HIGHWAY MAINTENANCE MANAGEMENT: A STUDY OF LEBUHRAYA DAMANSARA-PUCHONG (LDP)

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ABSTRACT

Practical and effective highways have been known to enhance the movement of people as well as products to boost the economy of a country. Without a proper maintenance system, highways can rapidly tumble into depreciation which in the end will affect the highways patron in terms of vehicle operation, time, reliability, and safety. The purpose of the present research was to evaluate the effectiveness of the highway maintenance management system of Lebuhraya Damansara-Puchong (LDP). The selection of LDP was related to some issues such as the high number of accidents, road congestion, flash floods and noise problem indicate that LDP has major concern to be addressed in relation to its practices in terms of the effectiveness of the maintenance management system**.** The study also attempted to propose improvements in policies and regulations of highway maintenance management system for LDP and the flow of communication in the Highway Maintenance Department. The study applied the qualitative case study approach in which the research explained the effectiveness of maintenance management system practices at LDP to overcome problems in maintenance work and improve the information management process which is critical in preparing a high quality work report. The study revealed the problems of effectiveness in the LDP highway maintenance system, the importance of the policies and regulations for work execution, observation and surveillance, and the significance of the flow of communication in the application of highway maintenance management system particularly in the preparation of high quality work report. Recommendations for future study are offered to provide opportunities for future researchers to continue this research, focusing specifically on the highway environment.

Keywords: maintenance management system, highway, observation, record management, communication

ABSTRAK

Lebuh raya yang praktikal dan berkesan didapati mampu untuk meningkatkan pergerakan individu serta barangan bagi meningkatkan ekonomi negara. Tanpa sistem penyelenggaraan yang sewajarnya, lebuh raya akan rosak dengan cepat dan ini akan memberi kesan terhadap pengguna lebuh raya dari segi penggunaan kenderaan, masa, kebolehpercayaan, dan keselamatan. Oleh itu, kajian ini bertujuan untuk menilai keberkesanan sistem pengurusan penyelenggaraan lebuh raya di Lebuhraya Damansara-Puchong (LDP). Pemilihan LDP adalah berkaitan dengan beberapa isu yang dihadapi dan perlu diberikan perhatian oleh LDP seperti jumlah kemalangan yang tinggi, kesesakan jalan raya, masalah banjir kilat dan masalah ganguan bunyi bising. Isu-isu ini telah dikenalpasti mempunyai hubungan dengan amalan pengurusan penyelengaraan yang dipraktikkan di LDP dan kajian ini akan memberi fokus dari segi keberkesanan sistem pengurusan penyelenggaraan di LDP. Selain itu, kajian ini juga bertujuan untuk memberikan cadangan penambahbaikan terhadap dasar dan peraturan sistem pengurusan penyelenggaraan lebuh raya untuk LDP dan aliran komunikasi di Jabatan Penyelenggaraan Lebuhraya. Kajian ini menggunakan pendekatan kajian kes kualitatif untuk meneliti keberkesanan amalan sistem pengurusan penyelenggaraan di LDP demi mengatasi masalah dalam kerja-kerja penyelenggaraan dan menambah baik proses pengurusan maklumat yang penting dalam menyediakan laporan kerja yang berkualiti. Kajian ini mendedahkan masalah keberkesanan sistem penyelenggaraan lebuh raya di LDP, kepentingan dasar dan peraturan untuk pelaksanaan kerja, pemerhatian dan pengawasan serta kepentingan aliran komunikasi dalam sistem pengurusan penyelenggaraan lebuh raya terutama dalam penyediaan laporan kerja yang berkualiti. Cadangan untuk kajian pada masa hadapan turut diutarakan bagi memberi peluang kepada penyelidik lain untuk meneruskan kajian ini dengan memberikan tumpuan khusus kepada persekitaran lebuh raya.

Kata kunci: sistem pengurusan penyelenggaraan, lebuh raya, pemerhatian, pengurusan rekod, komunikasi

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LIST OF ABBREVIATIONS

AR	Action Research
CBM	Condition-Based Maintenance
CCTV	Closed-circuit television
CM	Corrective Maintenance
DOE	The Government and Department of Environment
DOT	Department of Transport
DSS	Decision Support System
EIA	The environmental impact assessment
GDP	Gross Domestic Product
IM	Improvement Maintenance
KM	Knowledge Management
MHA	Malaysia Highway Authority
MKM	Maintenance Knowledge Management
MHHS	Highway Maintenance Management System
MIR	Maintenance Inspection Record
MIROS	Malaysian Institute of Road Safety Research
MMS	Maintenance Management System
MOSTI	Ministry of Science, Technology and Innovation
MPV	Multi-Purpose Vehicle
MTBF	Mean Time Between Failure
MTTF	Mean Time To Failure
NCR	Non-Conformance Record
ORJI	Observe, React, Judgment, Intervention Model
OTF	Operate To Failure
PDM	Predictive Maintenance
PM	Preventive Maintenance
RCM	Reliability-centered maintenance
RTB	Run To Breakdown
RTF	Run To Failure
SD	System Dynamic
SERVQUAL	Service Quality Model
SPAD	Suruhanjaya Pengangkutan Darat
TEMAN	Total Expressway Maintenance Management System
TPM	Total Productive Maintenance
VMS	Variable Message Sign

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Highway maintenance is becoming a very popular topic in recent years. The relationship between the transportation system and the growth of the nation and welfare of the society has highlighted the importance of the subject. According to the Ministry of International Trade and Industry of Malaysia, Malaysia's trade value for the year 2014 was RM1,449.6 billion, an increase of 24.8% compared to RM1,160.9 billion recorded in 2013[1]. The increased of the trade volume has underlined the importance of transportation system including the main roads in Malaysia.

There are various types of roads that exist around the world with all kinds of road that can normally be used by motorized traffic. Highway is defined as "*An area of land which the public at large have the absolute right to use to 'Pass and Repass without let or hindrance*" (City of York Council (GB), 2018). The highway is also usually available for public use despite the toll payment. In some places, the term highway is devoted to high capacity roads (Federal Highway Administration, 2013). A variety of different terms used in different countries as for example, in the USA, roads or highway known as 1) Arterials which consist of the interstate highway system, an expressway and freeway with multiple lanes with limited access and road corridor and other roads that are used in local areas; and 2) Collectors that connected local streets and road with Arterials (Committee on Ecological Impacts of Road Density, 2005). Meanwhile in the

[1] http://www.miti.gov.my/cms/content.jsp?id=com.tms.cms.article.Article_9aaf991b-c0a81573-2de0a562-d85bbedc

UK, roads are being classified into several categories such as 1) Motorways which are being administered by highway agencies; 2) Trunk roads that are also maintained by the highway agencies; 3) "A" roads – defined as the major roads network aims to provide a large-scale transport within or between regions; and 4) "B" roads - These roads are intended to connect different areas, and to feed traffics between A roads and streets of the smaller network; (East Riding of Yorkshire Council, 2016). In Germany, roads are being known as 1) autobahn - The motorway network; 2) Kraftfahrstraßen - express routes; and 3) Landesstraßen – regional roads (Anglo Info, 2016). France refers their toll roads as Autoroutes which connect large areas of France (Driving France, 2016). Roads in Malaysia are classified into two broad categories namely Federal Roads (which consist of Toll Expressways, National Highways, Regional Road Schemes and Minor Roads) and State Roads (generally comprises of the Roads within Federal Territories, Primary Roads, Secondary Roads, Minor Roads, Urban Collector Roads and Local Streets) (The World Road Association, 2005).

Practical and effective highways have been known to enhance the movement of people as well as products to boost the economy of the country. In Malaysia, the Malaysian Highway Authority known as MHA was established on October 24, 1980 is an organization that is in authority to oversee and implement the creation of the design, construction, regulation, operation and maintenance of the highway between the cities, impose and collect tolls, enter into contracts and provide matters that are related to highway. The Act 231 stated that MHA to collect tolls from motorists and other payments related to the use of other facilities along the highways. MHA will also be needed to conduct research, to ensure the use of the highway as well as other facilities more efficiently. In general, the exercise includes all things for improvement and better

use of highways and facilities available along the highway. However, with the implementation of the National Privatization Policy in 1983, the duties of MHA were amended to the body that regulates the construction and management of toll highways in Malaysia. This policy change is intended to ensure highway operators to always provide good quality, safe and convenient highways to users[2].

Malaysia highway can be divided into two categories; inter-urban and intra-urban (Khusairi, 2015). Inter-urban highways are networks that cross over state boundaries while intra-urban highways are confined to areas within state boundaries (MHA, 2016). In Malaysia, the highway operators are responsible for maintaining over 2,232 kilometers of highways. Today, there are 32 operational highways in Malaysia, and all are collecting tolls except the MRCB-owned Eastern Dispersal Link in Johor. The 32 highways are owned by 25 different operators (Penang Monthly, 2014; Wikipedia, the free encyclopedia, 2016). Refer to Table 1.1.

Table 1.1
List of highways and their respective operators

No	Code	Highways	Operators
1	E37	Lebuhraya Hubungan Timur Barat (SALAK)	Anih Berhad
2	E8	Lebuhraya Kuala Lumpur – Karak (KLK)	Anih Berhad
3	E8	Lebuhraya Pantai Timur (LPT1)	Anih Berhad
4	E9	Lebuhraya Sungai Besi (BESRAYA)	Besraya (M) Sdn. Bhd.
5	E5	Lebuhraya Shah Alam (KESAS)	Konsortium Expressway Shah Alam Selangor Sdn Bhd (KESAS Sdn. Bhd.)
6	E33	Lebuhraya Duta Ulu Kelang (DUKE)	Konsortium Lebuhraya Utara-Timur Kuala Lumpur Sdn. Bhd. (KESTURI)
7	E20	Lebuhraya KL – Putrajaya (MEX)	Lebuhraya KL – Putrajaya
8	E25	Lebuhraya Kuala Lumpur – Kuala Selangor (LATAR)	KL-Kuala Selangor Expressway Bhd

[2] Source http://www.llm.gov.my/background_EN.aspx

Table 1.1 (continued)

No	Code	Highways	Operators
9	E21	Lebuhraya Kajang – Seremban (LEKAS)	Lebuhraya Kajang – Seremban Sdn. Bhd.
10	E35	Lebuhraya Koridor Guthrie	Lebuhraya Koridor Guthrie
11	E17	Lebuhraya Lingkaran Luar Butterworth (LLB)	Lebuhraya Lingkaran Luar Butterworth (Penang) Sdn Bhd
12	E30	Lebuhraya Pintas Selat Klang Utara Baru (SHAPADU)	Lebuhraya Shapadu Sdn. Bhd.
13	E11	Lebuhraya Damansara – Puchong (LDP)	Lingkaran Transkota Holdings Bhd. (LITRAK)
14	E38	Lebuhraya Laluan Kedua Malaysia – Singapura (LINKEDUA)	Linkedua (M) Sdn. Bhd. (LINKEDUA)
15	E14	Lebuhraya Penyuraian Timur Johor Bahru (EDL)	MRCB Lingkaran Selatan Sdn. Bhd.
16	E10	Lebuhraya Baru Pantai (NPE)	New Pantai Expressway Sdn. Bhd.
17	E36	Jambatan Pulau Pinang	Penang Bridge Sdn. Bhd.
18	E15	Lebuhraya Butterworth – Kulim (BKE)	Projek Lebuhraya Usahasama Berhad (PLUS)
19	E29	Lebuhraya Seremban – Port Dickson	Projek Lebuhraya Usahasama Berhad (PLUS)
20	E1	Lebuhraya Utara Selatan (PLUS) (Northern Route)	Projek Lebuhraya Usahasama Berhad (PLUS)
21	E2	Lebuhraya Utara Selatan (PLUS) (Southern Route)	Projek Lebuhraya Usahasama Berhad (PLUS)
22	E1	Lebuh Raya Baru Lembah Klang (NKVE)	Projek Lebuhraya Usahasama Berhad (PLUS)
23	E3	North-South Expressway Central Link – Putrajaya Link (ELITE)	Projek Lebuhraya Usahasama Berhad (PLUS)
24	E12	Lebuhraya Bertingkat Ampang (AKLEH)	Projek Lintasan Kota Sdn Bhd
25	E13	Lebuhraya Kemuning – Shah Alam (LKSA)	Projek Lintasan Shah Alam Sdn. Bhd
26	E22	Lebuhraya Senai-Desaru (SDE)	Senai-Desaru Expressway Berhad
27	E18	Lebuhraya Kajang SILK	Sistem Lingkaran-Lebuhraya Kajang Sdn. Bhd (SILK)
28	E23	Lebuhraya Skim Penyuraian Trafik Kuala Lumpur – Barat (SPRINT)	Sistem Penyuraian Trafik KL Barat Sdn. Bhd. (SPRINT)
29	E26	Lebuhraya Lembah Kelang Selatan (SKVE)	SKVE Holding Sdn. Bhd.
30	E7	Lebuhraya Cheras – Kajang (GRANDSAGA)	Syarikat Grand Saga Sdn. Bhd.
31	E28	Sultan Abdul Halim Muadzam Shah Bridge	Jambatan Kedua Sdn. Bhd. (JKSB)
32	E38	Terowong SMART (SMART)	Syarikat Mengurus Air Banjir & Terowong Sdn. Bhd.

Source: Malaysian Highway Authority Official Portal, 2016

This highway network is as vast and diverse encompassing peninsular Malaysia. It covers the whole spectrum in terms of traffic carrying well over 5 million vehicles in 2013 (Jabatan Keselamatan Jalan Raya Malaysia, 2013). This highway network represents a monumental investment in infrastructure that is vital to the safety, welfare, and economic prosperity of all Malaysians.

The highway operators are not just there to provide good road for transportation purpose, they are also required to maintain and ensure that all of the roadside facilities and highway assets are in a functioning condition. The roadside fixings include signs, barriers, drainage structures, traffic lights, illumination fixtures, and rest areas (PLUS, 2014). All these highway infrastructure assets are under constant inspection, with increasing pressure from the government and from the public calling for more clarity, responsibility and more efficient used of the limited (public) resources available. That is why the maintenance management has become an important issue for all parties involved.

The World Bank (2013) concluded that an improper maintained highway represents an increase of safety threat to highway users, resulting to more accidents and the increased of human related and assets cost. For the record, the total number of road accidents in Malaysia has increased from 24, 581 cases recorded in 1974 to 462, 432 cases in 2012. A total increase of 1,780% of cases in the last 35 years. According to statistics, the number of fatal accidents (involving death within 30 days from the day of the accident) also increased from 2,303 cases recorded in 1974 to 6,917 fatal accidents or equivalent to 19 deaths in a day in 2012 (The World Bank, 2013). Furthermore, Malaysia lost RM9.0 billion dues to cost associates with accidents in 2011 (Ministry of Transport,

2014). Malaysian Institute of Road Safety Research (MIROS) estimated an annual cost of RM8.5 billion for the loss of 6,527 lives due to road accidents. Based on the 2008 gross domestic product value of RM528.3 billion, it is estimated that the loss of lives due to road accidents would remove about 1.6% of the Malaysia's GDP (MIROS, 2013). Therefore, a study should be done on a highway maintenance management system that is able to minimize cost of maintenance for the Malaysian government, highway operators and at the same time giving the best level of service and safety for highway users. A study by MIROS in 2014 concluded that, one of the major causes for accidents are the poor design of urban highways.

Highway maintenance is an ongoing process where maintenance mainly comprises of routine maintenance, periodic maintenance and preventive maintenance (Dekker, 1996). Highway routine maintenance involved repairs and cleaning that prevent deterioration of the road surface, engineering structures, the right-of-way facilities, as well as activities to preserve the qualities of the road to ensure traffic safety and comfort (Archutowska & Pieriegud, 2012). Whereas periodic maintenance, according to the Florida Legislature (2018 referred to the large scope activities and work required to recondition the depreciated sections of the transportation framework and returned it to a safe and working condition. Lastly, preventive maintenance as defined by Galehouse (2014) is a strategy designed for cost-effective treatment of existing road systems and equipment that maintain the system, slowing the deterioration of the future and to preserve or improve the state of the system without (substantial) expanding the capacity of the structure. All of these maintenance activities conducted by highway operators are normally managed via their Highway Maintenance Management System (HMMS).

HMMS is a considered by MHA as an important assets management tool which consist of highway network planning, highway asset condition assessment, technical investigation, review of design option as well as the implementation of maintenance works (PLUS, 2014). HMMS originated from Maintenance Management System (MMS) that can be defined as manual or computerized management tool for planning and budgeting maintenance, capital, repair and replacement of equipment and construction projects (U.S. Fish and Wildlife Service, 2002). According to Government of Canada Publications (2000), a good maintenance management system along with knowledgeable and skilled workers will be able to avoid health and environmental problem, prolonging the life span of assets by reducing the number of breakdowns, which in turn will lead to a reduction in operating costs, and improve quality of life. However, the implementation of such system in many countries has been unsatisfactory due to certain reasons such as user attitudes, financial problems, unskilled personnel and too complicated systems (Robinson R. , 1995). The same scenario happened to Malaysia (Pfordten, 2014).

1.2 The Lebuhraya Damansara – Puchong (LDP)

The study will be based on - LingkaranTrans Kota Sdn Bhd, or better known as LITRAK which is the operator of Lebuhraya Damansara - Puchong (LDP). Since the date of completion on December 18, 1998, this inter-urban highway offers easy access to urban areas such as Kepong, Bandar Sri Damansara, Bandar Utama, Taman Tun Dr. Ismail, Petaling Jaya, Sunway, Subang Jaya, Puchong and Shah Alam. LDP is considered as one of the important network to attract visitors and tourists to places of interest in the Klang Valley (Lingkaran Trans Kota Sdn Bhd, 2014). LITRAK was incorporated in 9 Mac 1995 and listed on Bursa Saham Kuala Lumpur on 19 December

1996. With regard to the ownership, Gamuda with 44.41% of shares owns LDP. The rest of the shares were distributed to Skim Amanah Saham Bumiputera - (7.29%); Kumpulan Wang Persaraan (Diperbadankan) - (7.11%); Kumpulan Wang Simpanan Pekerja (KWSP) - (7.06%); Institutional Investors - (27.71%); and Retail Investors - (6.42%).

LDP is the main highways in the Klang Valley, Selangor in Malaysia that connects major areas in Damansara and Puchong while reducing travel time between these cities. The main purpose of LDP is not only to reduce congestion in the city but also allow a greater capacity in terms of transportation in the north-south corridor. Apart from the LDP, which covers 40km, it also provides accessibility to these areas through highways that are available in the Klang Valley such as the Federal Highway, Kuala Lumpur Middle Ring Road 2 (MRR2), Sprint Highway (SPRINT), New Pantai Expressway (NPE), Puchong - Sungai Besi Highway and Sungai Buloh Highway. LDP is part of Kuala Lumpur Middle Ring Road 2 Scheme, which provides links to the industrial area of Shah Alam, Cyberjaya and Putrajaya (Lingkaran Trans Kota Sdn Bhd, 2014). The significant role of LDP can be seen from the average weekday tollable traffic that registered 502,100 vehicles in 2015 with the total revenue collected for 2015 equivalent to RM375,827,000 (LITRAK, 2015). This translated to daily collection of RM1,029,663. The revenue is expected to increase even though there are no toll hike due to rapid development projects in surrounding area and the increase number of vehicles using LDP every day.

Currently in LDP, the scope of maintenance works covers;

(a) Roadways shoulders and verges;

(b) Embankments and cut slopes;

(c) Road furniture, signage, safety barriers, road line markings, etc.;

(d) Traffic control devices;

(e) Drainage system;

(f) Bridges;

(g) Landscape and slope protection vegetation; and

(h) Highway related buildings.

Where appropriate, the scope of maintenance may include minor improvement works. In LDP, the maintenance practice has been confined to routine maintenance and curative maintenance. The routine maintenance covers the task of;

- Litter collection
- Sweeping of mainline roadways, interchanges, junctions, bus stops and pedestrian walkways
- Removal of vegetation/weed
- Removal of obstruction along the mainline
- Cleaning and repair road furniture
- Patching of potholes
- Landscape maintenance and daily watering
- Slope grass cutting
- General repairs

Drainage maintenance covers silt and rubbish removal and disposal, and cleaning of all surface drainage facilities, sumps, culverts, aprons, horizontal drains and subsoil drains. Meanwhile, the building maintenance covers general building cleaning for all office

premises, toll plazas and laybys. The work includes vacuuming of carpeted flooring, daily mopping and cleaning of tiled floors (common areas), regular cleaning of toilets, sweeping of driveways, car parks and compound, daily cleaning of toll plazas, replenishment of toiletries, 24-hours cleaning services to lay-by facilities and daily disposal of rubbish.

In terms of curative maintenance, it refers to the repair of replacement of any component of the highway facility that has been damaged due to vandalism, accident, storm or flood. The common item that need curative maintenance are safety barriers (steel guardrails, concrete barriers, etc.), signboards, lamp posts, manhole covers, drain gratings and minor roadside structures. For the repair and replacement of component damaged by traffic accidents, the expenditure ranged from RM147,000 to RM665,000 per year from 1999 to 2012, while a total of about RM348,000 had been spent in the same period to make good damages caused by vandalism.

The selection of LDP was related to some issues that need to be addressed in terms of its relation to the highway maintenance management. The first issue is the high number of accidents. LDP had the highest number of accidents in all areas in Petaling Jaya with 3,092 cases in 2008. One of the most dangerous spots is the stretch near Damansara Utama. As shown in Figure 1.1, other dangerous spot includes the bends or junctions near the LDP Furniture Plaza, Plaza Tol Penchala, Western Digital, Damansara Utama and Leisure Commence Square where most of the accidents happened. (Teng, 2009). Due to that, LDP is listed as one of the "killer road" in Malaysia due to its "accident-prone" trails (The Star, 2014).

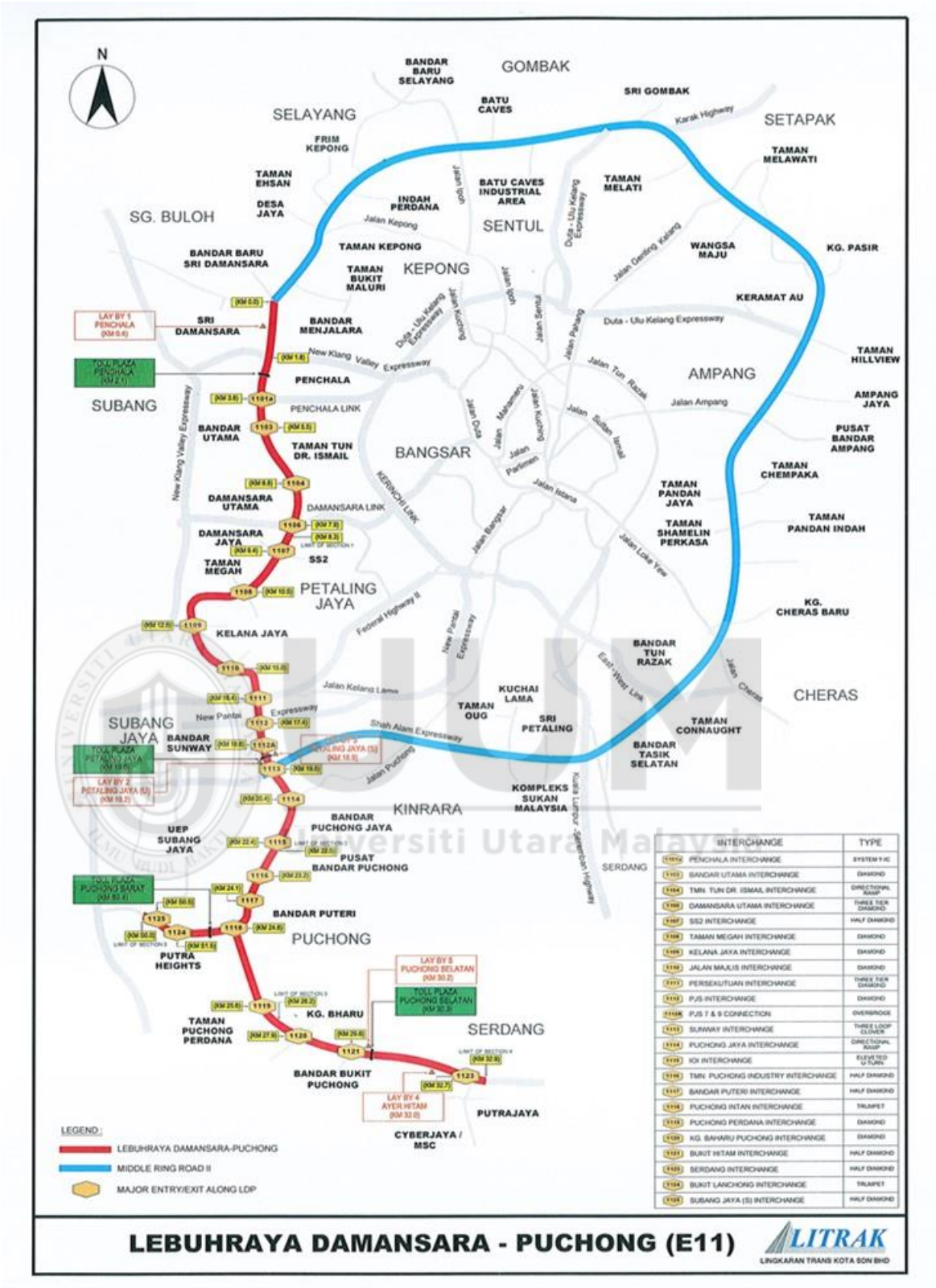


Figure 1.1
The Lebuhraya Damansara - Puchong (LDP) Route Map
Source: Lingkaran Trans Kota Sdn Bhd Website, 2014

According to Teng (2009), 50% of accidents happened in LDP occurred during wee hours when the traffic volume was very low. According to the study by MIROS in 2014, one of the major causes for accidents are the poor design of urban infrastructure such as highways because there are just too many surroundings constructions projects and that can be considered obstructions and contribute to accidents. Although, the highway was designed within the requirement from the authority that all existing junctions and accesses to the highway shall be maintained, but they need to be reconfigured for better and more efficient traffic movement. There are too many junctions for the highway to operate efficiently.

The density of junction along LDP is high. There are altogether 87 junctions in the north-bound direction with the average distance of 420 meters between adjacent junctions. In the south-bound direction, there are 93 junctions at an average of 400 meters spacing. This can be concluded that the route of LDP or LDP structures are not safe for the motorist. In addition, LDP has 180 junctions, which translate to one junction for every 200 meters, which is far less than the accepted international standard of at least 2km between each junction (Teng, 2009). However, according to the New Asian Highway classification and design standards, with Access-controlled motorway and Asphalt or cement concrete pavement type, LDP is considered as a "Primary" class highway (The United Nations Economic and Social Commission for Asia and the Pacific, 2001). According to The United Nation Economics and Social Commission for Asia and the Pacific (ESCAP) (2001), the 'Primary" class highway classification is based on Access-controlled motorway whereby "*Motorcycles, bicycles and pedestrians will not be allowed to enter the motorway in order to ensure traffic safety and the high running speed of automobiles*".

A study on LDP's maintenance management practice is required in relation to the increasing statistics of the money spent on maintenance expenditure and the high number of accidents recorded. LITRAK increased their maintenance expenditure to RM2, 270,000 in 2015 from RM1, 014,000 in 2014. An increase of 123%. However, the statistic also showed that LDP recorded 8.5 accidents which happened on daily basis. In relation to this mishap, there were significant losses in terms of associated human and property cost due to accidents (Yusoff, Mohamad, Abidin, Nor, & Salleh, 2013).

The second problematic issues related to LDP is flash flood. Thorndah & Willems (2008) in their research concluded that the main reason for any flash flood to happen is the improper management of drainage system. Flash flood also happen due to high population and also paved roads where water from a few minutes to half an hour downpour has no place to drain (Hasni, 2014). According to worldweatheronline.com (2016), Selangor received an everage of 224mm precipitation annually with an average of 21 rainfall day monthly. Therefore, an efficient drainage system is very crucial to mitigate any problem caused by heavy flow of rainwater.

LDP is an elevated highway. The tendency of water to flow downhill is huge. When the flood mitigation infrastructure such as water pump failure happened, floods will reoccur (Subramaniam, 2015). Other than that, the old culvert in LDP can no longer release high-velocity of water flow due to blockage causing the floods such as the flash flood that hit the IOI Mall in Puchong on 10 June 2015 (Tan & Lim, 2015). Adding to that, the reduced open soil area increases surface runoff (Subramaniam, 2015). These

incidents are not news anymore but somehow the LDP maintenance management practices still have no answer to address this occurrence.

The third issue is regarding the road congestion. LDP is one of the most congested highways in Klang Valley. The never-ending problems of traffic jam on the LDP happened daily especially during rush hours. LITRAK believes the development of 66 new development projects have sprouted since its opening in January 1999 has significantly contributed to this problem (LITRAK, 2015). The Institution of Civil Engineers (1989) as cited in Miller and Li (1994) defined congestion as conditions resulted from situation where too many people want to travel at a given time that the transportation system can accommodate. It is also refered to the delay in travel time because the movement of vehicles are slower than the acceptable speed (Weisbrod, Vary, & Treyz, 2003).

The traffic congestion prevents people from getting to and from their places of work in time which means spending time unproductively in heavy traffic resulting a huge drain on productivity (The Land Public Transport Commission (SPAD) , 2013). LDP tried to ease this condition by disseminating traffic flow information obtained from emergency telephones, CCTV and VMS boards. (Hossain, 2006). However, this initiative was unable to improve the bad traffic condition until today.

The last issue that need to be addressed by LITRAK is the growing noise problem regarding increase of requirements for goods, services and transportations. LDP existing 4-lane road has been upgraded to a 6-lane highway that passes through many areas of residential areas (Yusoff & Ishak, 2005). Noise pollution refers to any

unpleasant, damaging or irritating sound that can be harmful to people, wildlife or the environment (Polytechnic Institute of New York University, 2013). Intensity of a sound is measured by decibel (dB) and prolonged exposure to noise exceeding 50 dB (safe limit) will resulted to permanent level of tension (World Health Organization, 2016). Yusoff & Ishak (2005) further explained that the Government and Department of Environment, known, as DOE should no longer take things lightly in relation to noise nuisance as it should not be regarded as a development in terms of technology, but it is a sign of regression. It is important for conducting inspection and assessment exercise in making sure that building a new highway as well as after its construction complies with the Environmental Impact Assessment (EIA).

1.3 Problem Statement

The importance of highways to the wellbeing of society and the nation has emphasized the need to make sure that the highways available in this country are in good state. On that note, maintenance management practices applied by highway operators demand a closer look in meeting these objectives. In Malaysia, the normal practice of defining maintenance requirements by most operators is subjected to visual assessment of highway condition (Harun, 2009). Generally, maintenance activities are initiated due to user complaints (Mohamed N. W., 2010). This type of maintenance practice leads to the inefficient method of spending the maintenance budget (Harun, 2009). Currently, the Malaysian government allocated RM2,591.3 million for road maintenance, compared with RM1,087.5 million six years ago, an increase of 138% since 2006. On average, the allocation has been increased by 27.6% annually. The increased in maintenance expenditure however related to the increase in maintenance activity cost and not for the betterment of maintenance works (Sharaf & Youssef, 2001). This has

highlighted the need to identify the best highway maintenance practice for LDP in delivering the best service at the right cost.

According to Al-Mansour et al (1993), major maintenance activities can be divided into two main categories, namely corrective maintenance and preventive maintenance. However, the methods that are being carried out by highway operators in Malaysia including LDP is more towards corrective maintenance compared to preventive maintenance (Harun, 2009). This situation requires a research done to search for new and inventive maintenance strategies that aligned with highway operators' requirements as providing quality and safe highways are the regulations imposed on them by the MHA.

The implementation of the highway maintenance management system is a major concerned. Polis Di Raja Malaysia (PDRM) concluded that 10.6% out of 450,000 of accidents happened between 2007 – 2011 on the highways were caused by the highway's condition (Ministry of Transport, 2014). According to MIROS (2013), 19 people died on Malaysian road on a daily basis and out of this figure, 10 of this road casualties are motorcyclist (Ministry of Transport, 2014). In Malaysia, 23 persons from every 100,000 people were killed on the road compared to 3 persons in Sweden, UK and Netherland (Ministry of Transport, 2014).

The World Bank (2013) also stated in their reports that poor highway maintenance and poor road design has contributed to the high number of accident cases occurred on highways. The commitment from the authority in spending large amount of money to provide safe road infrastructures for all categories of road users (including pedestrians

and cyclists) is debatable due to these upsetting figures. Managing maintenance activities in proper manner required the establishment of maintenance management system regardless of manual or computerized system due to its ability in managing operation and work properly. Harun (2009) stated that in Malaysia, only PLUS (Utara – Selatan Highway) uses proper highway maintenance management system, Total Expressway Maintenance Management System, known as TEMAN. Other highway operators such as LDP regarded highway maintenance system as very costly to be applied for their highways (Harun, 2009).

The sophistication of the techniques applied for road asset management should be appropriate to the level of roads, and of available skills (Asian Development Bank, 2015). On that note, although the highway maintenance already experiencing many changes in terms of computerized highway maintenance system (PLUS, 2014), electronic reporting and communication which includes the online reporting and WhatsApp's application (Lingkaran Trans Kota Sdn Bhd, 2014), the decision making still falls on the people (The Chartered Institution of Highways & Transportation, 2012). Therefore the effectiveness of maintenance management will also relates to the ability and skills of highway maintenance manager and personnel/workers (Mohamed N. W., 2010).

The study of the implementation of highway maintenance management from the perspectives of practitioners will also need to look at the good management practice available. The main objectives for maintenance management according to Essex Highway Maintenance Strategy (2008) are highway system safety, serviceability of highway network, highway system sustainability, and lastly the highway customer

services. Therefore, safe approaches to the operation and maintenance of highway infrastructure require coordination among government agencies and with all highway stakeholders such as highway patrons and society. The importance of highway maintenance needs to be highlighted at the broadest level of planning and prioritizing within a sector perspective, including the role of maintenance and its benefits to highway operators, users, and beneficiaries. At the same time, it is necessary to build a broader understanding of highway maintenance objectives and benefits, planning and prioritization processes, and an ability to explain these issues when necessary (Penang Monthly, 2014).

In summary, the highway maintenance management system effectiveness in LDP need to be study in relation to issues related to the implementation of highway maintenance management practices. The effectiveness of maintenance management system according to Ma´rquez, Leo´n, Ferna´ndez, Ma´rquez, & Campos (2009) can be measured by how satisfactory a function achieved it intended goals and normally examined in terms of quality of service provided, viewed from user's perspective. In maintenance field, inspection effectiveness, repair effectiveness and maintenance generated failures are frequently ignored in the outline of the system as well as during the operation of that system (Crocker, 1999). The issues of high number of accidents, congestion, flash floods and noise problem indicate that LDP has major concern to be addressed in relation to its practices in terms of the effectiveness of the system, policy/regulations, and communication flows.

1.4 Research Questions

Research questions of the current study will relate to the problem statement in exploring the effectiveness of the highway maintenance management system in Damansara –

Puchong Highway (LDP). By identifying and understanding the issues related to the research questions, it is easier to study and explain more clearly on the structure of the studies that have been provided. Since the study adopted the qualitative research method approach, research questions are formulated as follows:

1. How maintenance management system implemented in Lebuhraya Damansara-Puchong?
2. What policies and regulations has been applied to the planning and record management function of the Lebuhraya Damansara-Puchong maintenance management system? and
3. How the communication flows in the maintenance management systems in Lebuhraya Damansara-Puchong?

On that note, this research study will not only focus on the use of the theory but also the applications that will provide an advice to the management in respect of the maintenance of the existing system since there is a lack of awareness about the importance of such integrated maintenance system by highway operators plus the lack of requirement to impose such system by the authority.

1.5 Research Objectives

The aim of this study is to investigate the role played by maintenance highway management system adopted by the LDP. This research is also to identify the weaknesses in the implementation of maintenance management system in LDP. This is considering that the efficiency and security of movement of people and goods is also dependent on the highway system to function properly. Therefore, it requires effective

maintenance policies, which focuses on the use of the optimum used of invested resources (Manoj, Shariat, Abdullah, & Devkota, 2012). Considering the above view, three main objectives were set for the present research project. The objectives of the study are as follows.

1. To study and to evaluate the effectiveness of the highway maintenance management system in Lebuhraya Damansara-Puchong,
2. To propose the improvement of policies and regulations of highway maintenance management system for Lebuhraya Damansara-Puchong, and
3. To propose improvement in terms of communication management between Maintenance Management Department, which would contribute to the increase of the management effectiveness of highway maintenance in Lebuhraya Damansara-Puchong.

1.6 Significance of the Study

The academic literature on highway maintenance management system are extensive. However, this research seeks to uncover the phenomenon in maintenance management system of Lebuhraya Damansara – Puchong, the strategy and practices, critical success factors and problems with the application of maintenance management regarding the maintenance practices. Irrespective of all issues recorded in the past, there is scope for maintenance management system (MMS), because of few fundamental explanations; the technological push, the economic necessity and safety aspect. Optimizing the maintenance management system is so far the main method in finding the optimal parity between the benefits and expenses (Dekker, 1996). MMS included in the decision support system allows for quantitative and objective decision making. The decision made is a decision that can be defended which enables it to be very suitable for group

decision-making. It allows parties responsible / operators to assess from an economic standpoint, satisfaction and safety resulted from the decision made.

This study will provide a proper view of the highway maintenance management system contribution to the wellbeing of the nation and human being and recommend improvement in the implementation of the system to reduce unnecessary expenditure by government agencies, highway operators and highway patrons. Lastly, the findings of this study would also help provide a blueprint for successful application of highway maintenance management system and enhancement of continual improvement to strive for excellence in quality, services and business of highway operators.

1.7 Limitation of the study

It is imperative to note that the current study carried out to assess the maintenance management practice in Lebuhraya Damansara-Puchong. No studies have been done on the effectiveness of highway maintenance management system in LDP and its relationship with the safety of highway patrons. This company has given its consent for the study to be conducted. However, due to the sensitivity and confidentiality issues, certain part of the information will not be disclosed to avoid any leaks of information to other parties that will jeopardized the reputation of the researched company. In fact, it was not possible to compare problems faced by the LDP and maintenance companies because of sensitive and confidential issues.

In conclusion, this study focuses only on the Maintenance Management Department in this company. Despite these sensitive issues, the study should be able to recognize the weaknesses and vulnerabilities of the improvement process.

1.8 Organization of the Study

This thesis consists of five chapters. The *first chapter* undertakes the background of the study, the problem statement, research questions, research objectives, research interests and constraints that exist in the study. The purpose of this study is to discover in more detail how the implementation of highway maintenance management system and how to improve the practice in systematic way.

The *second chapter* will present selected literature on related topics to facilitate comprehensive analysis and understanding of the current research. The chapter will include the evolution of maintenance management systems; definitions of maintenance management; the maintenance management; the maintenance strategy selection and optimization; the maintenance management problems; inspection and monitoring activities; record documentation management in highway; the effectiveness in maintenance management, the policy and regulations; communications within maintenance management and the Action Research for highway maintenance management.

The *third chapter* explains the methodology used for this study. This study employs triangulation of literature review, interviews and observations to gather relevant data in the LDP. This chapter discusses the basic study design, data collection and management, reliability and validity of the data, data analysis strategies and ethical considerations. It also outlines the basic study design and the rationale of this study.

The *fourth chapter* explains the results of the research through interviews; observations and document review that will be generated in themes or categories or identified patterns.

The *fifth chapter* discusses the findings, illustrates conclusions based on the examination of study results and review of the literature in the field, discusses the implications of the study for practice, and makes recommendations for further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter presents a review of the literature on the relevant theories and research related to the study. The objective of the chapter is to provide a background and present the arrangement of the study. The review begins with an overview of the history of maintenance, followed by the significance of the study and the discussion on maintenance management in highway operation. Additionally, information about maintenance is explored and explained in detail. The summary of this chapter serves as a synopsis and an outline of the literature that provides context for this study.

According to Steward (2004), the purpose of conducting a literature review are as follows: first, it combines a variety of different results, and provides opportunities for researchers to understand the areas that they know most, and second, the literature review allows researchers to deal with questions that are directly and indirectly related to research. With the ability to summarize and synthesize related research to advance a particular topic further, literature review also provides a clearer understanding of the whole research process in great details. It also helps in the learning process and in terms of the information communicated (Denney & Tewksbury, 2012).

All journal articles or references are cited according to the key terms used in the study. In this literature review, all the journal articles are from 2018 and before.

2.2 The evolution of maintenance management systems

Highway maintenance management system is a tool to optimize the allocation of a minimum level of resources required to achieve the desired level of production. The level of spending on labor, equipment and materials vary according to the suitability of the budget (Manoj, Shariat, Abdullah, & Devkota, 2012).

Maintenance management systems have evolved from basic accounting command to performance measurement system that is more complex (Burde, 2008). In 1940s, maintenance was considered as unavoidable cost and the only maintenance practice was corrective maintenance (CM) (Murthy, Atrens, & Eccleston, 2002). According to Burde (2008), the following chronology explains that there are differences in the characteristics of the maintenance management system approach used by the road managers from 1950 to the present time.

1950s: Fiscal Approach

Highways in the United States known as the U.S. interstate highway system were built to connect people and drive commerce (Natale, 2014). Former United States (U.S.) president, Ronald Reagan, stated that "The state of our transportation system affects our commerce, our economy, and our future" (Weingroff, 2013). Under this approach, the maintenance management is made up of controlling annual expenditure and allocation of resources based on historical cost modified by the changes in the price of labor and the cost of materials. This approach is then no longer appropriate when the allocation of resources is mostly related to an increase in the price of labor and the increasingly complex design (Burde, 2008)

1960s: Systems Approach

This approach is used when the road managers began to realize the need to rationalize the maintenance operation based on four major functions of management, namely planning, organizing, implementation and controlling. The system provides information that will enable road managers to allocate resources based on needs. It introduces objective measurement for production, resources requirements, work completion and cost of maintenance work in highway maintenance management process (Burde 2008 & Leslie et al., 1968).

1970s: Integrated Approach

Maintenance moved into a more integrated approach starting in 1970s which involved both government and private sectors due to new costly acquisition of defense equipment (Murthy, Atrens, & Eccleston, 2002). The maintenance management system (MMS) was also introduced in 1970 and started operating worldwide in 1975 (Amos, 1984).

1980s: Quality Revolution

Maintenance management approach included the quality plans to - improve the public perception with regard to the quality of transportation provided by the agencies. During this time, the agencies related to the U.S. transportation were The Department of Transportation (DOT), Federal Highway Administration, Maritime Administration and Federal Aviation Administration (FAA) (ALLGOV, 2016). The agencies practiced the quality plan to ensure that subcontractors (Burde, 2008 & Miller 1989) performed works done according to maintenance standard as most of the maintenance works. Typical standard for maintenance of road assets as stated by (Roth, 2017) used the following measurements:

- The International Roughness Index (IRI) to measure the roughness of the road surface which affects vehicle operating cost;
- The absence of potholes and the control of cracks and rutting, which effects safety and pavement performance;
- The minimum amount of friction between tires and road surface for safety reasons;
- The maximum amount of siltation or other obstruction of the drainage system to avoid destruction of the road structure; and
- The retro reflexivity of road signs and markings for safety purposes.

Pennsylvania Department of Transportation (PennDOT), formed quality breakthrough teams to enhance work process and resolve operational problems identified by the management (Poister & Harris, 1997). It is regarded as one of the pioneers for Total Quality Management (TQM) approach for the public sector (Harris, 1990).

1990s: Performance-Based Road Maintenance

The conventional method of subcontracting the work of road maintenance focuses on payments to work materials used. In contrast, the method of performance-based contracts emphasized on the work done by the subcontractors. The road managers stated in advance on the minimum level of the maintenance for roads, bridges and so forth so that it should be accomplished by subcontractors without indicating what kind of material, how the work is done or the amount of material used or required. The minimum level of maintenance according to Roth (2017) were based on features such as pavement; roadside assets; drainage system; bridges; vegetation and aesthetics; traffic services; emergency response services; and snow and ice control. Within each

feature, there is a series of functional activities, i.e., pavement group includes activities such as pothole patching, base repair, pressure grouting, and asphalt resurfacing (Roth, 2017). Each asset has been assigned a tolerance level of acceptance, for example, potholes are not acceptable if bigger than 75 mm x 100 mm (3" x 4") and more than 25 mm (1") deep (Roth, 2017). Payment will be made to subcontractors based on their ability to comply with the agreed performance requirements.

The change of approach in the management of highway maintenance is largely due to technological change, global competition, growing security requirements, environmental awareness and changes in laws and regulations (Garg & Deshmukh, (2006); Burde, 2008; Velmurugan & Dhingra, 2015). The changes require a new method as a venture of better use of maintenance resources and at the same time gaining public acceptance of the highway management system practices.

2.3 Definition of Maintenance

The term maintenance is very well-defined in various published literatures in multiple fields and disciplines. The history of maintenance as stated by Shenoy & Bhadury (1998), in the era before the World War 2, where most people described the maintenance as one of the causes of the increase in production costs without increasing the value of their products. Therefore, at the time maintenance is done only to repair a component when it breaks in view of the fact that it was the most economical alternative (Schokry, 2010). In this first approach of maintenance no actions were taken neither to detect the start of a breakdown nor to prevent breakdowns, known as reactive maintenance (Alsyouf, 2007).

The Second World War had changed everything drastically. During and after the World War 2, the advancement in scientific and technological began due to the demand for production has increased, people began to develop a different maintenance where it is cheaper as preventive care (Murthy, Atrens, & Eccleston, 2002). The rebuilding of industry particularly from Japan and Germany has put an increased on downtime which leads to more and more mechanisation and automation (KPMG, 2015). This coupled with the recognition that maintenance is one of the functions in the production system (Schokry, 2010). Periodic, planned and preventive maintenance were introduced during this period (Kister & Hawkins, 2006; Fredriksson & Larsson, 2012; KPMG, 2015).

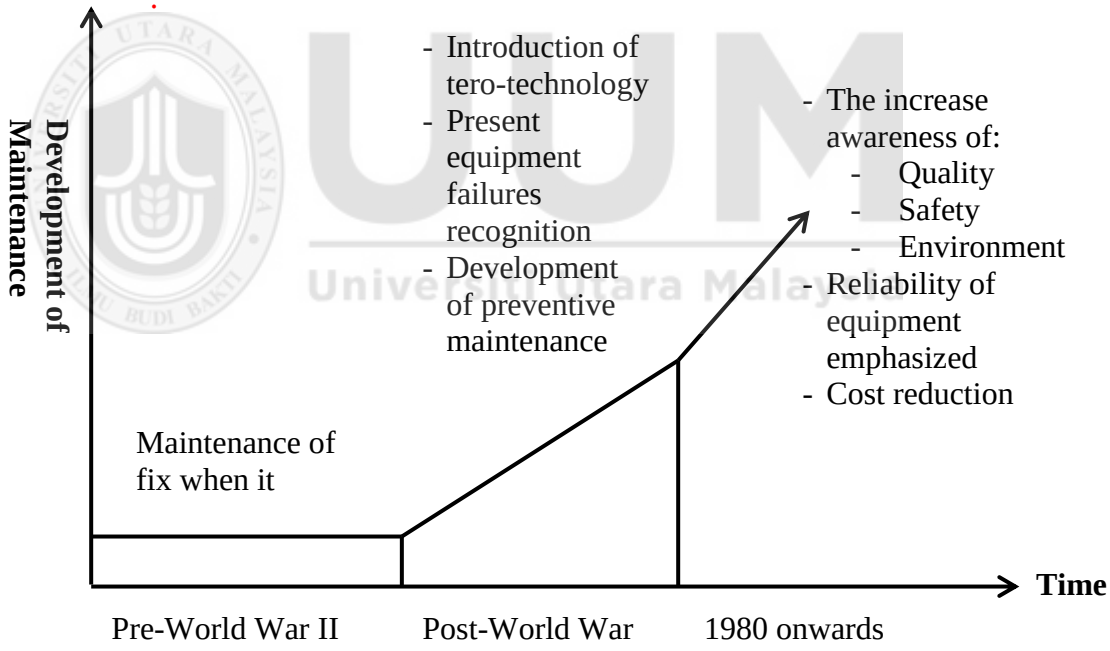


Figure 2.1
History of maintenance. The evolution of maintenance definition from Pre-World War II until recent
Source: Maintenance Resources Management: Adapting Materials Requirements Planning by Dinesh Shenoy and Bikash Bhadury, 1998

During 1980s, the rise of Japanese industry coupled with the low US industry's utilization and value-added activities (Division on Engineering and Physical Sciences,

1991) has increased the awareness of quality, safety and environment (Schokry, 2010). At the same time, maintenance also emphasized on cost reduction and reliability on equipment's with the introduction of the Reliability and Maintainability concept (Murthy, Atrens, & Eccleston, 2002). The development of "Centres of Excellence" from major players such as Shell, ICI, DuPont, and UKAEA has introduced CMMS, TPM, CAD, TQM which relates to maintenance management system (KPMG, 2015). Based on Figure 2.1, the definitions of the terms referred for maintenance in this paper are detailed in the following sections;

Maintenance was probably first defined in 1964 by the British Standard in 1964 or known as BS 3811:1964 in their '*Glossary of General Terms used in Maintenance Organization*' or '*Glossary of Maintenance Terminology'*, "Maintenance" defined as – "*work undertaken in order to keep or restore every facility to an acceptable standard*". After witnessing the changes in maintenance discipline, this definition now change to "*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*" (British Standard (3811), 1964)

According to the International Organization for Standardization (ISO), ISO 14224:2006, maintenance is regarded as the "*combination of technical and related administrative actions aimed to preserve an item or system in, or restore it to, a state in which it can perform its required function*". In addition, Dekker (1996) defined maintenance as "*all the technical and associated administrative functions intended to retain an item or system in, or restore it to, a state in which it can perform its required functions"*. Geraerds (1985) referred maintenance as *"all activities aimed at keeping*

an item in or restoring it to, the physical state considered necessary for the fulfilment of its production function". Dhillon (2002) defined maintenance as the required actions performed in keeping or restoring a system or part or equipment to its original functionality state. In general, most scholars in the maintenance management field to some extent agreed on the exact definition of maintenance as "*set of activities required to keep physical assets in the desired operating condition*" (Pintelon & Parodi-Herz, 2008)

In addition to the maintenance evolution, the maintenance practice has evolved from engineering practice to asset management (KPMG, 2015).

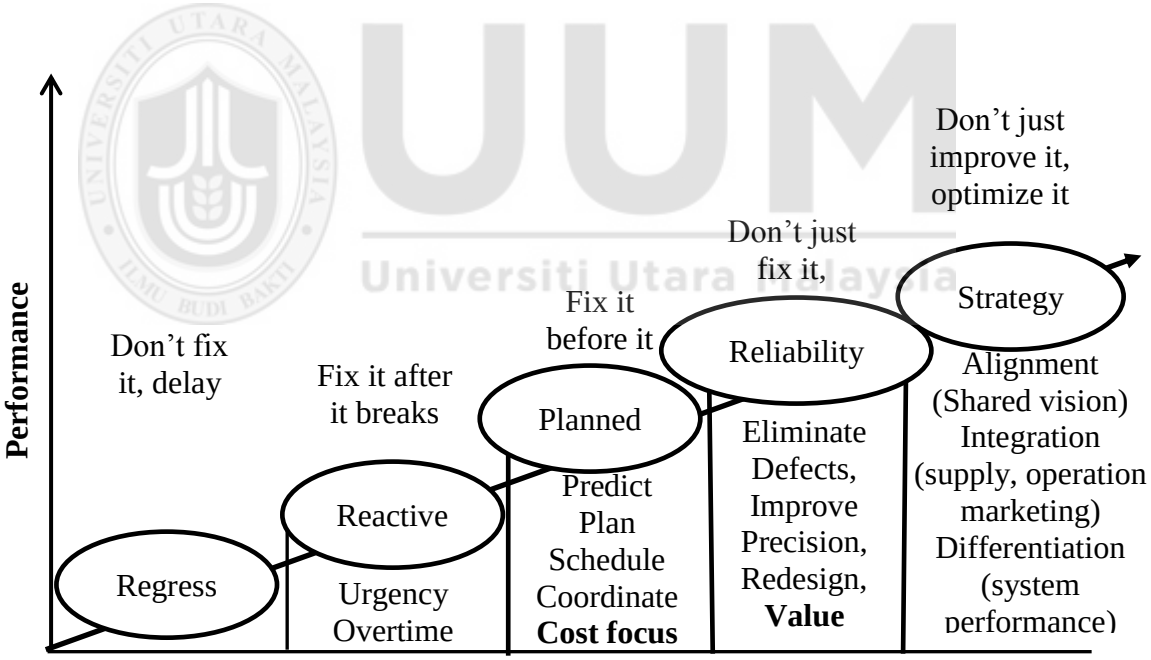


Figure 2.2
DuPont Stable Domain Model
Source: Macro-economic report with regards to the MRO market in Europe by KPMG, 2015

Based on Figure 2.2, maintenance related organization need to value the good engineering and maintenance practice; staff knowledge and also proven technologies, systems and services (KPMG, 2015).

Maintenance encompassed all facets of diciplines, such as manufacturing, information technology, medicine, law, engineering, accounting, human resource, buildings, infrastructures and transportation (Business Dictionary, 2015). Therefore, the definition of maintenance is identical between these fields. In transportation systems, especially in highway infrastructures such as pavements, structures, bridges and flyovers, drainage system and culverts, signage and other facilities such as lights and rest areas are intended to guarantee effective operation all through the anticipated service life. This maintenance function in consistence with the given security prerequisites identified with the risk to the staff, the public and the environment.

Roads Liaison Group in "*Code of Practice for Highway Maintenance Management*" publication (2005) stated that the function of maintenance activities can be divided into; 1) reactive maintenance (that consist of the work of inspections, complaints or emergencies); 2) routine maintenance (in reference to regular consistent schedule maintenance); 3) programmed maintenance (activities of resurfacing, reconditioning or reconstruction to a planned schedule); 4) regulatory inspection and maintenance of regulating other activities; and 5) weather and other emergencies that provide emergency response.

American Society of Civil Engineers (ASCE), divided maintenance into two subdivisions, namely physical maintenance and traffic service. According to ASCE, the physical maintenance is *"the preservation and maintenance of a highway, including all of its components, in as almost as practicable its original, as-constructed condition or its consequently improved condition"*. Meanwhile, the traffic services are defined as *"the operation of a highway facility and services incidental thereto, to provide safe,*

convenient, and economical highway transportation" (ASCE, 1971). Furthermore, The Maintenance Engineering Society of Australia, also known as MESA, give a standard maintenance definition as *"the engineering decisions and associated actions necessary and sufficient for the optimisation of specified capabilities"*. MESA further added that the *"capability"* stated in the definition is regarded to *"the ability to perform a specific action within a range of performance levels"*.

Performing an appropriate maintenance require techniques, technical skills, methods to use assets such as equipment, vehicles, equipment, machinery, materials, plants and systems in the right way (Velmurugan & Dhingra, 2015). The main objectives for maintenance are to ensure system function, system life and system safety (Khaira & Jain, 2012; Velmurugan & Dhingra, 2015). Furthermore, Moubray, (2003), stated that maintenance's key objective is to "*rapidly restore the equipment to its operational readiness state using available resources*".

Inadequately maintenained assets could lead to random breakdown that can affect production or service (Khaira & Jain, 2012; Velmurugan & Dhingra, 2015). This can ultimately resulted into under utilization of assets consequently lower productivity (Khaira & Jain, 2012). Realizing this, Simeu-Abazi and Sassine (2001) highlighted that the main purpose of maintenance engineering is to reduce the harmful effects of breakdown in order to enhance performance and dependability level. Maintenance management is the key factor to achieve this objective.

The central aim of maintenance management is "total asset life cycle optimization" i.e., maximization of availability and the reliability of assets in attaining the operational or

business goals (Harper, 1996; Garg & Deshmukh, 2006; Ma´rquez, Leo´n, Ferna´ndez, Ma´rquez, & Campos, 2009; Mahdi, Hossein, & Taha, 2010). On that note, the maintenance not only need to deal with the issues of technology but also a mix of issues pertaining technology, management, business and operation strategies (Pintelon & Parodi-Herz, 2008). According to Schokry (2010), maximizing the productivity at the lowest cost possible without compromising the quality and the safety standard is the main objective of maintenance. Therefore, the maintenance committment is constantly about optimizing productivity, minimizing cost and maximizing quality and safety of product, system or infrastructure.

2.4 Maintenance management

In general, the maintenance management is equivalent to terms for example: maintenance models; maintenance methods; maintenance techniques; maintenance systems; maintenance types; maintenance philosophies; and maintenance strategies regularly used by many scholars to describe the same concept of maintenance (Garg & Deshmukh, 2006; Fraser, Hvolby, & Tseng, 2015). In this regard, the current study will utilize the term "model/s" to describe maintenance methods; maintenance techniques; maintenance systems; maintenance types; maintenance philosophies; and maintenance strategies.

Industrial companies applied three main maintenance models, Corrective Maintenance (CM) where no maintenance procedures are perform until a breakdown occurs.; Preventive Maintenance (PM) that focused on implementing cyclical preventive inspection and preventive maintenance to reduce unplanned breakdown (cmmsPro, 2008) ; and lastly, Condition Based Maintenance (CBM) which technical diagnostics

methods were use such as vibration monitoring & analysis to know the actual condition of machine and equipment (Žilka, 2014).

A total of 48 various maintenance models were discussed in 8 previous review done by Noble (1984), Stoneham (1998), Sherwin (2000), Mostafa (2004), Garg & Deshmukh (2006), Schokry (2010), Fernández & Márquez (2012), and UK Essay (2013). As shown in Table 2.1, these eight significant reviews of maintenance model are selected in order to identify which maintenanc model/s gained more acceptance by academician and practicioners compared to others.

Table 2.1
Selected maintenance model review

Author (s)	Maintenance Models
David F. Noble, *"Forces of Production: A Social History of Industrial Automation"* (1984)	▪ Routine of Cyclic Maintenance; ▪ Planned Maintenance; ▪ Planned Inspection; ▪ Emergency of Breakdown Maintenance; and ▪ Minimum Maintenance.
Derek Stoneham, *"Management and Technology Handbook (1st Edition)"* (1998)	▪ Breakdown Maintenance; ▪ Total Productive Maintenance (TPM); ▪ Condition-Based Maintenance (CBM) ▪ Reliability-Centered Maintenance (RCM); ▪ Run-To-Destruction; ▪ Pre-Planned Maintenance; and ▪ Campaign maintenance.
David Sherwin,	▪ Basic Terotechnology Model; ▪ Advanced Terotechnological Model;

Table 2.1 (continued)

Author (s)	Maintenance Models
"A review of overall models for maintenance management" (2000)	▪ Total Quality Maintenance (TQMain); ▪ The Eindhoven University of Technology (EUT) Model; ▪ RCM; ▪ TPM; and ▪ Kelly's philosophy.
Ismail Samir Mostafa, "*Implementation of proactive maintenance in the. Egyptian Glass Company"* (2004)	▪ Scheduled Maintenance; ▪ CBM; ▪ Condition Monitoring; ▪ RCM; ▪ TPM; ▪ IJQRM; ▪ TQMain; ▪ Predictive Condition Monitoring; ▪ Maintenance Management Metric; ▪ Operating Maintenance Training and Administration; ▪ Run-To-Failure (RTF); ▪ Corrective Maintenance (CM); ▪ Planned Maintenance; ▪ Preventive Maintenance (PM); ▪ Equipment Asset Management; ▪ Preactive Maintenance; ▪ Productive Reliability; ▪ Proactive Maintenance; and ▪ Profit centre maintenance.
Amik Garg and S.G. Deshmukh *"Maintenance management: literature review and directions"* (2006)	▪ PM; ▪ CBM; ▪ TPM; ▪ RCM; ▪ Computerized Maintenance Management System (CMMS); ▪ Predictive Maintenance (PDM); ▪ Outsourcing;

Table 2.1 (continued)

Author (s)	Maintenance Models
	▪ Effectiveness-centered Maintenance; ▪ Strategic maintenance management; and ▪ Risk based maintenance.
Dr. Abed Schokry, *"Introduction to Maintenance"* (2010)	▪ RTF; ▪ PM; ▪ CM; ▪ Improvement Maintenance (IM); and ▪ PDM.
J. F. Gómez Fernández and A. Crespo Márquez *"Maintenance Management in Network Utilities (2012)*	▪ Techniques dealing with economic or financial aspects of maintenance; ▪ CMMS; ▪ Techniques about human resources management; ▪ Application of operations research or management sciences; ▪ Life cycle analysis; ▪ TPM; ▪ RCM; ▪ Simulation, inventories models; ▪ Reliability theory; and ▪ Expert system.
Essay UK *"The British Standard 3811"* (2013)	▪ CM; ▪ PM; ▪ Schedule Maintenance; ▪ Emergency Maintenance; and ▪ CBM.

Based on Table 2.1, the most discussed maintenance models were Preventive Maintenance (PM); Corrective Maintenance (CM), Condition-Based Maintenance (CBM); Total Productive Maintenance (TPM); and Reliability-Centred Maintenance (RCM) (Fraser, Hvolby, & Tseng, 2015). These maintenance strategies were widely adopted in maintenance research (Gandhare & Akarte, 2012).

Smith (2012) stated that The Chartered Institution of Highways and Transportation (CIHT) concluded that the highway maintenance model can be divided into the following categories;

a. Reactive Maintenance – the maintenance work performed based on complaints, inspection or reported emergencies regarding highway conditions such as clearing the traffic accidents, repairing damage resulted from accidents, filling potholes, etc.;

b. Routine Maintenance – the maintenance work based on systematic or cyclic activities inclusive of cleaning the drain and gutter, grass cutting, clearing vegetation, weed spraying, road sweeping, signboards washing plus the planted areas and trees maintenance;

c. Programmed Maintenance – the maintenance work that are being performed based on the approved planned schedule. The work listed under this type of maintenance such as resurfacing, road drainage improvement, road line painting, surface dressing, kerbing, strengthening or reconstruction of roads or walkways;

d. Winter Services – maintenance works that includes salting and clearance of ice and snow in making sure that the highway network is in functioning condition and safe to use;

e. Emergency Response – activities carried in response of other emergencies that is affecting the highway network and responding to the weather condition; and

f. Regulating and Inspecting - activities performed in relation to the activities of others within the road network.

However, Al-Mansour, Sinha, & Thomas, (1993); Gandhare & Akarte, (2012); Velmurugan & Dhingra, (2015) stated that the two main approaches of maintenance were Corrective Maintenance (CM) and Preventive Maintenance (PM). CM and PM are classified as Planned Maintenance whereas Unplanned Maintenance is classified for Emergency Maintenance only (Institute of Maintenance Management Education, 2013). CM, also known as breakdown maintenance, is regarded as the earliest model in the industry by the researchers where the maintenance is done after system failure meanwhile the PM is performed before system failure (Zaim, Turkyılmaz, Acar, Al-Turki, & Demirel, 2013). Wang, Chu, & Wu (2007) further explained that PM in practice is subdivided into periodic maintenance and predictive maintenance.

Periodic maintenance, also known as "time-based maintenance", is performed periodically to prevent sudden breakdown (Wang, Chu, & Wu, 2007). Whereas in predictive maintenance, also known as "condition-based maintenance", the maintenance activities performed are grounded on inputs obtained from dedicated measurement instruments such as ultrasonic testing, techniques of monitoring, sensor systems and vibration monitoring (Wang, Chu, & Wu, 2007). Conversely, the current practices of most highway operators in Malaysia gives more focus on the corrective maintenance, while preventive maintenance has been given a minor attention due to the lack of awareness and also regulation enforcement (Harun, 2009).

2.5 Maintenance strategy - Selection and Optimization

In published literatures by many academicians and professional, they give their opinion on various suitable maintenance management models that are best suited for their organization. General maintenance management models such as TPM, CBM, CM, PM

and PDM were evaluated to suite a particular asset/system in any organization as well as any industry.

Pintelon & Parodi-Herz (2008) stated that maintenance was initially considered as one component in the production process that cannot be avoided; it is basically unavoidable. Repair and replacement are carried out when necessary, and questions regarding their optimization has never been highlighted. Later, maintenance was related to technological issue, including not only optimizing technical maintenance solutions, but it also engaging the attention of the maintenance organization. Then, a function-scale maintenance, rather than a sub-function of production. Understandably, the current maintenance management is becoming a complex affair, which includes technical and management science, while still requiring the flexibility to cope with a dynamic business environment. Top management recognizes that taking a good idea from the maintenance strategy together with the implementation of various strategies that can really give the impression of a large fiscal impact (Pintelon L. , 2010).

According to the study by Ansell, Holmes, Evans, Pasquire and Price (2009), the best maintenance strategy to be selected depends on several factors such as the maintenance approach chosen must be able to resolve the problem, within the budget and have minimal distruption to the public. To deal with the maintenance management model selection and optimization of the approach, a few scholars have already discussed the decision support system (DSS) model that will help to implement appropriate maintenance methods to improve operational performance and optimize the cost / maintenance operations i.e., maintenance decision support system (Lin, Ambani, & Jun, 2009; Mahdi, Hossein, & Taha, 2010).

Maintenance optimization is taken as a mathematical discipline in operations research and the maintenance manager can see it as an effective instrument for the selection and optimization of maintenance strategy (Garg & Deshmukh, 2006). But now its impact on decision-making in the maintenance organization are still yet to be seen (Dekker, 1996).

Generally, optimization of maintenance is a combinatorial optimization problem because the maintenance plan consists of various measures of maintenance (Miyamoto, Kawamura, & Nakamura, 2000). For most countries including Malaysia, there is a continuous increment in consciousness of the need to improve utilization of the road sector budget in maintaining the current system. In this regard, the ideal maintenance practices are required thus, activities to enhance both the viability ('doing the right work') and productivity ('at the best value') of road maintenance operations have been sought (Garg & Deshmukh, 2006).

In the last two decades, a number of approaches, such as expert systems, model analysis, and system dynamics has been used to formulate planning and scheduling of highway maintenance (Fallah, Rahmandad, Triantis, & De-la-garza, 2010).

“Expert Systems” have become more prominent for pavement management in both highway network and airport systems (Ismail, Ismail, & Atiq, 2009). One of the advantages of expert systems is *“their ability to involve expert knowledge and subjective human reasoning”* (Chang Albitres, Krugler, & Smith, 2005) which are normally too complicated to be integrated into mathematical models. However, the lack

of agreement among experts in the field and inadequate approach to represent domain knowledge remains a major weakness (Ismail, Ismail, & Atiq, 2009).

Analytical modeling is the second approach for the budget planning and work scheduling for highway maintenance. This approach is to formulate the problem as a decision-making model in which the objective function (for example, reduce the overall cost) and constraints (for example, the minimum acceptable condition) is represented by a mathematical expression variable results (Gendreau & Soriano, 1998).

The third approach is the utilization of System Dynamics (SD). SD is a proper application approach for this setting because it reflects the dynamic state of the roads and to record the feedback loops that decides the physical deterioration of the road (Fallah et al, 2010).

Recently, researchers have concluded that the design and implementation of programming requires analysis of optimization which involves the consideration of various objectives (Fwa, Chan, & Hoque, 2000). Multi-objective optimization of various alternative decisions in road construction were also established as well as alternative answers to the objective matrix, where the ratio is used. This methodology is related to vast issues of scenarios and objectives to highlight the idea of multi-objective optimization to streamline the best alternatives for the road design (Brauers, Zavadskas, Peldschus, & Turskis, 2008).

The critical issues in discussing the optimization of maintenance model are related to the identified key indicators for measuring the efficiency of maintenance, which are

viability, reliability, accessibility, safety, and maintainability (Qingfeng, L.Wenbin, Z.Xin, Y.Jianfeng, & Y.Quingbin, 2011). According to Pintelon & Parodi-Herz (2008), the concept of an "optimized" maintenance program proposed a combination of maintenance engagements and policies. Optimized maintenance can also relates to E-maintenance due to the development of internet and telecommunication technology that contributed to advanced maintenance knowledge (Fernández & Márquez, 2012)

These optimization models are not limited to the above as many other models are being develop and practice all over the world as the optimization models are originally being introduced to assist managers and practitioners in production related industry. Therefore, further researches are needed in covering this area and identifying the best method in the Malaysia context especially in term of highway maintenance management as the maintenance practices in production are very similar with the practices in highway maintenance.

2.6 Maintenance management problem

Malaysian highway is under the supervision of Highway Authority of Malaysia (MHA). However, the highway operators are the parties responsible for maintaining over 2,232 kilometers of highways. These infrastructure providers always have limitation in terms of the available resources. As a result, highway operators or more precise, the highway maintenance department face problems in their efforts to optimize the allocation of resources between different competing objectives in terms of increasing capacity, maintaining and improving highway safety (Chassiakos, Panagolia, & Theodorakopoulos, 2005). Lack of effective maintenance management can be seen

through financial performance of the company and lead to safety hazard and loss of human lives (Sinha, 2015).

In explaining the highway maintenance management system, first we need to understand the difference between highway maintenance management and highway maintenance management system. The overall purpose of highway maintenance is to fix the defect and to preserve the highway assets and structures to its original condition. On the other hand, the highway maintenance management system is a tool to optimize the allocation of a minimum level of resources required to achieve the desired level of production at the level of spending of labor, equipment and materials which vary according to the suitability of the budget (Manoj, Shariat, Abdullah, & Devkota, 2012).

Miles & Syagga (1987) concluded that there are three main problems associated with maintenance management, insufficient financial; poor design; and bad management. The first problem of maintenance management is always being associated with financial. The lower appreciation for maintenance, coupled with increasing maintenance cost has made the maintenance task becomes increasingly difficult (Sharaf & Youssef, 2001). Highway requirement for maintenance keep increasing every year due to the assets deterioration factor and at the same time the fund allocated for this function are not adequate to satisfy all maintenance activity. Although, the money were increased for maintenance function, it is related to the increase of maintenance activity cost and not for the betterment of maintenance works (Sharaf & Youssef, 2001).

The second drawback correlated to highway maintenance is poor design (Miles & Syagga, 1987). Each year many accidents happened as a result of improperly

maintained highway and poor design of roads (The World Bank, 2013). According to The Levin Firm (2014), some of the more common accident-causing conditions that resulted from negligent road maintenance or design include the following:

- Potholes.
- Lack of signage.
- Poor road drainage system.
- Faulty traffic signals.
- Faded or missing lane markers.
- Burned-out streetlights.
- Uneven pavement.
- Debris on road.
- Poorly maintained bridges.
- Lack of warning regarding hazards.

The last problematic issues with regard for highway maintenance are related to bad management (Miles & Syagga, 1987). Highway maintenance management has experienced many aspects of changes such as computerized highway maintenance system (PLUS, 2014) and electronic reporting and communication (Lingkaran Trans Kota Sdn Bhd, 2014). However, the decision made for highway maintenance function is still at heart and this has not change by any means (The Chartered Institution of Highways & Transportation, 2012).

The effectiveness of maintenance management is related to the highway maintenance manager and the ability of the maintenance personnel / workers (Mohamed N. W., 2010). Simo˜es, Gomes, & Yasin (2011) further added that qualified maintenance

personnels are the factor for any effective maintenance system which relates to system's performance (Parida A. , Kumar, Galar, & Stenström, 2015; Salonen & Deleryd, 2011).

Effectiveness of maintenance system also relates to aligning the correct resources to the task (Tebow, 2009). Meanwhile according to Parida & Kumar (2006), the effectiveness of maintenance systems can be measured by internal effectiveness (reliability and efficiency of resource allocation, productivity, skill and competencies) and external effectiveness (customer satisfaction which translate to the growth profit). Ineffectiveness of maintenance management as discussed earlier will not only affect the financial performance of the company but also leads to safety hazards and loss of human lives (Sinha, 2015).

In 2016, Malaysia averaged at an estimated of 25 deaths per 100,000 people from road accidents (WOB Partner Content, 2017). According to WOB Partner Content (2017), Malaysia is ranked as having the 18th highest number of road traffic deaths in the world and the second highest in South East Asia. In developed country such as Sweden, the authority spends large amount of money to provide safe road infrastructures for all categories of road users (including pedestrians and cyclists) to the extent that even if accident do happen, it will not be resulted in serious injury or death. The system they use is known as The Safe System Approach (Nadeson, 2015). Based on this figure, it can be concluded that Malaysian roads, including the highways, need to adopt a better approach in designing their structures and facilities. At the moment, the Director General of Malaysian Highway Authority, YBhg, Dato' Ir Hj. Ismail Bin Md. Salleh, regards Malaysian highway engineers as only textbook engineers that still need lots of help to broaden their mind regarding highway designing matters. (Pfordten, 2014).

2.7 Inspection and Monitoring Activities

Inspection:

Systematic and proper maintenance work are very important in assisting to maintain the integrity of the structure and function of the road. A precise maintenance practice, inspection and reporting system will safeguard the successful highway maintenance management in terms of future work planning, personnel and budgeting. Inspection in the highway involves conducting inspection prior, during and after maintenance work. The reason of this inspection is to manage and control the quality of the maintenance work, to reduce the substandard work and to reduce re-work and waste. (Bolton Council, 2013). In LDP, inspection of highway assets and structures is done annually, quarterly and on ad-hoc basis. The inspection are done via driven inspection and walking inspection (Lingkaran Trans Kota Sdn Bhd, 2014).

Generally, the inspector does not have sufficient planning support to prevent any inefficient inspection or overlook undetected defects (Gordon, Akinci, & Jr, 2007). Maintenance strategy based on inspection activities is now considered to be an effective tool. Most of these methods rely on quantitative data from the inspection, rather than the qualitative and subjective data. According to Sheils, O'Connor, Breysse, Schoefs, & Yotte, (2010) each stage of the examination or inspection is being conducted for different purposes with different parameters, used to represent each procedure in the maintenance management model. During the inspection, the conformance of the merchandise based on the documentation is checked according to written instructions. This may also be in the form of review of the quality documentation compiled and supplied by the subcontractor or by the supplier.

The benefits and advantages of inspection activities are enabling assemblers to take responsibility for the quality of their work, reducing production and 'Shelf Wait Time', improving quality ratios and first-time acceptance throughout all manufacturing areas that use visual in-process inspection and providing an instrument for cross training in different manufacturing areas.

Inspection activities are generally dependent on the use of paper-based forms to document the results of the examination. However, with the recent advances in computer technology, information is gathered by the system which helps inspectors during inspections. Computing system is useful and practical in carrying out inspection activities which are often designed to suit a construction process; in other words, it serves as an aid in inspection activities.

Any specific inspection tasks will be carried out in the context of a knowledge-based and physical examination itself (Sunkpho, Garrett, & McNeil, 2005). Unfortunately, the development of such support systems is difficult and time consuming. For the record, the inspection carried out will not tell the operator why the error occurred and subsequently, no corrective actions can be taken to overcome the error. Thus, in order to address these issues, the implementation of preventive measures should be made at the operational level which will ensure that the desired work quality is achieved.

Monitoring:

Skyttner (2002) highlighted that monitoring activity involves the possibility of monitoring and calculating the consequences of the pattern and if necessary to forward early warnings; this must be carefully considered as a key of the survival tool. The main

reason of monitoring is to verify whether the activities of the object and its environment follow an expected pattern so that any unpredictable pattern can be identified at an early stage.

Maintenance activities monitoring is an independent verification that is provided by the maintenance staff in ensuring that the work has been completely done according to the work process and procedure. The emphasis of monitoring procedures can be one of the following: tools, work procedures, manpower and completed work quality.

Improving work quality and work completion in a short period of time has always been the issue for many industries. This issue is critical due to the difference in practice with different problem to solve.

Many ways have been identified to solve this issue. One of them is to build a reliable model that can assist in monitoring other aspects of the process. Other examples consist of utilizing inadequate information available to analyze and develop related model by using the basic principles, as well as to optimize the operating conditions, monitor and control the online system and maintain its performance.

This procedure is not just to monitor the development work. However, as indicated by Wetzstein, Karastoyanova, Kopp, Leymann and Zwink (2010), it is also to monitor the business processes across the organizational boundaries to facilitate the detection process and the process of valuation metrics.

Generally, the process of monitoring activity is conducted by a monitoring agent. These monitoring tasks are assumed as composite and refer to some measure of progress. According to other researchers, by creating a monitoring agent, it is intended to improve the quality of work of the operator. It is also to provide more space for the supervisory agent. This will indirectly provide the information in the form of measurement data. To regulate the constraints in the monitoring process, several agents are appointed to help smooth the process. It can also perform tasks cooperatively in which this monitoring approach will be illustrated with test scenarios using the measurement data of the industrial process (Pirttioja, Pakonen, Seilonen, Halme, & Koskinen, 2007).

Dickinson and Villeval (2008) cited that there is evidence which shows that high level of intensive work will occur when monitoring is carried out not during the normal inspection schedule. Meanwhile, according to Ge, Song and Gao (2013), the monitoring process that has been put into practice has become a key technology initiative for effective monitoring of industrial processes involving safety, quality, and operational efficiency.

2.8 Records and documentation management in highway

The records and the documentations in highway maintenance are very important. Related maintenance personnel have to know the primary method for documenting maintenance activities (Federal Highway Administration, 2013). Highway maintenance manager need to take an active role in creating, receiving, maintaining, and preserving adequate and proper documentation (in all formats, including paper and electronic) of their maintenance activities (Federal Highway Administration, 2013).

The maintenance documentation approach is to highlight and report the maintenance activities to top management or stakeholders. Documentation and records used in maintenance activities will be re-examine and analyze. According to the U.S Department of Transportation (2015), the highway maintenance project administration requires a substantial amount of documentation.

The process of managing record and information has long been introduced in organizations to ensure that all processes are in good working order. However, in the construction industry traditional methods are still being applied. With the emergence of computer technology, all existing work processes have been streamlined and are now used by most organizations in the construction industry. There is an increase in awareness among organizations towards the need to record information. Nevertheless, Craig and Sommerville (2007) mentioned that the adjustments and work processes in managing this information is increasingly becoming complicated, at the same time workers have not mastered the skills in how information is collected, stored and recorded.

It is important for workers to know how to manage information. Knowledge in managing records and information about the construction process is often based on the work done by an organization. It is also considered as the basis of creating, storing, and retrieving that information.

The information management process depends on the amount of information received and produced. The information received should be recorded to facilitate the analysis process for issuing a work report or analysis report. Today, there are a few companies

that have taken advantage of the situation by changing their performance and work process. Understanding of the system of record management should be emphasized by all companies (Craig & Sommerville, 2007; Gregory, 2005). In information management and analysis process, each organization must have the ability to measure any information to ensure the effective collection of such information. The performance of a piece of information can only be evaluated or measured with the information that is obtained in accordance with a predetermined benchmark.

Among all the definitions of information, Detlor (2010) explained about information as related to the management of the control of the information that is created, organized, collected, distributed, stored, and used as a way to promote something; it also to provide efficient and fast access to information which can be used by all people and organizations. In past studies, it was proposed that information is stored in a centralized database (Duranti, 1999). A centralize database will achieve the following:

1. Encourage all available information to be recorded. This is because it can be stored and re-used as evidence if it is needed.
2. Establish and operate a business in a centralized database.
3. Train talent in discharging their responsibilities in handling information.

It is important to remember that from a business point of view, management of record and information is crucial and thus, should be managed properly. The setting up of a centralized data system brings with it several advantages such as:

1. Information Processes in information management will grow smoothly and effectively.
2. Accelerated solution of the problem.

3. Confidence in getting quality information.
4. Information received better and steadier.
5. Reduction in the administrative burden where all the computing are done.
6. Provide better performance and more effective analysis.

A good record management will increase the level of confidence for organizations in making sure all the information is received and managed well. Duranti (1999) indicated that some organizations have taken the following steps to ensure that all information is safe and secure:

1. Reorganize the records in accordance with a predetermined format.
2. Verify all records.
3. Apply special characteristics to ensure that the information is not modified.
4. Restrict access to the information.
5. Record travel / out privileges of users who use the information.
6. Ensure records are not destroyed and copied without the written consent.

The difference between records and data information is that the former is defined as information recorded and stored in various media. While others said that the data also means representation of facts, figures and concepts that are easily processed and analyzed (McDonald, 2010; McLeod, Childs, & Heaford, 2007).

The difficulty of establishing a good report on information management has been studied. The list of the difficulties is as follows (Boisdeffre, 2006)

1. Lack of information being created.
2. Lost tracking.

3. Poorly managed.
4. Incorrect classified.
5. Poorly preserved.
6. Incomplete.
7. Disorganized.

The other concern in preparing a good report is the establishments and organizations structures in place and the crossing point between records management and archiving. In some cases, the records are archived and remain in a record management system without any analysis done. This makes it worthless since the information is not made available to the public.

Documentation is one of the crucial parts for the administration of highway projects where substantial and meaningful records are required. Conventionally, extensive paper-based documentation methods were used where substantial amount of capital and time spent to develop; analyze and store the documentation are needed**.** However, with the rapid advancement in communication field, easy and on the go information access, plus workforce with knowledge in information technology, this method will become outdated and obsolete very quickly. Based on preliminary study, documentation for highway maintenance project in LDP are now based on electronic correspondences, secured record sharing, adaptation control, cell phones and web facilitating and information authentic recovery framework.

All matters pertaining the highway maintenance management will eventually relate back to the people using it. The infrastructures made available to make people's life

easier. If any facilities are deemed to be unadded value to any individual, then that item will somehow get obsolete and perish. Although, highway will not become forgotten item in the foreseeable future, unsatisfied users will make issues out of it and it can become the next big thing that will affect the government. On that note addressing issues pertaining to highway is very crucial for highway operators and subsequently for the Malaysian government.

2.9 Effectiveness in maintenance management

Maintenance generally relates to occurrences that are normally uncertain, and irregular in nature. The process relatively reliant on human proficiency and abilities and it is quite dependent on human expertise and are typically beyond automation (Sinha, 2015). Without proper and systematic framework, the maintenance function will be difficult to be carried out effectively (Agbejule & Jokipii, 2009).

Effectiveness of maintenance system can be resulted from an optimization of maintenance planning and scheduling (Ma´rquez, Leo´n, Ferna´ndez, Ma´rquez, & Campos, 2009). According to Jonsson (1997), the maintenance management was the combination of components such as strategy, human factor, organization, support mechanism, tools and techniques. On that note, all these five aspects need to be linked together to be effective (Sharma, 2013). In addition, the effectiveness of maintenance system has long been associated with the cause of effect diagram (the fishbone) that bring the elements of manpower, material, method and machine (Williams, 2004); considerations, data, policies, techniques and tools (Ma´rquez, 2007). Each element determines the effectiveness of maintenance function (Irajpour, Fallahian-Najafabadi, Mahbod, & Karimi, 2014).

Maintenance authors as Ogaji & Singh (2003), Wang, Golnaraghi and Ismail (2004), Chang (2005), Edwin and Chaturvedi (2011) and other scholars, have utilized artificial intelligence techniques as fuzzy sets, neural networks, etc. for maintenance modeling and decision making. In addition, the models may need high human expertise, in order to be effective (Sinha, 2015).

There are many elements of effective maintenance management whose effectiveness is the key to the overall success of the maintenance practices. The first element is the maintenance policy which is essential for the continuity of operations and a clear understanding of the maintenance management program, regardless of the size of a maintenance organization. Usually, maintenance organizations have manuals containing items such as policies, programs, objectives, responsibilities, and authorities for all levels of supervision, reporting requirements, useful methods and techniques, and performance measurement indices.

A maintenance policy is normally the decision trigger (Rijsdijk & Tinga, 2016). Lacking such documentation, i.e., a policy manual will have a great effect on the effectiveness of maintenance management program. Therefore, a policy document containing all essential policy information must be developed. Söderholm, Holmgren and Klefsjö (2007) cited that maintenance standard, guidelines, criteria of European Quality Award and decision diagram were the tools identified to increase maintenance effectiveness. In addition, many researchers concluded that most problems associated with system reliability, availibility and maintainability can be solved by implementing the optimal maintenance policy (Ding, Kamaruddin, & Azid, 2014). Currently, maintenance policy assessments like the reliability centred maintenance process

(Moubray, 2004) dominantly rely on expert judgement (Ingvaldsen, Holtskog, & Ringen, 2013).

The second element identified that plays a very important role in the effectiveness of maintenance management is material control. Past experience indicates that, on average, material costs account for approximately 30 to 40% of total direct maintenance costs (Markow, 2011). Efficient utilization of personnel depends largely on effectiveness in material coordination. Material issues can prompt false starts, excessive travelling time, delays, unmet due dates, and so on. Steps for example job planning, coordinating with purchasing, coordinating with stores, coordination of issuance of materials, and reviewing the completed job can help reduce material related problems.

The third element is work order system. A work order authorizes and directs an individual or a group to perform a given task. A well-defined work order system should cover all the maintenance jobs requested and accomplished, whether repetitive or one-time jobs. In routine operation such as maintenance field, work system tends to be formalized and standardized (Ingvaldsen, Holtskog, & Ringen, 2013). The work order system is functional for management in controlling costs and evaluating job performance. Even though the type and size of the work order can differ from one maintenance organization to another, a work order should nonetheless contain information such as requested and planned completion dates, work description and its purposes, planned start date, labor and material costs, item or items to be affected, work category (preventive maintenance, repair, installation, etc.), and appropriate approval signatures.

The fourth element for effective maintenance management is equipment record. It plays a critical role in effectiveness and efficiency of the maintenance organization. Generally, equipment records are convened under four classifications: maintenance work performed, maintenance cost, inventory, and files. The maintenance work performed category contains chronological documentation of all repairs and preventive maintenance (PM) performed during the item's service life to date. Maintenance performance is dependent on the implementation of maintenance strategies by analysing the reduction in production cost (Au-Yong, Ali, & Ahmad, 2014). The maintenance cost category contains historical profiles and accumulations of labor and material costs by item. Typically, information on inventory is provided by the stores or accounting department. The inventory category contains information such as property number, size and type, procurement cost, date manufactured or acquired, manufacturer, and location of the equipment/item. The files category includes operating and service manuals, warranties, drawings, and so on. Equipment records are useful when procuring new items/equipment to determine operating performance trends, troubleshooting breakdowns, making replacement or modification decisions, investigating incidents, identifying areas of concern, performing reliability and maintainability studies, and conducting life cycle cost and design studies.

The fifth element is Preventive Maintenance (PM) and Corrective Maintenance (CM). The basic purpose of performing PM is to keep facility/equipment in satisfactory condition through inspection and correction of early-stage deficiencies. Three principle factors shape the requirement and scope of the PM effort: process reliability, economics, and standards compliance. PM is acknowledged from two points of view, which are known as the administrative and the operational. The administrative

perspective refers to the support for decision-making which facilitates the analysis of data (Söderholm, Hoimgren, & Klefsjö, 2007). In the meantime, the operational perspective refers to the implementation of maintenance actions in order to maintain the capability of a system to perform its intended functions (Bjorklund, Pribytkova, & Karaulova, 2010). Althought the costs for CM are three or four times higher than PM costs (Chitra, 2003), a major proportion of a maintenance organization's effort is spent on corrective maintenance (CM) including in the highway maintenance. Thus, CM is an important factor in the effectiveness of maintenance organization.

The sixth element is job planning and scheduling. Job planning is an essential element of the effective maintenance management. A number of activity may have to be implemented subsequent to the initiation of a maintenance job; for example, procurement of manpower, tools, and materials, coordination and delivery of manpower, tools, and materials, identification of methods and sequencing, coordination with other departments, and securing safety permits.

Maintenance scheduling is as important as job planning. A large number of studies has been conducted to highlight the importance of maintenance work scheduling (Herabat & Songchitruksa, 2003; Peshkin, Hoerner, & Zimmerman, 2004; Labi & Sinha, 2005; Pasupathy, Labi, & Sinha, 2007; Irfan, Khurshid, Labi, & Flora, 2009; Khurshid, Irfan, & Labi, 2009; Deshpande, Damnjanovic, & Gardoni, 2010; Gao, Xie, Zhang, & Waller, 2012).

Schedule effectiveness is based on the reliability of the planning function. For major jobs, in particular those requiring coordination, serious consideration must be given to

using methods such as Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) to assure effective overall control (Tehnical Maintenance Portal - TMP, 2014).

The amount of backlog within a maintenance organization is one of the determining factors of maintenance management effectiveness. In the road infrastructure, Maintenance Backlog (MB) is comprehended as the cost of bringing the current condition to a predefined level and has therefore a monetary implication (Rødseth & Schjølberg, 2017).

Identification of backlogs is important to balance manpower and workload requirements. Furthermore, decisions concerning overtime, hiring, subcontracting, shop assignments, etc., are largely based on backlog information (Tehnical Maintenance Portal - TMP, 2014). Management makes use of various indices to make backlog-related decisions. The determination of job priority in a maintenance organization such as highway operator is necessary since it is not possible to start every job the day it is requested. In assigning job priorities, it is important to consider factors such as importance of the item or system, the type of maintenance, required due dates, and the length of time the job awaiting scheduling will take.

The eight and the last element related to the effectiveness of maintenance management is performance measurement. Maintenance Performance Measurement (MPM) is a system that defined as the set of metrics used to quantify the efficiency and effectiveness of maintenance actions (Parida & Kumar, 2006). Parida A. , Kumar, Galar and Stenström (2015) stated that performance measurement is also used as a basis for

benchmarking internally and in comparison to other organizations. According to Parida and Kumar (2006), the following are considered important factors, justifying the implementation of a maintenance performance measurement process:

- measuring value created by the maintenance;
- justifying investment;
- revising resource allocations;
- health, safety and environment issues;
- focus on knowledge management;
- adapting to new trends in operation and maintenance strategy; and
- organizational structural changes.

Successful maintenance organizations regularly measure their performance through various means. Performance analyses contribute to maintenance department efficiency and are essential in revealing the downtime of equipment, peculiarities in operational behavior of the concerned organization, developing plans for future maintenance, and so on (Tehnical Maintenance Portal - TMP, 2014).

Maintenance effectiveness has been defined as "*the ratio between the requirements predetermined for performance and technical conditions and the actual results*" (Oil Industry Safety Directorate (India), 2012). Consequently, the maintenance effectiveness will not be achieved if any of these aspects are lacking. The Theory of Constraint (TOC) introduced by Dr. Eliyahu Goldratt in his book "The Goal" published in 1984 explained that limiting factor was considered a constraint which prevented the company from achieving its objective (Vorne, 2016).

Previously TOC was used to address the issues in manufacturing and production field (Pries, 2009; Migon, Borges, & Campos, 2010); medical (Ronen, Pliskin, & Pass, 2006); education (Goldratt & Weiss, 2005) and military (Kohil, Sharma, & Pastorino, 2009). However, the application of TOC is now being extended to explain the issues highlighted in transportation system (Zivaljevic, 2015) due to its function as a tool to analyze and resolve problem and as a method for measuring performance and assisting decision making process of management (Vorne, 2016).

2.10 Policy and regulations in maintenance management

An effective maintenance management rely on a maintenance policy as one of the key elements (Choudhury & Sharan, 2011). The maintenance management policy is regarded as a basic and integral parts of maintenance management function, namely planning, organizing, implementing and controlling (Bonde & Fulzele, 2013).

The policies and regulation pertaining maintenance management relates to maintenance management responsibilities for facilities, equipment and infrastructure when maintenance activities are required and how the maintenance work are performed (Cape Winesland District, 2015). Policies served to provide standardized maintenance function such as setting maintenance priorities, tools and equipment's (Board of Supervisors, 2005) and ensuring proper delivery of maintenance service according to the management's objectives.

"*Maintenance policy refers to formalized set of rules and guidelines to achieve good maintenance practice*" (Choka, 2012). Lee (1976) stated that maintenance policy is regarded as the ground rule for allocation of resources for different maintenance

alternatives made available for the management. According to Mckinley (2015), proper maintenance activities function will be impossible without appropriate maintenance policy and plan that were put in place because the maintenance policy address to the following maintenance questions;

- How should the maintenance work flow operate?;
- Whether the maintenance standard is provided to maintenance personnel to ensure the maintenance work quality;
- Do maintenance personnel acquire skill and knowledge to perform maintenance activities?;
- Whether the record management is in an efficient and systematic state for easy detection and resolvement of maintenance issues;
- Whether the budget is sufficient to deploy maintenance personnel to perform maintenance activities;
- Whether the maintenance issue be solved internally or externally; and
- Whether the maintenance activities comply with the statutory requirement or not.

Accurate maintenance policy always relates to maintenance effectiveness as it relates to the optimal use of maintenance resources such as fund, personnel, facility, tools, equipment and procedures (Choka, 2012). Seeley (1987) stated that the maintenance policy provides the management the ability to plan the long-term maintenance strategy and budgetary forecast. The long-term maintenance strategy covers all aspects of maintenance management which describes the systems and procedures to be used to plan and manage maintenance work (Choka, 2012).

2.11 Communications within maintenance management

Maintenance management system depends on other subsystems such as maintenance work planning and schedulling; budgeting, work organization and also maintenance information system to function properly (Choka, 2012). It is noted that despite the rapid advancement technology in communication, information management and communication within maintenance team is still regarded as problematic (Costa, 2017). Poor communication and resource management had been cited as the cause for improper maintenance practice rather than technical incompetence (Winbow, 2002; Costa, 2017).

Lack of smooth flowing of communication and information has deterred maintenance personnel to contribute ideas and suggestion for the improvement of maintenance function (Hansson & Backlund, 2003). Maintenance operational effectiveness relies on employees' understanding and involvement (Abraham, Crawford, & Fisher, 1999; Pintelon, Nagarur, & Puyvelde, 1999; Tsang & Chan, 2000; Hansson & Backlund, 2003).

Employees' empowerment is crucial for the successful implementation of maintenance system (Newall & Dale, 1991). Lack of empowerment has been identified as the driving factor for the lack of communication and the lack of teamwork which in the end will lead to the decrease of the organization growth drive (Singh, Gupta, Kumar, & Khan, 2016).

In addition, the lack of centralized information repository has prevented the smooth flowing of communication and information among maintenance personnel as many of

these were somehow lost in paper trails, emails and phone calls (Costa, 2017). Proper communication management if carefully implemented will lead to increase of integrity, reliability and cost reduction (Kamoun, 2005) and it also has a vital impact on organization's business performance (Costa, 2017).

2.12 Qualitative research study

Denzin and Lincoln (1994) defined qualitative research as;

"Qualitative research is multi-method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. Qualitative research involves the studied use and collection of a variety of empirical materials case study, personal experience, introspective, life story interview, observational, historical, interactional, and visual texts-that describe routine and problematic moments and meaning in individuals' lives."

The qualitative research is a detailed exploration of a topic of interest in which information and data are gathered primarily from case studies, observation, interviews, and so on (Kaplan & Maxwell, 2006; Harwell, 2011). Goodson and Walker (1991) revealed that '*the task of a research is to make sense of what we know'* and the sense we make is determined by the selection and our approach. Qualitative based approaches effectively measuring a complex function such as maintenance compared to quantitative models (Cresswell, 2007; Kumar, Galar, Parida, Stenstro¨m, & Berges, 2013).

According to Maxwell (1996); Kaplan & Maxwell (2006), the strength of qualitative research methods is on their utility in understanding the meaning and context of the phenomenon being studied, and certain events that occurred and the procedures that make up this phenomenon from time to time, in real life and natural settings. The

analysis strives for depth of understanding (Merriam, 2002). In conducting a qualitative research, types of question asked are very important (Merriam, 2002). In qualitative research question, the question of "what", "why "or "how" will often be used in the research of what is going on comparative to the subject (Kaplan & Maxwell, 2006; Guest, Namey, & Mitchell, 2013). Marshall and Rossman (1995) suggested that qualitative research is intended to (1) understand the study process, (2) explain the poorly understood phenomenon, (3) understand the difference between policy and theory stated and carried out, and (4) to find a variable context so far not specified.

2.13 Action Research approach for highway maintenance management study

Action Research (AR) was introduced by Kurt Lewin in his 1946 paper "Action Research and Minority Problem" (O'Brien, 2001). Lewin defined Action Research as "*a comparative research on the conditions and effects of various forms of social action and research leading to social action*". Sankaran and Tay (2003) stated that several authors (Abraham S., 1994; Sankaran, 1999; Easterby-Smith, Thorpe, & Lowe, 2001; McNiff, Lomax, & Whitehead, 2001; Coughlan & Coghlan, 2002; Dick, 2002) concluded that there are several reasons why AR is attractive to practising managers:

- It uses action as an fundamental part of research that incorporates thoughts and action;
- It is focused on the researcher's professional values rather than methodological considerations;
- It allows practitioners to research their own professional activities. It helps to improve practices at the workplace;
- It helps managers in their professional development by critically examining their own beliefs and practices;

- It helps managers to be multidisciplinary and work across technical, cultural, and functional boundaries;
- It helps managers in implementing change effectively. AR is founded on research relationship in which those managers involved are participants in the change process. It pursues both change in the form of action and understanding through research;
- It is problem-focused, context-specific, and future-oriented; and
- It helps to develop a holistic insight.

The researcher for AR study is a part of the process meanwhile for experimental research, the researcher tries not to influence the process of the study (McNiff & Whitehead, 2002). In addition, action research is a method used for study in the field which required less scientific approach (Lewin, 1946).

According to O'Brien (1998), action research is used in real situation rather than laboratory set-up due to its primary objective in solving real problem. Action research is also used by academician who were invited by the management of an organization that were aware of a problem requiring action research, but lacking the requisite methodological knowledge to deal with it.

Table 2.2
Comparison of Experimental study and Action Research study

What?	Experimental study	Action Research study
Who?	Conducted by university professors, scholars and graduate students on experimental and control group	Conducted by practitioners on practices in their field of work
Where?	In the environment whereby the variables can be control	In natural work field

Table 2.2 (continued)

What?	Experimental study	Action Research study
How?	Using quantitative methods to show, to a predetermined level of statistical significance, the causal relationship between variables	Using qualitative methods to describe what happened and understand the impact of interventions in work practices
Why?	To report and publish the conclusions of the study which can be generalized to larger population	To take action and effect positive change in working practices in certain work environments that were studied

Source: Action research: A guide for the teacher researcher by Geoffrey E. Mills, 2003

Action research has some features relates to it such as cyclic - similar recurrence of steps that comes in sequence, participative - active involvement of researcher and participants, qualitative - deals more with language than numbers and refective - critical reflection of process and research outcomes (O'Brien, 2001). The spiral of action research cycles involved four major phrases: "*planning, acting, observing and reflecting"* (Perry & Zuber-Skerritt, 1992). McNiff and Whitehead (2002) explained that in action research, the researcher need to;

- *evaluate the existing practice,*
- *recognize the feature that need to be enhanced,*
- *imagine the future,*
- *test it, and*
- *consider what happens,*
- *make adjustment to the plan based on what you have learnt and proceed with the "action",*
- *observe what you are doing,*
- *assess the changed action,*
- *[maintain] until you are contented with that aspect of your work.*

AR, according to Zuber-Skerritt (1992) was introduced by American psychologist, Kurt Lewin (French, 2009). Lewin (1946) proposed six phase stages of AR, "*analysis, fact-finding, conceptualisation, planning, implementation of action and evaluation*". Baskerville & Wood-Harper (1996) later revised AR methodology to five stage process known as "*diagnosing, action planning, action taking, evaluating and specifying learning*".

The difference of AR methodology stages relates to how others have changed the definition of AR and to emphasize different aspects of the study process. According to French (2009), the crucial steps for AR can be further simplified to Plan, Act, Observe and Reflect (Perry & Zuber-Skerritt, 1992) which is also the original work of Lewin in 1946. This model is deemed suitable for this research as the aim is to improve the current maintenance management practise in LDP for the benefit of related parties.

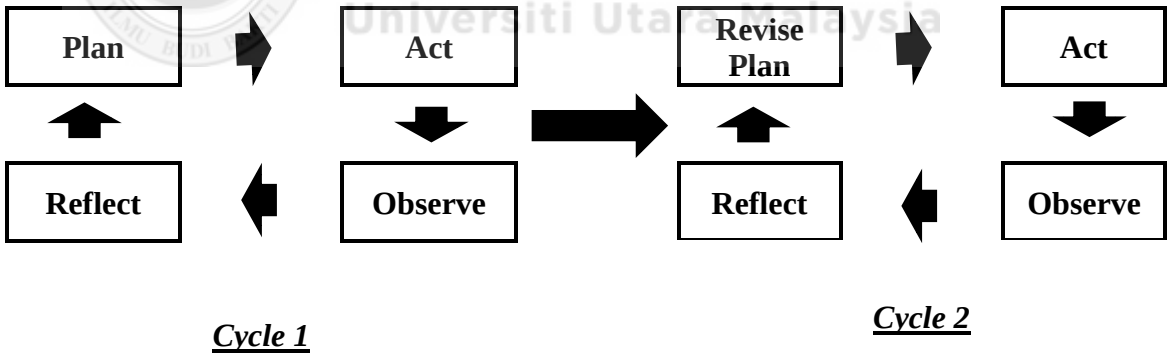


Figure 2.3
Action Research cycle
Source: An Introduction to Action Research by Dan MacIsaac, 1995

Yasmeen (2008) added that one of the principles of AR is about Theory, Practice and Transformation. Practice originated from theory and through practice theory can be enhanced with continuous transformation (Winter, 1989). AR processes enable

practitioners to justify and improve their practice (French, 2009). This principle of understanding a phenomenon are generally normal to the paradigm of qualitative research (O'Brien, 2001).

In the current study, the action research approach will be used in order to enhance the current maintenance practices for the betterment in the work quality, services and business for LDP. This objective can be achieved by understanding the current practice and applying ways to improve the practice. Discovery of new way to enhance work practice is evolution of knowledge which lead to evolution of practice. This evolution will continues as people are getting more advanced in acquiring new knowledge. In other words, action research applied for this study is due to the existence of shortcomings in the highway maintenance practices, formulate a plan to address these issues, implement the plan, assess the result and introduced additional strategies in an iteration approach (Rawal, 2006).

2.14 Conclusion of literature review

The concept of highway maintenance is very much understood by the related parties; highway agencies, highway operators and highway maintenance personnels. Then again, their awareness on the level of effectiveness and also the best practice of highway maintenance activities still need to be uncovered due to the roles played by the highways to accommodate nearly all facets of Malaysian citizen lives in terms of business and transportation means.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The objective of this research is to study the implementation of highway maintenance management system in Lebuhraya Damansara-Puchong (LDP). This research explains the methodology and research design method as a guideline which includes, design research, information gathering, sample selection and management methods, reliability and validity issues, principal reasoning and data analysis strategies.

The work will utilize the Qualitative Method approach in executing data collection and analysis whereby the research plan is comprised of interview sessions with selected employees of the Highway Maintenance Department and direct observation of the work activities of the highway maintenance team.

The qualitative method in the current research will relate to the understanding of some aspects of the academic tradition in psychology, sociology, anthropology, history, and their methods, which generate words, rather than numbers, as data for analysis. The basis for utilizing qualitative research is referred to the aim for "*more insight or a deeper understanding about the phenomenon under investigation"*, *"exploration of experience"*, plus *"development of meaning"* (Kapoulas & Mitic, 2012). In short, the qualitative research has been used for centuries in the realm of social sciences to examine the experiences, perspectives, and perceptions of people (Jameel, Shaheen, & Majid, 2018).

3.2 Research philosophy and research approach

A research philosophy relates to which data should be gathered, analysed and used to understand about certain phenomenon (Davison, 1998). Management research is regarded as the most effective method to solve operational problem in workplace (Johnston A. , 2014). According to Saunders, Lewis, & Thornhill (2012), the research philosophy can be divided into four perspectives namely positivism, realism, interpretivism and pragmatism. The differences of these concepts are explained in Table 3.1 as follows:

Table 3.1
Different data collection method of research philosophies

Research philosophy	**Popular data collection method(s)**
Positivism	*Highly structured, large samples, measurement, quantitative, but can use qualitative*
Realism	*Methods chosen must fit the subject matter, quantitative or qualitative*
Interpretivism	*Small samples, in-depth investigations, qualitative*
Pragmatism	*Mixed or multiple method designs, quantitative and qualitative*

Source: The Ultimate Guide to Writing a Dissertation in Business Studies: A Step-by-Step Assistance by John Dudovskiy, 2016

As shown in Table 3.1, the current research will use the interpretivism research philosophy due to the involvement of qualitative methods in the highway maintenance area as it will involve the collection of data and analysis from the related small samples of maintenance personnel from the highway operators. The qualitative research will explore issues and uncover major research arguments regarding the highway maintenance management practice, before analyzing the data to measure the effectiveness of highway management system practices in LDP.

In terms of the research approach, Saunders, Lewis, & Thornhill (2012) stated that the research approach is divided into two, which is deductive and inductive. Deductive approach relates to the concept of testing the theory meanwhile the inductive theory concerns with theory building (Gill & Johnson, 2010; Saunders & Lewis, 2011; Johnston, 2014). Therefore, as the current study wishes to collect data and would like to develop a theory based on data analysis, as a result, the research will adopt the inductive research approach.

The research aims to address the concerns of parties involved in this problematic highway maintenance system area and in-cooperation with the members of the system in transforming the system into a desired state. These objectives are deemed suitable to the goal of an action research (AR). According to Hall & Keynes (2005), action research is a "*study about practice performed by people who are involved with the practice with an aim to change and improve it*". AR is normally used in real life situation rather than experimental condition due to its focus of solving real problem (O'Brien, 2001). French (2009) stated that AR is related to systematic enquiry, critical reflection and strategic action. Therefore, AR in this study is viewed as a holistic approach to problem-solving allowing various method of research tools in qualitative research including literature review, interviews, observations, records and documentation review.

According to McNiff and Whitehead (2002), the purpose of AR is gathering data from field and testing it in the form of new practice to generate new knowledge of that situation to produce new theory in explaining how reality work. North Central Regional Educational Laboratory stated that action research is a study in the determination of

purposeful efforts to improve the quality and performance of the organization designed and studied by practitioners who will analyze the data to enhance their practice (College of Education and Human Development, 2005). In other words, action research is self-reflective inquiry in understanding own practices and environment where the practices being performed (Carr & Kemmis, 1986).

Holter and Schwartz-Barcott (1993) stated that AR does not require special data collection method which is very different from traditional research methodologies that requires a specific accepted method of data collection that is symbiotic with the data analysis methodology. For this study, data have been collected from several sources such as:

- The academic literature;
- Interview;
- Observation; and
- Records and documentation review.

The researcher for AR study is a part of the process meanwhile for experimental research, the researcher tries not to influence the process of the study (McNiff & Whitehead, 2002). The research design will involve conducting interviews with selected highway's maintenance personnel, and direct observation of maintenance management activities, including records and documentation review. The interviews will be conducted with 8 LDP's maintenance personnel. The stage of interviews and observation activities for this research design will also include a re-measure of important subject and general documents as an operation of gathering or collecting and

triangulating information data concerning the maintenance management function description.

3.3 Overview of Research Methodology

This study was conducted using qualitative paradigm. Qualitative research method is aimed to understand the experiences, perspectives, and thoughts of participants in the study (Harwell, 2011). Qualitative research conducted for the research study was due to the need of complex, and detailed understanding of the issue (Cresswell, 2007). Qualitative methods applied for this study will include;

- Interview which focus on small group and familiar with maintenance work process. In this research interviews, 8 selected maintenance personnel will be interviewed according to the interview plan. The interview will be proceeded from unstructured questionnaires to open-ended questions of semi-structured interviews.
- Direct observation comprising of all participants and non-participant monitoring, ethnographic diaries, video or any photographic records that enabled researchers to record and understand the context within which activities and events transpire.

Although qualitative research is characterized as an emerging and flexible design, a basic research plan was necessary to guide this research exploration (Alexander, 2004). The current study combined different methods to understand and to explore more of the situation, for example, each individual's experience and involvement in the organization. The interview was conducted using semi-structured questionnaires to open-ended discussions. The observation was conducted directly and transparently

including all participant and non-participant monitoring. The qualitative data and the interview transcripts used in the study were re-assessed and categorized for relevant findings, according to the research study requirement (Xia & Gong, 2014); and all linked documents: procedures, exercise instructions, and monthly reports were reviewed to see the position.

3.4 Population

The credible of qualitative research also depends on adequate sample size (Marshall, Cardon, Poddar, & Fontenot, 2013). According to Patton (2002), there are no rules regarding the sample size in qualitative study. The generalization from logical reasoning enables the study to be a credential research due to the relevant respondents were selected for the study instead of statistically drawn samples (Yin, 1989).

Cresswell (2007) emphasized on selecting the appropriate sample, as only qualified respondents will give credible information for the study. Since the qualitative research is more concerned on uncovering a phenomenon from the point of view of the participants, therefore, it is very important to select respondents where the most related information to the concerned phenomenon can be gathered (Merriam, 2002).

The population for the study were based on the characteristic of profession that most likely have related experience, think about, or have an understanding into the research topic (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). Dodge (2011) highlighted the need for the reseacher to identify the right 'gatekeeper' of the knowledge to acquire the best possible information.

The present study identified highway maintenance management personnels in LDP as the ‘gatekeepers’ as they are the one who are directly involved directly in maintenance management for LDP as well as preparing the reports and data with regards to highway maintenance management system used for the study.

The research interview involved 8 Maintenance Management personnel, with the session being conducted according to the interview plan. Normally, the respondents are those involved within the related discipline as specified in the research study (Raich, Mueller, & Abfalter, 2014). The participants were chosen based on the availability and agreement of personnel to be involved in this research.

3.5 Sampling procedures

The study utilized the theoretical sampling to know the experience of the phenomenon of interest. *Theoretical sampling is different from many other sampling methods in a way that rather than being representative of population or testing hypotheses, theoretical sampling is aimed at generating and developing theoretical data*. Unlike other sampling methods, theoretical sampling cannot be pre-planned and from the outset but comes at a later phase of the research process. A few advantages identified of theoretical sampling are;

- The possibility to strengthen the rigor of the subject if the study seeks to generate a theory in the research field;
- The application of theoretical sampling method can offer a certain social organization to data collection and data analysis operations, thus addressing one of the primary disadvantages of qualitative methods that link up to lack of structure; and

- This case of sampling usually integrates both, inductive and deductive characteristics, thus increasing comprehensiveness of subject areas.

An in-depth study of an individual's work experience is regarded as being an important part of the information. This helps to understand participants' perception of their experiences in maintenance management work process.

The targeted sample participants, who met the following stated criteria work in the Highway Maintenance Department. Consistency sampling plan is a statistical tool used in decision making based on information obtained from an existing experiment on whether to accept or reject based on the sample data (Appaia et al., 2014; Srivastava & Sharma, 2015).

3.6 Data Collection Strategies

The quality of qualitative research study depends on its validity and reliability (Golafshani, 2003). Lincoln and Guba (1985) concluded that the term trustworthiness, quality or rigor as an alternative for validity and dependability as a replacement for reliability are being used for qualitative studies. Researcher are able to use various approaches to address validity (trustworthiness/quality/rigor) and reliability (dependability) in qualitative research and the most popular one: is triangulation information from various data sources (Simon, 2011).

Patton (2002) recommended the use of triangulation since “triangulation strengthens a study by combining methods”. Yin (2002) mentioned in his book that triangulation can

be divided into two conditions, convergence of evidence (single study) and non-convergence of evidence (separate sub-studies) as defined in Figure 3.1 below:

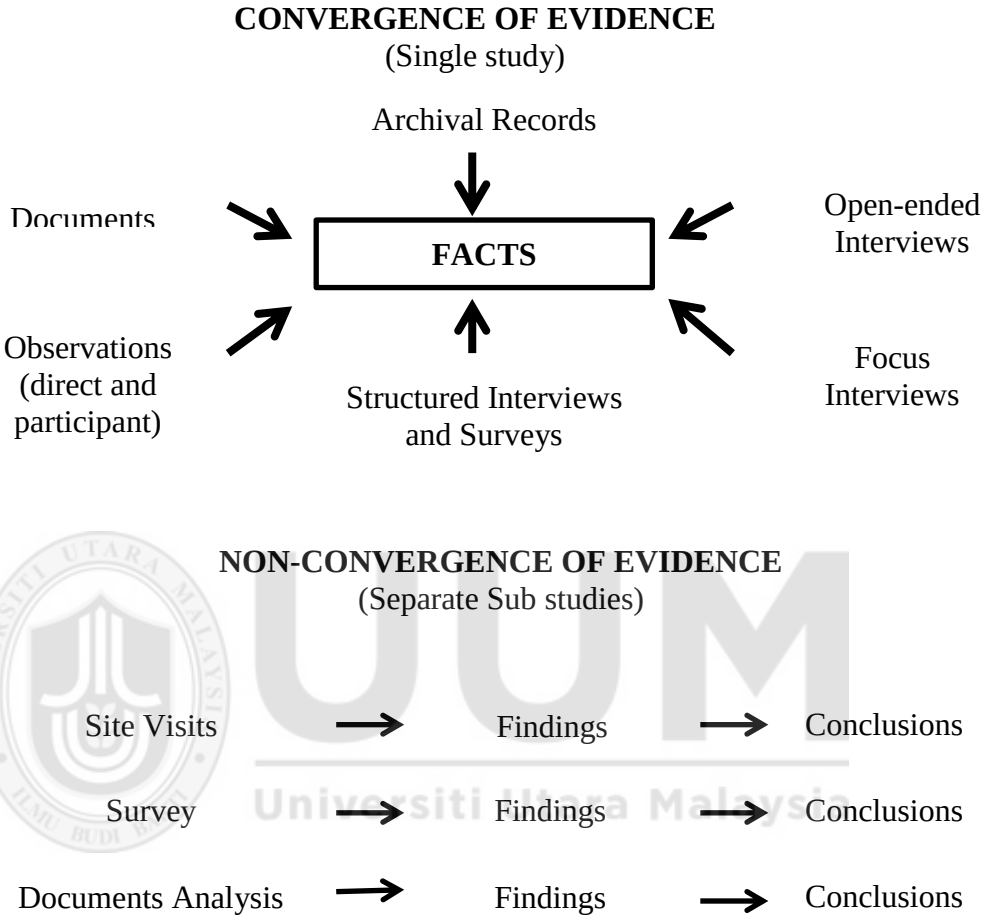


Figure 3.1
Convergence and Nonconvergence of Multiple Sources of Evidence
Source: Case Study Research: Design and Methods, 4th Edition by Robert K. Yin, 2002

Data from multiple sources need to be converged or aggregated to ensure that it is valid (trustworthiness) and reliable (Schwandt, 2007). Meanwhile, non-converge evidence will be used as part of the same study but the two methods will handle different statement (Yin, 2009). By establishing the validity (trustworthiness/quality/rigor), the evaluation of the research will be more credible, and the researcher will be able to remain behind the information provided with confidence (Guion, 2002).

According to Yin (2009), when the data is triangulated, the evidence will be strengthened by more than a single source; when various sources have been applied yet the data have not by any means been triangulated, usually every source of evidence is analyzed independently and comparison of the different analyses will be supported in the conclusions. A quality researcher will be able to reflex upon the researched phenomenon while continuously generate understanding about the study (Stenbacka, 2001).

A qualitative component is normally included in the research design: it is also to learn relationships between important events, to discover the main key issues and to ascertain that appropriate data are collected (Jepsen & Rodwell, 2008). In that respect, three elements in a research design; interview, observation, and document review formed the data collection strategy to answer the research questions.

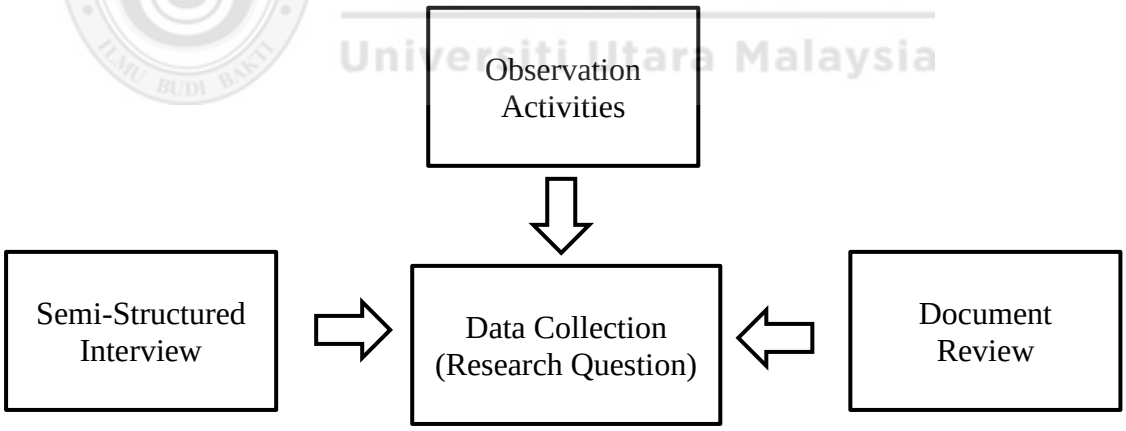


Figure 3.2
Research question adaptation for convergence of evidence

The convergence of evidence can be explained as in Figure 3.2, where all inputs of data, information are given from these three sources; by conducting semi structured interviews, observation of work process and document review. With the research design of this research field, it is advantageous for the researcher to receive all of the necessary

data. Each question should be about the goals of this study. The information collection strategies relate to each research questions in Table 3.2.

Table 3.2
Research question and data collection strategies

Research Question	Data Collection Strategies		
	Interview	**Observation**	**Document Review**
RQ1: How maintenance management system is implemented in Lebuhraya Damansara-Puchong?	✓	✓	✓
RQ2: What policies and regulations has been applied to the planning and record management function of the Lebuhraya Damansara-Puchong maintenance management system	✓	✓	✓
RQ3: How are the communication flows in the maintenance management systems in Lebuhraya Damansara-Puchong?	✓	✓	✓

The quality and the finding of trustworthiness of qualitative study depends on the credibility of data gathered, the accuracy of the analyses conducted, and research design employed (Margaret & Paul, 2015). According to Bhattacherjee (2012), regardless of the research design utilized, the objective of the researchers is to collect as many and as varied data as possible that can help him/her get the best view possible of the phenomenon of interest.

3.7 Interview design

The study will employ interview method to obtain understanding of the maintenance personnel. According to DiCicco-Bloom and Crabtree (2006), qualitative interviews can be divided into a few categories as unstructured, semi-structured and structured. The study will focus on unstructured and semi-structured, as structured interview will normally produced quantitative data (Whiting, 2007)

The role of unstructured interview is intended to put the interviewees at ease and unassessed and at the same time set the tone for the rest of the interview sessions as the researcher do not know in advance all questions related to the study (Hannabuss, 1996; Qu & Dumay, 2011). The unstructured or open-ended interviewing also regarded as a medium to establish rapport between interviewer and interviewees with the aim of gaining access to the perpective of the person being interviewed (Douglas, 1985; Fontana & Frey, 1994; Hannabuss, 1996; Qu & Dumay, 2011).

Fontana & Frey (1994) further expressed that gaining trust is very important in ensuring the success of unstructured interview. Holstein & Gubrium (1997) stated that this approach can highlight the "*how"* in social scientific discipline at the expense of the "*what*" of existing experience. Once the interviewer gained trust and created rapport with the interviewees, the researcher needs to construct, alter and create follow-up queries signaling principal purpose of the research (Qu & Dumay, 2011). This is done via semi-structured interviews method where the interviewees are persuaded to talk around the topic (Rowley J. , 2012). Qu & Dumay (2011) further highlighted that semi-structured interview is capable to reveal critical and often unknown issues concerning

human and organizational behavior. It is regarded as the most effective and efficient way to gather information for qualitative study (Kvale & Brickmann, 2009).

The current study will utilize the semi-structured interview that focused on the central issues of the study developed before the actual interview is being conducted (Knox & Burkard, 2009; Qu & Dumay, 2011). On the other hand, interviewer needs to remain open and flexible, so they can probe more details in the respondent's narrative (DiCicco-Bloom & Crabtree, 2006; Rowley, 2012). According to Qu & Dumay (2011), great care is needed before, during and after interview session in terms of the ways the questions are asked and interpreted. The basic characteristic of human conversation which permit the researcher to control the pace and adjust the sytle of asking question will generate the best response from the respondents (Hannabuss, 1996). On that note, the reseacher of this study approached this kind of interview from the perspectives of the respondents (Berg, 2001).

The study employed questions that had been developed based on the understanding of the process of maintenance work process and highway maintenance personnel's job description. In addition, phrasing of questions can be changed, explanations given and for some interviewees, where applicable, some questions can either be omitted or added to the interview. Robson (2002) has mentioned and it was supported by Dodge (2011), that the interviews should choose suitable participants as well as the sample size for the interviewing session, as this is one of the rules that needs to be conducted carefully. In relation to that, the interviews for the research study were conducted with eight selected maintenance personnel in the Maintenance Management Department from LDP and they are the people who are directly involved in the maintenance activities.

Present research utilized the interviewing process stated in "Qualitative Research Methods: A Data Collector's Field Guide" book by Natasha Mack, Cynthia Woodsong, Kathleen M. MacQueen, Greg Guest and Emily Namey, that was published in 2005. The participants in the interviews will be contacted by email to arrange for an appointment and the researchers will briefly explain about the purpose of the study, the study procedures, what is expected of a study participants, inclusive of the amount of time that may be required for participation, so that the interviewees will be assured that participation in the study is on voluntary basis and the interviewees can pull out from the study at any time. The interviewees will also be assured that their confidentiality will be protected and be well informed on the risks and benefits that are expected of the study.

Michael Quinn Patton and Michael Cochran mentioned in Brikci & Green, (2007) in A Guide to Using Qualitative Research Methodology, that participants in qualitative study must be freely consented to participate and not be pressured or unfairly being coerced. Mack, Woodsong, MacQueen, Guest, & Namey, (2005) stated that the interviews should be carried out in a private location without going outside where participants can feel that their privacy is fully protected. Encouraging participants to suggest the location where they would feel comfortable will help researchers greatly in ensuring the protection of participant's privacy (Mack et al., 2005) and let them share their views at ease (Qu & Dumay, 2011). In relation to that, the current study gave the participants the freedom to choose the location where the interview should take place.

Next, the interview was conducted through direct face to face communication. The procedure of the interviews was recorded to ensure that no data were lost; with the

interviews, then transcribed on paper and verified by the respondent. A sample of a uniform technique is shown in Figure 3.3. All of the Highway Maintenance Department Staff was invited to this research program. When the participants agreed, they were sent an invitation email to manage the interview session with the elaborate arrangement of time and engagement.

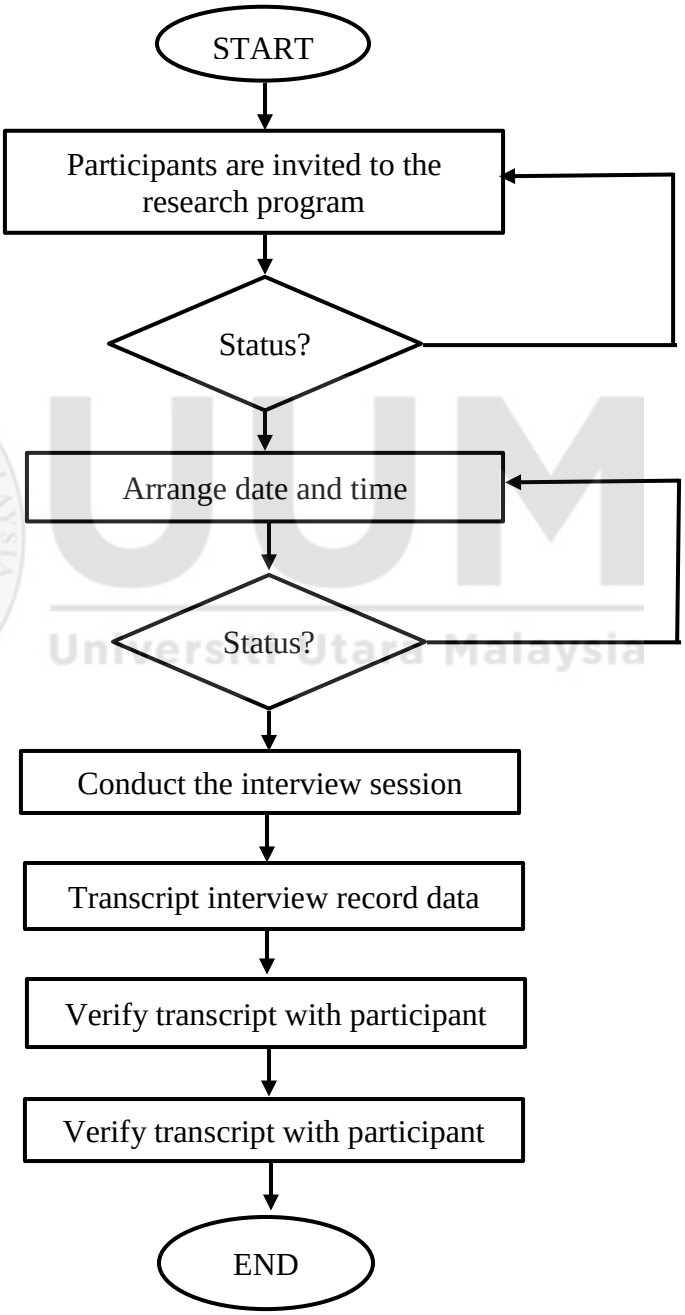


Figure 3.3
Procedure for interview session

All of the data were reviewed and coded for emerging themes and categories. In Atlas.ti, coding is the desirable mode of assigning the detail of information to a section of data, by using a word or short phrase taken from that part. Atlas.ti was the chosen software for data analysis in this study due to its relationship with Grounded Theory (GT) that was introduced in 1960s by Glaser and Strauss (Friese, 2017). In addition, Atlas. Ti, a software program for qualitative data analysis was employed to help with the organization of content, coding, and theme recognition. Atlas.ti offers a level of analysis below tagging that facilitates the process of GT open coding (Friese, 2017). This entry describes this practice and some applications and problems associated with it.

The coding of the data is the essence of the analysis (Raich, Mueller, & Abfalter, 2014). Rowley (2012) observes that the coding data is made to ensure that the result stay as close as possible and to obtain a key factor along with the interview participants' own words or their own terms.

The Part 1 qualitative research design for the present study that involved interview was conducted as follows with standard procedure aims to ensure that all information data are consistent and reliable with the objective of the research studies (Mack, Woodsong, MacQueen, Guest, & Namey, 2005):

1. All participants will be invited to the research program and will be informed of all related information regarding the study.
2. Interview sessions will use an audio recorder device and write-up (expanding the interview notes will be done within a day of completion of the interview sessions.

3. All transcript information content will be verified with all respective interviewees. Always remember to mention about the confidentiality of the information and it will only be used for this research study. A copy of complete written transcript will also be given to the interviewees

The data gathered from the interview will be reviewed and coded for emergent themes or categories, which then will form the basis of the research findings (Rowley J. , 2012). The interview will be characterized in five sections; every question will be illustrative as the key that ought to be ask in the interview session. The questions were adapted from Pamela R. Dodge (2011) study. The details of the interview guideline are as follows;

Part 1: Introduction and Demographic Information. This part will explain about the brief description and goal of the study. This is for the researcher to share with the participant and use to remind themselves to stay close to the topic. The basic factual or demographic questions for putting the participant's answers in context. These will vary depending on the purpose of the interview, but often include name, age, working experience and job title or role.

Example:

1. *Tell me about yourself?*
2. *How long have you been with this company?*
3. *Tell me about your work experience in Maintenance Management Department?*
4. *What is your technical background?*
5. *How would you describe yourself as maintenance personnel?*

Part 2: Research Question No.1: How maintenance management system is implemented in Lebuhraya Damansara-Puchong? The intention is to search for any information regarding the work planning, maintenance work process, and the problem of maintenance work activities.

Example:

1. *How do you plan your work activities?*
2. *Can you describe your work in the company?*
3. *What do you think about the work process in this company especially in Maintenance Management activities?*
4. *How often maintenance activities had been postponed or cancelled and for what reason?*
5. *What is your suggestion and expectation in improving work planning for maintenance activities?*

Part 3: Research Question No.2: What policies and regulations has been applied to the planning and record management function of the Lebuhraya Damansara-Puchong maintenance management system? The aim is to search for any information regarding the understanding of maintenance work, maintenance preventing activities, including corrective action. This part is also to explore the function of observation for maintenance personnel.

Example:

1. *What does maintenance mean to you?*
2. *How do you do about preventing any problems from occurring?*
3. *Do you know about periodic, corrective and preventive maintenance?*
4. *How many times have you done your observation or survey a day?*

5. *Are you willing to do observation or survey without any instruction from your superior? If not, why?*
6. *What is your opinion about lack of monitoring activities in maintenance of highway?*

Part 4: Research Question No.3: How the communication flows in the maintenance management systems in Lebuhraya Damansara-Puchong? The objective is to search for any information regarding the tasks of managing, collecting and compiling all related information regarding maintenance work and producing maintenance related report.

Example:

1. *How you manage your maintenance record activities?*
2. *How do you write your record?*
3. *What kind of issue that you are confronting in preparing your report?*
4. *How do you report your work status to your supervisor?*
5. *How frequently you talk with your superior about your work activities?*
6. *In the event that there are issues, how would you handle the circumstances that require you to prepare any supporting documents?*
7. *What is your recommendation to enhance the work process in dealing with the maintenance information record?*
8. *Who should be responsible to deal with this data and preparing the report?*

Part 5: Closing the Interview Session. In order to establish effective research findings, it is imperative that accurate information was gathered during the interview sessions and that questionnaires were answered honestly by participants. Additional questions to instigate open suggestions by participants to improve or change certain aspects of

the current situation or procedures will also provide vital information to formulate recommendations for improvement upon conclusion of the research study.

Example:

1. *Is there anything else that you might want to offer that I did not specifically get some information about?*

All result of the interviews will be recorded and written during the interview sessions. See Appendix: The interview form for writing all the information in the interviews sessions.

3.8 Observation and monitoring of maintenance activities

The qualitative studies normally engaged the "participant observation" where the researcher actively involved in the study setting (Kaplan & Maxwell, 2006). Merriam (2002) concluded that observation is considered as the best techniques to obtain the firsthand fresh perspective when the participants are unable to explain the phenomenon under research. The observation of daily maintenance activities is to understand more about the work process that is performed by Maintenance Personnel. The observation and monitoring involved multiple perspectives, for example:

a. How do they work (individuals / teams)?

b. How do they communicate with other parties?

c. How do they tackle the problems in maintenance activities?

d. How do they record all of the information?

e. How do they implement maintenance activities?

The current study utilized a framework by Edgar H. Schein (1999) in his book "*Process Consultation Revisited. Building the Helping Relationship*" known as ORJI Model. ORJI stands for Observation, Reaction, Judgment and Intervention. ORJI concentrates on what is inside our heads and how it influences hidden behavior.

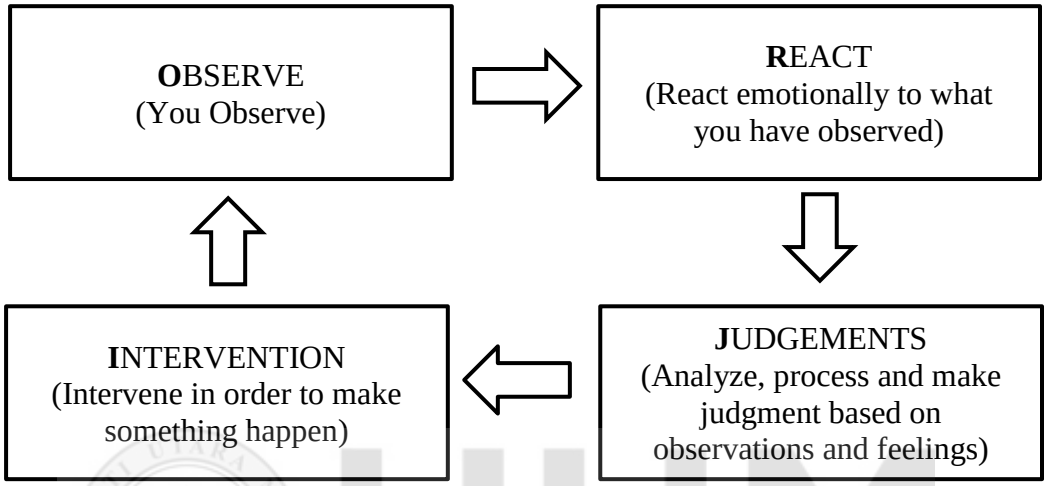


Figure 3.4
ORJI Model (Action Research Framework)
Source: Doing Action Research in Your Own Organization by David Coghlan and Teresa Brannick, 2014

The result of the observation activities was recorded similarly to the interview procedure. However, the subtle elements of the observation will be recorded as follows (Refer to Table 3.3):

Table 3.3
List of observations for Maintenance Observation Activities

No.	Description and Documentation
1	Date of Observation
2	Name of the Maintenance Project
3	Section of Maintenance Department
4	Subject / Item / Detail Observation
5	Type of Observation

Table 3.3 (continued)

No.	Description and Documentation
6	Meeting Point / Location
7	Document Reference
8	Time of Observation
9	Representative
10	Maintenance Person in Charge
11	Duration of Observation
12	Observation Status
13	Other Remarks

Through participant observation used for this study, the researcher was able to uncover important factors for an exhaustive of the research problem that were unknown at the beginning or at the designing stage of the study (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). Maintenance work process flow will be reviewed during the observation and monitoring activities with cross reference to the methodology and work instruction that has been utilized.

The observation and monitoring were done in 6 months, from January until June 2017. The activities were entered into one record database and summarized in the following chapter. The researcher followed and participated in all work activities identified as relevant to the study with the maintenance team.

3.9 Reviewing the maintenance record activities and their work description

Procedure of the maintenance work process and work instruction were surveyed. Each part of the information was taken as an instrument to produce information regarding the maintenance activities and the conclusion of the task.

The current study will examine the maintenance record to gather the information regarding the maintenance inspection activities which according to Derbyshire County Council (2015) will consist of work required identification; work planning, co-ordination and scheduling, and physical completion of the work. The details of work limitation for each maintenance personnel will be included in the reviewing process. The comparison between written documentation and actual process will be verified in this arena. This role will make the data analysis in triangulated data more accurate.

The importance of analyzing written texts and any artifacts is that they are genuine evidence and exist in such a manner and unlike the spoken word, they are physically enduring and thus can be singled out in space and time (Ahuja, 2007).

The document clustering technique is widely known as a useful information tool, to reconstitute the document, mining and collection of data and information (Kishida, 2003). There are several ways to collect and go over all the information, especially the data that has been recorded, as put forward by the previous scholars. Text analytics enable organizations to convert large volumes of human generated text into meaningful summaries, which support evidence-based decision-making (Gandomi & Haider, 2015)

Moreover, instruments that combine machine technology that not simply handle the price, time and accuracy issues in the field of learning documents, it also eases the work of the review team by making use of intelligent commentators, and enable collaborative work (Privault, O'Neill, Ciriza, & Renders, 2010).

In this study, a simple process flow was utilized from gathering all related text files and then reviewing it one by one and summarizing all the data in one folder. Later, the process of breaking down all the information that has been gathered in one folder will be aided by Atlas.ti software. Refer Figure 3.5.

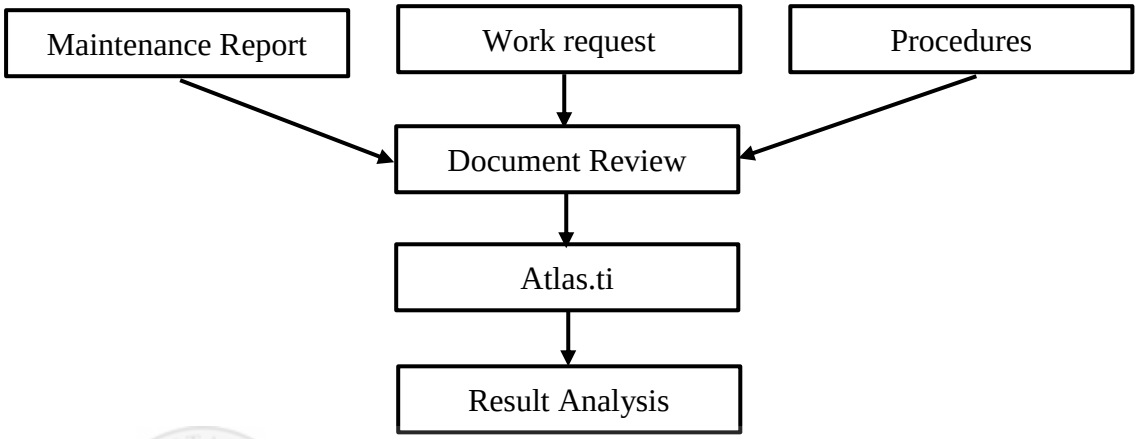


Figure 3.5
Process flow for document review

The analytical procedure is dependent on the data that has been compiled from these three sources: maintenance report, work request report, and procedures. This data is important to confirm the findings of this case study.

3.10 Qualitative Research Data Analysis

"Qualitative research study regarded as a form of intellectual craftsmanship where there is no single approach to perform qualitative research since data analysis is a process of making meaning" (Dodge, 2011). The study data analysis was guided by Six steps data analysis from Cresswell (2009). The analysis is in linear, hierarchical order as the process is not static, refer to Figure 3.6.

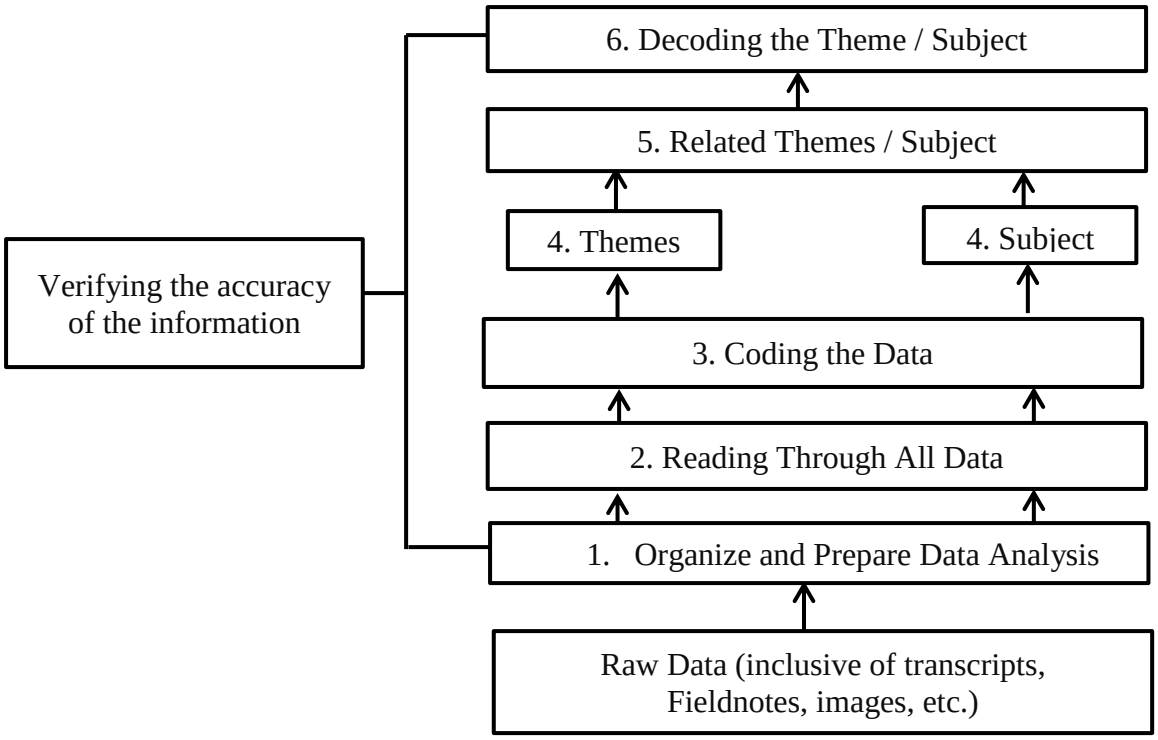


Figure 3.6
Six Steps in Data analysis in Qualitative Research
Source: Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 3rd Edition by John W. Cresswell, 2009

Step 1: Organize and prepare the data for analysis. For this step, information from audio records and interview documents are gathered and reviewed and then transferred into a single transcripts document.

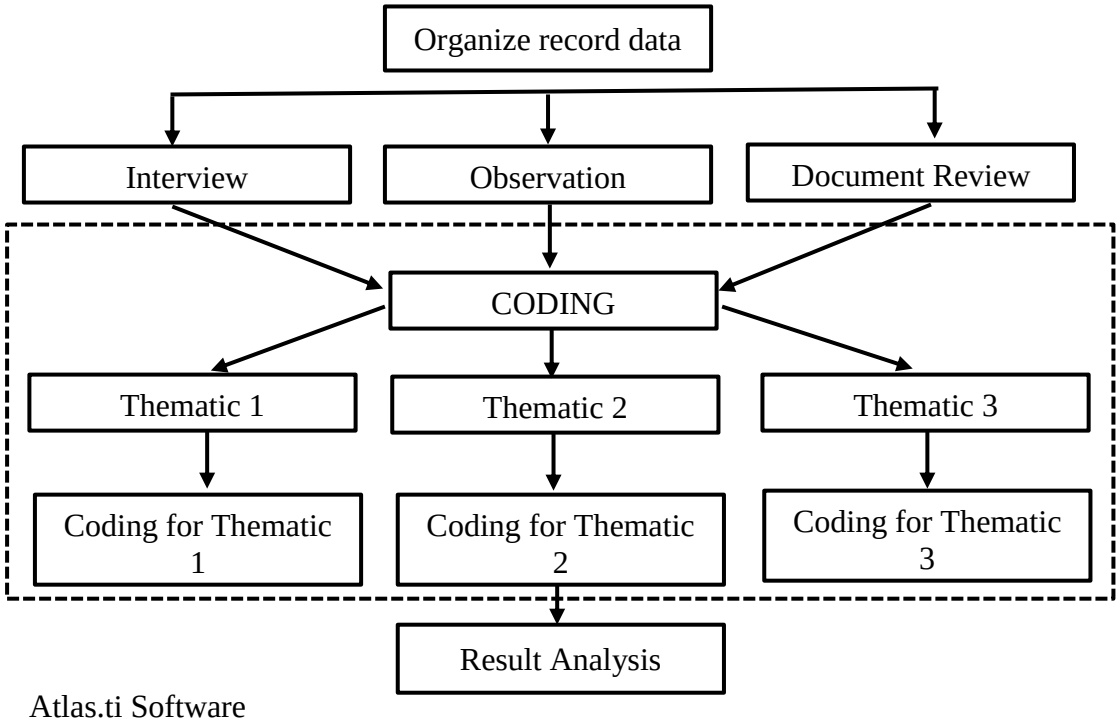
Step 2: Reading through all data. The second phase involved the analyzing of the overall meaning in the information from Step 1 to achieve a common sense of the ideas and information given by the interviewees.

Step 3: Coding the data. Begin a thorough analysis with the coding process. Organizing all the information into categories and labeling all information with condition by referring on the information given in the interview sessions.

Step 4: Themes / Subject. Use the encoding process to generate themes or settings or the description and category for analysis. Generate nodes for all information and analyze all the categories in a general description.

Step 5: Related themes/subject. Plan how the subject of the themes will be signified in the qualitative description. The phase combines all findings that emerged logically from the interviewing responses by incorporating them in a narrative.

Step 6: Decoding the Themes/Subject. This step is related to the lesson learned by the researcher. It is regarded as the 'essence' of the study (Lincoln & Guba, 1985). A researcher who observes and study the activities of the maintenance work process and additionally understands the participants' stories during the interviewing process will contribute to the full understanding of all data that have been gathered during the sessions.



Atlas.ti Software

Figure 3.7
Process flow for data analysis

A detailed analysis begins with the coding procedure, refer to Figure 3.7. The next step is to organize all the information into categories and labels all of the information with conditions by referring to the information given in the interview sessions. The coding procedure will identify the categories for analysis.

In this research analysis, codes will be brought forth for all the information and all categories will be examined in a general description in Atlas.ti. As a Qualitative Data Analysis (QDA) application, Atlas. it requires knowledgeable skills to achieve maximum accuracy out of the inquiry findings. Still, learning how to leverage from Atlas.it was made easy with the tutorials that were packaged with the software while workshops and trainings were readily extended for a more impressive result through special techniques.

In terms of research work process, before starting a certain process analysis, the necessary information must be obtained from all sources such as information from the project documentation, information from the interviews that was compiled, as well as information obtained during work observation.

3.10.1 Working with data files

Any information received was grouped according to the classified equation information, of which the same information must be kept in any "node" that has been prepared. For this study, all information gathered were achieved from three different sources: interviews, observation and review of activity documents.

Each source was used in accordance with the method that had been set out in the previous chapter, in which all information on the methods were arranged to suit the required needs of this research.

The important consideration in the work process of classifying information is to collect and collate all information received in accordance with the resources available. The complete list of each collection and classification process that were used in Atlas.ti applications are as follows:

Table 3.4
Nodes derived from all sources

No.	Sources	Nodes
1.	Document review	Maintenance reports
		Maintenance tender / work request
2.	Interviews	Age of participant
		Educational background
		Work experience
		Maintenance understanding
		Record management
		Work planning
		Work process flow
		Observation activity
		Problems
		Improvement

Table 3.4 (continued)

No.	Sources	Nodes
3.	Observation	Work process flow Record management

All of the information gathered was required to be uploaded in Atlas.ti application for analysis processing. The important process in work information management was prepared and placed in locations or sources that were listed. All similar information that was found in different sources must be stored in the same code to facilitate analyses and compilation of the work process.

Atlas.ti compiled all information according to sources and codes provided. Each uploaded information was relocated into the available codes; where the researcher was able to review all stored information from the existing code.

The documentation browser was also found in this application, where analysts could easily identify any information that was uploaded and revised the information obtained.

3.10.2 Working with codes

On each of the existing codes, the researcher was able to access all information easily. Analysts were also able to revise any encoded information on the findings and passing of each category or classification that was provided. Each of the information analyzed was prepared according to the research questions for this study.

The code also helped in the analysis by exploring all the data and the important information contained in the listed codes. Furthermore, all selected stored information could be modified according to the needs of the analysts. With regards to additional information, the analysts were also able to provide and create new coded information for each category. A code classification is required because the information recorded is sometimes used as guidance for any analysis, for example the provision of summary information for statistical diagrams.

3.10.3 Coding recorded data

The classification and encoding information process were also done using this application. The classification process was purposely created to gather and review all similar information in which each resource was associated with the topic and the result of the study.

The encoding information process should also provide an insight into the same information where it is being coded by the provided codes. It makes the analyst's job easier to do any reviewing process of the information. In addition, some of the encoded information can be associated with other sources of information. Therefore, by identifying the similarity of the information, the analyst should apply and use the same work process for the resources and existing codes.

3.10.4 Analysis option

For the next stage, the analyst can analyses the information directly such as a statistical analysis and prepare any work flow that was used in the work report. The researcher can also make any work analysis of the information on a regular basis according to the

work reporting requirements. By reviewing all available information thoroughly, it can give a better analysis in producing a good and comprehensive report.

A good work analysis normally uses all gathered information and useful method, and it usually follows the objective of the report itself. A good analysis method is necessary to make sure that all analytical work reports that were produced would be easily understood and interpreted by others.

The process of this analysis can be used as a guideline for the researcher to launch any systematic way for analysis work. By reviewing the transcribed interview, the researcher can create any codes that are relevant with the theme that has been set in the research study. The researcher can use a 'drag and drop', where all of the tools to copy and paste all relevant answers are uploaded into the relevant code.

The researcher can create a new code if needed when it is discovered that some important information needs to be raised or highlighted in this study. It was also placed and stored in the same code when several answers or information were found. Similar information will be grouped and given the right code.

The data collected, and each created code are labelled according to specific research themes. The answers given by the respondents revealed that the responses were almost the same for all the questions asked. The similarity of the answers was seen in each code. All of this information is important to maintain the authenticity of the information that was obtained from the research resource.

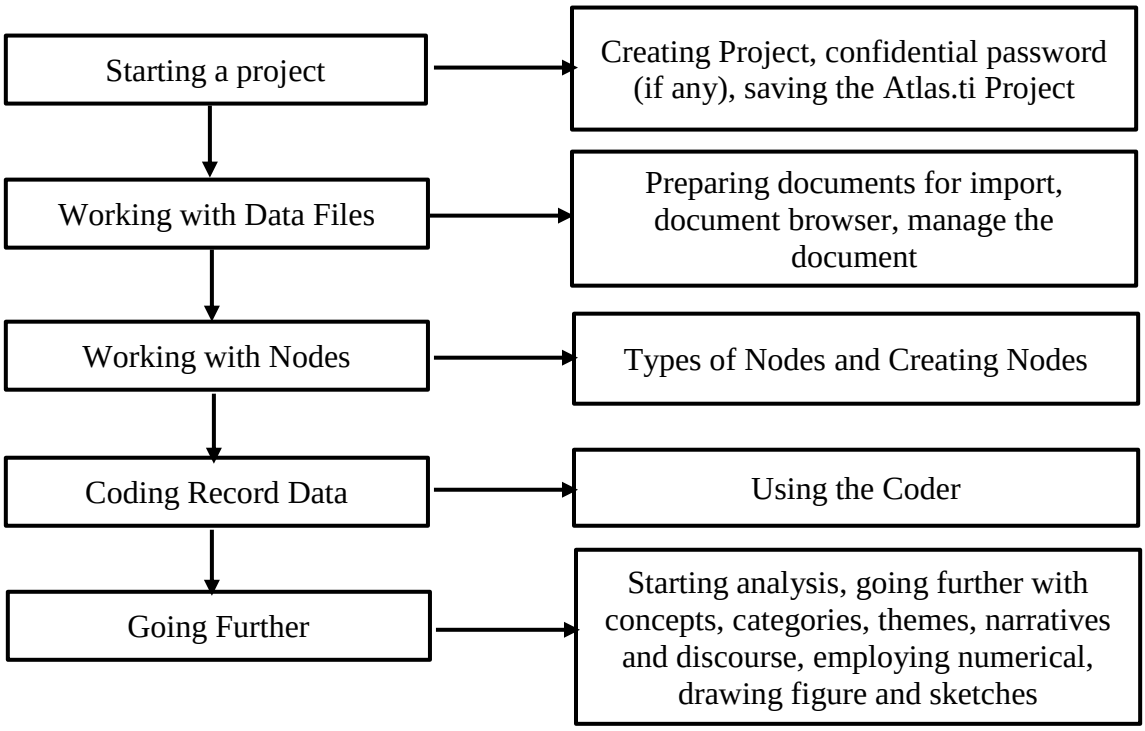


Figure 3.8
Atlas.ti software program procedure

The tutorials packaged in the Atlas.ti software provides a step-by-step animated guide whereby researchers can start practicing the software straight away. The procedures employing Atlas.ti software program is presented in Figure 3.8. Finally, a total number of nodes were produced, and they were clustered into categories or groupings in this AR study.

The description of the themes was represented in the qualitative narrative. This action combined all findings that emerged logically from the interview responses i.e., by integrating them into a narrative. From there the significance of the information is then translated. By exploring and observing the activities of the maintenance work process, reviewing the documentation and understanding the participants' stories during the

interviewing process a full comprehension of all the information gathered during the study was achieved.

The qualitative research is presented by the search for meaning and agreement, researchers considered a major tool for data collection and analysis of data, an inductive strategy and the investigation and the final product rich descriptive (Merriam, 2002) . Dodge (2011) explained that the data analysis for qualitative study gives a meaning for first impression and final compilation.

Subsequently getting to know all of the data, the results were generated by themes or categories or identifiable patterns. It is presenting a themed issue in describing qualitative research, it is not a straightforward procedure. Nevertheless, it seems both necessary and appropriate that we consider some of the limitations of qualitative research (Cassell, Buehring, Symon, & Johnson, 2006). The results of the analysis are explained in detail to reach the goals of research objectives.

The purpose of data is to protract or support the theory, the function should be underlined in the construction of the theories that has elements in the data collection (Johnston A. , 2014). In addition, Creswell (2009) and Esterbeg (2002) suggested that the research study must take after the coding procedure and data analysis, especially the open coding where the cognitive operation of the work rigorously with the information data, categorizing the information and ideas, and checking the lines by cables. Qualitative researcher coding is more than simply organizing the data where the principle of coding is to arrange the data to make them easier to understand (Catterall, 1996).

3.10.4.1 Data reduction

The first phase of qualitative data analysis involved the organization, reduction and reconfiguration of mass data is known as data reduction. "*Data reduction refers to the process of selecting, focusing, simplifying, abstracting, and transforming the data that appear in written up field notes or transcriptions*" (Berkowitz, 1997). The aim of data reduction is to reduce a data set. Lin, Tsai and Ke (2014) stated that the data reduction will resulted in the data itself becoming less significant, but the reliability of the original data set is strongly maintained. The result will keep fewer data count and more amount of the information, for instance, the result of interview transcripts while searching for similarities and differences in themes.

Code names were attributed to those themes that were detected and then organized into categories of associated topics, patterns, concepts, and ideas that emerged from participants' perspectives.

3.10.4.2 Data display

The second phase of qualitative data analysis is data display. Data display goes a step beyond data reduction to provide "*an organized, compressed assembly of information that permits conclusion drawing* (Miles & Huberman, 1994). The data displays are used to present all data into an accessible summary to arrive to the resulting conclusion. In that respect, there are various numbers of methods that can be used for arrangement and classification (Xia & Gong, 2014). Data display can be extremely helpful in identifying why a system (e.g., a given project) is or is not working well and what can be done to change it (Berkowitz, 1997). The final decision for the techniques used in the study was defined according to the results of data reduction. Once the appropriate technique was

identified, data displays were produced depending on each individual information, as well as in each case, to demonstrate findings across all available sources of data.

3.10.4.3 Conclusion drawing and verification

The third phase of qualitative data analysis is drawing initial conclusions based on cross-case information displays and then subjecting these initial conclusions to verification procedures. Reliable conclusions were drawn according to the methods and findings of this study (Xia & Gong, 2014). These routines were meant to assert that the findings were appropriate before they were labelled as conclusive. In qualitative research, the results were verified and deemed appropriate by evaluating their trustworthiness.

In general, the data analysis is presented in these three categories; the work process flow of maintenance department involving the maintenance work planning, the weaknesses in the implementing of maintenance management during the maintenance monitoring activities and the details of the report requirements needed by the top management.

These three classifications attempted to discover all of the details that can be utilized to accomplish the objective of the research. The researcher needs to note that not all data will fit specifically into one group or category of theme or description. Therefore, the write-up of all findings may be required to cut across different categories in order to gain better understanding and interpretation (Cassell, Symon, Buehring, & Johnson, 2006).

3.11 Conclusion of methodology

The study utilized the qualitative approach as the researcher would like to uncover the phenomenon transpired in highway maintenance management practices of LDP by seeking to describe and understanding the meaning of the central themes in the life of the participants (Kvale & Brickmann, 2009). The paradigm of Action Research was utilized due to the researcher is also the practitioner. Therefore, the researcher have more understanding of what is happening in the field of highway maintenance management, and how certain maintenance practices can be changed to improve the effectiveness of maintenance management system. Research information is gathered through various means of data accumulation including interview, observation of work activities, reviewing of work documentation and reports that would be used as qualitative data for further research analysis. In terms of data analysis, Atlas.ti software was used to explain the relationship between factors of maintenance practices and the effectiveness of highway maintenance management system.

CHAPTER FOUR

DATA ANALYSIS AND RESULT

4.1 Introduction

This section will analyze the data and trailed by discussion on the findings of this research in which the interview process including procedures and observations are reviewed based on these categories and identified patterns for the entire research. The primary method carried out was the face-to-face in-depth interview, with the objective to get participants to answer all of the research questions with the utmost accuracy.

Interviews were conducted at the participants' preferred premises at their convenience and comfort. Part of the interview sessions includes formulating questionnaires from which the participant's profile can be derived and developed. Also included in the interview process is a summary of the group characteristics of the participants.

In the final section of this chapter, a presentation of the research findings was derived from the interview sessions with the aid of Atlas.ti to summarize the following; examples of raw data collected, discussion of the themes generated from the data and how the results relate to the key construct of the overall research.

Lastly, the findings of this study are expected to provide a blueprint for successful application of highway maintenance management system and enhancement of continual improvement to strive for excellence in quality, services and business of highway operators.

4.2 Research work process

Due to the nature of the action research approach in the study, the collection of data pertaining to the research study involves a systematic process that focuses on objectives and collects various information sources namely from interview, observation and document review for analysis so that researchers can conclude the finding of the study. These three-methods were selected due to their inter-related factor to achieve triangulation of finding as interview data helped focus specific participant observation activities, and document analysis helped generate new interview questions.

In ensuring the information and the data captured in the research study are valid and in ethical manner, the transcripts of interview were sent to the interviewees to validate what was said during the interviews and to ensure that the written words in the transcript were those said by the interviewees. The interviewees then signed the transcript once the contents were as what they meant.

4.3 Data Analysis and Overview of the Results

The qualitative data was collected within 6 months based on the approval by Head of Department of Maintenance Management starting from August 2017. As mentioned earlier, the list of staff selected were based on their functions in Maintenance Management Department. The invitation was sent out to the Head of Department of Maintenance Management. He then identified his staff that will be participating in the study and each interview was conducted based on the availability of the staff according to their time, date and place. Out of 13 staffs under Maintenance Management Department, a total of 8 maintenance management personnel participated in this study. This number translated to 61.5% of the total workforce in the department. The total

number of participants involved was only 8 as many of them were having problems that could not be avoided. The normal reasons given were tight work inspection schedules, time - limitation and meetings. The objective of the study, questions and definition of terms were provided to the participants during each interview.

4.3.1 Participants Demographic

This section describes the findings from interviews session conducted by the researcher. The sessions were conducted in eight sessions participated by highway maintenance management staff. The findings of the interviews explained the reference to each respondent from the unit of analysis. Table 4.1 describe the unit of analysis and respondent lists interviewed to meet the purpose of this study. In the table, the respondent is recognized by the identity shown in the 'Respondent' column.

Table 4.1
Unit of analysis and respondents

Unit of analysis	Respondent	Gender
Maintenance Management Staff (Total = 8)	Respondent 1	Male
	Respondent 2	Male
	Respondent 3	Male
	Respondent 4	Male
	Respondent 5	Male
	Respondent 6	Male
	Respondent 7	Male
	Respondent 8	Male

4.3.1.1 Profile of Participants

The profile of participants using the Atlas.ti applications are presented in Table 4.2 below. Almost all of the participants interviewed gave their full cooperation. They

wanted to be important contributors and influence the outcome of the study. The participants wanted this study to be one way of describing what is happening in their company.

With all the information obtained, the study can be described according to the following categories: the number of participants, number of years with the company, technical education level and how the respondent describe themselves as a maintenance personnel.

Table 4.2
Profile of participants

No	Category	Description	Total
1.	Number of years with the company	More than 10 years	6
		5 to 9 years	1
		Less than 4 years	1
2.	Technical education level	No formal technical education	5
		Certificates	1
		Diploma	1
		Degree	1
3.	Describe yourself as a maintenance personnel	Committed to work	4
		Executing orders	4

1. Number of years with the company

During the interview sessions, it was noted that all 8 participants had given their full cooperation and had provided good responses. As shown in Table 4.2, from the results of the data analysis in participant profile, in which we can clearly conclude that because

75% of the employees that has been with the company for more than 10 years, we can consider this to be over-crowded. On the other hand, 12.5% of the employee was just under 10 years of service and another 12.5% of the employee was there in less than 4 years.

With the high number of years with maintenance management field, it also indicates the high level of work experience. The higher level of work expertise can give them the advantage in performing out their maintenance duties, especially in the field of highway maintenance. Indeed, experience in highway maintenance is important for every employee here.

2. Technical education level

Figure 4.2 shows that the participants had different levels of technical education in maintenance field. The levels of technical educational background comprise of 62.5% of the employees holding no formal technical education certificates as compared to one certificate holder, one diploma holders and one having a bachelor's degree qualification.

This research found that formal technical knowledge of workers in LDP was lacking and it will affect the smooth maintenance work process of the highest quality.

3. Describe yourself as a maintenance personnel

Table 4.2 shows that the participants were divided into two main categories in describing themselves as maintenance personnel. 50% of the respondents stated that

they are committed in giving their best service to the highway users and another 50% stated that they are merely executing orders regarding the maintenance work.

In summary, the value of maintenance is crucial in making sure that the best service is rendered to the highway users. In every aspect, the work done pertaining to the highway need to be deem as the deciding factor between life and death of the highway users. Therefore, all highway maintenance personnel need to appreciate whatever that they are doing has a major impact on others wellbeing and to the nation's economy as a whole.

4.4 Themes and Significant Statements

There are three main themes coded based on research framework and additional information required based on feedback by maintenance management department personnel in LDP. The themes coded in Atlas.ti application are the Effectiveness of maintenance management system, Application of policies and regulations to the planning and record management and Communication flow management. The second layer coding was developed based on the variances of answers provided by the participants.

4.4.1 Theme No. 1: Effective implementation of highway maintenance management system

Theme No.1 relates directly to Research Question 1 as stated in Chapter 1 as part of the research which addresses how effective the implementation of maintenance management systems for Lebuhraya Damansara-Puchong. The findings relate to the maintenance management practice particularly in planning activities in Maintenance

Management Department towards the completion of the maintenance activities and projects. The summary of the findings presented in Figure 4.3 explain the effectiveness of highway maintenance management system applied in LDP. Useful information acquired through interview sessions, observations and document reviews were considered as evidence and input for data analysis. The detailed breakdown of the interviews response for this research question is presented separately according to the themes and its significant statements.

Table 4.3
Findings on maintenance management practice particularly in activities towards the completion of the maintenance activities and projects

Theme	**Aspect**	**Number of times mentioned**	**Who mentioned**
Effective implementation of highway maintenance management system	i) Work planning		
	Do own planning	1	Respondent 1
	Work given	2	Respondent 3,5
	Do own planning based on work given	5	Respondent 2, 4, 6, 7, 8
	ii) Work description		
	Monitoring	8	Respondent 1, 2, 3, 4, 5, 6, 7, 8
	Do own research prior to executing work	4	Respondent 3, 4, 6, 8
	iii) Opinion with regards to the work process in the company		
	Satisfied	7	Respondent 1, 2, 3, 4, 5, 6, 7
	Need improvement	1	Respondent 8
	iv) Postponement or cancellation of maintenance work		
	Postponement	8	Respondent 1, 2, 3, 4, 5, 6, 7, 8
	Cancellation	2	Respondent 1, 5
	No cancellation	6	Respondent 2, 3, 4, 6, 7, 8
	v) Suggestion for improvement of work planning		

Table 4.3 (continued)

Theme	Aspect	Number of times mentioned	Who mentioned
Effective implementation of highway maintenance management system	Better quality of work	3	Respondent 7, 8
	Other suggestion	4	Respondent 1, 2, 3, 4, 5
	Work process already effective	1	Respondent 6

Based on the participants' profile, it can be concluded that the Maintenance Management Department was not facing any issues with the employees' work experience in executing maintenance work. Therefore, based on the interview and observation findings, most of the employees feel very comfortable in planning their work execution based on work schedule. The participants remarked as follow:

"I started off with yearly basis. Every year we have our action plan for our department and then for the company. So, from all the department action plan, then you consolidate and become a company action plan. It's a yearly affair which is incorporated in our budgetary process. And in budgetary come with the action plan. From the yearly action plan, I cascade down to have a yearly plan that, complete with all the timing and all the improvement and maintenance work that we are we going to do. It then cascades down from yearly down to monthly. And after that to the weekly duties." (Respondent 1)

In the work procedure, maintenance personnel are assigned to oversee any maintenance related issue until its completion. Therefore, the maintenance staffs are required to do their own work planning.

Another respondent stressed on the need of planning in accordance to the requirements by MHA:

"Usually planning, because Lebuhraya Damansara Expressway concessionaire which is monitored by the Malaysian Highway Authority. So, the Malaysian Highway Authority already had their own maintenance criteria that we had to perform so their plan will be combined with our plan and we will do the work based on that. About my work, the planning cannot be different from MHA's scope. It only will be adjusted but planning cannot be different from MHA's scope." (Respondent 2)

Employees' expertise is further displayed in the statement by other respondents as follows:

"They will give me the job with the solution or procedures already known. In this kind of case, I just execute the order. If their way is not suitable, I will inform them and normally they will agree with my suggestion." (Respondent 3).

"The work will be given to me and from there I will plan my activities to make sure that the work is executed and completed." (Respondent 4).

"Although the work was given to me, but I still need to plan how to execute the work because every situation and condition is different. Work becomes more challenging each day. When the highway first started there were not much user, and not much construction around. Nowadays, the problem is more and more due to a lot more vehicles and users, plus a lot of construction projects around." (Respondent 7).

The findings from the interviews and observations found that all the respondents are in the monitoring level. Their job descriptions are stated as follows:

"Major task of work is number one is we have landscaping and grass cutting... Then we also have building section... Third section that I have is curative maintenance. Curative maintenance is the bigger ticker maintenance work such as signboard's painting, guardrail, etc.… The forth section is that I have a drainage maintenance with the mainline… Basically, these are the works that looks like not so much in scope but when you go into detail, there's a lot of works to be performed." (Respondent 1).

Similar responses received citing that their job is more into planning mode. The remarks are as follows:

"With regards to my work, the planning cannot be different from MHA's scope. It only will be adjusted according to our work plan schedule without ignoring the criteria sets by MHA." (Respondent 2).

"LDP personnel will make their round, when they identify any improvement or repair work that need to be done, they will inform the contractor, or they will open tender with regard to the work." (Respondent 8)

In relation to the feedback of the respondents regarding their job description, based on the 15-observation conducted for the study, the researcher found that 80% of the

maintenance work activities were done without any representative from Highway Maintenance Management supervision. Although the document review of the job description mentioned about the maintenance work were done by the contractor is to be fully monitored by the maintenance staff. The observation result and the document review highlighted that the maintenance personnel did the work planning. However, they were not involved in the execution of the work plan.

With regards to the work process in the company, 88% of the respondents are satisfied with the current work process with only 12% stated that improvement is needed. The satisfied employees cited the following remarks:

"We do have a proper process to follow when the work requests out, the contractor will and can collect it, performed the work as instructed. During this time, you will monitor their work and then evaluate their performance based on the work performed." (Respondent 2).

"Everything is smooth and systematic here. The work flow is perfect." (Respondent 5).

On the contrary, respondent 8 is the sole participant who thinks that the work process practice by LDP should be improved citing the following remark:

"Hope that LDP will be transparent with its contractor." (Respondent 8).

In addition, to address the effectiveness of the maintenance management system in LDP, issues with regards to the postponement and cancellation to the maintenance works were raised. The findings in relation to this indicates that the postponement is something that is unavoidable in highway maintenance practice. All of the participants gave the same feedback that the postponement is although not often, it does happen due to certain reasons. The reasons cited by the respondent as follows:

"Even you have a problem also you have to see what kind of problem then we find way to solved it because we still need to do. You don't do something like avoid the maintenance. You don't do that." (Respondent 1).

Another participant further elaborates this issue by saying that:

"Postponement not often. We already provide a comprehensive schedule so the schedule that we've made based on the current situation. For example, we want to do cleaning work near the mainline indeed we cannot do it during the day and we had to do at night, so that kind of process we've included in the schedule, we will do it during night time. There will be one or two postponed works." (Respondent 2).

Other participants cited the reason of postponement are normally due to the weather condition, road condition and traffic condition. Their responses are as follows:

".. the maintenance work may be suspended for reasons of possible weather, such as rain. Apart from that, like it or not we still have to complete the job." (Respondent 4).

"Postponement also happened because of the weather, and road condition." (Respondent 5).

"There were jobs that need to be postponed due to unsuitable time, prime time, weather, heavy traffic, which required traffic management, rainy season and also because the location is too dangerous to do any maintenance work." (Respondent 7).

Changing the work priority, altering the work execution method, the value of the work is not worth it to the contractor and more time is required to solve the maintenance problem which were also mentioned as reasons for postponement of maintenance work. The remarks are as follows:

"The postponement normally involved work that is required more research done. That's why the work is postponed." (Respondent 3).

"The work will be postponed when there is urgent ad-hoc work that need to be performed." (Respondent 5).

"The postponement happens when the work is not worth it for the contractor and the area that need to be repair is not used by the road users." (Respondent 6).
"Job being postponed due to some other work has been identified as more important. For example, if LLM ask you to do something, that job becomes the priority and the planned work will be postponed." (Respondent 8)

In relation to the cancellation issue, 75% of the participants stated that no cancellation of highway maintenance work has ever take place in LDP. The responses are as follows:

"Currently cancellation in maintenance work never happen. The reason being is that the maintenance process is a continuous process that we had to do. Cannot be delayed. We need to do it no matter what. There will be some delays but no cancellation." (Respondent 2).

"So far there is no cancelled job." (Respondent 3).

"In terms of work cancellation, it is never happened. Like it or not you just need to do it." (Respondent 6).

Contrary to the no cancellation statements above, the cancellation did take place due to reasons cited by 25% of the participants. The remark for the cancellation works is as follows:

"It's really seldom we cancel the maintenance activity because even if we cancel it maybe because of maybe we have other priority, or maybe there are other alternative way of doing it better." (Respondent 1).

"We also have cancelled job but its belongs to MHA, for example, when a job is considered dangerous by MHA, so we have to cancel it." (Respondent 5).

The next dimension that analyst would like to find out in relation to the effectiveness of highway maintenance management system practice will be uncovered by asking the feedback whether there is any suggestion and expectation in improving work planning for maintenance activities. Based on the research findings, 87.5% has stated their opinion in improving the work planning process for maintenance activities. The feedback remarks are as follows:

"Frankly, I think what is most important is the maintenance staff need to be qualified and should have the necessary knowledge. They need to be focused and must be sensitive to what is required by the highway." (Respondent 3).

"If we can separate the work it will be even better. Drainage under this guy, ad-hoc work is under that guy, so it won't interrupt other people work. At the moment we need to handle everything." (Respondent 5).

In addition to the suggestions and recommendations discussed above, the participants also give feedback relating to the enhancing the quality of work. The remarks are as follow:

"When we talk about maintenance works, we cannot run away from discussing about the budget. I hope that the management or the related parties to provide adequate budget for us to perform the maintenance works so that we can achieve a better quality of work to better satisfy our highway users." (Respondent 2).

"We need to increase our quality of work. Sometimes, I have to guide my staff so that they can perform their job properly. If their work quality is good, other staff also will follow suit." (Respondent 7).

"LDP recently wanted the contractor to be multitasking which means that they need to do all the work that has been asked of them. However, my opinion, this shouldn't be as you cannot be master of all trade. You should only concentrate on the work that you familiar or have knowledge so that you can perform your level best and the work quality also will be better." (Respondent 8).

The feedback received from the respondents in relation to the work quality were also relates to the findings from the observations conducted during the information gathering process. The issue of the non-attendance of maintenance staff during the maintenance work activities is considered as a serious issue to avoid any deviation of work and non-conformity of work done by the contractor which will lead to additional expenses by LDP.

Apart from the ideas to enhance the maintenance work process, one participant cited that now the work process in LDP is already very effective. He remarked:

"For me, it is already in order. Already very effective. Even when I'm at home, other maintenance personnel will report to me by sending pictures, if there is a problem, urgent work. If they call I will come on the spot." (Respondent 6).

In addition, one respondent highlights the importance to understand the relationship between highway operators and Malaysian Highway Authority (MHA). He cited:

"It is the linkage between highway concessionaire and Malaysian Highway Authority (MHA). Although we are seeming like an independent party, but we are under the supervision of MHA. We are considered as a government asset as well. We are currently under the BOT arrangement, Built, Operate and Transfer. Once the concession is over, we will handover this back to the government to manage. There are so many things that relates to MHA. MHA is the agency that approved all your programmes, approved your upgrading works, and approved your pavement work, your maintenance works. Looking at the bigger picture, MHA is the father for all highway operators, which also under Ministry of Public Works (PWD) and Ministry of Works is under the Ministry of Transport. So, we cannot say we run independently. No. We still do routine maintenance, prevention maintenance, everything comes from the guidelines. There are books that we must follow." (Respondent 1)

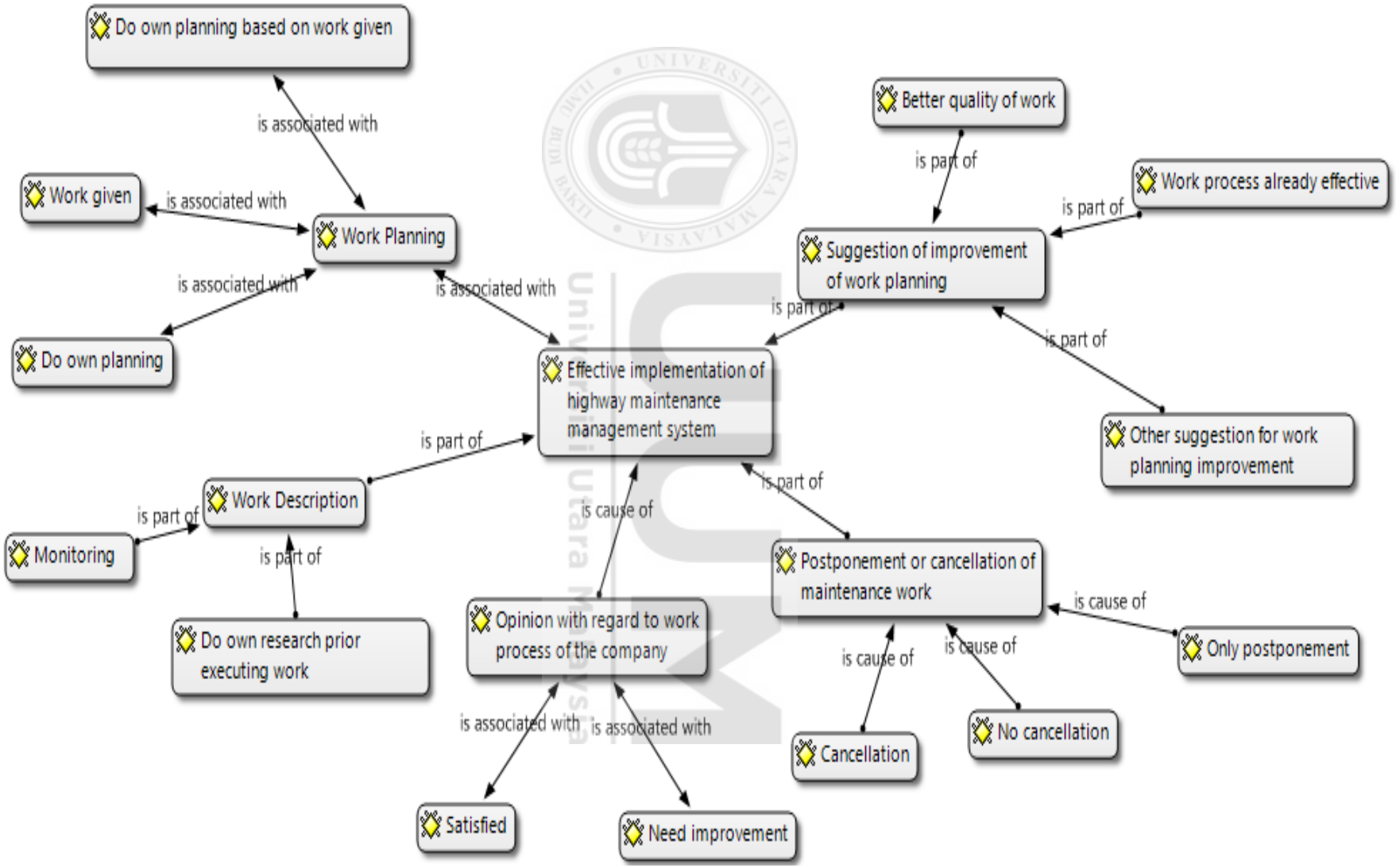


Figure 4.1
Atlas.ti finding on the Theme No. 1: Effective implementation of highway maintenance management system

In summary, the findings for Theme No. 1: Effective implementation of highway maintenance management system indicates that there are lacking in terms of work planning for highway maintenance in LDP. Based on Figure 4.1 from Atlas.ti software, the responses given by all the respondents, document review and observation can be summarized and listed as below:

1. Nodes for work planning for LDP showcased that participants have been divided between doing own planning, do own planning based on work given and relying on work given to them. The study shows that 7 of the participants are very comfortable in executing the work given to them. However, there is a problem in terms of non-attendance of the maintenance staff during maintenance work activities.
2. All 8 participants described the function are at monitoring level and 4 participants did their own research prior to executing the maintenance work. This lead to the issue of work preparedness. The problem arises when the maintenance work was not done according to what was required by the maintenance department resulted from inadequate manpower, tools and equipment to carry out the maintenance work activities.
3. In relation to work process, 7 participants indicated that they are satisfied with the work process with only 1 respondent stated that the work process still need improvement. This satisfaction of the employee reveals other issues. They seem to take their work for granted. The work process done by the contractors do not follow the procedures and representatives from LDP was not available during observation survey activities indicating weak application of prudent maintenance management practice.

4. The study also highlighted that the feedbacks received by the participants were divided in terms of postponement and cancellation of maintenance work. Although all of them stated that postponement is unavoidable, only 6 participants stated that no cancellation has ever taken place with 2 participants highlighted that there was cancellation of maintenance work. This indicate that there is miscommunication between maintenance personnel which usually arises through verbal and non-written communication.

5. In relation to the recommendation of LDP's work planning, only 1 participant stated that the work planning in LDP is effective and the other 7 mentioned that there were problems in terms of planning. The survey observation also indicated the same result. The most prominent is every participant has their own way or method of planning which indicates that the effectiveness of highway maintenance system in LDP is non-evidence.

4.4.2 Theme No. 2: Application of policies and regulations to the planning and record management function of highway maintenance management system

Theme No.2 relates directly to Research Question 2 as stated in Chapter 1 as part of the research which addresses what policies and regulations has been applied to the planning and record management function of the Lebuhraya Damansara-Puchong maintenance management system. The summary of the findings is presented in Figure 4.6 which explains the application of policies and regulations to the planning and record management function applied in LDP. The detailed breakdown of the interview response for this research question is presented separately according to the themes and its significant statements.

Table 4.4
Findings on policies and regulations to the planning and record management function in the highway maintenance management system

Theme	Aspect	Number of times mentioned	Who mentioned
Application of policies and regulations to the planning and record management function of highway maintenance management system	i) Maintenance definition		
	Maintenance is preserving the assets	6	Respondent 1, 2, 3, 4, 6, 8
	Maintenance is activities such as cleaning	2	Respondent 5, 7
	ii) Preventing problem		
	Prevention measure from monitoring activities	7	Respondent 2, 3, 4, 5, 6, 7, 8
	Prevention measure with future planning	1	Respondent 1
	iii) Definition for periodic, corrective and preventive maintenance		
	Understand all definition	8	Respondent 1, 2, 3, 4, 5, 6, 7, 8
	iv) Observation or survey in a day		
	Once	7	Respondent 1, 2, 3, 5, 6, 7, 8
	Twice	1	Respondent 4
	v) Observation or survey without instruction		
	Yes	8	Respondent 1, 2, 3, 4, 5, 6, 7, 8
	vi) Opinion on lacking in monitoring or observation		
	Work overloaded	4	Respondent 1, 4, 5, 8
	Sufficient	4	Respondent 2, 3, 5, 7
	Lack of focus	1	Respondent 3

The policies and regulations can be applied to the planning and record management function when the related personnel have good understanding with regards to the issues. In reference to the highway maintenance management system, the establishment of

rules and policies is only viable when the practitioners have adequate knowledge about the related maintenance concept. In relation to that, the participants in the study has given their definition of maintenance and different types of maintenance that were practice in LDP. The following section will discuss the feedback from interview sessions, document review and conducted observation pertaining to the Theme No.2.

In relation to the definition of maintenance, 75% of the participants stated that maintenance can be define as preserving the assets to its original condition. The remarks are as follows:

"Maintenance basically means to me number one is we preserve the asset. Yes, we preserve the assets that always in useable condition that has to provide safety for the road users." (Respondent 1).

"Maintenance is something that you do to keep things in its original condition for example you need to do the maintenance to road surface to avoid any damage…" (Respondent 4)

In terms of explaining the routine maintenance, corrective or curative maintenance and preventive maintenance, all of the participants managed to relate the maintenance works and the types of maintenance. The most significant remarks are as follows:

"Preventive activity is basically activities you carried out to prevent certain assets from getting worse. Preventive. Or sometimes, when people informed you about the drain are too small, you will enlarged it to avoid from flood case. Corrective, curative is when assets are damaged, you reinstate it, so you just go back to that original state. Useable state.
Routine works are the fixed works. Those activity has been fixed, for example litter collector is everyday duties, and same goes to landscaping, trimming, pruning and so on, those are quite routine. Routine are cyclical activity." (Respondent 1).

"Corrective is regarding damage, you have to repair, and highway, response time is very crucial. Preventive means that there should be a focus, we need to look, check, all assets to always be in good condition Routine maintenance involved the activities such cleaning, landscaping." (Respondent 3).

In addition, other participant remarks the definitions of maintenance types as:

"Routine maintenance is daily basis work such as cleaning and making sure no clog water inlet. Regarding corrective maintenance, if anything damaged due to accident, we need to repair or replace and preventive maintenance is like you make the water inlet wider to prevent flood." (Respondent 8).

With regards to preventing problems from occurs, based on interviews, observation and document review, the study discovered that all of the participants did practice their own measures based on their experience. As they all have a good understanding to what the preventive maintenance is all about, they utilize their knowledge in preventing any problems from occurring within their work context. Some of the significant remarks are as follows:

"Before something bad happens, we have to have prevention for all existing assets on the highway. Do not take anything for granted." (Respondent 3).

"From my experience, prevention can be done if we always monitor the condition of the road. If we do monitoring, we can avoid any damage or accident from happening." (Respondent 4).

"...if there is a danger area, hazardous road conditions, we will upgrade such as light installation, put up notices or signboards." (Respondent 5).

In terms of observation work, regular and structured monitoring is a key requirement of any highway maintenance management regime and a fundamental principle of continuous improvement. On that note, all of the participants in the study conducted a least one observation in a day and this activity is performed without any instruction from their superior. Some of the findings with regards to the matter are as follow:

"At least once a day. We called it looping. At least one loop every day, covering the whole stretch." (Respondent 5).

"I will do my own observation at least once a day but I will pick spots to do my observation." (Respondent 2).

In relation to conducting an observation without any instruction for superior, the findings are as follow:

"Although it's not a requirement. But for me you must be on the ground to see what is happening on the ground as you cannot visualized it. When we are at the field, we saw what happened, we can do the research, we can make a proposal, for prevention, for corrective maintenance." (Respondent 2).

"Yes, I will do my round without any instruction as I believe you need to be at the field to help to improve the highway." (Respondent 8).

For the last dimension in term of policies and regulation implementation in highway maintenance management, the participants were asked to give their opinion in the lack of monitoring function in LDP and the remarks were recorded as the research finding as follows:

"Lack of monitoring function happened when we or even our contractor was overloaded with too many works. For example, one person is capable to handle ten works at one time, however, if he needs to handle twenty work at the same time, it would be too much to ask, right? Sometimes, we may have overlooked certain work because it is considered less priority, or less impact work. We are human and not a robot, therefore less attention will be given to certain task but sometime when you give less attention and things happened. It sometimes beyond our capability." (Respondent 1).

"For me, it's a bit of lacking in terms of monitoring. Therefore, we need the contractor also to do the monitoring." (Respondent 4).

"Sometimes we may miss a problem because we already move to other location. 3:00 to 5:00pm we already at the office to prepare for night work." (Respondent 6).

"At the moment, the personnel also relying on their contractor to do the monitoring for the highway." (Respondent 8).

The view of lack of monitoring in LDP was not shared by half of the participants in the interview. Their feedbacks are as follows:

"It is not happening in LDP and we have a sufficient monitoring team. I am pleased to say that in LDP, we have several teams that make monitoring every day. Firstly, I had a supervisor, secondly, I have a mobile team and thirdly the patrol team itself. If patrol team sees something that needs repair, they will continue to inform the central control, the control will channel the information to related parties." (Respondent 2).

"We already have enough personnel for monitoring. However, we are lacking in terms of sensitivity, focus, apprehension, and staffs not enthusiastic about their work." (Respondent 3).

"Monitoring side is enough. It would be better if we have two team. One team do the monitoring, once they are back at the office, other team will take over to do the report. At the moment, we do the monitoring and we also do the paper work." (Respondent 5).

"At the moment, monitoring is sufficient enough as we have people on duty 24 hours a day and they will inform us if anything happens." (Respondent 7).

Based on observation and document review, the monitoring activity was normally dependent on time availability. This means that problems in monitoring work activity normally occurred due to limitation of time and work overload triggered by planning uncertainties in the department. The observation also found that sometimes the maintenance representative was not present during maintenance work activity. The researcher also discovered that all maintenance work that needed to be inspected was not done properly and did not meet the maintenance specification.

In addition to the application of the policies and regulation to the planning and record management function of highway maintenance management system, one participant highlighted the requirement for the top managements to have a good understanding of maintenance value. His remark is as follows:

"Operation maintenance is for me the initial stage. We want to create awareness on the part of management where maintenance of the asset management is one that should never be underestimated. I find now most of the top management wants to purchase new assets, build new assets, they forgot that when they have the assets, they must manage the assets. They are more excited to buy a new one. Get a new one, sophisticated one, and the latest. But when they get it, they push away the maintenance aspect. So, the top management need to be aware that they need to prepare the budget not only for obtaining the assets but also to maintain the assets. When I was with the government agency, they already being exposed to the value of maintenance and asset management. Awareness is already started but still not enough." (Respondent 2).

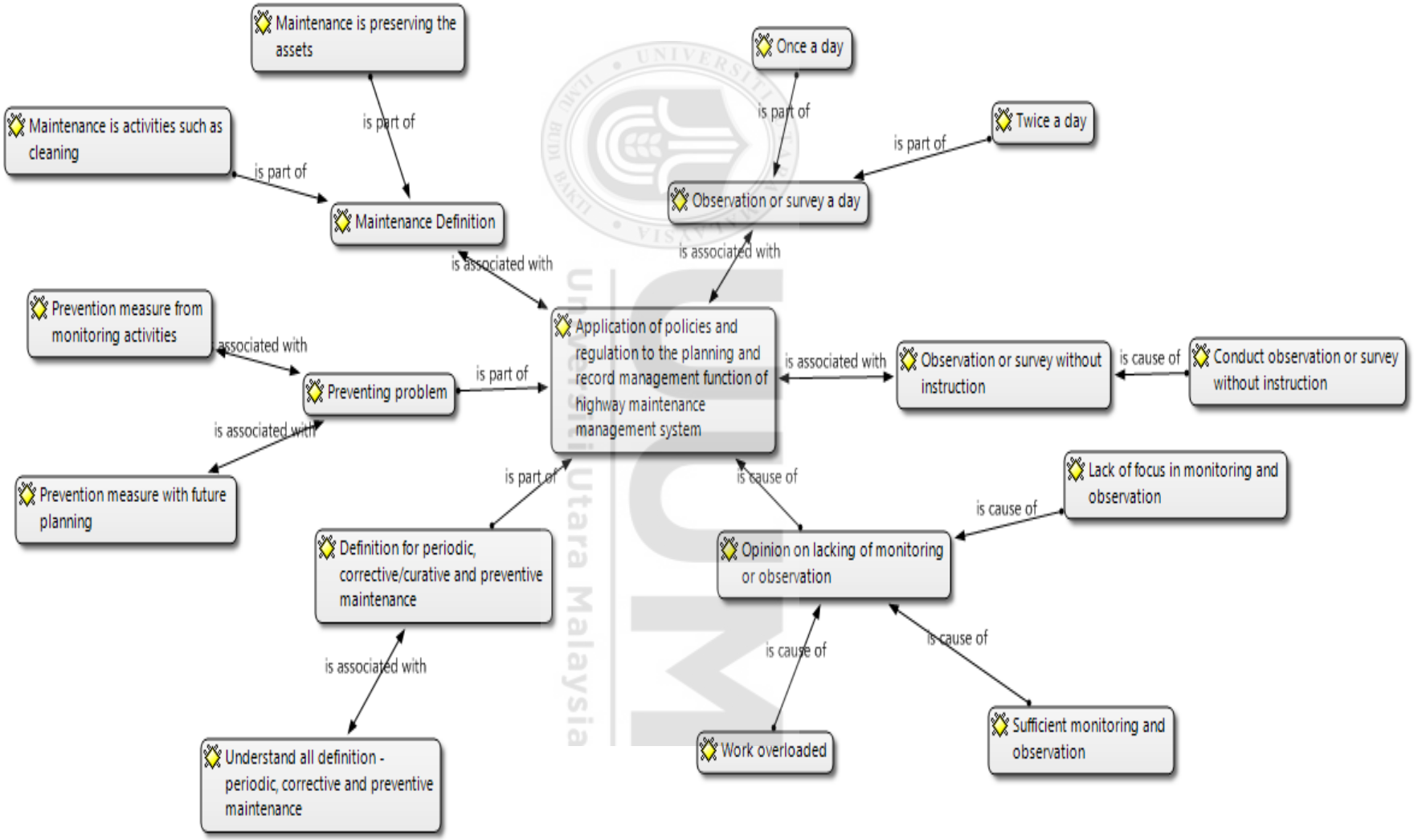


Figure 4.2
Atlas.ti finding on Theme No. 2: Application of policies and regulations to the planning and record management function of highway maintenance management system

In conclusion, the Theme No. 2: Application of policies and regulations to the planning and record management function of highway maintenance management system showcased a strong application of policies and regulations to the planning and record management function. Based on Figure 4.2 from Atlas.ti software, the responses given by all respondents, document review and observation can be summarized and listed as below:

1. In reference to the understanding of the maintenance value, the interview session found that 6 participants understand the definition of maintenance while the other 2 participants give their definition using the practicality of the maintenance itself which is the activities associated with the maintenance.
2. Another issue being highlighted in the Atlas.ti findings is on how prevention of the problem is taking place in LDP maintenance management. All participants stated that the prevention of the problem can be done via monitoring activities. 3 participants also cited that prevention correspondingly can be achieved using future planning. Although the respondents were in unity in saying that problems pertaining to highway maintenance can be resolved with monitoring function, non-attendance of maintenance personnel during maintenance work activities showed that maintenance staff was not aware on the importance of monitoring work for the highway maintenance project.
3. The finding concluded that all participants understand the meaning of periodic, corrective and preventive maintenance. They also do observation without any instruction from their superior at least once a day with one participant stated that they did twice observation every day.
4. The participants however seem divided in terms of their opinion on the lack of monitoring or observation function in LDP. This is also evidence in observation

survey done showing the lack of presence of LDP maintenance personnel. The importance in conducting monitoring activity is seen in the impact it had on the quality of maintenance work. It depends on how far the implementation of work monitoring to either result in the negative or positive way, which will give an impression to the users especially in the performance of work efficiency in this company. Limited time issue to carry out monitoring function occurs due to work not properly planned. Although, 3 participants remark that LDP has enough monitoring or observation function, 5 participants stated that they are overloaded with work that prevent them from conducting sufficient monitoring function. In addition, one participant stated that maintenance personnel need to be more focus in their monitoring duty. It highlighted the weak enforcement of policies and regulations to the planning and record management function of highway management system in LDP.

4.4.3 Theme No. 3: The communication flows in the application of the maintenance management systems

Theme No.3 relates directly to Research Question 3 as stated in Chapter 1 as part of the research which addresses the problem and issues currently encountered in the communication flows in the application of the maintenance management systems. Relevant information acquired through interview sessions, observations and document reviews were considered as evidence and input for data analysis. Theme No. 3 raised the issue of weaknesses in the communication flow in maintenance management system which is very crucial to prepare good quality maintenance report. The summary of the findings is presented in Figure 4.7 which explains the communication flows in the application of the maintenance management systems in LDP. The detailed breakdown

of the interviews response for this research question is presented separately according to the themes and its significant statements.

Table 4.5
Findings on communication flows in the application of the highway maintenance management system

Theme	**Aspect**	**Number of times mentioned**	**Who mentioned**
Communication flow in the application of the highway maintenance management system	i) Maintenance record management		
	Online	1	Respondent 1
	Online and hard copy	2	Respondent 2, 4
	Hard copy	5	Respondent 3, 5, 6, 7, 8
	i) Issue faced in record preparation		
	No issue	6	Respondent 1, 2, 3, 4, 7, 8
	Time consuming	1	Respondent 5
	Rainy season	1	Respondent 6
	ii) Work status reporting		
	Report	8	Respondent 1, 2, 3, 4, 5, 6, 7, 8
	iii) Superior discussion frequency		
	Monthly	1	Respondent 3
	Weekly	1	Respondent 1
	Daily	6	Respondent 2, 4, 5, 6, 7, 8
	iv) Preparation for supporting document		
	Source for proper documentation	8	Respondent 1, 2, 3, 4, 5, 6, 7, 8
	v) Enhancing maintenance record management		
	Already sufficient	3	Respondent 1, 6, 7
	Need enhancement	5	Respondent 2, 3, 4, 5, 8
	vi) Party responsible for data and record preparation		
	Each department	1	Respondent 1
	Highway Maintenance Department	7	Respondent 2, 3, 4, 5, 6, 7, 8

The communication flow is very crucial in getting work done effectively and efficiently. In ensuring the correct flow being practiced in the LDP, the third theme is trying to uncover the issues and problem that may exist in the maintenance management application. The query started by getting feedback on the type of maintenance management record being used in maintenance management department of LDP. The findings remarked are as follows:

One participant cited using online record management.

"We have our internal generated, internal design system called E-works which is a computerized maintenance management record and also budgetary accounting system." (Respondent 1).

2 participants mentioned that they used 50% online and 50% hard copy.

"Its 50:50 method. We have softcopy and hard copy. Normally the hardcopy is used when we want to send report to MHA. Everything need to be converted to hardcopy when we want to do reporting to MHA." (Respondent 2).

*"I record my work activities in my notebook. Once I arrived at the office, I will transfer whatever record into the computer." (*Respondent 4).

5 participants used the hard copy for their record management. Their remarks are as follow:

"I am not an online person. All records are hand-written." (Respondent 3).

"Here we use time sheet with type of work and location details, like record." (Respondent 5).

"My work activities start in the morning when I move to the site. I will be given camera, hand phone and diary. When arrived at the problematic area, I will snap pictures, note down the location. Then I will go back to the office, print out the work request. If it's an urgent case, I will WhatsApp the pictures and the contractor will straightaway come to the location." (Respondent 6).

Based on the document review, the main report for maintenance department was prepared on monthly basis. The report will consist of all matters pertaining to the

activities done by the department. Each contractor will submit their monthly report relating to the work performed for LDP. All this report then compiled by the Highway Maintenance Department staff and submitted to the top management of LDP as well as to the MHA.

In relation to that, during observation, maintenance staff were spotted carrying the work request whenever they are on-site, and the contractors' and the suppliers' will have their own copies. Any updates or on-going work reporting were seen done via WhatsApp application by highway maintenance personnel as well as the contractors' and suppliers'. During this actual observation, a few gaps was noted concerning the maintenance work quality especially in information or record management was not being done properly which lead to difficulty in tracing any monitoring record, incomplete work reference and unsynchronized work report.

In terms of problem faced in preparing the maintenance report, most of the participants explained that there is no problem arise in report preparation. Their remarks are as follows:

"No problem. As long as you don't close the issue, the system will keep on prompting you regarding the matter that there is certain item is still not yet closed or in progress. If you don't close and you don't respond, it will also affect your performance." (Respondent 1).

"No problem as far as we have a good cooperation with our contractor. Whatever that we asked for, they will do it promptly." (Respondent 7).

Other participant mentioned that he thinks preparing the record is time consuming.

"The trouble that we face when we do the monitoring and do the reporting because preparing the report is time consuming." (Respondent 5).

As stated in maintenance management system requirement, all work related to maintenance activity must be recorded. The top management requires that they be provided with quality reports on all daily tasks conducted by maintenance department. This is to enable the management to find out the status of any maintenance activity and at the same time able to notify MHA as and when required.

Next question asked in relation in ensuring the correct communication flow being practiced in the LDP. The following findings indicates that all employees used reports in reporting work status to their superior.

"I will get the reports from our sub-contractor and supervisors. After that, I will prepare the report for Head of Department." (Respondent 2).

"The report will go to Highway maintenance department." (Respondent 3).

With the introduction of WhatsApp application, many employees utilize this method as one of the reporting type.

"Based on WhatsApp, hardcopy and softcopy, the report will go to Highway maintenance department." (Respondent 4).

"We have WhatsApp, we have hardcopy. Depends on situation." (Respondent 7).

Next part, the study explains how frequently the employee talk with their superior about their work activities. The findings indicate that most of the participants communicate with their superior on daily basis. The significant remark as follow:

"Very frequent. Daily basis." (Respondent 2).

"Daily basis. Our WhatsApp is always full due to non-stop interaction." (Respondent 5).

"Daily basis, sometimes, two or three times a day." (Respondent 7).

Meanwhile, if there are issues, the participants asked how they would handle the circumstances that require them to prepare supporting documents. The findings found that all employees will look for the complete information pertaining to that issue(s). However, there are different degree of sourcing for the additional required information.

"Normally in terms of emergency case, we will seek our senior management approval first to proceed then follow up by a documentation because at that time action is more important than preparing certain paper. You cannot have a proper documentation where everybody signed already then only you carry out the rectification work. At times you don't have such a luxury time." (Respondent 1).

"If there are any issue, if I had to prepare a report, first I need to get detailed information about the issue. So, I will get the info from my subordinates then I will generate a report for submission to the boss. If the info or the details are not adequate, I will go to the location myself." (Respondent 2).

"I will source for the information myself. Sometime if you want to wait for the information from the boss it will takes time, so it is better for you to for the information yourself. That's why certain task needs to be postponed due to the delays in boss approval." (Respondent 6).

In terms of giving suggestion or recommendation in enhancing maintenance record management, the study findings remark the following feedback:

"I think the system is already quite good. If we have any item that has not being closed yet, etc. then follow up with our supervisors and our down liners. Compared to 10 years ago, now some of our software is written internally based on our requirement, our knowledge and our experience. So, to me, it's very useful already. When you have this maintenance system software, it will assist you on how you manage the report, reporting, and use it to monitor our staffs." (Respondent 1).

Other participant suggested on having adequate equipment or device in performing maintenance duty.

"Because now we are in the era of technology, the online era, paperless, so for me if supplied with hardware that is more up to date, it will be very much helpful. For example, if supervisors or subordinates were provided with smartphones, he can capture the image and then WhatsApp to us. This means it will be a great help if we are supplied with good hardware, in terms of mobile phones, in terms of data plan." (Respondent 2).

Another participant cited the need to give new contractor ample time to understand the practice of highway maintenance.

"In this process, the most important is highway contractors should not have to be change often. For example, there is new contractor, however after 3 month or so due to possible favoritism and what not, they are terminated. The contractors need be given time to gain knowledge regarding their work, highway procedures, knowledge of traffic management which is very important. Highway company should give a briefing to the contractor every 3 months about safety or any current issues regarding the highway." (Respondent 3)

One of the participants suggested that LDP should follow the maintenance system from other highway which for him resulted in better quality of work.

"We should have a system that, a person does the monitoring and passed all the info to other person which has all details with regards to how many man power, how much the lorry fee, etc. Its means that the monitoring team are not required to be at the office, all they need to do is call the office and give all the details to the office people. Once the monitoring team arrived at the office all documentation is already prepared. Therefore, it's going to be more efficient." (Respondent 5).

The last query posted to understand the communication flow was on who should be responsible to deal with this data and preparing the report. The finding for this dimension stated that Highway Maintenance Management should be the party responsible to deal with maintenance data and to prepare a complete report pertaining to their work.

"Highway Maintenance Management." (Respondent 2, 3, 4, 5, 6, 7, 8).

The participants also raised their concerned with regards to the communication flows matter. The responses are as follows:

"Highway maintenance, for me personally is no big deal, the relationship between employees and contractors should be good because they need each other. The staff should be more concerned in respect of their duties. We must think and always make sure of the safety of highway users. We need to have people who are qualified about highway section maintenance. Higher education people who think in providing people with highway maintenance education. MHA should make a requirement for

appointment of highway personnel should have at least a diploma in highway maintenance. Training, motivation, courses should be held to ensure that all parties understand their respective roles. Need to think about the safety of others..." (Respondent 3).

"pertaining to the work practice in LDP, they need to be transparent in work so that the contractor can have the full faith in them." (Respondent 8)

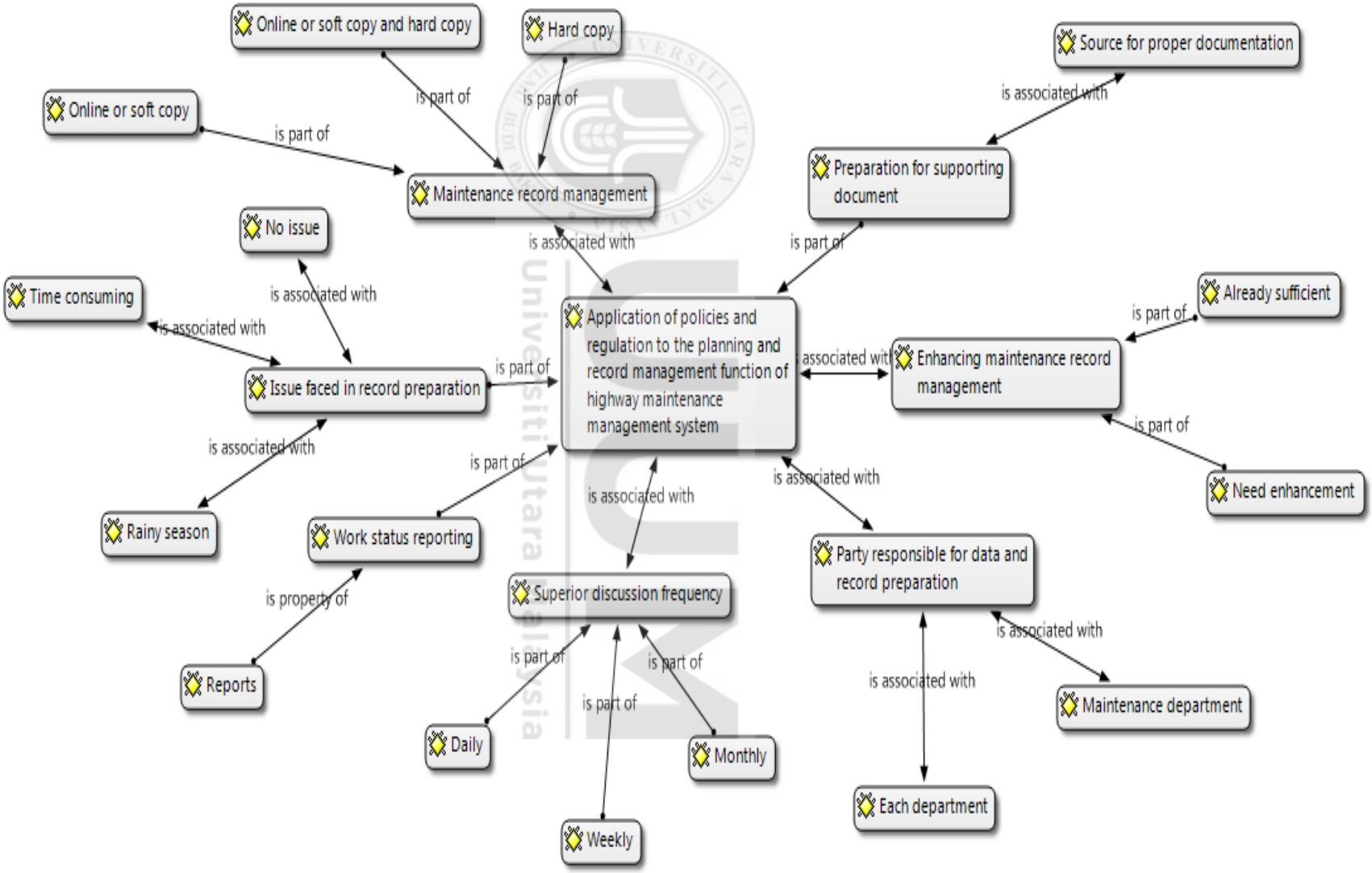


Figure 4.3
Atlas.ti finding on Theme No. 3: The communication flows in the application of the maintenance management systems

In summary, for the Theme No. 3: The communication flows in the application of the maintenance management systems, based on Figure 4.3 from Atlas.ti software, the responses given by all the respondents, document review and observation can be summarized and listed as below:

1. According to the finding, the result indicates that a drastic action needs to be taken. Information management record is required in any work process especially in maintenance management. Now, the reporting of work varies from one employee to the other and only one person utilizes the online reporting system whereas 4 of the participants still are using the hard copy. Another 3 participants used the combination of hard copy and soft copy in terms of maintenance record management. Based on the interviews, document review and research observation, it was found that the maintenance department did not practice a good centralized work information and planning. Even though each staff keep his own filing and book keeping daily, consolidation of records already known as a complicated exercise. Besides, tracking of work record can be time consuming, especially whenever there was a need to rectify certain issue under certain circumstances.
2. In preparing the record, 6 participants indicate no issues and another 2 cited that record preparation is a time consuming task and faces problem when it is in rainy season, respectively. All the participants used reports as the way to report their work status. This report can consist of hard copy reports such as monthly report, weekly report, daily report and timesheet. They also employ soft copy reports such as visual reports using WhatsApp's application.
3. The communication flow from Atlas.ti findings showcased that 6 participants discussed their work with their superior on daily basis. Another 2 cited they

only met their superior on monthly and weekly basis respectively. Apart from that, all of the participants are very resourceful and have no problem in getting additional information to execute the work given. This is due to the broad experience that they have. In general, work experience is a key contributor to the success of an organization as it helps the work process to become more robust and efficient.

4. In terms of enhancing the maintenance record management, only 3 participants stated that the system they are using is already enough to record they work activities. The other 5 participants remarked that the record management system need enhancement. The document review found that the procedure did not specify how to manage the information management process. ISO standards simply states that every information shall be dealt with in an orderly way and each information is considered important.

5. The last finding from Atlas.ti application with regard to the communication flows in the application of the highway maintenance management system showcased that 7 participants regard the Highway Maintenance Department as the party to be responsible for the data and record preparation. The sole participant remarked that each department should be responsible for the data. This finding further supports the outcome from observation research which stated that the section head of maintenance department just manage and regulate information in their own department. This leads to some issues including the difficulties in analyzing incomplete information, each staff submitted different information and lastly the limited time available in preparing the final report that resulted in an inadequate or unsatisfactory report.

4.5 Chapter summary

In conclusion, this chapter discusses in detail about the result and data analysis that were carried out on the collected raw records data from the preceding process through interview sessions, document review and research observations. The raw data was converted into transcripts to serve as inputs to a Qualitative Data Analysis application software system called the Atlas.ti; a useful data analysis tool for studies and researches. The output from Atlas.ti was also presented in this chapter in detailed manner.

The results and findings from this research indicate that inefficiency exists in maintenance management practice resulting from poor maintenance management. The issues raised that needed to be addressed could be summarized as follows; the problems on the effectiveness of highway maintenance system in LDP, the importance of the policies and regulation for work execution, observation and surveillance and improper communication flows in the application of the highway maintenance management system particularly in the preparation of good quality work reports.

A detailed discussion and recommendation to tackle these issues is addressed in the next chapter, chapter 5 in which suggestions of improvements in certain areas are also included.

CHAPTER FIVE

DISCUSSIONS, RECOMMENDATIONS AND CONCLUSIONS

5.1 Introduction

This section sets forward ideas for further discussions, recommendations and conclusions. The recommendations and suggestions on action plans to be considered for execution to improve the work process under study is meant to accommodate the main objectives of this whole study.

5.2 Discussion

In brief, the purpose of this research was to conduct a study on the current work process in the Maintenance Management Department specifically in maintenance management. Through this research, the knowledge capacity of the employees on maintenance management in the highway and maintenance procedures of the Maintenance Management Department was identified as the root cause which contributed to the maintenance management issues that arose.

This research provided the analysis and consolidates the areas of improvements through recommendations and action plans. The current study adopted the empirical investigation method to study the company's performance within its Maintenance Management Department. With the cooperation of its employees, information in various forms were collated and analyzed to help the employees understand the importance of their roles and functions in maintenance management.

The objective of this research is to provide solutions to overcome the shortcomings and difficulties in the Maintenance Management Department of a highway operator company, particularly in the implementation of maintenance management in the following areas:

- Work planning
- Monitoring
- Reporting and documenting

The elaboration of the research outcomes in this chapter is strictly based on and refers to the problem statement of the research as identified in Chapter 1. In highway maintenance, weaknesses in the implementation of maintenance management can have a major impact on the work process, especially in the work completion section and this could be caused by various factors which normally could be narrowed down to the company management itself.

By applying the qualitative data analysis method, this research managed to derive the recommendations on plans of actions to remedy the weaknesses and enhance the operation of the department under study. Findings from the study also revealed the importance of proper management of information flow from the work planning stage to the preparation of a good final report on maintenance. In addition, the proposed improvements for a new maintenance work process have also been implemented. The new maintenance work process flow will be introduced and explained in this chapter to help the work process activity in the Maintenance Management Department to be more efficient and systematic.

5.2.1 Discussion on finding 1 – Effective implementation of highway maintenance management system

The first discussion will be based on the finding of Theme 1 - Effective implementation of highway maintenance management system. The importance of planning in relation to the effectiveness of any program can be traced back from the ancient times. Sun Zi, a Military General in China from around 500 BC, highlighted the importance of planning in one of the oldest military treatises in the world; namely "The Art of War" (Rødseth & Schjølberg, 2017). Zi (2009*)* stated that *"he who is victorious in the temple computations before battle is the one who receives more counting rods"* (p. 79). Dwight David Eisenhower, American politician and Army general who served as the 34th President of the United States from 1953 until 1961, also stated that *"Plans are worthless, but planning is everything"* (Eisenhower, 1957).

Planning function developed from management principles work by Dr W. Edwards Deming (2000) and Dr Peter F. Drucker (1954) has been used in maintenance planning by Palmer (2013). Based on the finding, the creation of the maintenance work plan is regarded as not difficult as all the participants involved in the planning process. This is also related to the vast experience of the respondents in which making them very comfortable in terms of making work plan. However, experience alone was not enough as effective maintenance management also require the maintenance personnel to acquire relevant skills and knowledge (Kangwa & Olubodun, 2003). Thus, maintenance management personnel need to develop their skills and knowledge regarding maintenance activities as at the moment, only 3 personnel attached with the Highway Maintenance Department in LDP has formal knowledge in maintenance field whereas the other 5 personnel were still lacking in this area. Lack of sufficient skill and

knowledge may lead to bigger issue such as poor quality of maintenance work. Although, today's maintenance planning has been supported by guidelines from related parties and handbooks from maintenance expert (Palmer, 2013; Peters, 2015), the need for knowledgeable personnel is still very essential to ensure the effectiveness of maintenance management as mentioned by the repondents of the current study.

Knowledgeable personnel has a great impact of the maintenance effectiveness (Björling, Galar, & Kumar, 2013). Human intellectual complemented by the rapid advancement in information and communication technologies has contributed to the more efficient, effective and economic system competitiveness (Parida A. , Kumar, Galar, & Stenström, 2015). In relation to that, it is known that human intelligent has some limitation. Therefore, the aid of a system is required to assist human in managing a complex and expensive assets (Björling, Galar, & Kumar, 2013).

A good and effective highway maintenance is formulated based on accurate knowledge of the properties of the materials used, well-researched engineering principles, developed and validated computer programs and also the interaction with the existing ground and the environment (Kirkup, 2016). Integration and inclusion of maintenance knowledge management (MKM) into the processes and infrastructures of highway maintenance creates the foundation for a more comprehensive approach to ICT-based maintenance solutions (Björling, Galar, & Kumar, 2013). Hence, the establishment of database for maintenance management work is very crucial in ensuring a smooth and effective highway maintenance management practice.

In addition, based on the study finding, the maintenance planning function in LDP also has a different problem. Maintenance Management Department in LDP has struggled in terms of "silo thinking" with regards to its planning function. This problem describes a phenomenon whereby different personnel employs different planning methods. It is a situation where different disciplines, such as maintenance and production, in an organization perform independent planning for the same physical asset (Rødseth & Schjølberg, 2013).

The concept of silo thinking discussed in the work of Rødseth & Schjølberg (2017) specified that it can lead to inefficient resource management of the assets resulting to unnecessary downtime and reduced profit. Therefore, it is evident from the research finding that the planned maintenance was not being implemented systematically resulting in poor maintenance management approach. These findings are consistent with previous research that the maintenance function cannot be carried out satisfactorily without a thorough and systematic approach (Sinha, 2015).

Maintenance planning is related to maintenance policies (Wang, 2002). Typically, maintenance policy defines the category of each maintenance activities planned (Zhao, Wang, & Zheng, 2014). The plans of action are used to provide guidelines and direction for further maintenance activities (Waeyenbergh & Pintelon, 2002). In LDP, 3 types of maintenance policies were used i.e., Preventive Maintenance (PM); Corrective Maintenance (CM); and Routine Maintenance (RM). It is learnt that all types of maintenance activities performed in LDP subsequently will fall under these 3-maintenance categories and these are supposed to provide an effective maintenance system for LDP. However, the objective to achieve an effective maintenance

management is not an easy task because it relates to the events which is very much unpredictable and uncommon (Sinha, 2015). In relation to that, maintenance management personnel of LDP stated that currently, the maintenance budget is below the need of requirements. As a result of this allocation constraint, the quality of maintenance work performed has been affected.

The surrounding development projects and the significant increase of LDP users also contributed to the escalation of maintenance works that need to be performed in LDP. Therefore, the budget allocated is not sufficient to maintain the assets of the highway resulting in too many assets not functioning well (Ali & Lin, 2011). The study finding further added that sometimes maintenance work was delayed due to the work value were too low for the contractor to execute. Therefore, LDP delayed the maintenance works until it is profitable for the contractor to perform. These findings are broadly in line with the work of El-Haram & Horner (2002) who stated that maintenance work were delayed due to the budget allocated is not sufficient to cover the needs for maintenance.

The task of handling the maintenance operation have to be effective in meeting the restricted level of availability of an asset (Alabdulkarim, Ball, & Tiwari, 2015). Maintenance operation in this case refers to maintenance activities such as repairs, inspection and preventive maintenance (Wijeratne, Perera, & Silva, 2014). The maintenance operation has been identified with a lot of problem and it is evident from the result of the study such as the problem in terms of work process done was not following the procedures, non-attendance of LDP's maintenance personnel during the maintenance work activity, lack of monitoring activity, different reporting methods and

problematic record management system. The finding is consistent with those of researchers that stated that maintenance operation problems can be resulted from lack of benchmarking (Adebanjo, Abbas, & Mann, 2010; Singh, 2011; Shaaban & Awni, 2014); lack of communication and information (Mohamed, 2005; Leong, Zakuan, & Saman, 2012); lack of teamwork (Rolfsen & Langeland, 2012; Aspinwall & Elgharib, 2013); lack of commitment of employees towards maintenance (Singh & Ahuja, 2014; Mosadeghrad, 2014); lack of training (Singh, Gohil, Shah, & Desai, 2013; Mosadeghrad, 2014); lack of proper planning and implementation (Singh, Gohil, Shah, & Desai, 2013; Abreu, Martins, Fernandes, & Zacarias, 2013; Mosadeghrad, 2014; Ding, Kamaruddin, & Azid, 2014); lack of top management support (Kodali, Mishra, & Anand, 2009; Singh, Garg, & Deshmukh, 2008; Kumar, Singh, & Shankar, 2015); and lack of effective performance measurement (Parida & Kumar, 2009; (Lad & Kulkarni, 2010). The lack of effective maintenance operation as evidence from the study did not seems to effect the work satisfaction of the highway maintenance personnels.

The finding showed that eventhough the employees stated that the maintenance management operation in LDP is in the mess due to many problems cited, however it did not have any impact of the job satisfaction as 7 respondents stated that they feel satisfied with the current work process. This issue has been mentioned in Bednarska & Szczyt (2015) work that one of the factor for job satisfaction is social relation.

Employee will view the support he got from his organization, the situation of his employment and his evaluation of the work climate in order to visualize his job satisfaction (George & Zakkariya, 2015). This statement is further explained in other

studies with regard to the relationship between person-organization fit and job satisfaction (Chen, Sparrow, & Cooper, 2016). According to Kottke & Sharafinski (1988), employee tend to put great importance on the feedback and support from the people that are close to them. Supervisor support and encouragement such as empowerment enable the employee to make important decision with regard to their work (Chen, Sparrow, & Cooper, 2016), which in the end will boost the moral of the employee and ultimately will enhance their job satisfaction. This situation can be found in the findings of the study where the employee feeling satisfied with the work process practices in highway maintenance department due to the authority given by their superior which has boosted their job satisfaction level which lead them to stay with the company (George & Zakkariya, 2015).

Other dimension that relates to the lack of effective implementation of highway maintenance management in LDP is associates with the dearth of understanding of the maintenance work value. Maintenance work is still regarded as a "necessary evil" by many organization until today (Fraser, 2014; Cooke, 2003; Zio, 2009). Although the attitude for maintenance has changed for the past 15-20 years (Fraser, 2014), there is still general tendency to avoid maintenance function in order to reduce cost (Danish & Siddiqui, 2016).

The respondents of the study also indicate that key stakeholders did not understand the value of maintenance function which lead to insufficient of budget that was allocated for maintenance activities. In relation to that, all participants of the study stressed that postponement in maintenance work is normal. One respondent cited that the postponements were required because the value of the maintenance work were

inappropriate for the contractor to do. Therefore, maintenance management personnel will accumulate the maintenance work until it is profitable for the contractor to perform (Dekker, 1995). Tam & Price (2008) echoed the reason of work postponement due to the amount of time and money limitation. Apart from that, the other reason cited for the postponement of maintenance work was due to traffic condition, weather and the change of work priority. In relation to the traffic condition, sometimes maintenance work need to be postponed because the high volume of the traffic using the location where the maintenance work has been scheduled making it dangerous to perform any work. Very bad traffic congestion will also be initiated if maintenance work being proceed in high volume of traffic users. In addition, weather condition will also be the deciding factor whether the maintenance work can be performed as scheduled or have to be postponed.

The weather condition such as rain will definitely effect the maintenance work. Eventhough the maintenance work is still being performed during rain, the work quality will not be good and will be a waste of money, resources and time. The last factor for maintenance work postponement is the change of work priority. A respondent stated that a job is being postponed due to some other work which has been identified as more important. For example, if MHA asked LDP to rectify some assets or structures, that job takes the priority and the planned work will be postponed.

The study finding has uncovered the problems with regard to the maintenance management effectiveness in LDP. It is now known that the maintenance work planning practiced were unsynchronised which mean that unreliable and inconsistent result will be produced that will lead to interuption to highway operation and also unsafe highway

for the users. Although the maintenance personnel consulted in the study stated that they are performing the monitoring function of maintenance work performed, the own planning that they did in the first place will effect the result of the work. Eventhough 7 out of 8 respondents indicate that they are satisfied with the maintenance work process, they also mentioned about the improvement that can be undertaken to enhance the work planning.

5.2.2 Discussion on finding 2 – Application of policies and regulations to the planning and record management function of highway maintenance management system

The second discussion of this study will be based on the application of policies and regulation to the planning and record management function of highway maintenance. Policies and regulation application can only be viable if personnel or people that will be affected by the practice understand about identified rules. The research finding concluded that not all of the maintenance management personnel grasped the meaning of the maintenance management concept.

The definition of maintenance by six of the respondents stated that maintenance is preserving the assets to its original condition. The definition echoed the previous study that define maintenance as the combination of all technical and administrative action to ensure the system is in functioning condition (Reason, 2000; Swanson, 2003; Basri, Razak, Hasnida Ab-Samat, & Kamaruddin, 2017). Dhillon (2002) simplified the maintenance definition to “a collection of actions executed on an asset with the aim of keeping an asset in, or restoring it to, a specified condition”. This definition by Dhillon is linked to the definition given by the six respondents of the current study. Apart from

that, another two respondents have given the definition for maintenance is the activities relates to the maintenance such as cleaning. The cleaning function in maintenance work is under the routine maintenance or better known as Preventive Maintenance (PM) of Cyclical Maintenance (Strategic Plan for Preserving Iowa's Buildings and Monuments, 2003) where the maintenance work performed after specific period to reduce the risk of system failure (Basri et al, 2017). Preventive maintenance also can be associates with planned or scheduled maintenance practice (Caldeira & Guedes, 2007).

The used of PM as accident or problem prevention measure happened in LDP is as mentioned by 7 of the respondents in the findings of the current study. The maintenance personnel stated that they executed the prevention measures from monitoring activities. This statement of preventive maintenance method echoed the previous studies that denotes this type of preventive maintenance as Condition-Based-Maintenance (CBM) (Garg & Deshmukh, 2006; Jardine, Lin, & Banjevic, 2006; Prajapati, Bechtel, & Ganesan, 2012; Bousdekis, Magoutas, Apostolou, & Mentzas, 2015).

United States of America - Department of Defense (2008) highlighted that the goal of CBM is to perform maintenance activities when there is evident for such need. Therefore, the highway maintenance workers are required to possess relevant skills such as observation or monitoring skill to accomplish the tasks and generally different people have different skills and educational backgrounds (Gao, 2007; Alabdulkarim, Ball, & Tiwari, 2015).

Monitoring function as highlighted in the second theme of the study finding performed by all 8 of the respondents as they said that they will conduct at least one observation a

day. LDP personnel also indicates that they did their own observation even without the instruction from their superior. The reason cited for this is due to their understanding of their roles and responsibilities in providing good and safe highway for the users. The finding resonances the first theme that 7 of LDP highway personnel are satisfied with their works. Nevertheless, the study findings highlighted that the maintenance personnel also mentioned about insufficient monitoring function being conducted in LDP indicating the improper application of policies and regulation in their highway maintenance practice.

In order to achieve proper maintenance function, both technical and administrative action such as supervision must be performed (Parida & Kumar, 2006). Based on the study finding, 4 personnel out of the 8 respondents stated that there was a lacking in terms of observation or monitoring function take place in highway maintenance department. As a result, a successful maintenance management system will not be achieved. All of the 4 respondents testified that work overload that they experienced has prevented them from performing much needed monitoring or supervision role.

In relation to this work overloading, highway maintenance personnel did not provide much needed focus in their roles which lead to ineffective maintenance work performed. It is noted that if more corrective maintenance performed by the maintenance personnel rather than preventive maintenance, they will be stuck with more and more corrective maintenance (Tebow, 2009). According to Gao (2007) PM management always relates to resource limitation problem such as skilled maintenance personnel. In relation to that, better utilization of this limited skilled worker is very crucial for PM management.

The study finding for the application of policies and regulation has highlighted a few prevalent issues. Although, all of the personnel understood about the concept of maintenance, maintenance methods such as periodic, corrective and preventive maintenance and how the maintenance management should function, but they seem to lose their focus in prioritizing their work. Error in maintenance work can be caused by ineffective supervision, inaccuracies in focus and fault in judgment (Sheikhalishahi, Pintelon, & Azadeh, 2016). In the current study, overloading of work is cited as the main culprit for this condition. However, if a right system is being applied, it will assist maintenance personnel in performing their work more effectively. In the end, the root elements for the successful maintenance management system are the maintenance practice and the work management itself.

In relation to the policies and regulation pertaining to LDP highway maintenance practice, although LDP is committed in providing top notch facilities to their users, they are bound to follow the policies, procedures and regulations determined by the Malaysian Highway Authority (MHA), as the monitoring body to ensure the maintenance and upkeep of the highways is up to the standards (MHA, 2016). Malaysia's former Prime Minister, YAB Datuk Seri Abdullah Ahmad Badawi's first address as acting Prime Minister to the Oxbridge Society on March 6, 2003 was a forthright indictment of what ails this country.

"The way I see it, the malaise affecting Malaysia that may well jeopardize our way forward is a case of having first world infrastructure and third world mentality. From poor execution and inept management to shoddy maintenance and appalling customer service, Malaysia is in danger of possessing the hardware, but little software."

This comment not only focused on the low maintenance of facilities at government building areas but also the private buildings, inevitably give indirect impact on the maintenance of the highways. Therefore, the policies and regulations without proper execution will be meaningless.

5.2.3 Discussion on finding 3 – The communication flows in the application of the maintenance management systems

In reference to the study finding from the aspect of communication flows in the application of the maintenance management system, the respondents seem divided in terms of work reporting. As stated in the finding, only one person fully used the online system whereas another 5 respondents still rely on hard copy reporting. Another 2 participants used a mix of hard copy and soft copy reporting. Unsynchronized information flow has created another problem for maintenance management (Gao H. , 2007).

Work management in maintenance is the process of recording, tracking and maintaining all the maintenance activity data (Tebow, 2009). According to Gao (2007), the data and information are very limited at the beginning of maintenance work activity making the maintenance scheduling a complex task. The different types of reporting method identified from the research finding indicates the problem in terms of work reporting in LDP's highway maintenance practice.

A new work process implementation should be able to help the work process activity in the Maintenance Department to be more efficient and systematic. The finding

somewhat contradicted with the responses from the study participants which stated that they faced no issue in their maintenance work and record preparation.

It is well understood that whenever communication and information are not flowing laterally, workers will not be able to report and identify the source for maintenance activity and will result to inappropriate enhancement of the assets or structures (Hansson & Backlund, 2003; Phogat & Gupta, 2017). Proper maintenance activities can be performed when all personnel in the department shared a common objective, otherwise the expected target will not be achieved (Rolfsen & Langeland, 2012).

A concern highlighted by a respondent in relation to the issue faced in record preparation was the long time required to prepare maintenance record. This finding is broadly in line with the previous issue that many employee are overwhelmed with works which prevented them from effectively executed works assigned to them. One of the example cited in the study finding that relates to the consequence of work overload is the lack of focus in doing observation or monitoring duties. This will lead to further problem as the shifting from preventive maintenance strategy to corrective maintenance strategy will involved extra cost for maintenance work.

Nevertheless, all of the maintenance personnels unitedly expressed that they are used by reporting requirements imposed on them and prepared multi-type of reports such as yearly, monthly, weekly and daily reports. Their extensive experience in relation to work performed, making work reporting function seems like an easy task. In relation to that, the well-planned and smoothly run jobs produce overall satisfaction for the

maintenance personnel which explained why 7 out of 8 respondents have been with LDP for more than 5 years.

All related personnel will source for any additional information themselve to enhance the quality of information in their reports. They really potray themselves as personnel that can be relied on when it relates to highway maintenance management. In the work of Ylipää, Skoogh, Bokrantz, & Gopalakrishnan (2017), they denotes the maintenance department personnel to be the sole supplier for assets dependability. It is because compared to other occupation, mistake made by highway maintenance personnel can lead to severe or fatal injuries. Therefore, their judgement should be acurate and precise in their work as well as in their reporting.

In another dimension, in terms of communication flow in maintenance management system, the frequency of discussion between the workers and their superior is very crucial. On that note, based on the study finding, 6 out of 8 personnel mentioned that they have daily discussion with their superior in terms of work related matters. In the era of internet and social media, the demand for transparency in terms of work activities has increased (Abeysekera, 2013).

New devices, new applications are being introduced on a daily basis making it imposible not to be connected with others. In that sense, the technology advancement has assisted maintenance management personnel to have a better communication flows which help them to perform their work better as they need to understand that they play a very crucial role in providing a safe transportation method for the highway users.

5.3 Recommendation

This section will be based on the result of the findings in Chapter 4. In the analysis, the Maintenance Management Department in LDP has failed to regulate the work flow processes effectively. In relation to that, the new method in regulating the maintenance work flow process has been identified to facilitate in addressing the problem encountered by the Maintenance Management Department.

The new work flow process can assist to manage the maintenance work activities devised by the Maintenance Management Department. Consequently, any work plan from the Maintenance Management Department must be described in more detail to make sure that complete information is received by the relevant parties such as the project team, and contractors. In relation to that, all maintenance work activities will consider the relevant work requirements such as Maintenance Management Personnel Capacity (knowledge, skills, experience, and infrastructure) and Maintenance Management Environment (policies, technologies, regulations) in achieving the successful completion of maintenance project. The success is measured by the quality of the work performed, cost spent and the timeliness of the work as highway maintenance work is very crucial to make sure that the assets and structures are in good condition for the safety of the highway users.

5.3.1 Maintenance work planning

Based on the finding to the analysis of Theme No.1, the study concludes that the better work planning can be achieved if all maintenance work are prepared and are continually monitored by the maintenance management department. They need to perform these activities until the maintenance projects are completed to ensure the accuracy of the

maintenance work according to the agreed standard. This will also eliminate or reduce the non-compliance maintenance work activity. The implementation of adequate monitoring will enable the maintenance work process to function at its best level and also will ensure the good maintenance work quality.

The work request will be handled systematically to avoid overlapping with other maintenance work activities and will make sure that the schedule of this new work input will follow the correct sequence of other maintenance work activities, stayed in the course of maintenance work planning and in line with maintenance management personnel schedule. The central factor for this is the smooth communication process flow.

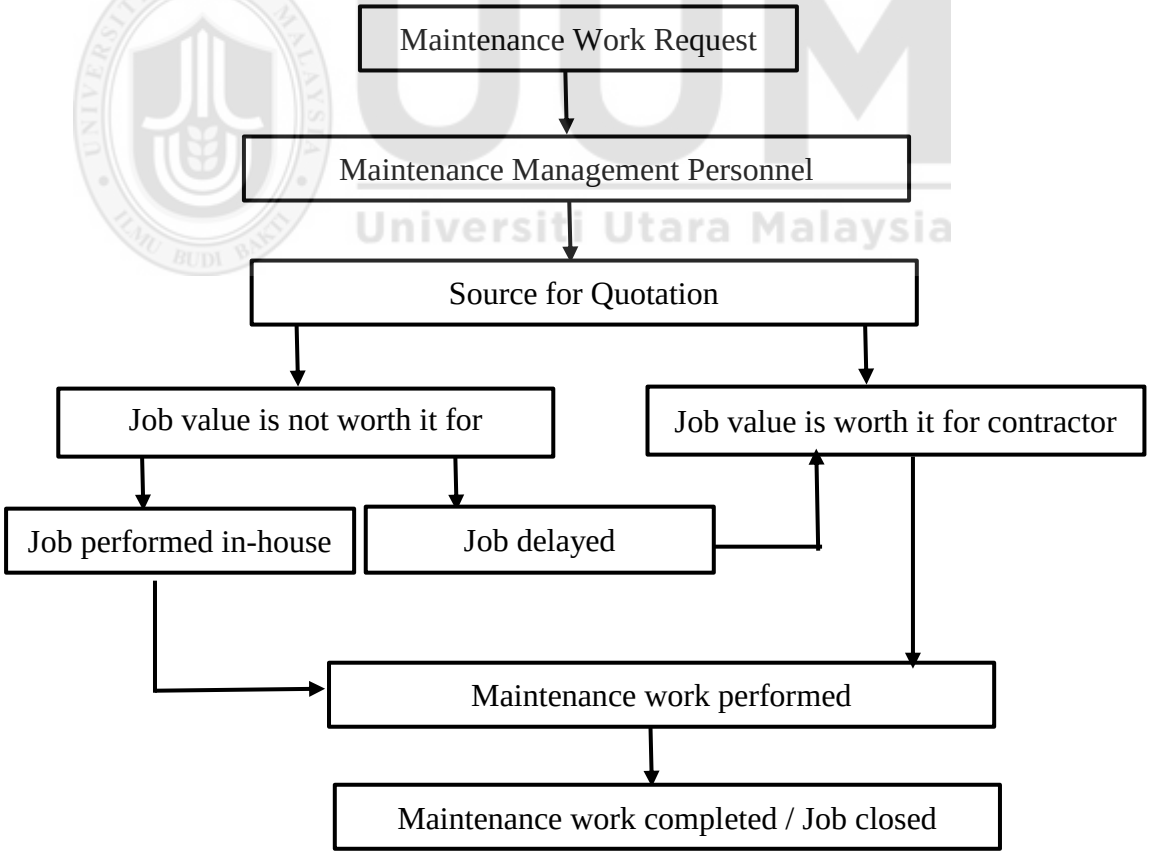


Figure 5.1
Maintenance work process flow before improvement

Based on Figure 5.1, the current maintenance work process showed the improper way of conducting a maintenance work. The new proposed improvement shown in Figure 5.2 is able to improve the present situation by improving certain process flow. The step such as sourcing for quotation need to be eliminated as it is both time consuming and not cost effective. It will also open the window for improper business conduct which has affected many contractors that do not have good relationship with highway maintenance personnel. This non-transparent work practice will also lead to other outcome such as low-quality work and ultimately will put the life of highway users in grave danger.

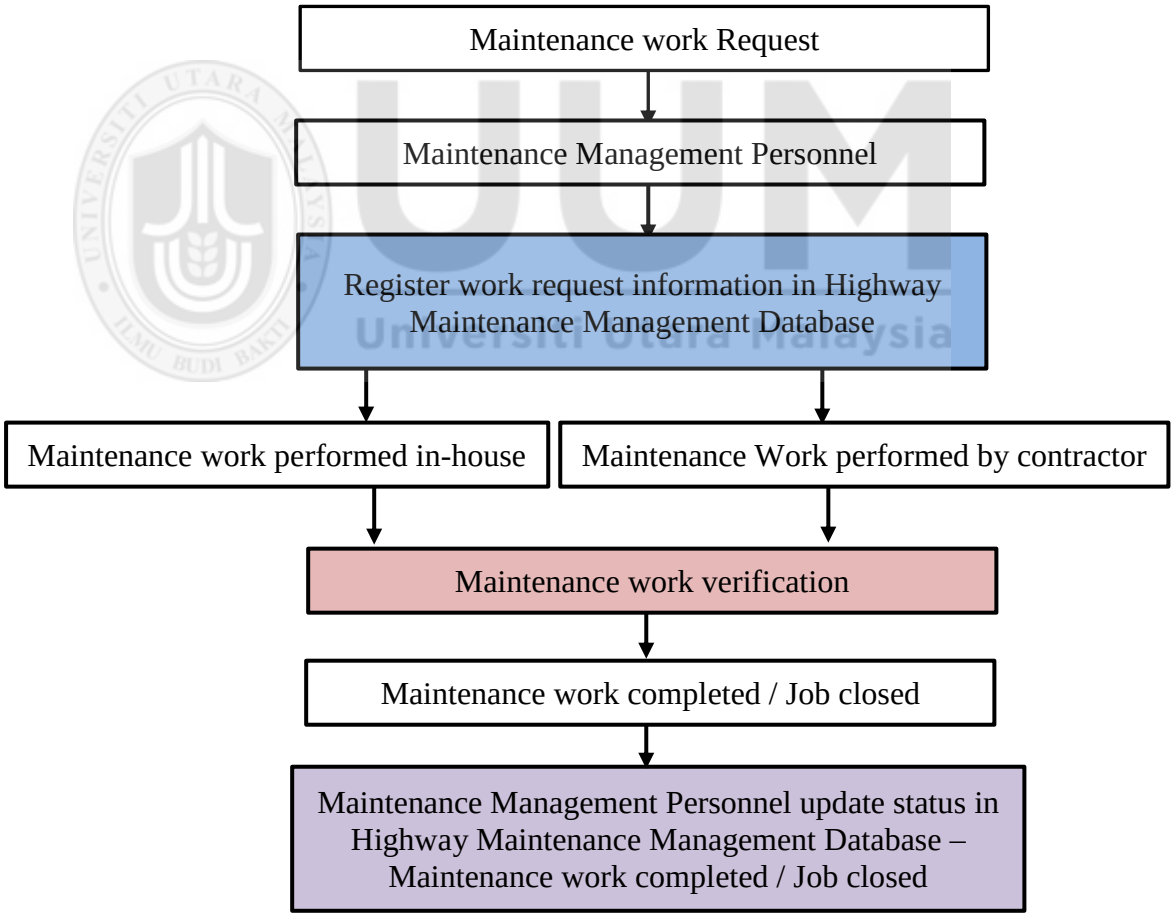


Figure 5.2
New maintenance work process flow

Based on the new and improved maintenance work process shown in Figure 5.2, three proposed improvement were identified. The justification for each improvement is described as follow:

1. Register work request information in the Maintenance Management Database.

   The database will have all the information regarding the types of work, work duration, cost of materials required, list of contractors with relevant skills and experiences and all of equipment required. The database will also record all maintenance activities performed which will be important in preparing a good quality maintenance report.

2. Maintenance work verification.

   The task will be performed by the maintenance management personnel for each maintenance work. This process is essential to make sure that all parties that performed the maintenance work whether the in-house team or the appointed contractor will meet the required standard of maintenance work imposed by the Maintenance Management Department. This will avoid any repetition of the problem.

3. Maintenance Management Personnel update status in Highway Maintenance Management Database – Maintenance work completed / Job closed.

   Maintenance Management Personnel can update the work status for each maintenance activity performed which can assist other personnel, the department head or MHA in relation to maintenance job conducted in LDP. In relation to that, it will also aid the preparation of quality work report.

The improved maintenance work process framework is considered as internal work process monitoring to better managed the maintenance operation and to help during any

official inspection conducted by the relevant authorities such as MHA or JKR. The new work process flow will also be more transparent not only to the maintenance management personnel and relevant authorities, but also for the contractors attached with maintenance management in LDP. The contractors will in the end benefits from this exercise because they can protect their profit margin by referring to the standard pricing provided by LDP.

The new work process can further be used to make sure that the quality of work to be at the best level as per standard set. The maintenance personnel can avoid mistakes and failures to make sure that each maintenance work has been done according to the established specifications before closing any maintenance work. Furthermore, LDP should also focus on the professional aspect of its employees. This will ensure that the services rendered to the highway users are accordance to specification and requirements. LDP must warrant that the service performance meets the minimum standards.

The role of employees needs to be clarified and ensure that all employees understand how their jobs contribute to customer safety. To enhance performance and service quality, the most appropriate methods and reliable technology and equipment must be selected.

The maintenance management personnel need to have more collaboration with the appointed contractors to finalize the requirements that are needed for any maintenance work. They need to be very detailed and meticulous in their work to prevent any errors during the maintenance activities being performed. The final agreement between LDP

and their contractors need to be achieved to indicate that the contractor will delivered work quality as per requirements by LDP.

The implementation of the new workflow process requires an establishment of a new function in the maintenance management department. The personnel who will be assign to this portfolio, will coordinate all matters which involved the planning of maintenance work, keeping all information with regards to maintenance works' type, getting all the quotations materials and equipment pricing, handling all reports and documentation. The personnel will report to the Maintenance Management Assistant Manager that will resulted in better flow in work reporting and improve the distribution of work related information to the relevant parties.

The new section will be known as the Database Section as its relates and managed all maintenance work requisitions, including maintenance work documentation, maintenance personnel scheduling and deployment and manages the database in relation to maintenance management functions. Figure 5.3 refers to the new organizational chart of Maintenance Management Department.

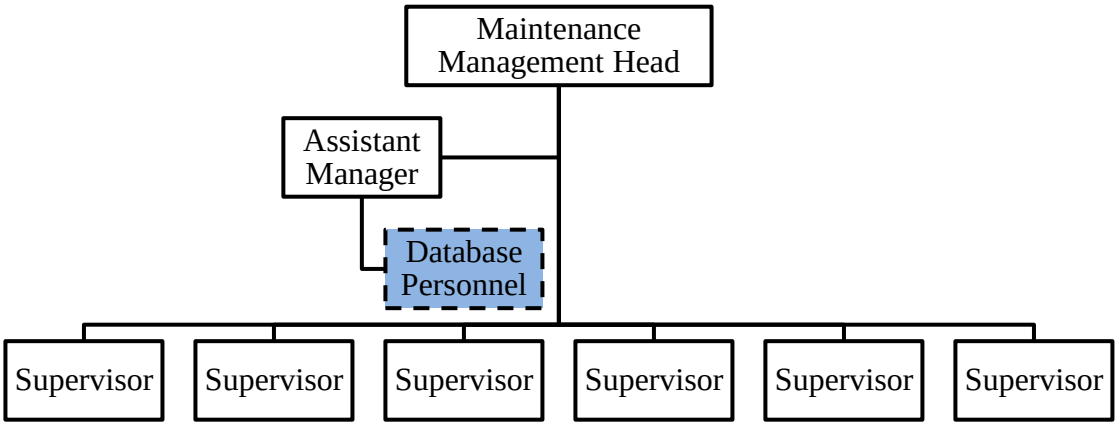


Figure 5.3
The new organizational chart for Highway Maintenance Management Department

The job description for the new section were detailed up as follows:

1. Managing the maintenance work planning, receiving all maintenance work request and request from maintenance personnel and then register them in the database and followed by informing related maintenance personnel regarding the maintenance work project. Any required maintenance work will be examined by maintenance personnel which will fall under 3 types under Highway Maintenance Management portfolio which are routine, preventive and corrective maintenance.
2. Updating the maintenance work status accordingly.
3. Managing any unsolved matters or issues pertaining to maintenance management activities.
4. Assigning maintenance observation duties to related maintenance personnel.
5. Managing and preparing the maintenance report including daily schedule, weekly program, monthly updates, yearly reports, progress reports and updates as per required.
6. Managing the documentation and filing system for all maintenance project for easy reference, traceability and for audit purpose.
7. Liaising with all related maintenance department personnel, approved contractors and head of maintenance management department in any matters pertaining highway maintenance.

The implementation of the recommendation can face many difficulties such as poor reception and bad review by the affected staff due to normal human behavior of trying

to resist change as much as possible. It is also the case of time taken to adopt to the new work process. Nonetheless, utilization of the new work process will make sure that the maintenance operation operates in the most effective and efficient way.

The improvement in terms of work planning will not be the only factor to ensure the effective maintenance management system. Other factor such as the performance of the contractors also need to be put under serious consideration. In relation to that, the strict monitoring should be put in place to make sure that the work is performed as required. Highway personnel should discuss and inform the contractors prior, during and post any maintenance activity performed to enable all parties understood their function. This cooperation is vital for any successful implementation of new highway maintenance management procedure. This will lead to more transparent business conduct which will be preferable for the contractors registered with LDP. It also will increase the profile of LDP in the eye of highway authorities such as MHA and JKR.

In summary, without involvement and commitment of everybody related to highway maintenance management, the implementation of the new work process will be difficult. However, with proper education and communication, involvement and participation and the support from the management all employees were able to adapt to this process eventually.

5.3.2 Maintenance work policies and regulation to the planning and record management function

In relation to the finding of Theme No. 2, the understanding and awareness of all the concepts pertaining to the highway maintenance matter will not be the deciding factor

whether the maintenance project going to be success or not. The application of this understanding is far more crucial. The knowledge will not be of any value if one does not take any action with regards to it. In relation to this, the maintenance management department realized that an action plan needs to be put in place to ensure that all maintenance management activities have a higher successful rate.

Maintenance policy were advised to be adjusted during any maintenance activities to take advantage of the latest maintenance procedures. High level of maintenance performance can be achieved if the action planned were executed properly when a proper maintenance policy was put in place. True to its definition, the maintenance policy refers to set of administrative, technical and managerial actions to guide maintenance management decision (Moya, 2014). In relation to the finding, the study concludes that the current practice of maintenance in LDP was divided into routine, preventive and corrective maintenance. The Figure 5.4 showcase the current maintenance practice in LDP.

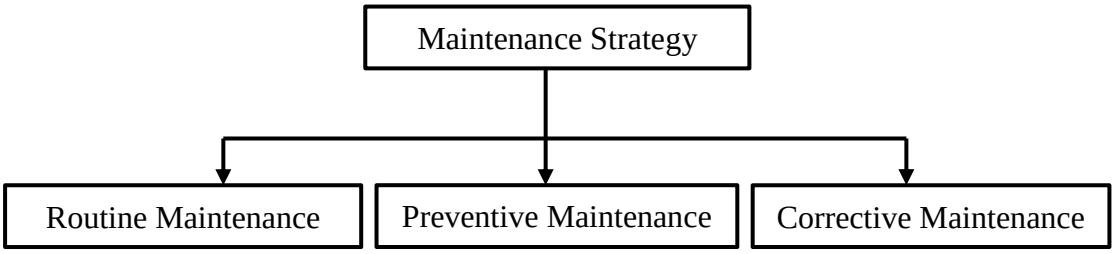


Figure 5.4
The current maintenance practice in LDP

The current practice in highway maintenance management for LDP has been around since the launch of LDP in 1999 and its now be found as the reason why the system has failed to address many issues pertaining maintenance management system problems.

Nowadays, the highway assets managers need to understand that good preservation, preventive maintenance, and programmed maintenance are essential to economical highway assets performance and life. According to the finding and analysis by David Tod Geaslin in his work "Geaslin's Inverse-Square Rule for Deferred Maintenance Effort - Proof of Exponential Breakdown Cost Escalations" have shown that investing USD1.00 at the appropriate time in pavement maintenance can save USD4 to USD10 in future costs (Figure 5.5).

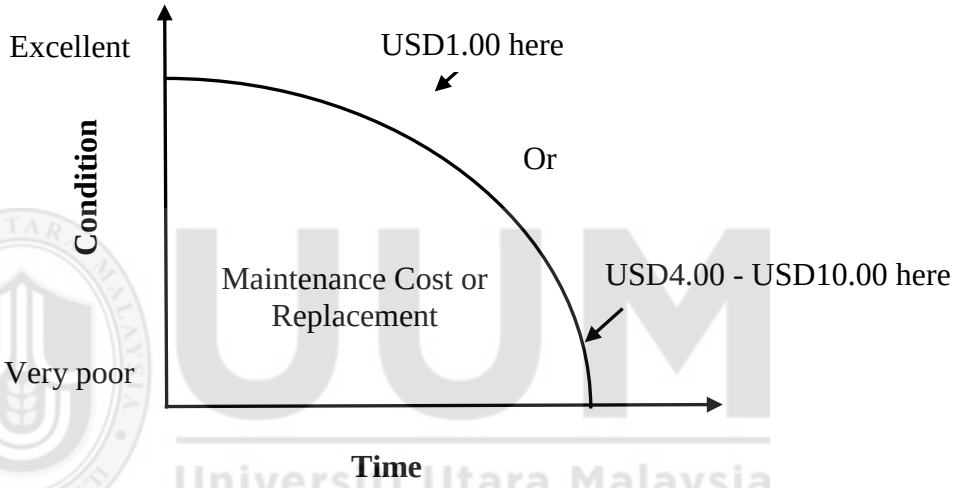


Figure 5.5
Cost of deferring maintenance
Source: Geaslin's Inverse-Square Rule for Deferred Maintenance Effort - Proof of Exponential Breakdown Cost Escalations by David Todd Geaslin, 2014

The analysis provided by Geaslin (2014) is very practical and believable validation of the fact that maintenance costs, when not applied early in the form of preventive maintenance, result in greatly increased costs for the highway operator and for highway users who uses these facilities. Many facilities purely reliant on reactive maintenance could save much more than 18% by instituting a proper preventive maintenance program. On that note, the system practiced in LDP need to be revised to address the

current condition and the study has proposed the following maintenance management framework.

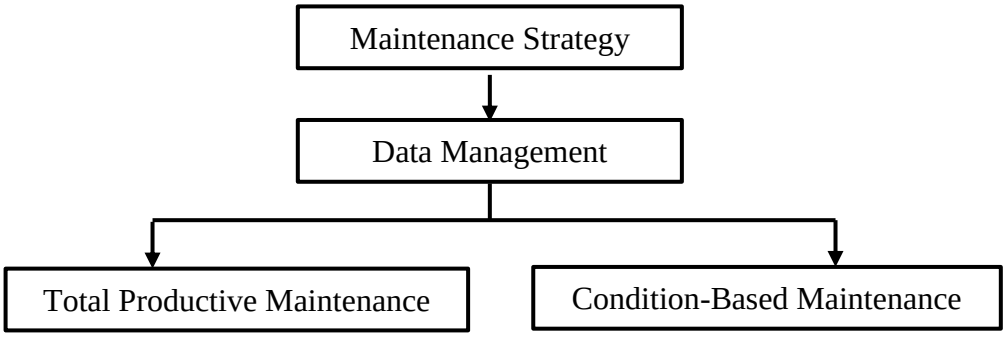


Figure 5.6
Proposed maintenance management system

Based on Figure 5.6 which relates to new maintenance framework, the study once again highlighted the needs for the database management section. The principal function of this database management in this context is to perform the control function of planning and scheduling, performance measurements and maintenance tactics. This database management section will automatically generate the maintenance checklist to make sure all related personnel understood what need to be done for any maintenance project. The checklist practice will provide a good based for quality maintenance reporting as the study revealed that the Maintenance Management Department has different ways of reporting and it has created major problem in terms of reporting task for the maintenance department.

The maintenance practices also change to Total Productive Maintenance (TPM) and Condition-Based Maintenance (CBM) and no longer be confined to routine maintenance, preventive maintenance and corrective maintenance. The reasons for this is because TPM is regarded as one of the most highly successful methods for continuous

improvement and CBM is chosen for the context of highway maintenance. The concept of TPM is based on the planned approach that relates to routine maintenance to preventive maintenance. The objective of TPM is to reduce the emergency and unscheduled maintenance activities to the minimum level. Other features for TPM are the support of management and the empowerment of the employees to take appropriate action with regards to maintenance practice. On the other hand, CBM is required due to its philosophy of monitoring the actual condition of the assets and decide what maintenance work is required. Both new maintenance strategies are not new to the maintenance personnel to perform because the concepts are somewhat the same with the previous maintenance strategies plus the maintenance personnel already has vast experience in highway maintenance work. Therefore, the execution of these maintenance strategies should be a smooth process.

The problems cited such as lack of monitoring activities due to insufficient workforce, work overload and lack of focus during monitoring duties will be addressed with the implementation of TPM and CBM strategies as the monitoring function now not only confined to highway maintenance personnel but to the whole company employees, from top management to the working level employees. This will ensure effective highway maintenance management system.

In summary, the maintenance management system in LDP need to be revised to provide more effective and efficient service to its users. The problems faced by highway patrons can be eliminated or reduced if LDP adopt the new maintenance management strategies. As the saying goes, *"if you want something you never had you have to do something you've never done - JD Houston"*. The maintenance policy is not a natural phenomenon

which happen unexpectedly. It involved choices made by the people with authority. Therefore, top management in LDP should recognized the problems related to LDP and make changes to the policies that are being around all this while that has contributed to the many mishaps in LDP which in the first place can be avoided if the right decision was made.

The maintenance policy for LDP is proposed to be in the following sequence;

1. Maintenance policy which is also known as the highest-level documents applicable for all maintenance project.
2. Maintenance strategy which will be updated as and when required.
3. Maintenance program which refers to the database section of highway maintenance management department that host all the maintenance requirements.
4. Maintenance checklist that been generated automatically for every maintenance project.
5. Schedule of work which are issued to the related maintenance personnel.

5.3.3 Work communication management in preparing quality report

Based on the finding of the Theme No. 3 in the previous chapter, it was revealed that the Highway Maintenance Management had difficulties in preparing a good quality report. This condition happened due to all maintenance personnel had managed their own report and in their own format. The bottom line of this issue is that the maintenance management personnel should understand the importance of preparing a good quality report which include useful information such as work inspection activity that was done.

This will enable the capturing of all relevant information about the maintenance project so that the information will not be lost, compiled and stored.

The obligation of each maintenance personnel is to submit their maintenance work progress and status to enable this information to be included in the department report. This is required as evidence that every task listed under the maintenance project checklist has been performed. Therefore, if any error or issue arises during any maintenance project, the rectification process will not take a long time due to every item has already been registered under the maintenance project checklist.

The maintenance management department can manage the maintenance work planning, observation schedule, work status with the introduction of centralized database system. This will enable the department to produce a good quality maintenance report as and when required by any related parties such as the top management and the authorities. Figure 5.7 showcased the current work process flow in the LDP's maintenance management meanwhile, Figure 5.8 explained the new improved work process flow that highlighted the purposely created database system that assists in the gathering and compiling of all related maintenance work details.

Improving the quality of information across all asset classes (i.e. structural, pavement, drainage, structures, technical works and technology) is the key to achieving operational efficiency and effectiveness. Enhancing asset data with performance, operational and maintenance data will help create a useful knowledge management strategy. When responding to either planned or responsive maintenance works, the platform can be relied upon to generate data on the specific maintenance activities, the

components used and its location. This will allow operatives or contractors to arrive on site with the relevant knowledge and components to accurately excavate the relevant part of the maintenance duties and make the repair. This work, in turn, can help the maintenance management department to plan, manage and complete the maintenance project.

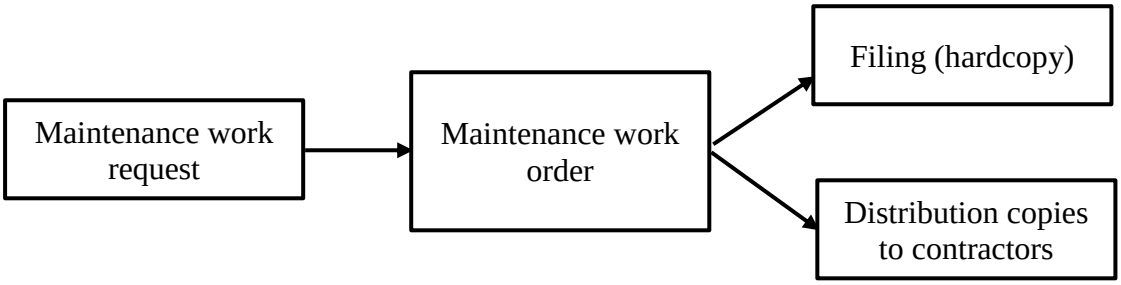


Figure 5.7
LDP's previous work process flow

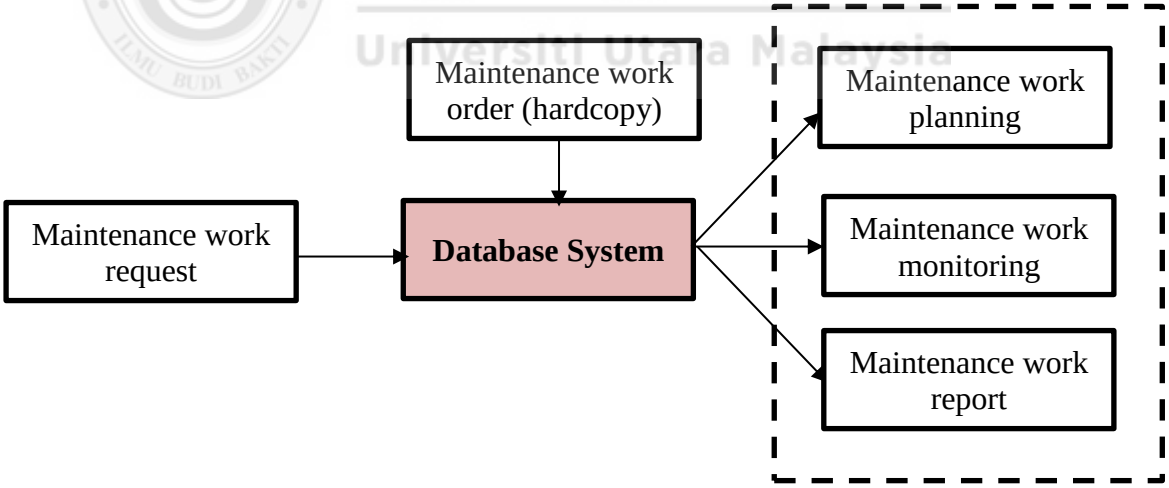


Figure 5.8
LDP's improved work process flow

The implementation of new improved work process flow will give a few advantages as follows;

1. Maintenance work will be more organized with proper planning;
2. Work planning will enable the maintenance personnel to know the details of the maintenance project that being assigned to them and can update the status accordingly;
3. Maintenance work monitoring can be managed properly which includes internal inspection and work surveillances;
4. Maintenance report can be prepared on time which includes all the updates and status. The report is produced in the same format and in a systematic way;
5. Information of maintenance work can be compiled in a proper way; and
6. Record traceability will be more efficient by using record indexes.

The database management section is very crucial for LDP due to its abilities to save lives and money. More specific benefits are:

- More rational resource allocation decisions. Database management help maintenance manager to rationally identify priorities for resource expenditures for highway hardware purchase, maintenance, and repair. The rationale for expenditure decisions can be provided easily to upper management, other decision-makers, the public, or the media.
- Simplified cost estimating and budget processes. Database management section track costs. Cost tracking supports the preparation of more detailed and accurate cost estimates and budgets.
- Cost savings. Better information, more accurate cost data, more timely decisions, and other efficiency improvements combined to reduce the costs of acquisition, maintenance, upgrade, and replacement of assets.

- Timely, accurate, complete data access. Database management section create a centralized database that can be accessed quickly. The inventory of assets, their location, condition assessment, maintenance and repair history, and other relevant information can be shared in real time and continuously updated. Responding to inquiries ranging from simple questions to complex analyses is easier and faster. Easy access to information helps managers, executives, and policymakers.
- Improved safety through faster response to customer service requests. Concerns about the safety of signs, signals, pavement markings, and other highway safety elements account for a significant part of the interaction between highway operator and highway users. Quicker access to data about the safety elements facilitates faster customer service and makes LDP safer.
- Reduced duplication of effort. Because centralized database management section will be able to information, duplication of effort (for example, multiple data entry) is reduced or eliminated.
- Improved data clarity and consistency. Standard definitions, measurements, and formats improve the accuracy and reliability of data.

The database system will assist the top management in getting a clear picture of what is happening in the maintenance management department. The new process flow implementation will help to provide a complete maintenance work requirement for the department and able to produce quality reports as and when required by the management and relevant government agencies.

In terms of traceability, the documentation of the information must be kept by the company in a good and proper manner. This is important to retrieve and search for information pertaining to certain maintenance work project, particularly when an evidence is required. The former work process stated in the finding only focus on storing and keeping the hardcopy of the record and it has been managed manually. The new work process employs both methods, hard copy and soft copy, to give the advantage of traceability of the records which signaled a more efficient way of work process for the maintenance management department.

5.4 Recommendation for future studies

The current study gives some direction for future research in terms of identifying other ways of collecting information for highway maintenance research since the research in this area is relatively new and the related literature pertaining to Malaysian context is still limited. Research paradigm other than qualitative case study should be given consideration as it would give a new perspective and can be more comprehensive. It should be borne in mind that the study has other limitation as there were small number of respondents due to poor understanding of the value for maintenance might affect findings, which upon the analyzing of the data, appear to be of some importance in the study. Perhaps this is one of the weakness of exploratory research. However, suggestion was made for the future research.

The importance of the research is to achieve the objective and to bring new knowledge and benefits to the company and academicians. Some of the areas in maintenance management that can be researched in the future:

1. The recognition of quality in maintenance work in reducing rework activities;

2. The efficiency of maintenance management staff and its relationship with quality management; and
3. The gap in relationship between maintenance management and organization management level.

The study highlighted on the importance of centralized database system for the Maintenance Management Departments in terms of the work process flow in ensuring the effective and efficient maintenance management activities. This process can be implemented in other departments and the study also provided the opportunity to be used in other highways in Malaysia. As such, the research can be discussed in other field other than maintenance management as well.

5.5 Conclusion

In conclusion, the research accomplishes its objective of finding ways to overcome the problem and difficulties that are being experienced in the LDP's Highway Maintenance Management Department. The study managed to identify the effective maintenance management practice in maintenance management projects, the issues that had occurred during the research, provided analysis that can benefit the company and contributed to academic knowledge. The framework for the effectiveness and the efficiency of maintenance management can be simplified as follows;

1. Structural development (Development of the team);
2. Systems development (Development of the computerized maintenance management system (CMMS);
3. Work flow control (Formalizing work planning, scheduling and supervision);
4. Maintenance effectiveness (Doing the right maintenance at the right time); and

5. Maintenance efficiency (The lowest cost maintenance for optimum effect)

Recommendation for future studies is also proposed that will provide new dimension for others to continue the study in maintenance management field, especially in the highway maintenance management.

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APPENDIX

THE INTERVIEW PROTOCOL

HIGHWAY MAINTENANCE MANAGEMENT:
A STUDY OF LEBUHRAYA DAMANSARA-PUCHONG (LDP)

PENGURUSAN PENYELENGARAAN LEBUHRAYA: SATU KAJIAN DI LEBUHRAYA DAMANSARA-PUCHONG (LDP)

Date : _____

Time : _____

Department : _____

Name : _____

Position : _____

Instructions (to be read to the interviewee)
Arahan (untuk dibaca kepada yang ditemu bual)

These interview sessions were conduct as a part of the research study in Highway Maintenance Management: A Study of Lebuhraya Damansara-Puchong (LDP). The purposes of this research are:
Sesi temu bual ini ialah sebagai sebahagian daripada kajian penyelidikan dalam Pengurusan Penyelengaraan Lebuhraya Damansara-Puchong (LDP) . Tujuan kajian penyelidikan ini adalah:

- To identify how deep the knowledge of maintenance management in highway, especially in the maintenance department.
  Mengenalpasti berapa dalam pengetahuan pengurusan penyelengaraa di lebuhraya , terutama di Jabatan Penyelengaraan

- To identify in more detail about the issues that occur in maintenance management in this company.
  Mengenalpasti dengan lebih terperinci mengenai isu-isu yang berlaku dalam pengurusan penyelengaraan di syarikat ini

- To provide an analysis of the study and suggestions that can improve and enhance the maintenance management in providing a safe highway.
  Menyediakan analisis kajian dan juga cadangan yang boleh memperbaiki dan meningkatkan pengurusan penyelengaraan dalam menyediakan sebuah lebuhraya yang selamat.

- To accomplish the company's mission -"*to be a sustainable, reputable and leading highway service provider*"
  Untuk mencapai misi syarikat - " untuk menjadi peneraju dalam penyediaan perkhidmatan lebuh raya yang mampan dan berwibawa"

This interview sessions will be audio-recorded and write out within a day of the completion of the interviews sessions. This is confidential information and it will only be use in this research study. The copy of written transcript from the interview will be given to interviewee. Interviewees were guaranteed complete secrecy and their responses will be kept completely confidential. The interview will be conducted in 5 mains topics. This entire interview is designed to take approximately one hour. The interviewee can freely ask any question regarding this interview session.

Sesi temu bual akan akan direkodkan dan akan ditulis dalam masa sehari selepas selesainya sesi temu bual . Segala maklumat adalah sulit dan ia hanya akan digunakan dalam kajian penyelidikan ini . Salinan transkrip bertulis daripada temu bual akan diberikan kepada yang ditemu bual. Ditemubual telah dijamin kerahsiaan lengkap dan jawapan mereka akan dijaga dan dipastikan sulit sepenuhnya . Temubual akan dijalankan dalam 5 topik utama . Seluruh sesi temu bual direka bentuk untuk mengambil masa kira-kira satu jam . Ditemu bual bebas menanyakan apa-apa soalan mengenai sesi temu bual ini.

HIGHWAY MAINTENANCE MANAGEMENT:
A STUDY OF LEBUHRAYA DAMANSARA-PUCHONG (LDP)

Part 1: Introduction and Demographic Information
Bahagian 1: Pengenalan dan Maklumat Demografi

1. Tell me about yourself
1. *Ceritakan tentang diri anda*

2. How long have you been in this company?
2. *Berapa lama anda berada dalam syarikat ini?*

3. Tell me about your work experience in Maintenance Department?
3. *Ceritakan kepada saya tentang pengalaman kerja anda di Jabatan Penyelengaraan*

4. What is your technical background?
4. *Apakah latar belakang teknikal anda?*

5. How would you describe yourself as a maintenance personnel?
5. *Bagaimana anda mengambarkan diri anda sebagai seorang kakitangan penyelenggaraan?*

Part 2: Research Question No.1
Bahagian 2: Soalan Kajian No.1

What is maintenance management practice particularly in maintenance planning activities in Maintenance Management Department toward the completion of the maintenance activities and projects?
Apakah amalan pengurusan penyelenggaraan terutamanya dalam aktiviti perancangan penyelenggaraan di Jabatan Pengurusan Penyelenggaraan ke arah penyiapan aktiviti dan projek penyelenggaraan

1. How do you plan your work activities?
1. *Bagaimanakah anda merancang aktiviti kerja anda?*

2. Can you describe your work in the company?
2. *Bolehkah anda terangkan kerja anda dalam syarikat?*

3. What do you think about the work process in this company especially in Maintenance Management activities?
3. *Apa pendapat anda tentang proses kerja di syarikat ini terutama dalam aktiviti pengurusan penyelenggaraan?*

4. How often maintenance activities been postponed or cancelled and for what reason?
4. *Berapa kerap aktiviti penyelenggaraan ditangguhkan atau dibatalkan dan mengapa?*

5. What is your suggestion and expectation in improving work planning for maintenance activities?
5. *Apakah cadangan dan harapan anda dalam meningkatkan perancangan kerja untuk aktiviti penyelenggaraan?*

Part 3: Research Question No.2
Bahagian 3: Soalan Kajian No.2

How to overcome the weakness and lack of maintenance activities in the work process of the project completion particularly in highway management and maintenance activities?
Bagaimana untuk mengatasi kelemahan dan kekurangan aktiviti penyelenggaraan dalam proses kerja penyiapan projek terutamanya dalam aktiviti pengurusan dan penyelenggaraan lebuh raya?

1. What does maintenance mean to you?
1. *Apa makna penyelenggaraan kepada anda?*

2. How do you do about preventing any problems from occurring?
2. *Bagaimana anda melakukan pencegahan bagi mengelakkan sebarang masalah daripada berlaku?*

3. Do you know about periodic, corrective and preventive maintenance?
3. *Adakah anda tahu tentang penyelenggaraan berkala, pembetulan dan pencegahan?*

4. How many times you done your observation or survey in a day?
4. *Berapa kali anda melakukan pemerhatian atau tinjauan dalam sehari?*

5. Are you willing to do observation or survey without any instruction from your superior? If not, why?
5. *Adakah anda bersedia untuk melakukan pemerhatian atau tinjauan tanpa apa-apa arahan dari pihak atasan anda? Jika tidak, mengapa?*

6. What is your opinion about the lack of monitoring activities in the maintenance of highway?
6. *Apakah pandangan anda mengenai kekurangan aktiviti pemantauan dalam penyelenggaraan lebuh raya?*

Part 4:Research Question No.3
Bahagian 4: Soalan Kajian No.3

How to enhance the work process in gathering and analyzing on maintenance activities information as well as in preparing a good quality report?
Bagaimana untuk meningkatkan proses kerja dalam mengumpul dan menganalisis maklumat aktiviti penyelenggaraan serta menyediakan laporan yang berkualiti?

1. How do you manage your maintenance record activities?
1. *Bagaimana anda menguruskan rekod aktiviti penyelenggaraan anda?*

2. How do you write your record?
2. *Bagaimana anda menulis rekod anda?*

3. What kind of issue that you are confronting in preparing your report?
3. *Apakah isu yang anda sedang hadapi dalam menyediakan laporan anda?*

4. How do you report your work status to your supervisor?
4. *Bagaimana anda melaporkan status kerja anda kepada penyelia anda?*

5. How frequently you talk with your superior about your work activities?
5. Berapa kerap anda bercakap dengan penyelia anda mengenai aktiviti kerja anda?

6. In the event that there are issues, how would you handle the circumstances that require you to prepare any supporting documents?
6. *Sekiranya terdapat sebarang isu, bagaimana anda akan mengendalikan keadaan yang memerlukan anda untuk menyediakan dokumen sokongan/tambahan?*

7. What is your recommendation to enhance the work process in dealing with the maintenance information record?
7. *Apakah cadangan anda untuk meningkatkan proses kerja yang berkaitan dengan rekod maklumat penyelenggaraan?*

8. Who should be responsible to deal with this data and preparing the report?
8. *Siapa yang perlu bertanggungjawab untuk menguruskan data yang diambil dan menyediakan laporan?*

Part 5: Closing the interview Session
Bahagian 5: Penutup Sessi Temu Bual

Is there anything else that you would like to offer that I did not specially ask about?
Adakah terdapat apa-apa lagi yang anda ingin tawarkan kepada saya atau bertanya tentang sebarang perkara khusus?

Researcher's Remarks:
Ulasan penyelidik

Thank you for your valuable time in participating in the interview session. The information you have contributed will be significant and important to the success of this research study. If you have any further thoughts on this topic, you are welcome to call me.
Thank you.
Terima kasih untuk masa anda yang berharga dalam menyertai untuk sesi temubual ini. Maklumat yang anda sumbangkan akan menjadi perkara penting dalam menjayakan kajian penyelidikan ini . Jika anda mempunyai apa-apa pemikiran lanjut mengenai topik ini , anda dialu-alukan untuk menghubungi saya. Terima kasih.

THE INTERVIEW TRANSCRIPT

HIGHWAY MAINTENANCE MANAGEMENT:
A STUDY OF LEBUHRAYA DAMANSARA-PUCHONG (LDP)

PENGURUSAN PENYELENGARAAN LEBUHRAYA: SATU KAJIAN DI LEBUHRAYA DAMANSARA-PUCHONG (LDP)

Date : _____

Time : _____

Department : _____

Name : _____

Position : _____

Instructions (to be read to the interviewee)
Arahan (untuk dibaca kepada yang ditemu bual)

These interview sessions were conducted as a part of the research study in Highway Maintenance Management: A Study of Lebuhraya Damansara-Puchong (LDP). The purposes of this research are:
Sesi temu bual ini ialah sebagai sebahagian daripada kajian penyelidikan dalam Pengurusan Penyelengaraan Lebuhraya Damansara-Puchong (LDP). Tujuan kajian penyelidikan ini adalah:

- To identify how deep the knowledge of maintenance management in highway, especially in the maintenance department.
  Mengenalpasti berapa dalam pengetahuan pengurusan penyelengaraan di lebuhraya , terutama di Jabatan Penyelengaraan

- To identify in more detail about the issues that occur in maintenance management in this company.
  Mengenalpasti dengan lebih terperinci mengenai isu-isu yang berlaku dalam pengurusan penyelengaraan di syarikat ini

- To provide an analysis of the study and also suggestions that can improve and enhance the maintenance management in providing a safe highway.
  Menyediakan analisis kajian dan juga cadangan yang boleh memperbaiki dan meningkatkan pengurusan penyelengaraan dalam menyediakan sebuah lebuhraya yang selamat.

- To accomplish the company's mission -"*to be a sustainable, reputable and leading highway service provider*"
  Untuk mencapai misi syarikat - " untuk menjadi peneraju dalam penyediaan perkhidmatan lebuh raya yang mampan dan berwibawa"

This interview sessions will be audio-recorded and write out within a day of the completion of the interviews sessions. This is confidential information and it will only be use in this research study. The copy of written transcript from the interview will be given to interviewee. Interviewees were guaranteed complete secrecy and their responses will be kept completely confidential. The interview will be conducted in 5 mains topics. This entire interview is designed to take approximately one hour. The interviewee can freely ask any question regarding this interview session.
Sesi temu bual akan akan direkodkan dan akan ditulis dalam masa sehari selepas selesainya sesi temu bual . Segala maklumat adalah sulit dan ia hanya akan digunakan dalam kajian penyelidikan ini . Salinan transkrip

bertulis daripada temu bual akan diberikan kepada yang ditemu bual. Ditemubual telah dijamin kerahsiaan lengkap dan jawapan mereka akan dijaga dan dipastikan sulit sepenuhnya . Temubual akan dijalankan dalam 5 topik utama . Seluruh sesi temu bual direka bentuk untuk mengambil masa kira-kira satu jam. Ditemu bual bebas menanyakan apa-apa soalan mengenai sesi temu bual ini.

THE INTERVIEW SESSION RECORD

Part 1: Introduction and Demographic Information

1. Tell me about yourself?

2. How long have you been in this company?

3. Tell me about your work experience in Maintenance Department?

4. What is your technical background?

5. How would you describe yourself as a maintenance personnel?

Part 2: Research Question No.1

What is maintenance management practice particularly in inspection planning activities in Maintenance Management Department towards the completion of the maintenance activities and projects?

1. How do you plan your work activities?

2. Can you describe your work in the company?

3. What do you think about the work process in this company especially in Maintenance Management activities?

4. How often maintenance activities been postponed or cancelled and for what reason?

5. What is your suggestion and expectation in improving work planning for maintenance activities?

Part 3: Research Question No.2

How to overcome the weakness and lack of maintenance activities in the work process of the project completion particularly in highway management and maintenance activities?

1. What does maintenance mean to you?

2. How do you do about preventing any problems from occurs.

3. Do you know about periodic, corrective and preventive maintenance?

4. How many times you done your observation or survey a day?

5. Are you willing to do observation or survey without any instruction from your superior? If not, why?

6. What is your opinion about the lack of monitoring activities in maintenance of highway?

Part 4: Research Question No.3

How to enhance the work process in gathering and analyzing on maintenance activities information as well as in preparing a good quality report?

1. How do you manage your maintenance record activities?

2. How do you write your record?

3. What kind of issue that you are confronting in preparing your report?

4. How do you report your work status to your supervisor?

5. How frequently you talk with your superior about your work activities.

6. In the event that there are issues, how would you handle the circumstances that require you to prepare any supporting documents?

7. What is your recommendation to enhance the work process in dealing with the maintenance information record?

8. Who should be responsible to deal with this data and preparing the report?

Part 5: Closing the interview Session

1. Is there something else that you might want to offer that I didn't specifically get some information about?

Verification

Name of Interviewee : _____

Section : _____

Signature : _____

Date of Interview : _____

Thank you for your time and willingness to participate in this research study. As mentioned earlier, this information is confidential, and it will only be used for this research project. You will receive a copy of the written transcript from this interview for your review.