjung Pelepas, Kempas and Pasir Gudang, and between Pasir Mas and Rantau Panjang. The **Figure 2.1** shows the KTM.

Along 438 km of the system is double track and electrified. They include parts of the West Coast Line between Gemas and Ipoh and the whole Kuala Lumpur-Port Klang branch line as well as the stretch between Kuala Lumpur and Sentul – Batu Caves branch line. The double-track and electrified portions between Kuala Kubu Bharu and Seremban and the Port Klang to Kuala Lumpur branch lines are utilized as the commuter train services (Wikipedia, 2019). Rail transport in Malaysia. In Wikipedia, The Free Encyclopedia.

Figure 2.1: KTM (Keretapi Tanah Melayu). (Wikipedia, 2019).

2.3.2 Sabah State Railway.

There is a 134 km railroad line connecting Tanjung Aru close Kota Kinabalu and Tenom inside of Sabah state. The line is the main railroad on the island of Borneo. Other than normal passenger trains worked by the Sabah State Railway Department, the tracks are additionally used to for the North Borneo Railway tourist train. The line has been experiencing absence of maintenance for a long time and in 2006, the Malaysian Government financed restoration works for the line. A pipe dream is to have a railroad line from Kota Kinabalu to Kuching through Brunei however the expense of this would mean looking for subsidizing from Brunei. The **Figure 2.2** shows the Sabah State Railway (Wikipedia, 2019).

Figure 2.2: Sabah State Railway. (Wikipedia, 2019).

2.3.2 Express Rail Link (ERL)

One of Malaysia's two quickest rail lines is the 57 km standard check line between Kuala Lumpur and KLIA and KLIA2. Contingent upon whose definition utilized, this line may not be viewed as fast line in light of the fact that the most extreme speed utilized is 160 km/h. The line was developed by Express Rail Link Sdn Bhd, which also works the two train administrations which utilize the line, in particular the KLIA Express and KLIA Transit. The **Figure 2.3** shows the Express Rail Link (Wikipedia, 2019).

Figure 2.3: Express Rail Link (ERL). (Wikipedia, 2019).

2.3.3 Light Rapid Transit (LRT).

There are two frameworks which are called LRT in Malaysia. Two are utilized in Kuala Lumpur to ferry paying passenger while the automated individuals mover is utilized at Kuala Lumpur International Airport to ferry passenger from the Main Terminal Building and the satellite building.

The three light rapid transit lines in Kuala Lumpur are the Kelana Jaya Line, the Ampang Line and Sri Petaling Line. The Kelana Jaya Line is a driverless programmed framework and is 45.1 km long, running between the north eastern rural areas of Kuala Lumpur and Petaling Jaya toward the west of Kuala Lumpur. It is for the most part lifted aside from a 4 km extend where it goes underground and there is a short at review extend.

The Kelana Jaya Line was totally operational from June 1999. The most established system Ampang Line is 46.4 km and comprises of two sublines, running between the suburb of Sentul in the north of Kuala Lumpur, and Ampang in the east, and also Sri Petaling in the south. Trains fan out to either Ampang or Sri Petaling at Chan Sow Lin station about halfway of the two lines. The line was totally opened on 1998. On 30 June 2016, Kelana Jaya Line and the Sri Petaling Line expansion have finished and begin activity. The **Figure 2.4** shows the LRT (Wikipedia, 2019). Rail transport in Malaysia. In Wikipedia, The Free Encyclopaedia.

Figure 2.4: Light Rapid Transit **(**LRT). (Wikipedia, 2019).

2.3.5 Mass Rapid Transit (MRT).

In December 2010, the administration endorsed the usage of the MRT venture and declared primer anticipates the primary line, extending 60 km from Sungai Buloh to Kajang through 35 stations. The line will go through the city centre and will serve densely populated suburban areas including Kota Damansara, Mutiara Damansara, Bandar Utama, Taman Tun Dr Ismail, Bukit Damansara, Cheras, Bandar Tun Hussein Onn and Balakong, with an aggregate catchment populace of 1.2 million individuals. The first stage of MRT had begun on Dec 2016. The **Figure 2.5** shows the MRT (Wikipedia, 2019). Rail transport in Malaysia. In Wikipedia, The Free Encyclopaedia.

Figure 2.5: Mass Rapid Transit (MRT). (Wikipedia, 2019).

2.3.6 Monorail.

Malaysia's solitary monorail framework is utilized for public transport in Kuala Lumpur. It is 8.6 km long, running from Titiwangsa in the north of focal Kuala Lumpur, to KL Sentral just toward the south of the city center. It has 11 stations. The line comprises of two parallel rails for more than halfway aside from toward the end stations where switches blend the two rails into a solitary rail before entering the station. The whole system is raised. The framework utilizes two-car trains which were made in Malaysia. It is worked by Rapid Rail Sdn Bhd.

There is proposition to build monorails in Penang, Johor Bahru, and Melaka however resistance has been vociferously expressed by Malacca residents worried about the framework being strange in the memorable downtown territories. The federal administrative centre of Putrajaya was additionally expected to have a monorail network

and the main station and a few meters of track have been manufactured. In any case, the venture has been delayed due to costs and the Malaysian government felt that it was not a priority project for the time being even though good public transportation would attract many Malaysians to re-locate to this new under populated city. The **Figure 2.6** shows the monorail (Wikipedia, 2019). Rail transport in Malaysia. In Wikipedia, The Free Encyclopaedia.

Figure 2.6: The monorail. (Wikipedia, 2019).

2.3.7 Cable Car Rail System (Funicular).

The Penang Hill Railway in Penang is only cable car rail system type (funicular) in Malaysia. The line is comprised of two separate areas, with the total length at 1.2 km. The two areas are single lines with passing circles at halfway. The tracks are meter check and have a slope of over half. The **Figure 2.7** shows the funicular (Wikipedia, 2019). Rail transport in Malaysia. In Wikipedia, The Free Encyclopaedia.

Figure 2.7: The funicular. (Wikipedia, 2019).

2.4 Important of the maintenance.

Maintenance measures are commonly required in a large variety of fields (Kiefer et al. 2018). According to Stemstrom, maintenance can be described as the

combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can

perform a required function (Stenstrom, 2014). The objective of maintenance is act as total life cycle improvement of an asset. Furthermore, with technological advancement and globalisation, systems have turned out to be complex in an effort to improve their quality, effectiveness and accessibility.

The challenge in optimizing performance and cost of rolling stock maintenance is to integrate the policy on maintenance concepts, maintenance locations and maintenance intervals (Vos and Van Dongen, 2015).

2.5 Maintenance category

Maintenance is a large industry (Gouws and Trevelyan, 2006). Maintenance planning very complex, high accessibility systems is vital (Yin and Arellano, 2007). Maintenance can be observed and upgrade based on its performance (Samat et al. 2011). Cheng and Tsao (2010) state that the maintenance of rolling stock can be categorized into two types: corrective maintenance and preventive maintenance (Cheng and Tsao, 2010). The time intervals at which preventive maintenance is planned are reliant on both the life distribution of the parts and the total cost involved in the maintenance action, but corrective maintenance cannot be avoided when component failure obtain. The total cost of maintenance based on the rates in performing preventive maintenance and corrective maintenance. Generally, more constant preventative maintenance drives up the total maintenance costs for train. Then, proper preventative maintenance can potentially decrease the risks related with rolling stock mechanical failure. Thus, railway systems operators are frequently ignore the safety risks against the maintenance costs. Rather than

maintenance strategy selection in the manufacturing industry, the maintenance of train also impacts passenger comfort. Because preventative maintenance and corrective maintenance influence these three factors (safety, comfort, and cost), railway system operators must set a maintenance strategy that strives for an ideal equalization. The **Figure 2.8** shows the maintenance hierarchy.

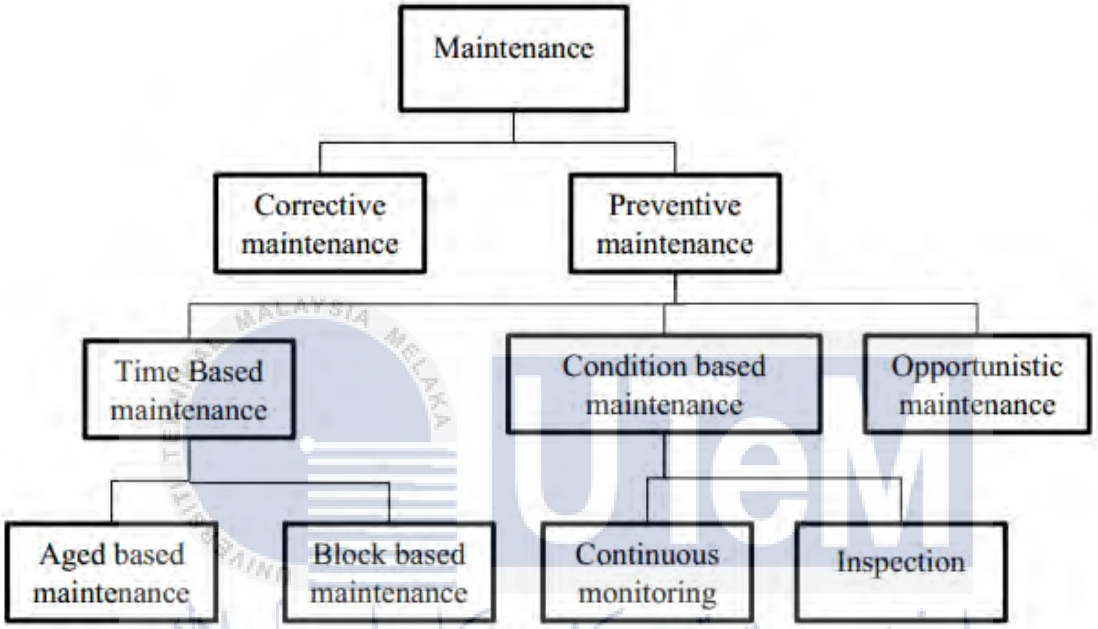

Figure 2.8: The maintenance hierarchy (De Jonge, 2017).

2.6 Service maintenance of the train.

Maintenance optimization can be a key factor to improve the productivity of railway companies (Giacco et al., 2014). A railway system needs a considerable measure of maintenance. To counteract startling breakdowns however much as could reasonably be expected, preventive maintenance is required (Journals, 2013).

Andres et al. (2015) found that they assume that every train must undergo maintenance checks after a certain number of hours or kilometres of travelling time or distance. Maintenance procedures are divided depending on their level, defined by the maximum times and distances established by the regulations. For high level maintenance procedures (taking place every several months or years), trains are unavailable for routing purposes (Andrés et al. 2015).

2.7 Risk Assessment Approach.

Safety Professionals use a risk matrix to evaluate the different risks of hazards and incident when perform job risk analysis. There are three components of the risk matrix; severity, probability, and risk assessment.

2.7.1 Severity.

Severity is the measure of harm or misconduct a hazard could make and it is ranked on a four-point scale as stated:

Catastrophic (4) - Operational conditions such as human error, environment, lack of design, elements, subsystems or component failures, or lack of procedures can usually lead

to death or loss of key systems, thus requiring immediate shutdown of the unsafe activities or operations.

Critical (3) - Operational conditions such as human mistake, environment, lack of design, elements, subsystems or component failures, or lack of procedures can usually lead to severe injury or loss of key systems, thus requiring immediate correction action.

Marginal (2) - Operating conditions can usually cause minor injury or minor system illness or damage to human error, environment, lack of design, subsystem or component failure or lack of procedures can be overcome or controlled without major injury, disease or damage to the primary system.

Negligible (1) - Operational conditions such as staff errors, environment, lack of designs, subsystems or component failures or lack of procedures will not cause damage, or less than minor damage, illness, injury or system damage.

2.7.2 Probability.

Probability is a potential danger that occurs and it is positioned on a five-point scale:

Frequent (5)	-	Likely to occur often in the life of an item.
Probable (4)	-	Will occur several time in the life of an item.
Occasional (3)	-	Likely to occur sometime in the life of an item.
Remote (2)	-	Unlikely but possible to occur in the life of an item.
Improbable (1)	-	It may be considered an impossible event occur in the life of an item.

2.7.3 Risk Assessment.

Risk assessment value is determined by multiply the score of probability with the severity value as shown in **Figure 2.9.**

	Severity			
Probablity	Catrastrophic - 4	Critical - 3	Marginal - 2	Negligible - 1
Frequent - 5	High - 20	High - 15	High - 10	Medium - 5
Probable - 4	High - 16	High - 12	Serious - 8	Medium - 4
Occasional - 3	High - 12	Serious - 9	Medium - 6	Low - 3
Remote - 2	Serious - 8	Medium - 6	Medium - 4	Low -2
Improbable - 1	Medium - 4	Low - 3	Low - 2	Low -1

Figure 2.9: Risk Assessment (Industry Safe, 2018).

2.8 Strategy for preventive actions.

As rail transport is capital intensive and has a long life span, its operation and maintenance requires a long term and sustainable strategy. A maintenance strategy includes the identification, analysing and implementation of many repair, replace and check decisions (Damjan Maletic, 2013). Historically, review about railway scheduling and planning has concentrated mostly on train operations and timetabling. The purpose is to schedule maintenance so as to minimize cost or timetable changes (Boland et al. 2013). A final field of conducted research is work timing and resource scheduling, which usually concerns an operational or mid to short term tactical level (Boland et al. 2013).

Stenstrom (2014) mention that strategic planning involves collecting information, setting goals, translating goals to specific objectives and setting up activities to achieve the objectives (Stenstrom, 2014). The measurement of performance in organisations needs to be synchronizing with the organisational strategy. Following the steps of the strategy, objectives are separated into tactical and operational plans. The results of the strategy are constantly surveyed by collecting data, accumulating the data into information and reporting the outcome information back to the strategic, tactical and operational planning.

The aim behind the improvement issue is to discover a pattern of maintenance windows that allows a needed train movement to be run and that limits the cost for train activities and maintenance.

By, effective time table we mean that tracks are handed over by the train operators to maintenance engineers only in cases if maintenance has to be carried out on those track segments and as long as the work duration requires (Budai and Dekker, 2004).

CHAPTER 3

METHODOLOGY

31 Introduction

The actions that need to be carried out to achieve the objectives of this project include literature review, refer some journals, articles or any materials regarding to this project. The actual data that received from the local train daily maintenance routine will be analysed deeply. **Figure 3.1** shows a flow chart summarized of the methodology that being used in this research. In this flow chart, every point will be reviewed one by one in this chapter in order to achieve the objectives of this research.

This chapter contains five sections. After the introduction, the next section delineates the general methodology of the project. Section **3.2** discuss about the literature review. Then, in the section **3.3** discuss about the monitoring on the train. The next stage is about data collection from the local train. Nest, interview is making to make the understanding about the objectives increase. Analysis discusses on the stage **3.6** and **3.7**. The last stage in this chapter covers by writing report.

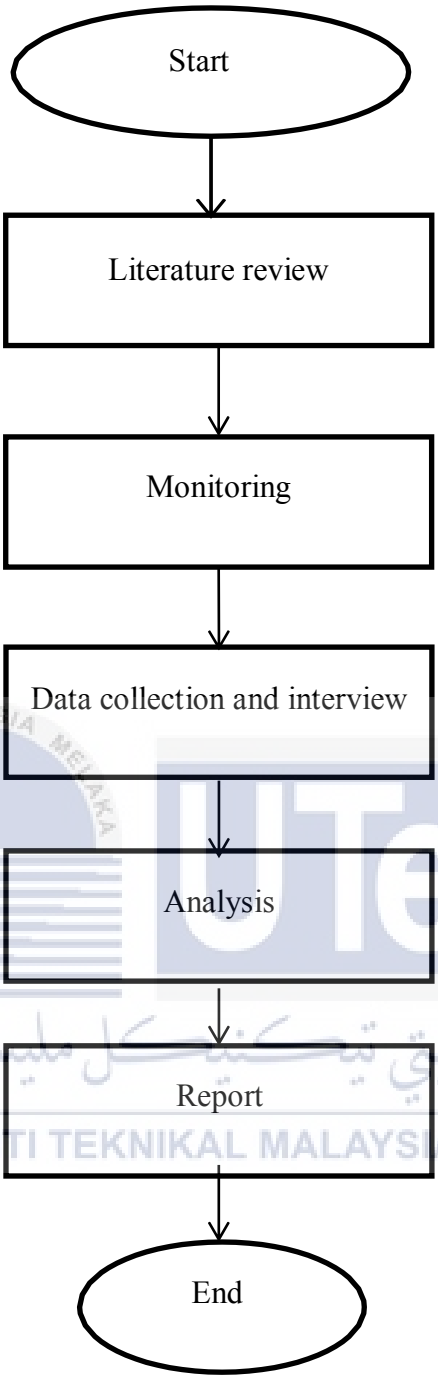

Figure 3.1: The Flow chart of the methodology

32 Literature Review

Literature review is the main method that being used for the methodology of this project. In order to understand the fundamental of the project, the literature review is the most important things that need to be studied. Many journals, articles or any other issues from the old research relating to this project are reviewed deeply. Literature review is carried out in order to collect all the information on the project satisfaction.

33 Monitoring using the DDU (Driver Display Unit)

A centralized, on board system that monitors, controls, and analyse vehicle system problems is vital for addressing the problems of rail manufacturers and transit authorities. Driver Display Unit (DDU) as shown in **Figure 3.2** is to watch the train running status and to work some key device, for example, pantograph up and down, isolation and inhibition. Then, driver can download train activity data includes fault type, apparatus working status, framework information. When the problems happen in the train, the DDU will display the maintenance problems so the technician will take actions to overcome the problems.

Figure 3.2: Driver Display Unit (DDU).

3.4 Data Collection of Maintenance Issue on the Train.

In this section, the actual data were collected from the local train daily maintenance routine. They provided nine months' period of the maintenance issue data for Express train by daily maintenance routine. The maintenance routine is recorded by technician into the daily report. The data will show the type of the maintenance issue on which express train, when it occurs and also the attachment. The samples data on the train Express101 and its maintenance issue that have been collected as shown in **Figure 3.3**. From the data, analysis will be conducted by arrange the collected data to determine the most critical maintenance issue. We can also determine the strategy of the maintenance and the result will be discussed in the next chapter.

Name	Date modified	Type	Size
Express101 01 - DDU motor circuit https	25/9/2017 9:31 AM	Adobe Acrobat D...	147 KB
Express101 02 - EB https	23/10/2017 9:17 AM	Adobe Acrobat D...	76 KB
Express101 03 - ddu mcb https	31/10/2017 8:56 AM	Adobe Acrobat D...	93 KB
Express101 04 - DDU https	8/11/2017 8:51 AM	Adobe Acrobat D...	121 KB
Express101 05 - DDU https	14/11/2017 9:20 AM	Adobe Acrobat D...	123 KB
Express101 06 - EB https	15/11/2017 11:56 ...	Adobe Acrobat D...	75 KB
Express101 07 - DDU https	15/11/2017 11:59 ...	Adobe Acrobat D...	169 KB
Express101 08 - DDU https	16/11/2017 9:08 AM	Adobe Acrobat D...	164 KB
Express101 09 - DDu https	27/11/2017 9:39 AM	Adobe Acrobat D...	198 KB
Express101 10 -EB https	13/12/2017 8:59 AM	Adobe Acrobat D...	76 KB
Express101 11 - service parking https	14/12/2017 9:37 AM	Adobe Acrobat D...	63 KB
EXpress101 12 - EB https	18/12/2017 9:27 AM	Adobe Acrobat D...	74 KB
Express101 13 - EB https	3/1/2018 9:39 AM	Adobe Acrobat D...	75 KB
Express101 14 - Air Cond Pass https	9/1/2018 10:34 AM	Adobe Acrobat D...	61 KB
Express101 15 - DDU and all https	12/2/2018 3:52 PM	Adobe Acrobat D...	86 KB
Express101 16 - door 11-2 https	19/2/2018 10:12 AM	Adobe Acrobat D...	63 KB
Express101 17 - redundancy https	19/2/2018 10:35 AM	Adobe Acrobat D...	90 KB
Express101 18 - Redundancy https	26/2/2018 10:08 AM	Adobe Acrobat D...	88 KB
Express101 19 - Redundancy mode https	5/3/2018 12:14 PM	Adobe Acrobat D...	137 KB
Express102 07 - service brake https	12/10/2017 4:14 PM	Adobe Acrobat D...	67 KB
Express102 08 - aircond https	23/10/2017 9:02 AM	Adobe Acrobat D...	72 KB

Figure 3.3: Sample of the collected data.

35 Interview

On 11th March 2019, the interview session has been done with the technician manager of the company when doing the site visit, as shown in **Figure 3.4**. The important of interview session is to understand with deeper the objectives of this research. Other than that, the main goal of this site visit is to know the level severity of the maintenance issues and to learn how the operation of the train. Besides, this site visit also gives the experience on how the staffs perform the tasks in the train.

Figure 3.4: Interview session with technician manager of the company.

3.6 Weighted Decision Matrix

Weight decision matrix analysis is a useful technique to use for a decision making process. It is particularly powerful where one has a number of good alternatives to choose from, and many different factors to take into account. This makes it a great technique to use in almost any important decision where there is no clear and obvious preferred option. Being able to use a Decision Matrix Analysis means that one can take decision confidently and rationally, at a time when other people might be struggling to make a decision.

Score = Quantity X Severity Scale X Time Consume to Solve (3.1)

3.7 Tabulate and analysis data of maintenance issues on the train.

In this section, a detailed analysis of the maintenance on the local train will be conducted based on the data collected from the maintenance routine of the local train. The analysis will be started by arrange the data as shown in **Table 3.1**. Then, from the table, it can obtain the maintenance or problems which have higher number of quantity that occur in the train.

Then, the **Table 3.2 s**tated the critical maintenance issues using Weighted Decision Matrix from **Equation 3.1**. Next the graph will be plotted regarding to the most the critical maintenances issue on the train. From the plotted graph, the pattern shows the critical maintenance or problems on the train in nine months' period of time from September 2017 to May 2018. After that, a detailed analysis can be carried out from that pattern on the graph. There are 8 trains in total that will be analysed from Express101 to Express108. Each of them will be analysed in detail based on the pattern on the graph. Thus, a continuous maintenance strategy can be done in proper way and time.

Table 3.1: The table type of the failure.

Name train	Failure	Quantity
Express101	1. Emergency brake	6
	2. Brake malfunction	1
	3. MCB malfunction	6
	4. Service or parking pressure low	1
	5. Air condition	1
	6. Door	1
	7. Redundancy	4
	8. Speedometer not tally	1
	9. DDU malfunction	1
	Total	22

Table 3.2: Table of level severity of maintenance issues.

Train Name	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				**Time consume to solve**					
			Neglible-1	**Marginal-2**	**Critical-3**	**Catastrophic-4**	**None-1**	**Low-2**	**Moderate-3**	**High-4**		
X101	1. Emergency brake	6	1				1				6	3.2
	2. Brake malfunction	1				4				4	16	8.5
	3. MCB malfunction	6				4				4	96	51
	4. Service or parking pressure low	1				4				4	16	8.5
	5. Air condition	1		2						4	8	4.3
	6. Door	1		2					3		6	3.2
	7. Redundancy	4		2				2			16	8.5
	8. Speedometer not tally	1				4			3		12	6.4
	9. DDU malfunction	1			3					4	12	6.4
	Total	22									188	100

CHAPTER 4

RESULT AND DISCUSSION

41 Introduction

In this chapter we are going to cover the result and discussion about the quantity, severity scale and time consume to solve the problem and maintenance issues in the trains. Every train have their own maintenance issues that have to be focus on.

From the quantity aspect, we carried out the number of maintenance issues that occur in every train from X101 until X108. Then the most quantity of maintenance issues that happen in every train is highlighted. From the data we can make the specific focus on that maintenance issues.

From the severity scale aspect, we carried out the level severity of the maintenance issues that occur in every train. The highest of the severity level about the maintenance issues are needed to be focus on. In the severity scale, there are four categories of severity which are in order of severity from negligible, marginal, critical and catastrophic.

From the time consumes aspect; we carried out the time taken to solve the maintenance issues. There are many stages in this part such as time consumes to solve the maintenance issues below six hours and more than one day.

From the product of these categories, we choose the highest number of results as the most critical maintenance issue that need to focus on.

42 Analysis by Train

4.2.1 Train X101

The **Table 4.1** shows the weighted decision matrix in the train X101. Based on the table, MCB (main circuit breaker) has the highest number of quantity of the maintenance issue occurs that is 6. MCB malfunction is the most severity maintenances issue that happen in the train X101. In the severity scale MCB malfunction stated the highest scale of severity that is catastrophic. MCB malfunction takes more than 4 days to repair.

From the **Figure 4.1**, MCB shows the highest ranking that is 51% from the maintenances issue occur in train X101 then followed by the brake malfunction, service brake pressure low and redundancy that are 8.5% each one. By the way redundancy is not severity because based on the severity scale it score only 1 point that means the failure not important and can be neglect.

Table 4.1: Table of weighted decision matrix in the train X101

Train Name	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				**Time consume to solve**					
			Neglible-1	**Marginal-2**	**Critical-3**	**Catastrophic-4**	**None-1**	**Low-2**	**Moderate-3**	**High-4**		
X101	1. Emergency brake	6	1				1				6	3.2
	2. Brake malfunction	1				4				4	16	8.5
	3. MCB malfunction	6				4				4	96	51
	4. Service or parking pressure low	1				4				4	16	8.5
	5. Air condition	1		2						4	8	4.3
	6. Door	1		2					3		6	3.2
	7. Redundancy	4		2				2			16	8.5
	8. Speedometer not tally	1				4			3		12	6.4
	9. DDU malfunction	1			3					4	12	6.4
	Total	22									188	100

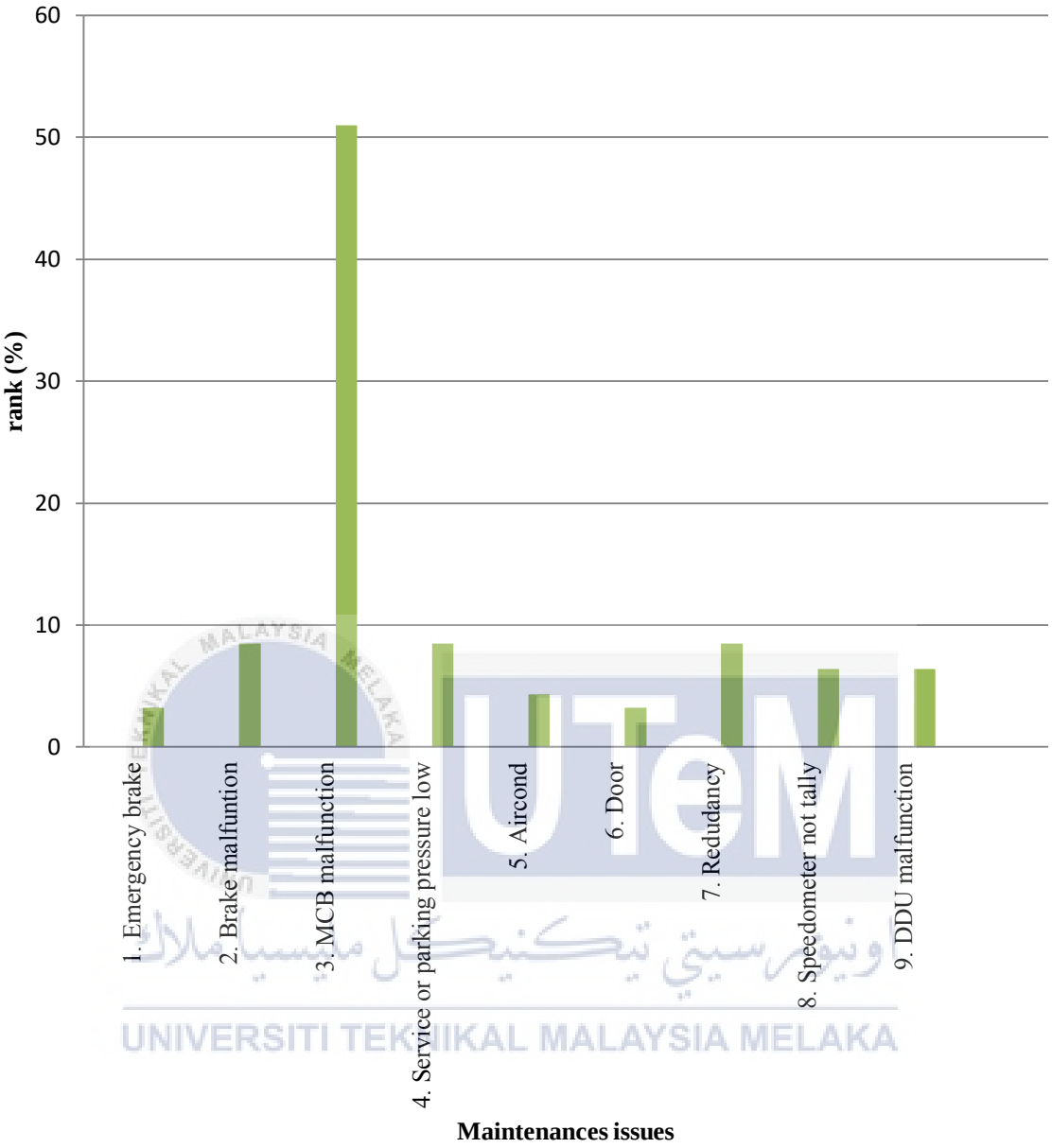

Figure 4.1: Bar Chart of maintenances issue against rank in the train X101.

4.2.2 Train X102

The **Table 4.2** illustrates the weighted decision matrix in the train X102. Based on the table, redundancy has the highest number of quantity of the maintenance issue occurs that is 5. By the way redundancy is not severity because based on the severity scale it score only 1 point that means the failure not important and can be neglect. Redundancy takes lower than 6 hours to overcome the failure.

From the **Figure 4.2**, service brake shows the highest ranking that is 30% from the maintenances issue occur in train X102 then followed by the traction converter (20%) and redundancy (12.5%). Service brake is the most severity maintenances issue in the train X102 based on the severity scale. It scores 4 points that is catastrophic and also it takes more than one days to settle the problem.

Table 4.2: Table of weighted decision matrix in the train X102

Train name	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				**Time consume to solve**					
			Neglible-1	**Marginal-2**	**Critical-3**	**Catastrophic-4**	**None-1**	**Low-2**	**Moderate-3**	**High-4**		
X102	1. Air condition	2		2						4	16	10
	2. Redundancy	5		2				2			20	12.5
	3. Gearbox	2	1				1				2	1.3
	4. Traction motor	1				4				4	16	10
	5. Service Brake	3				4				4	48	30
	6. Toilet	1		2						4	8	5
	7. Door	3		2				2			12	7.5
	8. Emergency brake	3	1				1				3	1.9
	9. Traction converter	2				4				4	32	20
	10. Testing part	2	1				1				2	1.3
	11. Brake trial	1	1				1				1	0.5
	Total	25									160	100

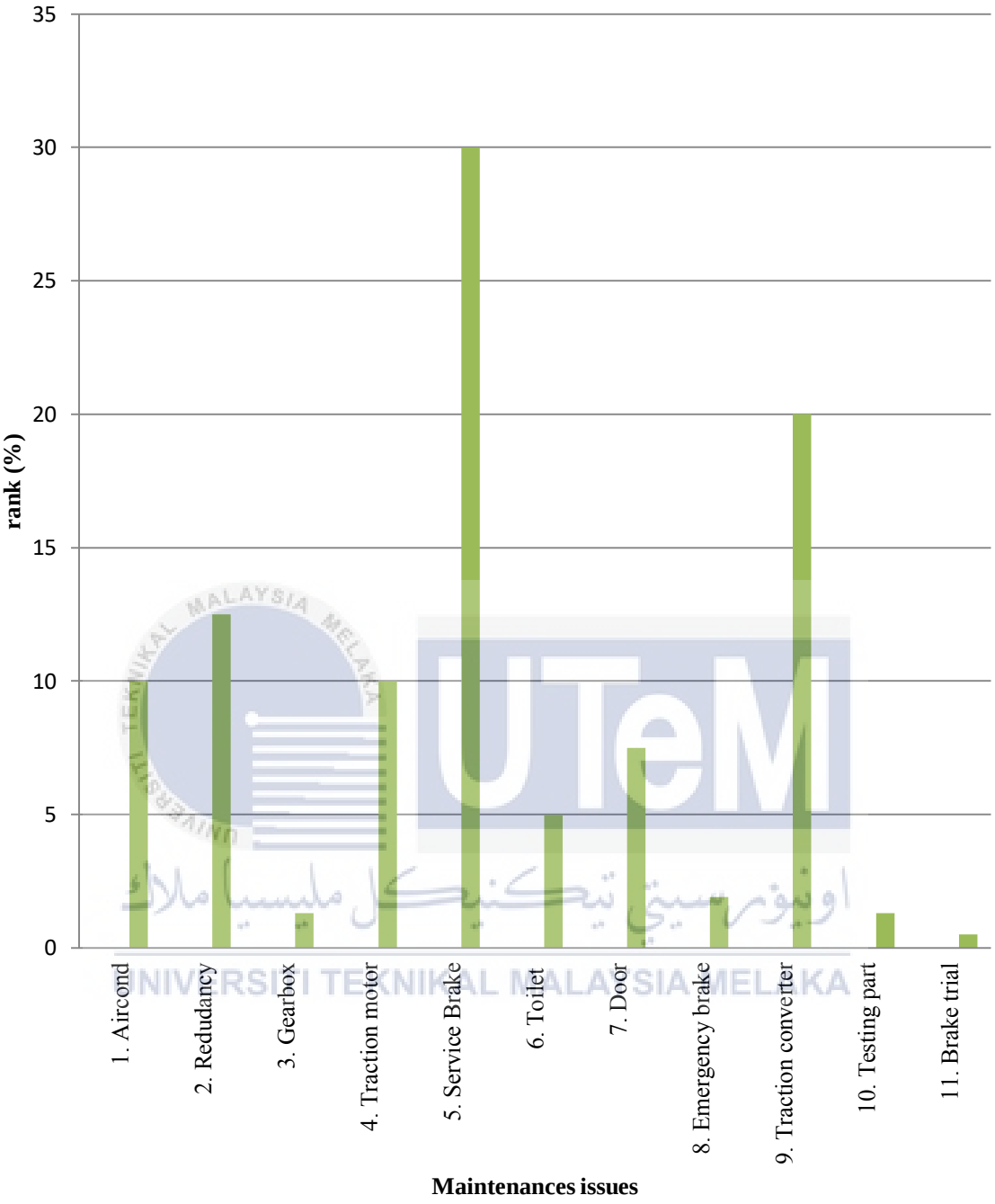

Figure 4.2: Bar Chart of maintenances issue against rank in the train X102.

4.2.3 Train X103

The **Table 4.3** shows the weighted decision matrix in the train X103. Based on the table, BCU (brake control unit) failed has the highest number of quantity of the maintenance issue occurs that is 12. BCU failed is the most severity maintenances issue that happen in the train X103. In the severity scale BCU failed stated the highest scale of severity that is catastrophic. BCU failed takes more than one days to settle the problem.

From the **Figure 4.3** BCU shows the highest ranking that is 39.4% from the maintenances issue occur in train X103 then followed by the service brake pressure low (13.1%).

Table 4.3: Table of weighted decision matrix in the train X103

	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				**Time consume to solve**					
			Neglible-1	**Marginal-2**	**Critical-3**	**Catastrophic-4**	**None-1**	**Low-2**	**Moderate-3**	**High-4**		
X103	1. Brake not release	2				4				4	32	6.6
	2. Emergency brake	9	1				1				9	1.8
	3. BCU failed	12				4				4	192	39.4
	4. Auxiliary converter malfunction	2				4				4	32	6.6
	5. Service Brake	4				4				4	64	13.1
	6. Light malfunction	1		2					3		6	1.2
	7. Parking brake service pressure low	2				4				4	32	6.6
	8. Jerking	8		2			1				16	3.3
	9. Door	5		2					3		30	6.2
	10. Failure auxiliary compressor	2				4				4	32	6.6
	11. Traction motor replacement	1				4				4	16	3.3
	12. Oil dielectric below limit	1		2				2			4	0.8
	13. Gearbox	1	1				1				1	0.2
	14. Toilet	2		2						4	16	3.3
	15. Redundancy	1		2				2			4	0.8
	16. Hit something	1	1				1				1	0.2
	Total	54									487	100

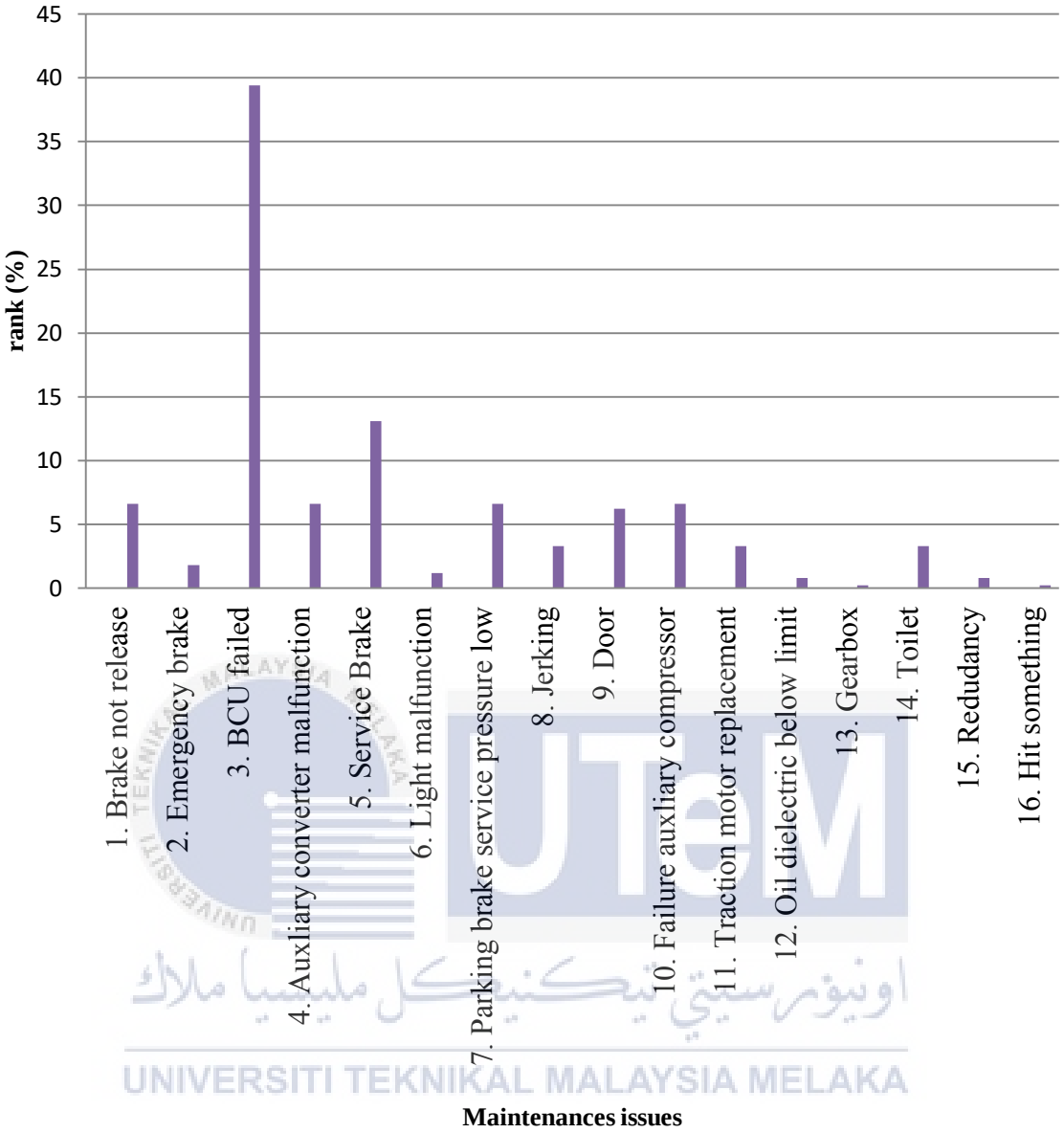

Figure 4.3: Bar chart of maintenances issue against rank in the train X103.

4.2.4 Train X104

The **Table 4.4** shows the weighted decision matrix in the train X104. Based on the table, BCU (brake control unit) failed has the highest number of quantity of the maintenance issue occurs that is 8. BCU failed is the most severity maintenances issue that happen in the train X104. In the severity scale BCU failed stated the highest scale of severity that is catastrophic. BCU failed takes more than 4 days to settle the problem.

From the **Figure 4.4**, BCU shows the highest ranking that is 25% from the maintenances issue occur in train X104 then followed by the service brake pressure low (15.7%) and wheel slide protection disturbed (9.4%).

Table 4.4: Table of weighted decision matrix in the train X104

	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				Time consume to solve					
			Neglible-1	Marginal-2	Critical-3	Catrastrophic-4	None-1	Low-2	Moderate-3	High-4		
X104	1. Redundancy	8		2				2			32	6.3
	2. Overload	1			3				3		9	1.8
	3. Motor replacement	1	1					2			2	0.4
	4. Parking service brake pressure Low	5				4				4	80	15.7
	5. Air condition	6		2						4	48	9.4
	6. Jerking	1		2			1				2	0.4
	7. Brake not release	2				4				4	32	6.3
	8. Toilet	2		2						4	16	3.1
	9. Emergency brake	4	1				1				4	0.8
	10. Auxiliary converter rear locked	1				4				4	4	0.8
	11. BCU failed	8				4				4	128	25
	12. Spark at train pantograph	1				4				4	16	3.1
	13. Transformers leaking	1				4				4	16	3.1
	14. DDU CAB blank	1			3					4	12	2.3
	15. Door malfunction	2		2					3		6	1.1
	16. Bird carcass stuck at ADD hose near pantograph	1	1				1				1	0.2
	17. Fault operation central appear at DDU	1			3					4	12	2.3
	18. Headlight side 2A1 malfunction	1		2						4	8	1.6
	19. Wheel slide protection Disturbed	3				4				4	48	9.4
	20. Hit something	1	1				1				1	0.2
	21. Coupler malfunction	1		2			1				2	0.4
	22. Traction converter rear blue box	2				4				4	32	6.3
	Total	54									511	100

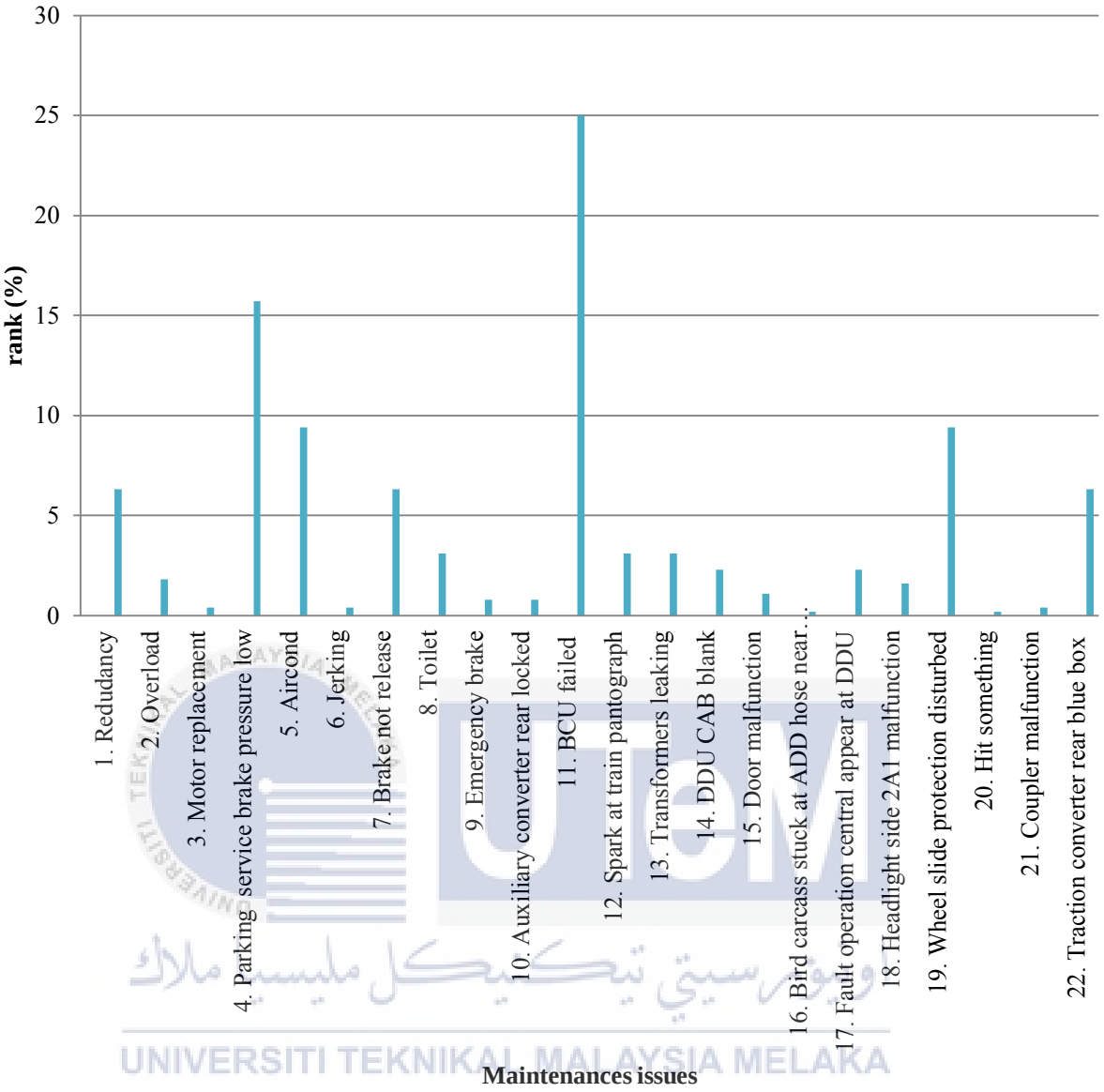

Figure 4.4: Bar chart of maintenances issue against rank in the train X104.

4.2.5 Train X105

The **Table 4.5** illustrates the weighted decision matrix in the train X102. Based on the table, toilet has the highest number of quantity of the maintenance issue occurs that is 8. By the way toilet is not much severity because based on the severity scale it score only 2 points that means the failure not much important. However, toilet maintenances can affect the customer's satisfaction when it happens regularly. Toilet takes more than 1 day to overcome the failure.

From the **Figure 4.5**, toilet shows the highest ranking that is 21.4% from the maintenances issue occur in train X105 then followed by the DDU failed (20.1%). Redundancy stated in the third ranks that are 16.1%.

Table 4.5: Table of weighted decision matrix in the train X105

	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				**Time consume to solve**					
			Negligible-1	**Marginal-2**	**Critical-3**	**Catastrophic-4**	**None-1**	**Low-2**	**Moderate-3**	**High-4**		
X105	1. Emergency brake	5	1				1				5	1.6
	2. BCU failed	1				4				4	16	5.4
	3. DDU failed	5			3					4	60	20.1
	4. Toilet	8		2						4	64	21.4
	5. Redundancy	6		2						4	48	16.1
	6. Master controller jammed	1			3					4	12	4
	7. Main compressor	1			3		1				3	1
	8. Door malfunction	5		2					3		30	10
	9. Speed sensor out of range	1		2			1				2	0.7
	10. Hit something	1	1				1				1	0.3
	11. Auxiliary converter in red box	1				4				4	16	5.4
	12. Speed encoder axle 4 defective	1		2					3		6	2
	13. Failure auxiliary compressor	2				4				4	32	10.7
	14. Air pressure low for pantograph lifting	2		2			1				4	1.3
	Total	40									299	100

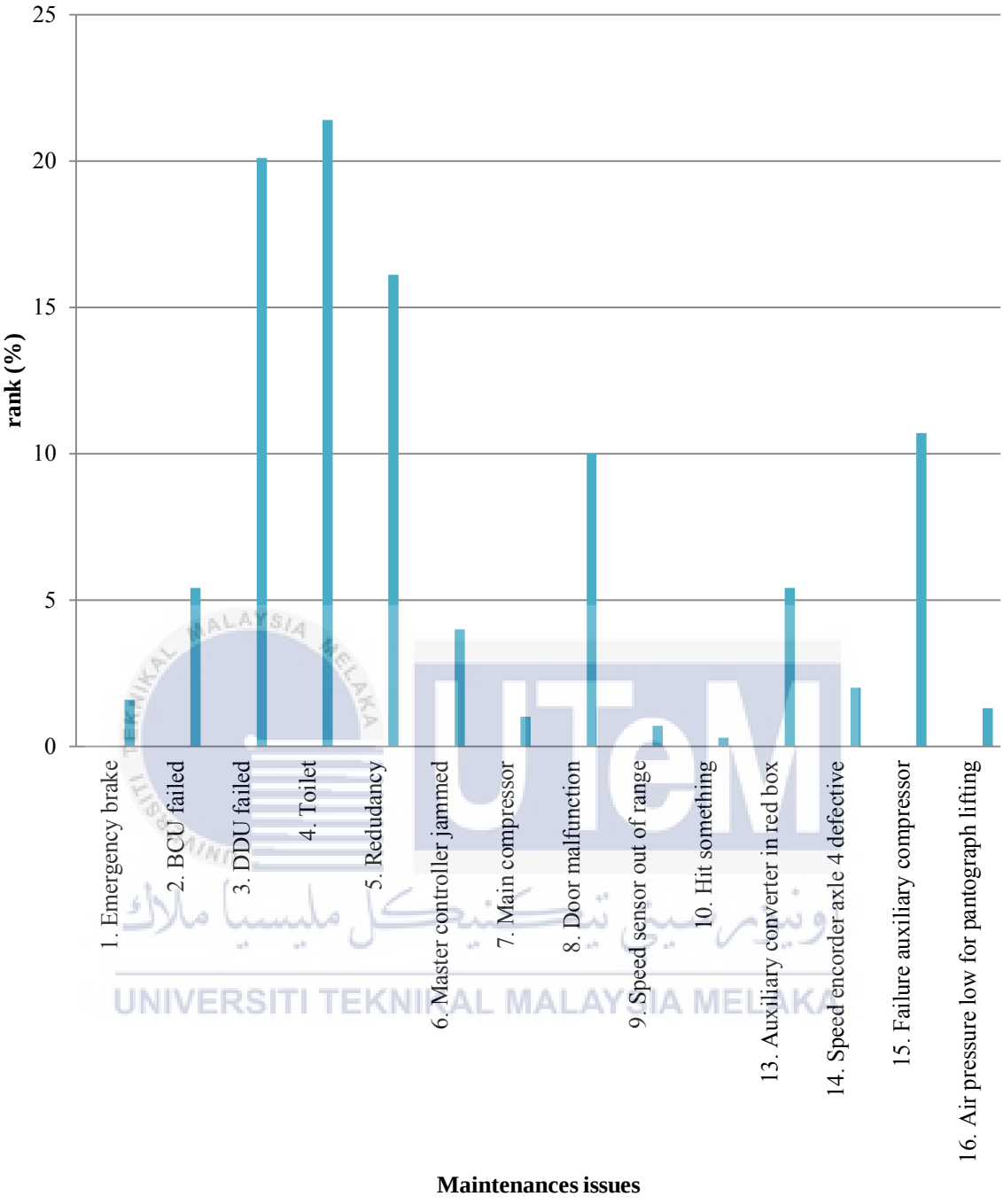

Figure 4.5: Bar chart of maintenances issue against rank in the train X105.

4.2.6 Train X106

The **Table 4.6** shows the weighted decision matrix in the train X106. Based on the table, air condition has the highest number of quantity of the maintenance issue occurs that is 12. By the way air condition is not much severity because based on the severity scale it score only 2 points that means the failure not much important. However, air condition maintenances can affect the customer's satisfaction when it happens regularly. Air condition takes more than 4 days to overcome the issue.

From the **Figure 4.6**, air condition shows the highest ranking that is 31% from the maintenances issue occur in train X106 then followed by the auxiliary converter rear (20.7%). Door and toilet malfunction shared the third ranks that are 11.6%.

Table 4.6: Table of weighted decision matrix in the train X106

	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				Time consume to solve					
			Neglible-1	Marginal-2	Critical-3	Catastrophic-4	None-1	Low-2	Moderate-3	High-4		
X106	1. Air condition	12		2						4	96	31
	2. Emergency brake	7	1				1				7	2.1
	3. Redundancy	7		2				2			28	9
	4. APC malfunction	1				4				4	16	5.1
	5. Door malfunction	6		2					3		36	11.6
	6. DDU circuit breaker	1			3					4	12	3.8
	7. Auxiliary converter rear appeared on DDU	4				4				4	64	20.7
	8. Toilet	4		2						4	32	11.6
	9. Service brake pressure low	1				4				4	16	5.1
	Total	43									307	100

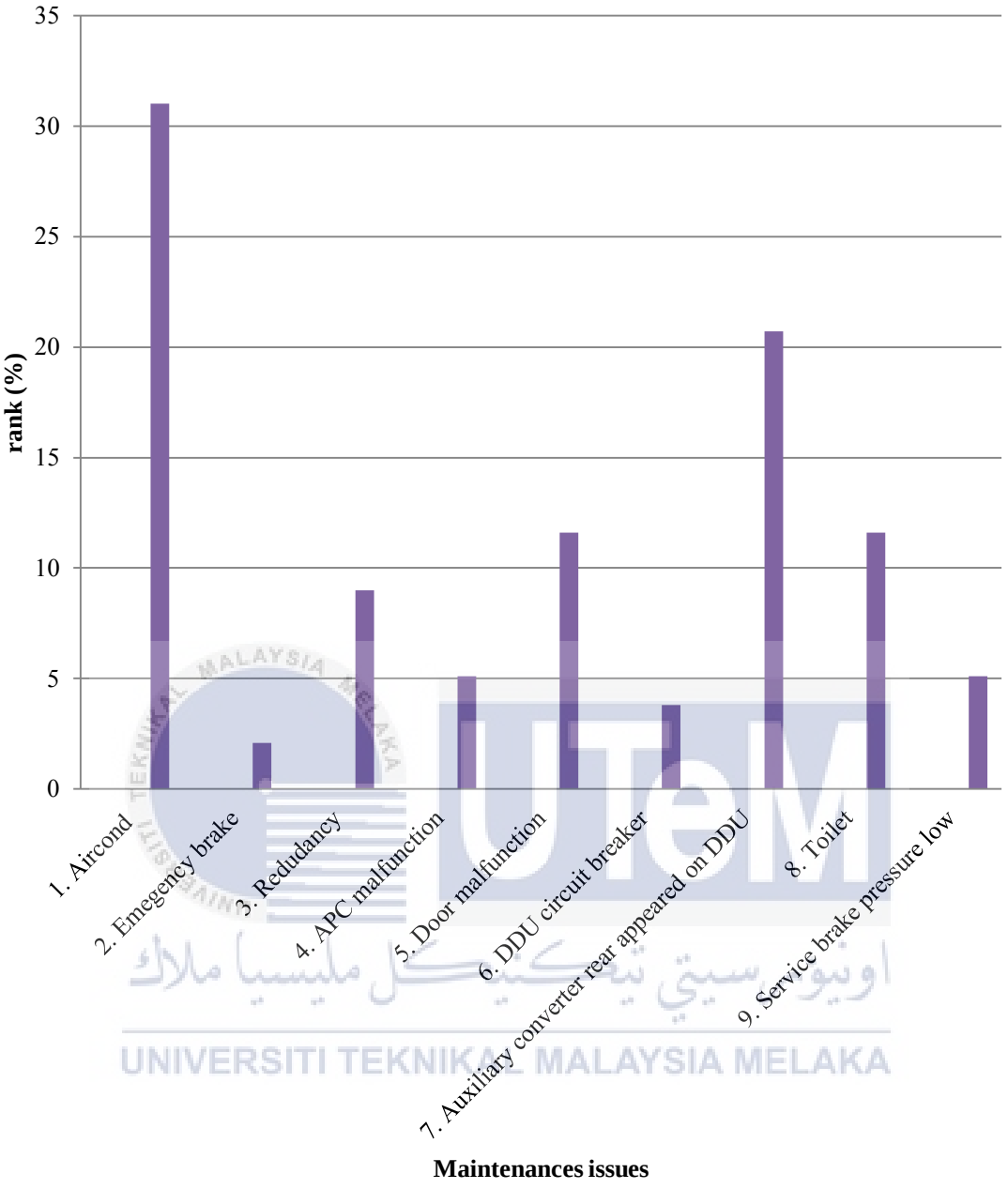

Figure 4.6: Bar chart of maintenances issue against rank in the train X106.

4.2.7 Train X107

The **Table 4.7** illustrates the weighted decision matrix in the train X107. Based on the table door malfunction has the highest number of quantity of the maintenance issue occurs that is 20. By the way door malfunction is not much severity because based on the severity scale it score only 2 points that means the failure not much important. However, door malfunction maintenances can affect the customer's satisfaction when it happens regularly. Door malfunction takes more than 4 days to overcome the failure.

From the **Figure 4.7**, door malfunction shows the highest ranking that is 24.8% from the maintenances issue occur in train X107 then followed by battery CB trip and brake test unsuccessful that are 9.5%.

Table 4.7: Table of weighted decision matric in the train X107.

	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				**Time consume to solve**					
			Neglible-1	**Marginal-2**	**Critical-3**	**Catastrophic-4**	**None-1**	**Low-2**	**Moderate-3**	**High-4**		
X107	1. Air condition	4		2						4	16	4.7
	2. Emergency brake	10	1				1				10	3
	3. Door malfunction	20		2						4	160	47.5
	4. Parking brake pressure low	1				4				4	16	4.8
	7. Traction not available	1				4				4	16	4.8
	8. Light malfunction	1		2						4	8	2.4
	9. Battery CB trip	2				4				4	32	9.5
	10. Auxiliary compressor malfunction	1				4				4	16	4.8
	11. Brake test unsuccessful	2				4				4	32	9.5
	12. Speedometer	1		2					3		6	1.8
	13. Hit something	4	1				1				4	1.2
	14. Toilet	2		2						4	16	4.8
	15. Redundancy	1		2				2			4	1.2
	Total	50									336	100

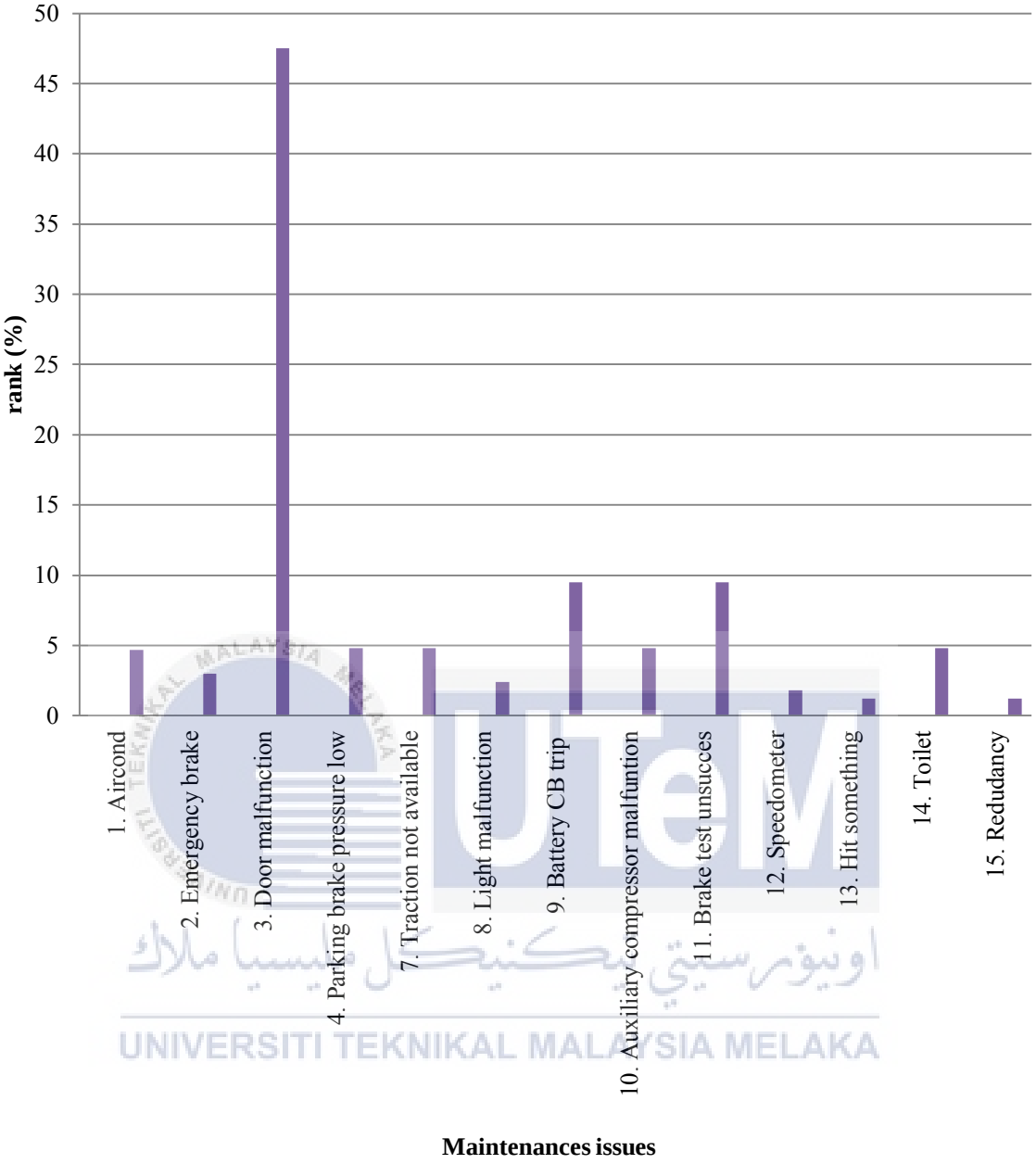

Figure 4.7: Bar chart of maintenances issue against rank in the train X107.

4.2.8 Train X108

The **Table 4.8** shows the weighted decision matrix in the train X108. Based on the table, emergency brake has the highest number of quantity of the maintenance issue occurs that is 13. By the way emergency brake is not much severity because based on the severity scale it score only 1 point that means the failure not much important because the emergency brake just applied on the train and only take least time to settle the issue.

From the **Figure 4.8**, door malfunction shows the highest ranking that is 25% from the maintenances issue occur in train X108 then followed by the toilet (21.7%) and service parking brake pressure low (12.4%).

Table 4.8: Table of weighted decision matrix in the train X108.

	Failure	Quantity	Decision Criteria								Total	Percentage (%)
			Severity scale				Time consume to solve					
			Neglible-1	Marginal-2	Critical-3	Catastrophic-4	None-1	Low-2	Moderate-3	High-4		
X108	1. Door malfunction	8		2						4	64	24.8
	2. Redundancy	7		2				2			28	10.9
	3. Emergency brake	13	1				1				13	5
	4. Air condition	4		2						4	32	12.4
	5. Toilet	7		2						4	56	21.7
	6. Hit something	1	1				1				1	0.4
	7. Wheel slide protection disturbance	1				4				4	16	6.2
	8. Lower beam malfunction	2		2						4	16	6.2
	9. Service parking brake pressure low	2				4				4	32	12.4
	Total	45									258	100

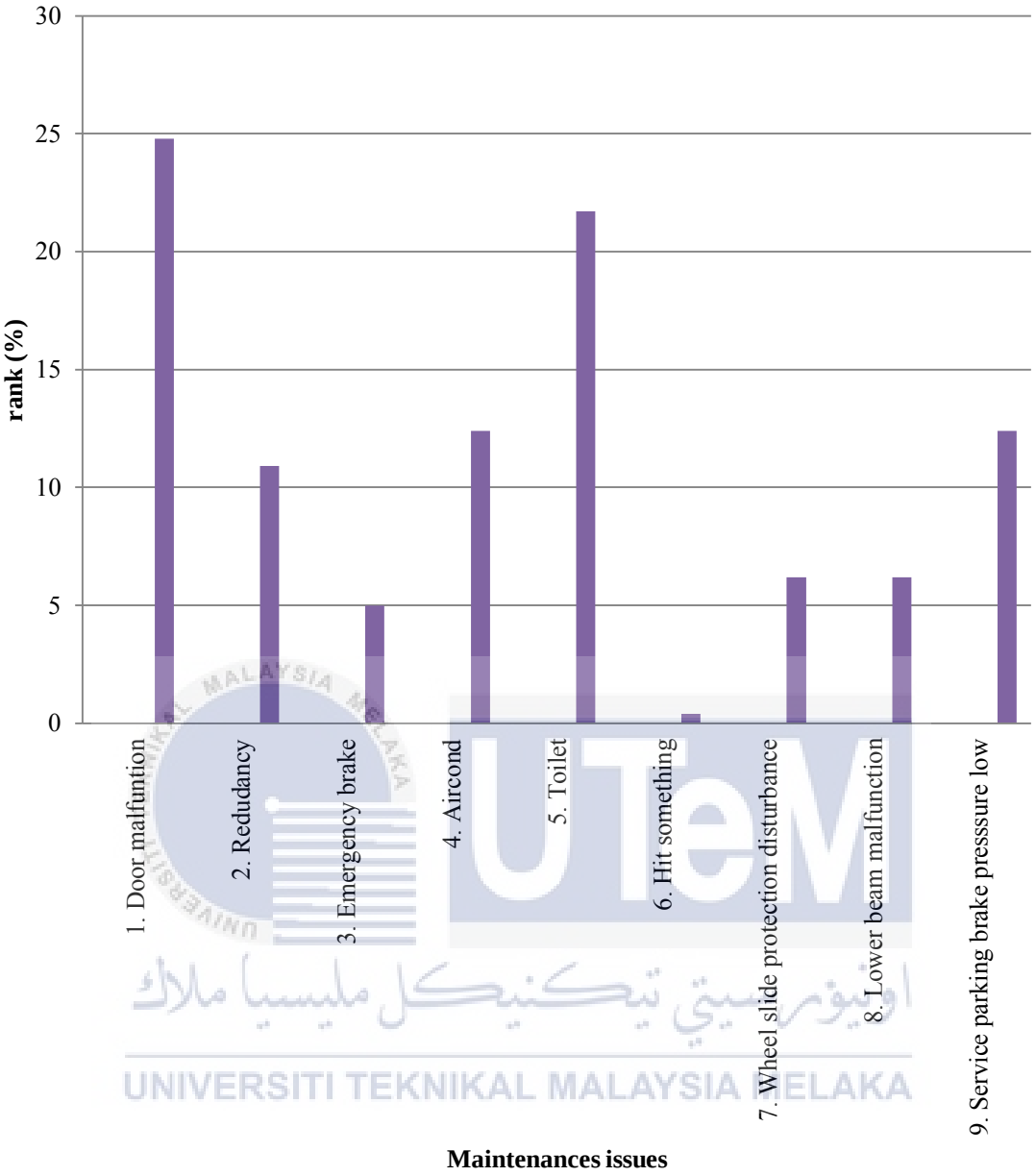

Figure 4.7: Bar chart of maintenances issue against rank in the train X107.

4.3 Total weighted by The Train

From the **Figure 4.9**, train X104 shows the highest total weighted that is 511 score. It means that train X104 must be highlighted compared the others train. Top three of the maintenance issues in that train are BCU failed, service brake pressure low and wheel slide protection disturbed.

Train X103 is in the second rank which has 487 score. The top most maintenance issues that happen in the train are BCU failed and service brake.

Train X105 and X106 have same value of the weighted that are 300 score. The least number of the score are 160 from train X102.

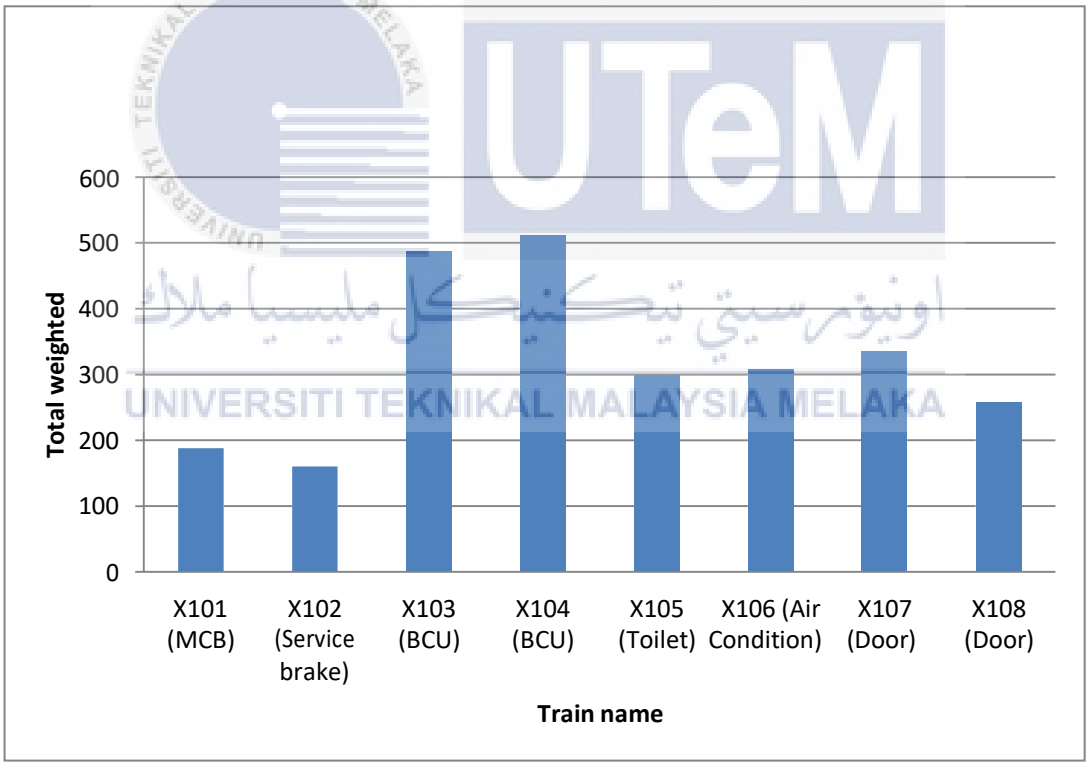

Figure 4.9: Graph of train against total weighted

4.4 Discussion

There are many types of maintenance issues happen regularly in the train. These kinds of maintenance issues occur in the train are based on the several factors. There are many factors that lead to this situation such as the life expectancy of the tools, natural disaster, accident that involves the train and others technical problems. The inspections and monitoring are the main points to make sure the maintenance process still on the track.

For train X101, the highest maintenance issues happen in that train is motor circuit breaker (MCB). The quantities of the motor circuit breaker occur are 6 times. Motor circuit breaker also has the highest severity if the issues happen. The process for repairing take a long time to solve that is more than four days. Based on the weight decision matric, motor circuit breaker has the highest percentage that is 51% and score 96 points after calculation. The strategies that the technicians take are first they make visual check cabinet and found MCB tripped. That MCB is related with motor. Then they check all wire at MCB and found the wire not losses and secure back. Then they suspect the motor problem and change the new motor taken from store. To repair the broken motor takes more than one day in time. Then they switch on back the MCB and start up the train and found no failure. To make sure the MCB run smoothly, the technicians make a complete monitoring to avoid any risk.

For train X102, the highest maintenance issues happen in that train is service brake. The quantities of the service brake occur are 3 times. Service brake also has the highest severity if the issues happen. The process for repairing take a long time to solve that is more than four days. Based on the weight decision matric, service brake has the highest percentage that is 30% and score 48 points after calculation. The actions that the technicians take are first they try to perform brake test and found brake not release failure appear at DDU. After that, they take read out at cabin and found parking brake fault not

applied. Then, they check leak at EP panel and if the leak not happen they check pressure at that panel and found failure. The technicians try readjusting pressure to 7 bars. 7 bars are the normal level of pressure for brake. Then, they check the axle and found one air hose at parking brake has major leak. They change the air hose taken from the store and make the brake test and found normal and the failure gone. To avoid the risk, happen, monitoring process is important to that service brake.

For train X103, the highest maintenance issues happen in that train is brake control unit (BCU) malfunction. The quantities of the BCU breakdown occur are 12 times. BCU also has the highest severity if the issues happen. The process for repairing take a long time to solve that is more than one day. Based on the weight decision matric, BCU breakdown has the highest percentage that is 39.4% and score 192 points after calculation. The strategies that the technicians take are first they make visual check at all EP panel and found the EB solenoid valve have major leak. Then they replace the EB solenoid valve and clean the emergency brake block. They also check leak at all piping EP panel and found normal. After that, the technicians start up train and perform brake test several times at cabin and found normal. The read out BCU cabin found no active failure occur. Then they carry out test track and found no failures appear.

For train X104, the highest maintenance issues happen in that train is brake control unit (BCU) malfunction. The quantities of BCU breakdown occur are 8 times. BCU also has the highest severity if the issues happen. The process for repairing take a long time to solve that is more than one day. Based on the weight decision matric, BCU malfunction has the highest percentage that is 25% and score 128 points after calculation. The technicians take the complete actions to solve the problems. Firstly, from BCU read out no failure capture base on incident date and time. Then, they cleaning the connector BCU and perform visual check. From the visual check, they found abnormal situation. After that, the

technicians secure back and perform the brake test short and long and found normal condition. Then, they continue test track for several time and found satisfactory. To avoid any risk, happen the monitoring process is the important action in this case.

For train X105, the highest maintenance issues happen in that train is toilet malfunction. The quantities of the toilet malfunction occur is 8 times. It also has the medium severity if the issues happen. The process for repairing take a long time to solve that is more than four days. Based on the weight decision matric, toilet breakdown has the highest percentage that is 21.4% and score 64 points after calculation. The technicians take the complete actions to solve the problems. At first, they try to flush the toilet but no development of pressure failure is occurred. Then, they try to check air supply from the train to the toilet and found everything is in normal condition because when the flush is performing, there is no air supply to the toilet. After that, the technicians try to check both squeeze valve found everything is normal and the air supply from the train to the toilet also in normal condition. They suspect that there is no signal from the toilet controller to the toilet. This situation may cause the toilet cannot receive air supply from the train. Then, they check the connector from the train found that there is a pin that is already sunken. The technicians try to put the pin back to normal position and reconnect with toilet and found the toilet operates as normal. They have to modify the connector from the train to the toilet because it may cause the toilet system is malfunction. Lastly, they test a few times and found satisfactory.

For train X106, the highest maintenance issues happen in that train is air condition malfunction. The quantities of the air condition breakdown occur is 12 times. Air condition malfunction also has the medium severity if the issues happen. The process for repairing take a long time to solve that is more than four days. Based on the weight decision matric, air condition has the highest percentage that is 31% and score 96 points after calculation.

The strategies that the technicians take are firstly, they check software at DDU and found abnormal situation at that air condition. Then, they proceed to change the air condition with the new air condition taken from the store. The broken air condition takes more than one day to repair it. After that, the technicians perform check software again at DDU and found normal condition. Then, they start up the train and monitor temperature of the air condition and found normal condition. The monitoring process still continues to avoid any risk happen.

For train X107, the highest maintenance issues happen in that train is door malfunction. The quantities of the door breakdown occur is 20 times. Door malfunction also has the medium severity if the issues happen. The process for repairing take a long time to solve that is more than four days. Based on the weight decision matric, door malfunction has the highest percentage that is 47.5% and score 160 points after calculation. The technicians take the complete actions to solve the problems. Firstly, they perform the visual check at door mechanical and electrical part and found abnormal condition. Then, the technicians perform visual check the ramp mechanical and also found abnormal condition. After that, they start up the train and the failures still remain, and then proceed to change the new door taken from the store and secure back all connection. To repair the broken door takes more than four days. Then, the technicians initialize the door back and test it to open and close for several times. The result found satisfactory and monitoring process still continues to avoid any risk happen.

For train X108, the highest maintenance issues happen in that train is door malfunction. The quantities of the door breakdown occur is 8 times. Door malfunction also has the medium severity if the issues happen. The process for repairing take a long time to solve that is more than four days. Based on the weight decision matric, door malfunction has the highest percentage that is 24.8% and score 64 points after calculation. The

strategies are same with the actions taken in the train X107. Firstly, they perform the visual check at door mechanical and electrical part and found abnormal condition. Then, the technicians perform visual check the ramp mechanical and also found abnormal condition. After that, they start up the train and the failures still remain, and then proceed to change the new door taken from the store and secure back all connection. To repair the broken door takes more than one day. Then, the technicians initialize the door back and test it to open and close for several times. The result found satisfactory and monitoring process still continue to avoid any risk happen.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The first objective of this research is to analyse about the routine maintenances and problems that occur on the train. This analysis shows that, there are various types of maintenances and problems happen on the train daily. This kind of situation can give the impact to the train company and also can affect the business in the future. Thus, to make sure this situation can be avoiding with success, preventive maintenance is the key point to be highlight.

The most maintenance issues happen in the train is brake control unit (BCU). From the eight trains that analysed, the result shows that BCU is the highest rank in the train X103 and X104. BCU also one of the higher severities in the maintenance issues on the train because when it happens, the operation of the train will stop immediately. Therefore, the BCU maintenance problem must be focus more than other maintenance issues.

The second objective of this research is to study the preventive maintenance for the future. In this case, to avoid the maintenance issues happen frequently in the future, the preventive maintenance is important. A maintenance strategy includes identify the problems, analysing and implementation of many repair, replace and find solution. The technicians take the complete actions to avoid the maintenance issues happen. Although the maintenance issues and problems cannot be settle totally, the actions to reduce the problems is important in other to make sure the operation of the train still on the track.

With the success actions, its can improve the customer's satisfaction and this can lead to the increase reputation of the company and business profit.

5.2 Recommendation

In the future, it is recommended that the duration of the research should be extended about one year or more. It is because; the longer the time duration for the research to run, the more precise data and information will produce at the end of the research. For this research, it takes only nine months for the data collection of the maintenance issues on the train. It is limited data for the analysis to be more precise. However, the analysis for this research still complete although the data collection is only for nine months.

In addition, for the next research, the factors of the maintenance issues occur in the train can also be analysed to find the root cause of the problems. When the root cause of the problems has found, it is easier for the company to take preventive actions early. With this taking action, the company can avoid the repeated problems and it can lead to the company profit increase with success.

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APPENDICES

Appendix A: Gantt Chart for PSM 1.

Week / Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Find supervisor										MID SEM BREAK						
Project title selection																
Discussion with supervisor																
Research study																
Writing report																
Introduction																
Literature review																
Methodology																
Slide presentation																
Presentation																
Submission of final report																

Appendix B: Gantt Chart for PSM 2

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Working time for PSM 2										MID SEM BREAK					
Site visit															
Data collection															
Data analyze															
Submission of progress report 2															
Report writing															
Submission of report															
PSM 2 presentation															

Appendix C: Site visit with Supervisor

Appendix D: ERL Monitoring Room.