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Public Railway Depot Maintenance and Maintenance Work based on Work Breakdown Structure (WBS) to Improve Maintenance and Maintenance Performance

Iffah Ariqoh Fakrunnisa [a]
Yusuf Latief [b]
Nurul Inayah Wardahni [c]

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Abstract

Maintenance and upkeep of railway facilities are important to reduce the risk of work accidents. However, in some cases, there is equipment that is damaged and the equipment is very old. This is due to a lack of attention to public railway depot maintenance and maintenance work. This research discusses the evaluation of financing for maintenance and upkeep work, where in reality in the field, many railway maintenance facilities cannot be used properly due to negligence in the maintenance process. The aim of this research is to improve the maintenance and maintenance performance of railway depots in the aspects of structural buildings, rails, and equipment supporting the maintenance of railway facilities. The method used in this research is a literature review, case study, and survey conducted by distributing questionnaires to several experts, namely those carrying out maintenance activities at PT Kereta Api Indonesia (Persero), PT LRT Jakarta, and several sources who participated in the construction of the railway depot. The results of this research are the WBS of maintenance and upkeep work which is used to improve the maintenance and maintenance performance of railway depots.

Corresponding author:
Iffah Ariqoh Fakrunnisa,
Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Depok, West Java 16424, Indonesia.
Email address: iffahariqoh@gmail.com

[a] Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Depok, West Java 16424, Indonesia
[b] Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Depok, West Java 16424, Indonesia
[c] Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Depok, West Java 16424, Indonesia

1 Introduction

Transportation is a tool to support humans in mobility or moving places (Pratandari, 2019). Mobility can be done in various ways and modes of transportation, both public transportation and private transportation. However, in big cities where traffic jams are commonplace, public transportation is often an alternative for people to travel, one of which is trains. The train is an alternative mode of land transportation that is comfortable, safe, and economical and is in demand for urban residents. This is because the available departure schedules tend to be on time, and hassle-free, and the station locations are spread across almost every region. In train operations, to maintain and maintain the condition of train carriages in good condition, maintenance, maintenance personnel (human resources), and facilities must also be provided properly (Alfaris et al., 2019).

Railway facilities maintenance is an activity carried out to maintain the good condition of the railway so that it remains suitable for operation in accordance with the required provisions. Based on Ministerial Regulation number PM 18 of 2019, the places used for maintenance of railway facilities consist of the Depo (Locomotive Depot) and Service Hall, where small-scale maintenance is carried out at the Depot and large-scale maintenance is carried out at the Service Hall (Lidén, 2015; D'Ariano et al., 2019; Siami-Irdemoosa et al., 2015; Suresh et al., 2021). Maintenance carried out at Depo includes daily, monthly, six-monthly and annual maintenance. The depot oversees the Operational Area (DAOP).

Basically, depots have to carry out train maintenance in a timely and good manner to support good service quality, but in implementation, there are still several problems that occur, for example, delays in train maintenance times and inadequate maintenance facilities (Firawansyah, 2018). Negligence above will have a negative impact on the company and shows that there is a lack of Implementation Operational Standards (SOP) that are implemented in the field. Important care and maintenance is carried out in accordance with approved SOPs and strict supervision. To overcome negligence and improve performance in maintenance and upkeep work, a Work Breakdown Structure (WBS) for maintenance and maintenance work was created. The objectives of this research are as follows: 1) Defines the maintenance and upkeep activities currently implemented at public railway depots. 2) Create a WBS for inspection, maintenance and upkeep work at railway depots (Golpayegani & Emamizadeh, 2007; Nijland et al., 2021; Sharma et al., 2018).

Literature Review
Railway depot maintenance performance

Performance is the result of work whose quality and quantity can be achieved by carrying out tasks in accordance with the responsibilities given (Mangkunegara, 2017). Maintenance performance can be interpreted as the state or condition of actions/processes in carrying out maintenance functions when measured from time to time (Samat et al., 2011). Maintenance performance is measured and monitored comprehensively to achieve optimal maintenance excellence (Deborah, 2024). Maintenance performance measurement systems, for example, databases and indicators, can develop from the need to measure various processes (Stenström, 2012). According to Weber & Thomas (2005). Performance indicators are divided into 3, namely: failure rate, downtime maintenance costs, and functional/service quality.

Work breakdown structure (WBS)

WBS is a hierarchical decomposition of the scope of work that must be completed by the project team, to achieve goals and provide expected results (PMI, 2013). In the management process, according to (Ajizah, 2018), functions to define the project scope, identify stakeholders, develop a detailed list of tasks, estimate time and costs, and evaluate project needs. Maintenance and upkeep work can be supported by WBS (Alsadila & Latief, 2020). WBS on maintenance and upkeep work can be used to compile a list of activities carried out on maintenance and upkeep work, apart from that the WBS can also include the resources and equipment needed for a project (Fatmasari & Latief, 2018). By creating a WBS, it is hoped that it can cover all work elements involved in depot maintenance so that it can reduce the risk of work accidents.

Inspection, maintenance, and maintenance work

Basically, According to Lind & Muyingo (2012), Maintenance work is divided into 2, namely preventive action and corrective action. Where preventive action is maintenance carried out to maintain the condition of facilities and infrastructure in good condition, by carrying out inspection, detection, and replacement of components that are visible at the beginning of damage (Stutts, 2001), and Corrective action works to repair the overall elements of a work that have been damaged and cannot function as they should (Horner et al., 1997).

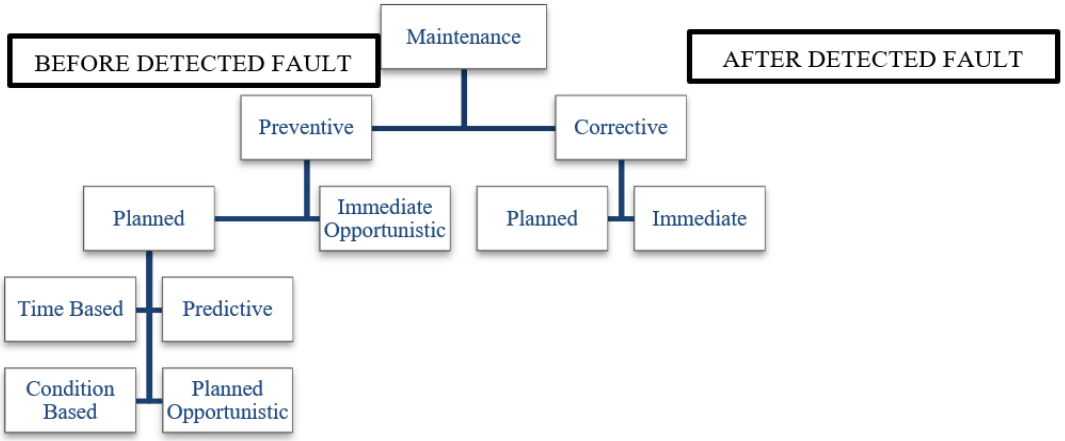

Figure 1. Division of maintenance types
Source: Lind & Muyingo (2012)

PM No. 18 of 2019 states that maintenance of railway facilities (locomotives, trains, carriages, and special equipment) aims to maintain their reliability.

General railway depot inspection work

Inspection work is the most important task in the railway industry to ensure the safety of the railway system and control costs (Li et al., 2015), this also applies to deposits. The depot inspection refers to the guidelines issued by the Minister of Transportation of the Republic of Indonesia. Inspection work at the depot is work carried out preventively; to determine the condition of the depot components and decide what steps to take in the future so as to reduce the possibility of components being damaged or failing (Stutts, 2001).

General railway depot maintenance work

Railway management plays an important role in responding to public railway business pressures. In fact, society's expectations for maintaining the safety and health of users on the one hand and market requirements for cost-effectiveness and service levels on the other hand have become important goals in public railways. In light of these issues, railway companies are making significant efforts to apply a reliability-based and risk-informed approach to improving maintenance, with the aim of reducing operational expenditure while maintaining high safety standards (Macchi et al., 2012). Maintenance work on public railways is carried out preventively; to reduce the possibility of failure in railway components and/or maximize operational benefit efficiency.

General railway depot maintenance work

Maintenance is an activity directed at a goal to ensure the functional continuity of a production system or equipment so that the results obtained are as desired (Mahardiono, 2015). Improvements According to Horner et al. (1997), included in corrective action, where work is carried out to restore the function of an equipment/building. Maintenance work according to Minister of Transportation PM Regulation No. 32 of 2011 is divided into 3 classifications, including:

a. Classification A (severe): Repairs/replacements that disrupt operations.
b. Classification B (medium): Repairs/replacements that pose a risk of disrupting operations.
c. Classification C (light): Repair/replacement that does not disrupt operations.

2 Materials and Methods

From the operational model and research methodology used, there are 2 X variables (X1. WBS, Variable

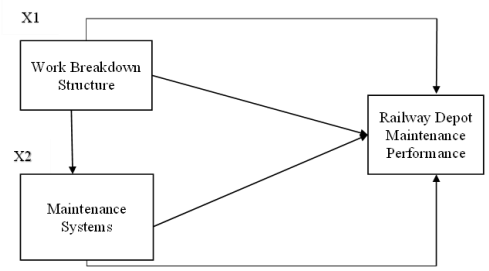

Figure 2. Operational model research

3 Results and Discussions

Types of maintenance and upkeep activities currently implemented at public railway depots

The results of Research Question (RQ) 1 are expert validation regarding current maintenance and maintenance activities for public railway depots. In the validation process of each activity, work is accepted when more than 2 experts approve maintenance and maintenance activities.

Table 1
Types of maintenance and maintenance inspection activities at public railway depots

No	Inspection, Maintenance, and Maintenance Activities	Yes No
2.1	Inspection Work	
2.1.1	Inspection/Inspection	Yes
2.2	Maintenance Work	
2.2.3	Routine maintenance	Yes
2.2.4	Regular maintenance	Yes
2.3	Maintenance Work	
2.3.1	Minor Damage Treatment	Yes
2.3.2	Moderate Damage Treatment	Yes
2.3.3	Severe Damage Treatment	Yes

WBS related to station building maintenance activities

The results of RQ1 are expert validation regarding maintenance and upkeep categories in the work packages for Depot Workshop Buildings, Depot Office Buildings, MEP Depot Buildings, Rails, and Railway Facilities Maintenance Support Equipment. In the validation process for each work package, work package statements are accepted if more than 2 experts agree that the work is required for inspection, maintenance and upkeep work. There were 133 work packages consisting of inspection, maintenance and upkeep activities (Odolinski, 2019; Vansteenwegen et al., 2016; Sangiorgio et al., 2020).

Table 2
WBS maintenance and care activities based on category in scope

WBS Level 1	WBS Level 2	WBS Level 3	WBS Level 4		WBS Level 5		
Job Name	Job Family	Type of work	Code	Work Packages	Inspection	Maintenance	Maintenance
Workshop	Structure	Bottom Structure	1.1.1.1	Precast Concrete Piles	Yes	Yes	Yes
Building			1.1.1.2	Structural Steel Piles	Yes	Yes	Yes
Depot			1.1.1.3	Cast Concrete Drilled Posts	Yes	Yes	Yes
Public							
Railways			1.1.1.4	Well Foundation	Yes	Yes	Yes
			1.1.1.5	Empty Stone and Gabion Pairs	Yes	Yes	Yes
			1.1.1.6	Pack. Pile Cap (Insitu Cast Concrete)	Yes	Yes	Yes
		Upper Structure	1.1.2.1	Pack. Steel Column	Yes	Yes	Yes
			1.1.2.2	Pack. Steel Beam	Yes	Yes	Yes
			1.1.2.3	Pack. Floor Slabs	Yes	Yes	Yes
			1.1.2.4	Steel Roof/Crown	Yes	Yes	Yes
	Architecture	Ceiling	1.2.1.1	Exposed Metal Ceiling	Yes	Yes	Yes
		Wall	1.2.2.1	Concrete wall	Yes	Yes	Yes
			1.2.2.2	Paint Brick Wall	Yes	Yes	Yes
		Floor	1.2.3.1	Floor Hardener	Yes	Yes	Yes
Office	Structure	Bottom Structure	2.1.1.1	Precast Concrete Piles	Yes	Yes	Yes
building			2.1.1.2	Structural Steel Piles	Yes	Yes	Yes
Depot			2.1.1.3	Cast Concrete Drilled Posts	Yes	Yes	Yes
Public							
Railways			2.1.1.4	Well Foundation	Yes	Yes	Yes
			2.1.1.5	Empty Stone and Gabion Pairs	Yes	Yes	Yes
			2.1.1.6	Pack. Pile Cap (Insitu Cast Concrete)	Yes	Yes	Yes
		Upper Structure	2.1.2.1	Pack. Concrete Column	Yes	Yes	Yes
			2.1.2.2	Pack. Concrete Blocks	Yes	Yes	Yes
			2.1.2.3	Pack. Floor Slabs	Yes	Yes	Yes
			2.1.2.4	Pack. Ladder	Yes	Yes	Yes
			2.1.2.5	Steel Roof/Crown	Yes	Yes	Yes
	Architecture	Ceiling	2.2.1.1	Plywood Concrete Ceiling	Yes	Yes	Yes
			2.2.1.2	Acoustic Concrete Ceiling	Yes	Yes	Yes
		Wall	2.2.2.1	Concrete wall	Yes	Yes	Yes
			2.2.2.2	Paint Brick Wall	Yes	Yes	Yes
			2.2.2.3	Wet Area Ceramic Brick Wall	Yes	Yes	Yes
		Floor	2.2.3.1	Floor [Hardener	Yes	Yes	Yes
			2.2.3.2	Ceramic floor	Yes	Yes	Yes
		Pack. Doors, Wood, Frames	2.2.4.1	Pack. Glass Doors and Aluminum Frames	Yes	Yes	Yes
			2.2.4.2	Pack. PVC Door (Toilet)	Yes	Yes	Yes
			2.2.4.3	Pack. Window	Yes	Yes	Yes
Mechanical,	Mechanical	Air Conditioning System	3.1.1.1	Chiller	Yes	Yes	Yes
Electrical,							
Plumbing			3.1.1.2	Compressor	Yes	Yes	Yes
			3.1.1.3	Condenser	Yes	Yes	Yes
			3.1.1.4	Metering Devices	Yes	Yes	Yes
			3.1.1.5	Control Panel/Power	Yes	Yes	Yes
			3.1.1.6	AHU/FCU/Ducting	Yes	Yes	Yes
			3.1.1.7	Pump	Yes	Yes	Yes

WBS Level 1	WBS Level 2	WBS Level 3		WBS Level 4		WBS Level 5	
Job Name	Job Family	Type of work	Code	Work Packages	Inspection	Maintenance	Maintenance
			3.1.1.8	Pipe installation	Yes	Yes	Yes
	electrical	Power Supplies	3.2.1.1	Medium Voltage Panel	Yes	Yes	Yes
			3.2.1.2	Medium Voltage Main Distribution Panel (LVMDP)	Yes	Yes	Yes
			3.2.1.3	Load panels	Yes	Yes	Yes
			3.2.1.4	Lighting system	Yes	Yes	Yes
			3.2.1.5	Lighting Control System	Yes	Yes	Yes
			3.2.1.6	Under Floor Duct and/or Raised Floor System	Yes	Yes	Yes
			3.2.1.7	Land system	Yes	Yes	Yes
			3.2.1.8	Lightning protection system	Yes	Yes	Yes
			3.2.1.9	Fire Alarm and Detector Systems	Yes	Yes	Yes
			3.2.1.10	Sockets and Switches	Yes	Yes	Yes
		Panel (including MEP)	3.2.2.1	Transformer	Yes	Yes	Yes
			3.2.2.2	UPS	Yes	Yes	Yes
			3.2.2.3	Voltage Panel	Yes	Yes	Yes
			3.2.2.4	Distribution Panel	Yes	Yes	Yes
		Electronics	3.2.3.1	Telephone	Yes	Yes	Yes
			3.2.3.2	Sound system	Yes	Yes	Yes
			3.2.3.3	Computer/internet network system	Yes	Yes	Yes
			3.2.3.4	Television channels and CCTV	Yes	Yes	Yes
			3.2.3.5	Building Automation System (BAS)	Yes	Yes	Yes
	Plumbing	Waterways	3.3.1.1	Sewer	Yes	Yes	Yes
			3.3.1.2	Clean Water Channels	Yes	Yes	Yes
			3.3.1.3	Sanitary Equipment	Yes	Yes	Yes
			3.3.1.4	Water heater	Yes	Yes	Yes
			3.3.1.5	Water faucet	Yes	Yes	Yes
			3.3.1.6	Dishwasher	Yes	Yes	Yes
		Fire Protection System	3.3.2.1	Fire safety housekeeping	Yes	Yes	Yes
			3.3.2.2	Means of Exit (EXIT sign)	Yes	Yes	Yes
			3.3.2.3	Fire detection and alarm systems and emergency voice communication systems	Yes	Yes	Yes
			3.3.2.4	Light fire extinguisher (APAR)	Yes	Yes	Yes
			3.3.2.5	Fire pump system	Yes	Yes	Yes
			3.3.2.6	Standpipe and hose systems or building hydrants	Yes	Yes	Yes
			3.3.2.7	Automatic sprinkler system	Yes	Yes	Yes
			3.3.2.8	Fire extinguisher connection	Yes	Yes	Yes
			3.3.2.9	Fire extinguishing system	Yes	Yes	Yes
			3.3.2.10	Smoke control and management system	Yes	Yes	Yes
		Plumbing and	3.3.3.1	Plumbing system	Yes	Yes	Yes

WBS Level 1	WBS Level 2	WBS Level 3	WBS Level 4		WBS Level 5		
Job Name	Job Family	Type of work	Code	Work Packages	Inspection	Maintenance	Maintenance
		Pump Systems					
			3.3.3.2	Clean water pump alarm trip	Yes	Yes	Yes
			3.3.3.3	Installation and fixtures	Yes	Yes	Yes
			3.3.3.4	Sanitary fixtures	Yes	Yes	Yes
Rail Works	Geometric	Railway Geometrics	4.1.1.1	Free space	Yes	Yes	Yes
			4.1.1.2	Width of railroad track	Yes	Yes	Yes
			4.1.1.3	curved	Yes	Yes	Yes
			4.1.1.4	straightness and evenness of the railroad	Yes	Yes	Yes
	Drainage Works	Railway Drainage	4.2.1.1	Railway drainage	Yes	Yes	Yes
	Railway Structure	Bottom Structure	4.3.1.1	Railway body construction	Yes	Yes	Yes
			4.3.1.2	railway body protection	Yes	Yes	Yes
			4.3.1.3	strengthening retaining walls	Yes	Yes	Yes
			4.3.1.4	counterweights	Yes	Yes	Yes
			4.3.1.5	sub-ballast work	Yes	Yes	Yes
			4.3.1.6	ballast work	Yes	Yes	Yes
		Superstructure	4.3.2.1	bearing	Yes	Yes	Yes
			4.3.2.2	rail	Yes	Yes	Yes
			4.3.2.3	rail mooring	Yes	Yes	Yes
			4.3.2.4	rail connection	Yes	Yes	Yes
			4.3.2.5	money order	Yes	Yes	Yes
Ancillary equipment Railway Facilities Maintenance	Lifting Jacks	electrical	5.1.1.1	Sockets and Switches	Yes	Yes	Yes
			5.1.1.2	Load Resistance Sensor System and Lifting Nut	Yes	Yes	Yes
			5.1.1.3	Control Panel	Yes	Yes	Yes
			5.1.1.4	Upper Limit and Lower Limit Sensor System	Yes	Yes	Yes
		Mechanical	5.1.2.1	Hydraulic	Yes	Yes	Yes
			5.1.2.2	Buffer	Yes	Yes	Yes
			5.1.2.3	Lever	Yes	Yes	Yes
			5.1.2.4	Spring	Yes	Yes	Yes
			5.1.2.5	Wheel	Yes	Yes	Yes
			5.1.2.6	Poles	Yes	Yes	Yes
			5.1.2.7	Lifting Nut and Security Nut	Yes	Yes	Yes
			5.1.2.8	Jack Bearings	Yes	Yes	Yes
			5.1.2.9	Spindle Jack	Yes	Yes	Yes
			5.1.2.10	Gearbox	Yes	Yes	Yes
	Overhead Cranes	electrical	5.2.1.1	End carriage (electrical)	Yes	Yes	Yes
			5.2.1.2	Wire rope hoist (electrical)	Yes	Yes	Yes
			5.2.1.3	Crane electrical (electrical)	Yes	Yes	Yes
		Mechanical	5.2.2.1	End carriage (mechanical)	Yes	Yes	Yes
			5.2.2.2	Wire rope hoist (mechanical)	Yes	Yes	Yes
			5.2.2.3	Crane electrical (mechanical)	Yes	Yes	Yes
	Generator	electrical	5.3.1.1	Battery	Yes	Yes	Yes

WBS Level 1	WBS Level 2	WBS Level 3		WBS Level 4		WBS Level 5	
Job Name	Job Family	Type of work	Code	Work Packages	Inspection	Maintenance	Maintenance
			5.3.1.2	Diesel motors	Yes	Yes	Yes
			5.3.1.3	Charging Alternator	Yes	Yes	Yes
			5.3.1.4	Installation and Control Panel	Yes	Yes	Yes
		Mechanical	5.3.2.1	Lubrication	Yes	Yes	Yes
			5.3.2.2	Air Filter	Yes	Yes	Yes
			5.3.2.3	Cooling	Yes	Yes	Yes
			5.3.2.4	Fuel	Yes	Yes	Yes
		Etc	5.3.3.1	Generator Room	Yes	Yes	Yes
	Compressor	electrical	5.4.1.1	Compressor (Electrical)	Yes	Yes	Yes
		Mechanical	5.4.2.1	Mechanical Pneumatic	Yes	Yes	Yes
	Fork Lifts	electrical	5.4.1.1	electrical	Yes	Yes	Yes
		Mechanical	5.4.2.1	engine	Yes	Yes	Yes
			5.4.2.2	Hydraulic	Yes	Yes	Yes
			5.4.2.3	Mechanic	Yes	Yes	Yes

From the results of expert validation on the WBS, it is known that 133 work packages contained in the WBS for depot maintenance and upkeep work were approved for inspection, maintenance and upkeep work.

4 Conclusion

Before the WBS was created, there were 46 work packages that required maintenance and care activities consisting of inspection, maintenance, and care. The WBS created is based on maintenance performance. From the WBS that has been created, 46 guidelines were obtained consisting of inspection, maintenance, and care guidelines. BIM modeling is made based on maintenance and care WBS already.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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In the future, this WBS is suitable for integration with the financing of each inspection, maintenance, and upkeep work.

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