The Development of Maintenance and Care System for Public Railway Facility Infrastructure Integrated with Building Information Modeling (BIM) Software Based on Work Breakdown Structure (WBS)

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Article history:	**Abstract**

Post-construction maintenance is crucial to maintain a building's reliability. In some cases, damages often occur due to negligence in the post-construction maintenance process. This research discusses the maintenance system of railway station buildings where currently the railway station facility is often cannot be used properly due to negligence in the maintenance process. Maintenance that is not carried out properly will be very detrimental to many parties. The purpose of this research is to improve the maintenance performance of the railway station building from the structural scope, station supporting facilities scope, and plumbing scope. The case study of this research is Manggarai Station building which is one of the largest railway station buildings in Indonesia. The methods used in this research are literature review, case study, and survey conducted using questionnaires from several experts such as people who are in charge of the maintenance activities in PT Kereta Api (Persero), PT LRT Jakarta, and some from the contractors who built the railway system infrastructure and also take charge of the post-construction maintenance and care. The results of this research are in the form of WBS-based BIM modeling and guidelines used to improve performance in maintaining the reliability of station buildings.

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1 Introduction

In quite dense urban areas, appropriate public transportation is highly needed in order to sustain the economy, population mobility, and long-term development (Kennedy et al., 2005). Public transportation is highly dependent on its function and maintenance (Kennedy et al., 2005). Trains are a great form of public transit in this densely populated city. Funding the operation and maintenance systems of transit is a frequent difficulty for densely populated cities, which is compounded by the necessity of railway infrastructure to the functional and efficient running of these places (Dickens, 2015). The funding is highly dependent on efficient operation and maintenance activities (Dickens, 2015).

The maintenance of a railway infrastructure is crucial (Lidén, 2015). It needs to be done in order to have a well-functioning transportation system (Lidén, 2015). The maintenance work consists of various numbers of activities (Lidén, 2015). Currently in Indonesia, the maintenance and care of public railway infrastructure is carried out regularly (Sanjaya, 2017). This is done to ensure the safety and comfort of train travel because it involves many parties and people (Sanjaya, 2017). The operational condition of public railway facilities and infrastructure must always be maintained so that trains can pass. Most incidents related to damage to railway infrastructure facilities are due to the lack of supervision of the maintenance and care activities.

According to the Regulation of the Directors of PT Kereta Api Indonesia (Persero) Number PER.U/KL.104/V/1/ About Guidelines for Inspection, Maintenance, and Care and Energy Control of Buildings, public railway infrastructure in Indonesia is divided into 3, namely the railway lines, the train stations, and the train operating facilities. The train station building is included in one of the public railway infrastructures that is highly needed because the train station is the place where trains depart and stop, as well as the place where passengers get on and off.

The objectives of this research are as follows to create WBS for maintenance work on railway station buildings, to create maintenance and care guidelines for railway station buildings, and to create WBS-based BIM modeling to be integrated with maintenance guidelines (Al-Kasasbeh et al., 2021; Lu et al., 2017; Bryde et al., 2013).

Literature Review
Public railway facility infrastructure maintenance performance and policy

Performance is a comparison between the *input* and *output* productivity of each system (Liyanage & Villalba-Romero, 2015). Maintenance performance itself is a condition of action or process in carrying out maintenance functions which is measured from time to time (Ding & Kamaruddin, 2015). According to (Weber & Thomas, 2005), performance indicators are divided into 3, namely: failure, maintenance costs, and maintenance-related downtime. According to (Ding & Kamaruddin, 2015), maintenance policies can be grouped into different groups according to how damage and maintenance are handled. In general, there are 5 (five) types of maintenance policies which are classified into 3 categories, namely; Repair/restore for corrective maintenance, Prevent damage or maintain reliability for preventive maintenance and predictive maintenance, and *Coorporate/Improve* for *Autonomous maintenance* and design out maintenance.

Work breakdown structure (WBS)

Project managers rely on work breakdown structures (WBSs) as a foundation for planning and managing project schedules, budgets, and adjustments (Elsye et al., 2018). A work breakdown structure (WBS) is a useful tool for managing a project's time, money, and other performance metrics throughout its lifecycle (Burghate et al., 2018). Work breakdown structures (WBS) and guidelines can be useful inputs for maintenance methods, as stated in (Aryaningrum et al., 2018), and (Ilham et al., 2018). The work breakdown structure (WBS) is a useful tool for maintenance activity planning because it establishes a hierarchy of tasks, resources, and time required to complete maintenance and care tasks (Aryaningrum et al., 2018; Ilham et al., 2018). Therefore, WBS can be a guide for those carrying out maintenance and care activities.

Building information modeling (BIM)

BIM is a very complex information system that consists of 3D visual aids whose performance is highly dependent on the level of detail of the data applied therein (Fargnoli et al., 2019). According to (Fatmasari & Latief, 2018),

Economic, technical, social, and environmental factors are the four facets of building information modeling (BIM) that impact maintenance performance, particularly for structures. It is highly feasible to integrate maintenance process information management with BIM as an ICT use, according to (Omar et al., 2018). Integrating the WBS code with construction records and linking it to project activities without data loss is crucial to the BIM idea (Park & Cai, 2017).

Maintenance guidelines

In Indonesia, guidelines regarding maintenance and care of railway station building infrastructure are regulated in PM No. 23 of 2011, Regulation of The Minister of Public Works no. 24/PRT/M/2008, PM No. 20 of 2019 and PP no. 56 of 2009 and is also regulated in PT KAI's Service Regulations.

2 Materials and Methods

From the operational model of research and research methodology that are used, there are 4 X variables (X1. Maintenance Activities, X2. WBS, X3. Maintenance Guidelines, X4. BIM) and 1 Y variable which is railway station building maintenance performance where the X variable is interconnected to each other in order to achieve the Y variable which is the Railway Station Building Maintenance Performance.
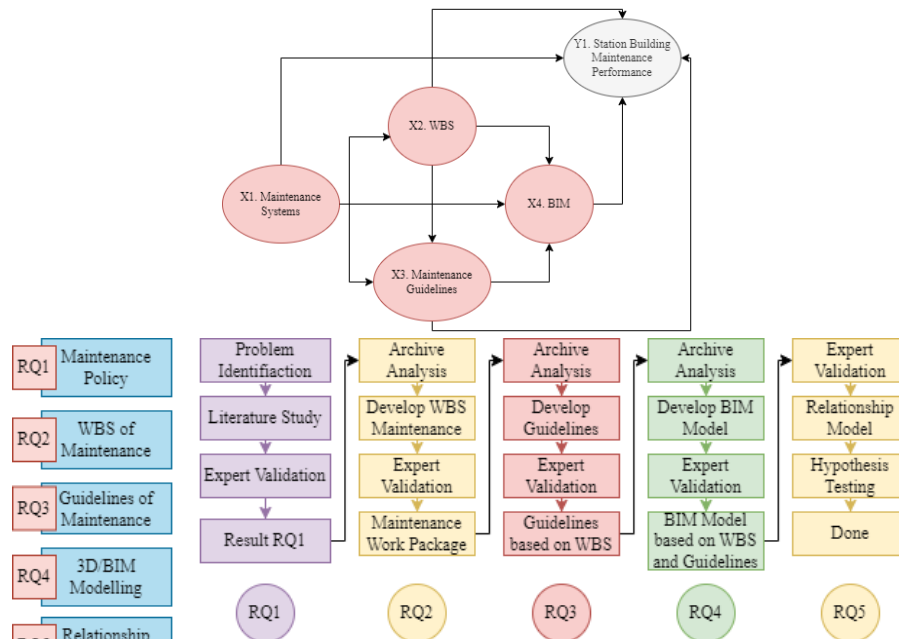

Figure 1. Operational model of research (Left) and research methodology (Right)

3 Results and Discussions

WBS in relation to station building maintenance activities

The results of RQ1 are expert validation regarding maintenance and care categories in work packages in the structural scope, supporting facilities scope, and plumbing scope. In the validation process for each work package, a maintenance category is accepted if more than 2 experts agree that this work category is required in the related work package. There are 46 work packages that require maintenance and care activities consisting of inspection, care, and maintenance.

Table 1
WBS maintenance and care activities based on category in the structural scope, station support scope, and plumbing scope

WBS Level 2 Scope of Work	WBS Level 3 Type of Work	WBS Code	WBS Level 4 Work Packages	WBS Level 5 (Maintenance and Care Category)		
				Inspection	Maintenance	Care
Structural Scope	Bottom Structure	X.1.1.1	Concrete Piles	Yes	Yes	Yes
		X.1.1.2	Structural Steel Piles	Yes	Yes	Yes
		X.1.1.3	Cast Concrete Bored Pile	Yes	Yes	Yes
		X.1.1.4	Well Foundation	Yes	Yes	Yes
		X.1.1.5	Tamping and Gabion Pairs	Yes	Yes	Yes
		X.1.1.6	Pile Cap Work	Yes	Yes	Yes
	Upper Structure	X.1.2.1	Column Work	Yes	Yes	Yes
		X.1.2.2	Beam Work (1st Floor and above)	Yes	Yes	Yes
		X.1.2.3	Floor Slabs Work	Yes	Yes	Yes
		X.1.2.4	Ladder Work	Yes	Yes	Yes
		X.1.2.5	Steel Roof/Crown	Yes	Yes	Yes
Station Support Scope	Supporting Facilities	X.2.1.1	Ticket Counter	Yes	Yes	Yes
		X.2.1.2	Water Installation	Yes	Yes	Yes
		X.2.1.3	Firefighter	Yes	Yes	Yes
	Platform	X.2.2.1	Lights	Yes	Yes	Yes
		X.2.2.2	Pathway Signage	Yes	Yes	Yes
		X.2.2.3	Directions Signage	Yes	Yes	Yes
		X.2.2.4	Platform Safety Sign	Yes	Yes	Yes
Plumbing Scope	Waterways	X.3.1.1	Clean Water Channels	Yes	Yes	Yes
		X.3.1.2	Sewer	Yes	Yes	Yes
		X.3.1.3	Sanitary equipment	Yes	Yes	Yes
		X.3.1.4	Water heater	Yes	Yes	Yes
		X.3.1.5	Dishwasher	Yes	Yes	Yes
	Air Conditioning System	X.3.2.1	Chiller	Yes	Yes	Yes
		X.3.2.2	Compressor	Yes	Yes	Yes
		X.3.2.3	Condensor/Cooler	Yes	Yes	Yes
		X.3.2.4	Metering Device	Yes	Yes	Yes
		X.3.2.5	Panel Control/Power	Yes	Yes	Yes
		X.3.2.6	AHU/FCU/Ducting	Yes	Yes	Yes
		X.3.2.7	Pump	Yes	Yes	Yes
		X.3.2.8	Pipe installation	Yes	Yes	Yes
	Fire Protection System	X.3.3.1	General	Yes	Yes	Yes
		X.3.3.2	Fire Safety Housekeeping	Yes	Yes	Yes
		X.3.3.3	Exit Way Facility (EXIT)	Yes	Yes	Yes
		X.3.3.4	Fire detection and alarm systems and emergency voice	Yes	Yes	Yes

			communication systems			
	X.3.3.5	Fire extinguisher	Yes	Yes	Yes
	X.3.3.6	Fire pump system	Yes	Yes	Yes
	X.3.3.7	Standpipe and hose or hydrant systems	Yes	Yes	Yes
	X.3.3.8	Automatic sprinkler system	Yes	Yes	Yes
	X.3.3.9	Fire extinguisher connection	Yes	Yes	Yes
	X.3.3.10	Fire extinguishing system	Yes	Yes	Yes
	X.3.3.11	Smoke control and management system	Yes	Yes	Yes
Plumbing and pump systems	X.3.4.1	Plumbing system	Yes	Yes	Yes
	X.3.4.2	Clean water pump alarm trip	Yes	Yes	Yes
	X.3.4.3	Installation and fixtures	Yes	Yes	Yes
	X.3.4.4	Sanitary fixtures	Yes	Yes	Yes

Maintenance and care guidelines based on maintenance and care WBS

In the RQ2 research process, the researcher reviewed maintenance and care guidelines based on the Regulation of The Minister of Public Works No. 24/PRT/M/2008 and Regulation of the Directors of PT Kereta Api Indonesia (Persero) Number PER.U/KL.104/V/I/KA-2020. However, the researcher found several shortcomings of the guidelines, that is the lack of guidelines regarding the inspection and maintenance of work package items that need to be maintained and looked after in station buildings (Lidén, 2015; Kovacevic et al., 2016; Santiana et al., 2022; Farrington-Darby et al., 2005). So the researcher carried out expert validation once more on the guidelines that had been refined by technically using 5 experts to validate, and if less than 3 experts disagreed regarding the guidelines, it will be reviewed based on the experts' input.

Table 2
Example of a WBS-Based guidelines template that has been developed with examples of sewerage maintenance and care work

	Plumbing Sewer	
Code	Description	
WBS Level 2	Work Classes	Plumbing Scope
WBS Level 3	Type Of Work	Waterways
WBS Level 4	Work Package	Sewer

Work Package	Alternative Designs/Methods	Activity	Time Span
Sewer	-	Inspection	Every day
		Care	One a month
		Maintenance	Tentative

Implementation Method
Inspection Work
Conditions Of Implementation
Implementation

a. Pipe checks are carried out routinely every day.
b. Checking the condition of the pipe for leaks
c. Analyzing whether maintenance/care is necessary

Maintenance Work
Conditions Of Implementation

Implementation
a. Check the vertical channels of dirty water on the building, especially channels that use PVC material, check at every connection that uses glue as a connector. If there is a leak, close it immediately.
How to fix:
1) Sand or roughen the cracked surface or at the end of the joint.
2) Apply PVC glue to the area that wants to be connected.
3) Reconnect the part.
b. Clean the open channels of dirty water around the building from items that can interfere with the flow of water in the channels, at least once a month.
c. In the closed dirty water channel, check through the channel control tank, give bars made of iron rod as a waste barrier so that the channel is not clogged.

Care Work
Conditions Of Implementation

Implementation
 a. Preparing equipment and materials needed for pipe maintenance
 b. Replacing pipe parts that have leaks, according to predetermined specifications

3D BIM Modeling in the WBS-Based Manggarai Station Building Case Study

The BIM model was created using Autodesk Revit 3D. This BIM modeling has been created based on a WBS that has been validated with previous experts. Based on the findings of many experts, it can be shown that BIM is excellent for visualization and coordination. In the post-construction stage, BIM has high potential to be used in maintenance information systems, especially for public railway infrastructure, in this case station buildings (Martínez-Aires et al., 2018; Tausworthe, 1979; Macchi et al., 2012).
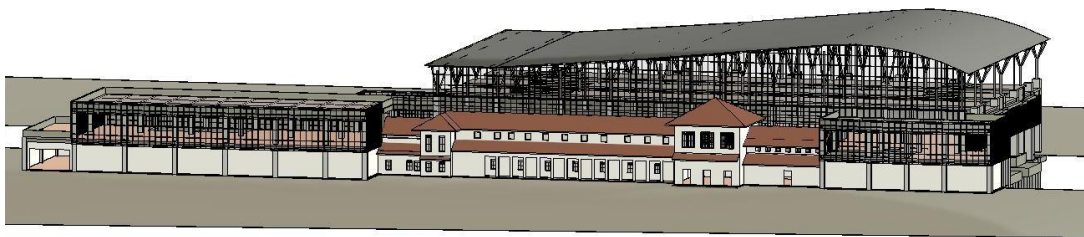

Figure 2. BIM Model in the WBS-Based Manggarai Station Building Case Study

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's they have no competing interest.

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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