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Improving Port Performance and Modeling Its Impact Using BPM and BPMN Simulation: A Case Study of Batu Ampar Port

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Abstract

This research discusses the cargo terminal at Batu Ampar Batam port. The root cause of the low performance is that the flow of data and information, both internal and external, has not been well systemed. This research helps improve the cargo terminal business processes, especially those related to its dwelling time performance. Business process improvement is carried out by combining BPM methods in the form of streamlining and benchmarking processes and referring to regulations related to the implementation of Inaportnet at ports. In addition, the results of the improvement were also tested for their impact with the simulation method using the BPMN simulation tool, Visual Paradigm. The results of this study indicate that improving business processes with streamlining and benchmarking methods that refer to the application of Inaportnet, can reduce the dwelling time performance of the Batu Ampar Batam port cargo terminal.

INTRODUCTION

Based on the data recap of cargo handling at the BPPB port from 2014-2018, the highest percentage of total cargo handling in Batam is at Batu Ampar Port, reaching 53%. This indicates the importance of Batu Ampar Port as a gateway for goods entering and leaving Batam. Additionally, data from BPS shows that the export-import volume at Batu Ampar Port, Batam, is also significant and tends to increase by 6 to 20% from 2014-2018.

Geographically, Batu Ampar Port is strategically located right in front of the Singapore Strait, an international shipping route used by vessels from the Malacca Strait heading to Asia. According to the International Transport Forum's Transport Outlook 2017, the projected cargo traffic in Southeast Asia will reach 143 million TEUs by 2030, representing the largest increase in total global cargo traffic. This is a potential cargo traffic that will pass through the Malacca and Singapore Straits. Furthermore, according to BP Batam's head, Lukita Dinarsyah, around 60,000 ships pass through the Malacca Strait every day. However, Batam captures only 5-10% of this potential (Sumatera.bisnis.com, 2018). This strategic geographical location should be a significant advantage for Batu Ampar Port to serve as a transshipment hub for large cargo vessels passing through this trade route.

However, the great potential of Batu Ampar Port is not supported by good terminal performance. The container capacity at Batu Ampar Port is not yet competitive with other ports in the same area. Compared to Singapore Port, which has a capacity of 30 million TEUs/year, Batu Ampar Port, Batam, only has a

container capacity of 500,000 TEUs/year. Even when compared to nearby national ports like Kuala Tanjung and Belawan, Batu Ampar Port is still far behind.

The conditions on the ground, which are still mostly manual, and the equipment and facilities that are still inadequate, ultimately result in significant losses for Batu Ampar Port, Batam, such as errors in recording container stacking times, the number of containers entering/exiting, the duration of vessel docking, and so on. These losses are compounded by the loss of opportunities for the port to generate more significant revenue if port activities, particularly at the cargo terminal, could be carried out as efficiently as possible using digitalized, automated, and integrated equipment, facilities, and systems with relevant stakeholders. Port customers also experience losses due to the inefficiency of port services, such as the long dwelling time. According to Marine Traffic (2017), the average dwelling time at Singapore Port is only 0.8 days (United Nations Conference on Trade and Development, 2019). This figure is still far from the average dwelling time at Indonesian ports, which reaches 3.01 days (Dashboard Dwelling Time INSW, 2017).

Based on the existing conditions at Batu Ampar Port, it can be concluded that there is a gap between the existing service capacity and the significant service potential that has not been maximized. The low service capacity at Batu Ampar Port's cargo terminal is due to inadequate systems, equipment, and facilities. The fundamental problem that needs to be addressed first is related to the flow of data and information between the port logistics community and within Batu Ampar Port itself. The Indonesian government, through the Directorate General of Sea Transportation (Dirjen Hubla/Director General of Sea Transportation), developed an IT platform called Inaportnet to integrate data and information exchange among port logistics communities. The implementation of Inaportnet in Indonesian ports is the government's effort to support the Indonesian National Single Window (INSW) program, which aims to create a globally competitive national logistics system. This research essentially relates to Business Process Management (BPM), which can be used to improve business processes within an organization, such as issues in the flow of data and information between logistics communities and improvements to the port's facilities and information systems. Improving business processes, facilities, and information systems is complex and cannot be accomplished with just one BPM method. Combining several methods will yield better improvement proposals, such as combining BPI and BPR.

There have been several studies related to BPM in the maritime sector, particularly ports. A recent study by Saragiotis (2019) discusses several literature reviews on BPM in the port sector. One mentioned in it is Islam et al. (2013), which developed a process reengineering framework at port terminals. The study aimed to reengineer the container transport process at the port using trucks to introduce a truck-sharing arrangement system that could potentially reduce the number of empty truck trips. Additionally, there is a study by Cimino et al. (2017) that discusses the evaluation of the impact of using smart technology in ports. The evaluation of the impact of technological changes at ports in this study was conducted using BPMN simulation. The simulation was in the form of a before/after technology change business process simulation. Another study (Vieira et al., 2015) proposed using a port community system (PCS) in the form of a port single window (PSP) at the Port of Santos, Brazil. The use of PSP improved the existing port information flow, ultimately reducing logistics costs and increasing user satisfaction by reducing dwelling time. Another

study by Ridwan (2014) designed a port performance metric model to improve port quality by integrating Six Sigma and system dynamics.

Based on Saragiotis (2019), it can be seen that research on Business Process Improvement (BPI) in the port sector is very rare, if not nonexistent. Most studies in the port sector use the Business Process Reengineering (BPR) method. Therefore, this study adds research related to BPI to help address the complex problems in this study.

This research uses BPI and BPR, as well as Business Process Model and Notation (BPMN) as tools to simulate the impact of changes to port business processes, which were previously manual, becoming digitalized and integrated using the Inaportnet platform, supported by equipment and facilities development. The model used as the primary reference in this research is Islam et al. (2013). Additional models used to complement the first model are Adesola and Baines (2005) on the model-based and integrated process improvement methodology (MIPI). The third model is Harrington (1991) to complement the BPI process in the form of streamlining stages. The final model, as a simulation tool, is the study by Cimino et al. (2017).

RESEARCH METHOD

This study uses the model by Islam et al. (2013) as the main reference model. This model examines the reengineering of container transport processes in ports using trucks to introduce a truck allocation system that potentially reduces the number of empty truck trips. The main reference model will be applied to improvements related to facilities and information systems using the BPR method, while business process improvements will utilize the BPI method with the aid of additional models. The additional model by Adesola and Baines (2005) and Cimino et al. (2017). The data related to this research includes document analysis, interviews, and field observations. Document analysis is used to obtain data on the general description of the organization where the research object is located, data related to the system components of the research object, which consist of inputs (cargo), boundaries, stakeholders, machines, outputs (cargo handling and port services), objectives, and processes (interaction between people, machines, and cargo), as well as regulations related to port operations, Inaportnet, and other relevant regulations. The analyzed documents can include organizational documents from the research object and additional related documents accessed through the internet.

The interview method is used to gather data and information about the implementation of business processes at the research object (Batu Ampar Port, Batam) as they occur in the field, the flow of data and information in the ship and cargo service business processes at Batu Ampar Port, issues or constraints in the implementation of these business processes, and expectations for improvements in the business process performance. Interviews are conducted with several sources, including top management of the research organization, the Head of the Work Unit overseeing the implementation of business processes in the field, and technical/operational staff managing port service processes in the field.

Field observation is carried out to obtain additional data and to verify the data and information gathered through the document analysis and interview methods. Field observation involves directly watching and observing the implementation of the business processes at the research object in the field.

Data processing is performed using Microsoft Office applications (Word, Excel, Visio, and PowerPoint). Descriptive data is processed using MS Word, numerical

data is handled with MS Excel, image data is managed with MS PowerPoint, and business process data represented in diagrams is processed using MS Visio. Additionally, an extra application, Visual Paradigm, is used to model business processes into As-Is and To-Be models, featuring a BPMN (Business Process Modeling and Notation) menu.

Data analysis is conducted using several tools and methods, including Value Added Analysis, Fishbone Diagram, non-value-added activity analysis in streamlining, BPMN simulation for business process performance, and analysis of constraints in implementing process improvements. Value Added Analysis is used to examine existing business processes to identify which processes add value to customer services. It also helps in identifying issues that need to be addressed. These issues are further analyzed using the Fishbone Diagram to pinpoint symptoms and root causes of the problems that need solutions. The Research flow can be seen in Figure 1.

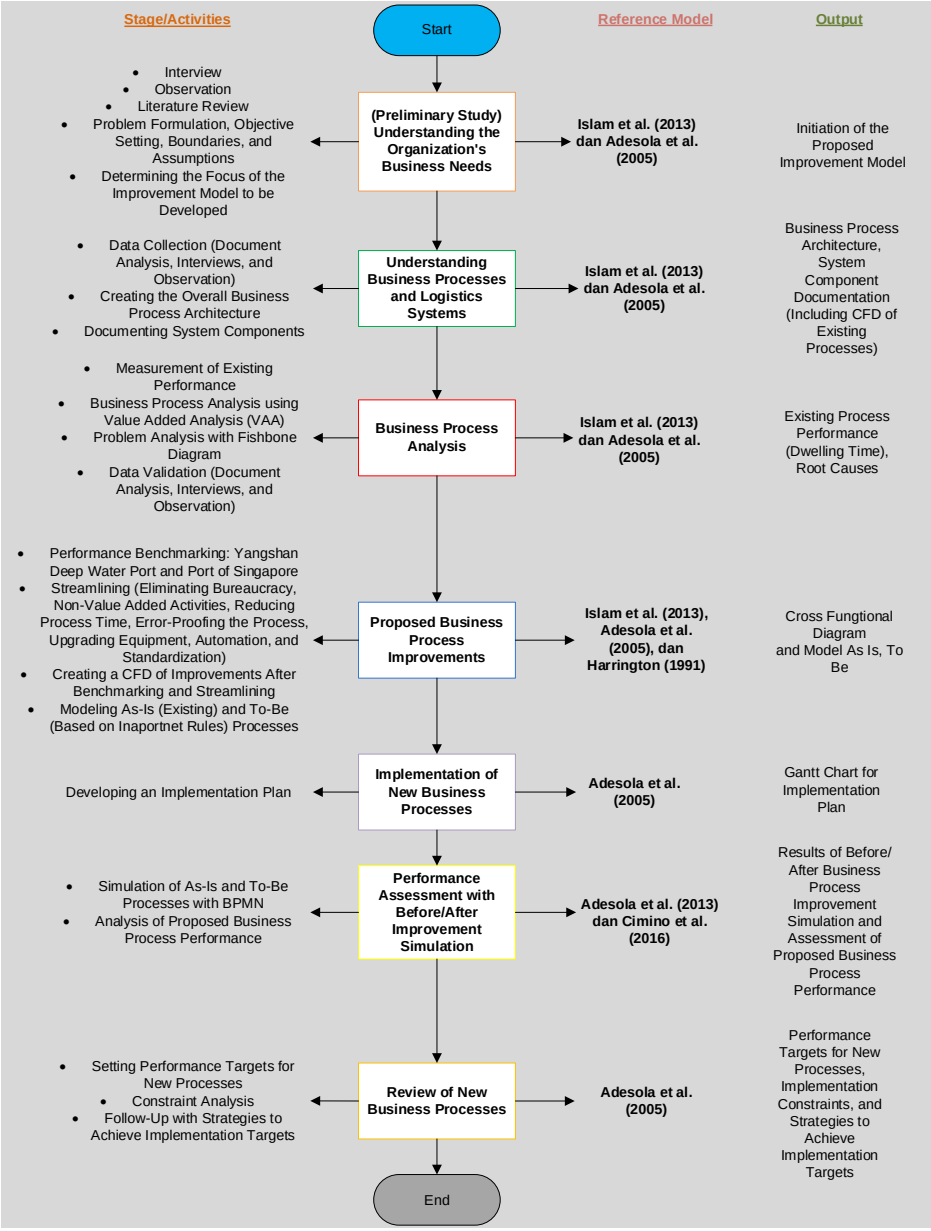

Figure 1. Research Flow

RESULTS AND DISCUSSION

A. Business Process Existing of the Cargo Terminal at Batu Ampar Port, Batam

The business processes related to dwelling time at Batu Ampar Port, Batam, are divided into three stages:

a. Pre-clearance: This includes the process of cargo handling via the pier and stacking with direct transport/special equipment and the preparation of customs declaration documents (PIB) to be submitted to Customs.
b. Customs Clearance: This involves the physical inspection of containers, verification of customs documents, and issuance of the Goods Release Approval Letter (SPPB) by Customs.
c. Post-clearance: This stage includes the handover of goods from the stacking area, issuance of service receipts for pier and stacking space usage, and the payment process for ship and cargo services using a host-to-host system at the general terminal of Batu Ampar, Batam.

Table 1. Business Process Flow in General at Batu Ampar Port

Port of Loading	*Port of Discharge*		*Port Process*				*Inland Transport Process*		*Manufacture/Production Process*	
			Dwelling Time *Pre Clearance* → *Customs Clearance* → *Post Clearance*							
Port Waters			**Port/Customs Area/Temporary Storage Facility (TPS)**				**Buffer Area**	**Inland Transport**	**Outside the Port**	**Production System**
Pre Arrival	*Arrival at Port Limit*	*Docking/Unloading*	*Berthing-Stacking in CY*	*Customs Clearance*	*Container Handling/Hand-over*	*Gate-Out System*	*Lini II*	*Hub & Spoke System*	*Bonded/ CFS/Factory Storage*	**Production Process**
Departure of the ship from the loading port	Arrival of the Ship in Port Waters, waiting to dock at the Wharf	Ship docked at the Wharf, waiting for the unloading process	Unloading process until storage in the Container Yard (CY)	Customs Clearance process until Customs Approval (SPPB)	Handling of goods/container until payment of storage fees (SP2/Tila)	Release of goods (container) from the port area (Temporary Storage Facility (TPS)/Transit Office	Relocation of Storage Location	Land Transport Process (Trucking)	Goods arrive at the importer's location (warehouse /factory)	Goods used in the production process

Source: Processed by the author based on observations and interviews

Based on the root cause analysis conducted using the fishbone diagram, several root causes were identified that contribute to the gap between the potential and the service capacity of the cargo terminal, particularly in terms of container capacity and dwelling time, which are the main services of a cargo terminal. The fundamental problem is a bottleneck in the flow of information and goods in container services and the dwelling time for ships entering and leaving the port. The operational system remains manual and has not yet been digitized, particularly in the field, which is the first entry point for port service data. Furthermore, the existing system is not integrated with relevant stakeholders. The limited equipment and facilities also contribute to the poor performance of the Batu Ampar Batam cargo terminal. Based on this, it can be concluded that the current operational system, equipment, and facilities prevent Batu Ampar Batam Port from fully leveraging its strategic location. As a result, the terminal's service capacity is smaller than its potential.

B. Business Process Improvement Proposals

Based on the research methodology, Business process improvements at Batu Ampar Port are carried out through the following steps:

a. Streamlining process based on Inaportnet Rules and Benchmarking with Port of Singapore and Yangshan Deep Water Port, Shanghai.
b. Designing Business Process Improvements Related to Import Dwelling Time at the Cargo Terminal of Batu Ampar Port, Batam. The improvement in the loading and unloading process can significantly reduce processing time compared to the previous system. Previously, the process took 1 to 2 days to handle only 40-90 containers. The new process design incorporates more advanced unloading equipment, with all data digitized and transferred via the system. Additionally, it assumes that the supporting dock facilities for other loading and unloading activities are also upgraded. Based on this, the time required to process the same number of containers, 40-90 containers, could be reduced to just 1-3 hours.
c. Process Improvement Design for Goods Delivery from Staging. This new process design proposes the use of the Inaportnet and INSW systems integrated with the in-house port terminal system at Batu Ampar Batam, enabling digitalization and automatic processing through these system integrations. Additionally, the container dispatch process is supported by more advanced handling equipment such as RTGs (Rubber-Tyred Gantry cranes) and mobile cranes. Trucking companies within the terminal will be under the supervision of Pelindo or BUP. These trucks will be responsible for transporting goods out of the terminal gate to be handed over to designated trucking services or carriers appointed by the goods owner. This will result in a more organized goods release process, reducing queueing at the exit gate and shortening the release time from the previous 30 minutes to an hour per container to 15 minutes per contain
d. Process Improvement Design for Issuing Wharfage Service Receipts. In this improvement design, all processes are carried out through the in-house BUP system for wharfage services, namely YOM and PJBA, which are already integrated with the Inaportnet system. This integration simplifies data transfer between systems, eliminating the need for hardcopy requests for issuing wharfage service receipts. It is proposed that the in-house BUP system be further developed to connect with the loading/unloading equipment on site, allowing cargo handling and staging activities to be automatically recorded in the system without manual data entry. This minimizes recording errors and reduces the time needed to input data for reporting, as reports can be generated directly from the system with data entered automatically. Validation by Kasatker (Head of the unit) is no longer necessary. Previously, this process could take about 10 hours depending on the data entry speed of the personnel. With the new design, the process time can be reduced to just 50 minutes to 1 hour.
e. Process Improvement Design for Service Payments Through Host-to-Host System. In this improvement design, all processes are conducted through the in-house BUP system, namely FBMS (Financial Billing Management Systems). FBMS is then integrated with the Inaportnet system, making data transfer easier. Estimation and actual cost calculations for port services

continue to be done within FBMS, and internal verification by Kasubbag (Head of Subsection) is also carried out within FBMS. FBMS is connected to the bank system that collaborates with BPPB, facilitating the holding and deduction of funds for port service payments through this system integration. Ultimately, the payment receipt generated by FBMS will be transferred to the Inaportnet system, allowing service users/agents to download the receipt directly from their Inaportnet accounts.

C. Performance Analysis of Proposed Process Design

The performance analysis of the proposed process design is presented as a summary of time performance, comparing the existing process with the proposed streamlined process. The summary of performance for wharf services, goods delivery from staging, issuance of wharfage service receipts, and service payments through the host-to-host system before and after streamlining can be found in Tables 2 and 3.

Table 2. Performance Recap of the Process Before and After Streamlining

No.	Process	Time (Working Hour)		Number of Process Stages		Parties Involved	
		Before	after	Before	after	Before	after
	Pre-Clearance						
1	Loading and unloading via the wharf and staging with direct transport goods/special equipment (estimated 60-90 containers)	24 to 48 hours (depending on bad weather, equipment malfunction, performance of the stevedoring company)	3-4 hours (Notification of PIB before arriving at the port)	6	7	3	4
	Customs Clearance						
2	Physical inspection, customs document verification, and issuance of SPPB (Customs Approval)	12-24 (https://www.kemenkeu.go.id/sites/default/files/djbc.pdf)	Black Box (not considered in this study, as it is outside the internal port processes)				
	Post Clearance						
3	Delivery of goods from staging (per container)	0.5-1 (for container release only, other stages are not counted)	1 hour 10 minutes (for all stages)	5	5	2	2
4	Issuance of wharfage service receipts and use of staging area	Not listed in SOP and never calculated	0.83 (50 minutes)	5	3	2	2
5	Payment process for ship and goods services through the host-to-host system	Not listed in SOP and never calculated	6,42	20	16	3	3

Business process improvements at the Batu Ampar Batam Port Cargo Terminal affect port performance, particularly in terms of dwelling time. The changes in dwelling time before and after the business process improvements can be seen in Table 2.

Table 3. Changes in Dwelling Time Performance at Batu Ampar Batam Port Cargo Terminal

No.	Process	Process Duration (Working days, 1 day = 24 hours)	
		Before	**After**
1.	*Pre-clearance*	1-2	0,17
2.	*Customs clearance*	0,5-1	never calculated
3.	*Post- clearance*	never calculated	0,35
Total *Dwelling time*		**2-3 days**	**Approximately 0.5-1 day excluding customs clearance**

The dwelling time listed in Table 2 assumes that the number of containers unloaded is 60-90. This is the typical number of containers unloaded from ships that regularly arrive from Singapore and Malaysia. Additionally, this time is based on the assumption that port facilities, infrastructure, and systems have been improved and upgraded according to the needs of the new system and benchmarking results. Improvements and upgrades to facilities and infrastructure are necessary to enhance the dwelling time performance at the Batu Ampar Port Cargo Terminal. These improvements include extending the wharf to 1 km, increasing the draft depth to 12 meters, expanding the storage yard to 12 hectares, and replacing handling equipment with more advanced and automated machinery (based on observations and interviews with port officials). Moreover, this must be supported by road infrastructure improvements to and from the port by the Batam city government. With these enhancements, the service capacity of the Batu Ampar Port Cargo Terminal could be estimated to increase about threefold from the current capacity, potentially reaching 1 million TEUs per year or even 5 million TEUs (Strategic Planning Team BP Batam, 2020). At the very least, for short-term development, the facilities and infrastructure at Batu Ampar Port should be comparable to those at IPC Port in Jakarta.

D. Analysis of the Weaknesses and Strengths of the Proposed Process

Table 4. The Weaknesses and Strengths of the Proposed Process

No.	Process	Weeknesses of existing process (As Is)	Strengths of proposed process (To Be)
1.	Loading and unloading via the wharf and staging with direct transport equipment/special equipment	- The process is not detailed enough, particularly lacking clear time records for each stage in the process. - Some processes are still performed manually. - The process lacks detail regarding input and output documents. - It does not show interactions with related agencies outside of BUP.	- More detailed time records for each stage of the process and input/output documents. - Processes that were previously manual have been automated or digitized. - The process now shows interactions with other related agencies outside of BUP.

No.	Process	Weeknesses of existing process (As Is)	Strengths of proposed process (To Be)
2.	Delivery of goods from staging	- The process is not detailed enough, particularly lacking clear time records for each stage. - Some processes are still performed manually, without using a system. - The process lacks detail regarding input and output documents.	- More detailed time records for each stage of the process and input/output documents. - Manual processes have been automated or digitized.
3.	Issuance of wharfage service receipts and use of staging area	- The process is not detailed enough, particularly lacking clear time records for each stage and its input/output documents. - Some processes are still performed manually, without using a system. - There are still duplicate processes that should be unnecessary.	- More detailed time records for each stage of the process and input/output documents. - Manual processes have been automated or digitized. - Duplicate processes have been eliminated and simplified.
4.	Payment process for ship and goods services through the host-to-host system	- The process is not detailed enough, particularly lacking clear time records for each stage and its input/output documents. - Some processes are still performed manually. - There are still duplicate processes that should be unnecessary.	- More detailed time records for each stage of the process and input/output documents. - Manual processes have been automated or digitized. - Duplicate processes have been eliminated and simplified.

E. Simulation of the To-Be Model for Goods Loading and Unloading Process

This simulation uses an application that provides BPMN creation and simulation functions, namely Visual Paradigm 16.2. This application was chosen as one of the simulation tools for this study because it is user-friendly and is referenced in additional literature for this research, such as Cimino et al. (2017). The simulation aims to evaluate the changes in time performance between the process before improvements (As Is model) and after improvements (To Be model), by applying simulation scenarios. In this study, only one process will be selected for simulation. The chosen process is closely related to the performance of the Batu Ampar Port Cargo Terminal itself, specifically the goods loading and unloading process.

The As-Is model is simulated with specific scenarios created based on the time data for each stage of the process as explained in the existing process section of

this study. The To-Be model simulation involves the goods loading and unloading process that has undergone improvements through streamlining and benchmarking. This simulation also involves determining the number of resources related to loading and unloading available at the port and its supporting parties. The number of resources available for the To-Be model simulation is the same as in the As-Is model, and it uses the same simulation scenarios. The results of the As-Is and To-Be model simulations can be seen in the image below.

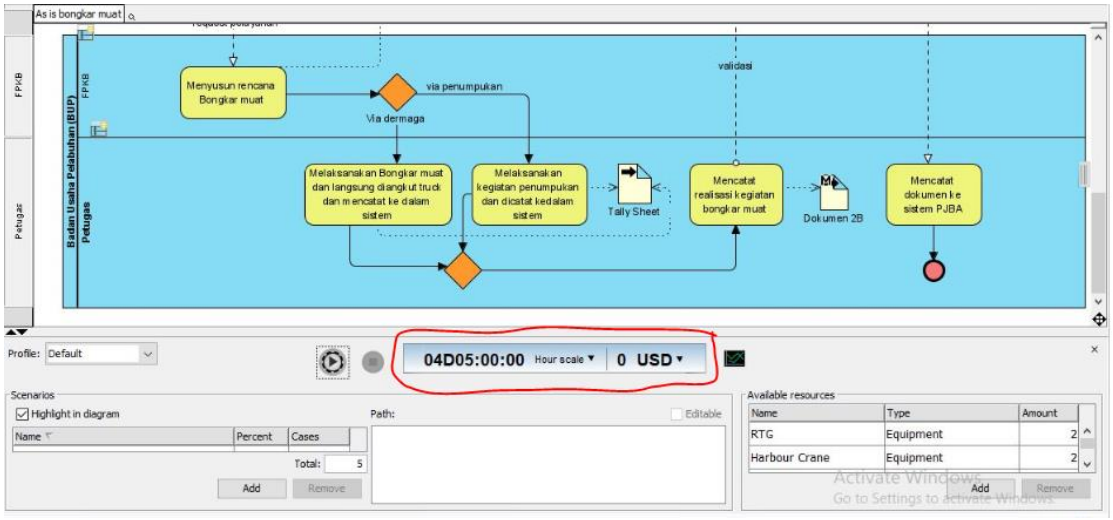

Figure 2. Results of the As-Is Model Simulation

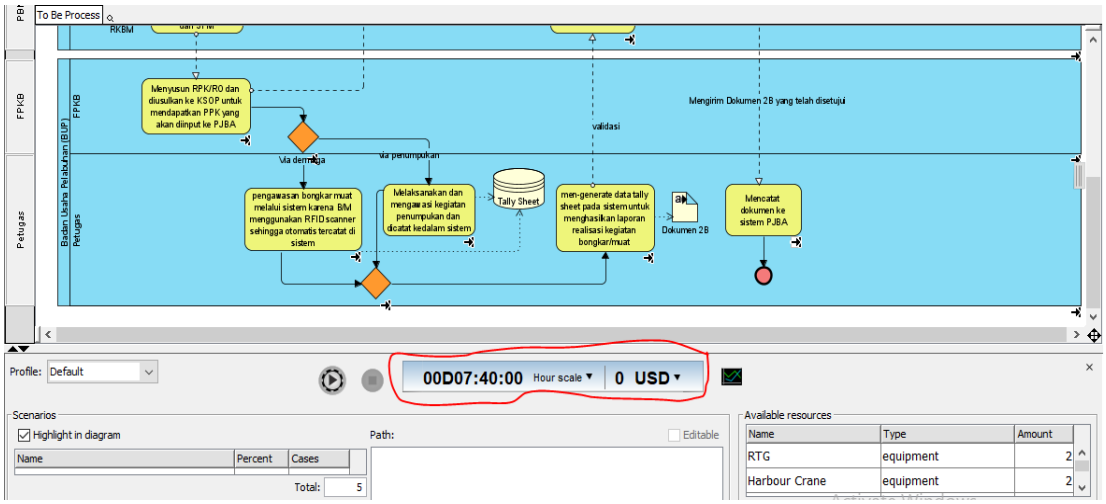

Figure 3. Results of the To-Be Model Simulation

CONCLUSION

Business process improvements were made to the processes related to the dwelling time at the Batu Ampar Batam Port Cargo Terminal, specifically pre-clearance (loading and unloading services, particularly for import containers). Customs clearance was excluded as it is handled by external parties, namely customs, and post-clearance (delivery of goods from staging, issuance of wharfage services, and payment through the host-to-host system). Improvements were carried out using

a combination of BPR (Business Process Reengineering) and BPI (Business Process Improvement) methods, including streamlining based on the implementation of Inaportnet and supported by benchmarking processes.

After improvements were made to the Batu Ampar Batam Port Cargo Terminal's business processes, the results were tested by simulating the business processes before and after the improvements. This was done to assess the impact of the changes on process performance, particularly in terms of time efficiency. Simulations were conducted to ensure that the performance results of the business process improvements were not significantly different from the simulated process improvements. The business process simulation used Visual Paradigm, which includes a BPMN simulation feature. After simulating one process, specifically the loading and unloading service process, it was found that the simulation results (before: 4 days, 5 hours; after: 7 hours, 40 minutes, assuming 5 ships are serviced simultaneously) did not differ significantly from the time performance results based on streamlining and benchmarking improvements (before: 1-2 days; after: 3-4 hours, assuming 1 ship is serviced at a time). Although the time performance differences between the simulation results and the improvements based on streamlining and benchmarking may initially appear significant, considering the different assumptions about the number of ships serviced simultaneously makes the difference in figures seem reasonable and closer.

This study does not address the export process or processes related to customs clearance. Future research could include these aspects that have not been discussed. Additionally, this study does not cover the feasibility testing of the proposed business processes. Future research should include a feasibility study to determine whether the proposed processes are viable for implementation.

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