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## The Effect of Land Crane Maintenance and Land Crane Operators on Scheduling and its Implications on Operational Safety of Loading and Unloading at PT Samudera Maritime Indonesia

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**Abstract:** Operational safety in cargo loading and unloading activities at Jetty Nusantara is greatly influenced by the effectiveness of scheduling land crane usage, which depends on two main factors: land crane maintenance and land crane operator skills. Several issues often encountered, such as reliance on designated cargo handling (PBM) parties, unexpected breakdowns of land cranes, and insufficient operator skills in crane operations, can affect operational safety. Poorly managed scheduling also worsens operational conditions, leading to fatigue, equipment damage, and an increased risk of workplace accidents. This study aims to analyze the impact of land crane maintenance and land crane operator skills on scheduling crane usage and its impact on operational safety in cargo loading and unloading at PT Samudera Maritime Indonesia. Using a quantitative approach and cross-sectional design, this study involved 70 respondents selected using the Slovin formula. The collected data were analyzed using SmartPLS software. The results of the study show that land crane maintenance and land crane operator skills have a positive and significant effect on scheduling crane usage and operational safety in cargo loading and unloading. The findings indicate that quality training and adequate training facilities can enhance employees' ability to manage risks and improve their performance. Effective scheduling also contributes to improved operational safety. The recommendations from this study are for PT Samudera Maritime Indonesia to continue improving land crane maintenance and the quality of training to support operational safety in the future.

**Keywords:** land crane maintenance, land crane operator, crane usage scheduling, operational safety in cargo loading and unloading.

### INTRODUCTION

Loading and unloading activities are one of the important activities in port operations that have a significant impact on the smooth distribution of goods (Fendy, 2023). This activity

includes the process of moving goods from ship to land (unloading) and vice versa, from land to ship (loading), which involves various types of heavy equipment, including land cranes, forklifts, and other transportation equipment. Efficiency in the loading and unloading process is very important to maintain the smooth flow of goods, because delays in this process can cause delays in the distribution of goods, which ultimately have an impact on the entire logistics system, both domestically and internationally. In addition, in the context of a port that has a high traffic volume, a fast and timely loading and unloading process is the main determinant of the port's competitiveness.

The problems faced by PT Samudera Maritime Indonesia in loading and unloading activities at Jetty Nusantara began with the process of appointing a certain company as a loading and unloading party (PBM). In this system, PT Samudera Maritime Indonesia relies on loading and unloading operations on one company appointed to manage the entire process of moving goods from ship to land and vice versa. Although the appointment of this PBM can provide convenience in initial coordination and administrative processes, this creates a significant dependency on one party. This dependency risks increasing the operational burden for PT Samudera Maritime Indonesia, because any problems that arise at the PBM, such as delays in delivery or unprepared equipment, can directly affect the entire loading and unloading flow at the port.

In addition to dependence on one loading and unloading party (PBM), another problem often faced by PT Samudera Maritime Indonesia in loading and unloading operations at Jetty Nusantara is the occurrence of breakdowns or sudden damage to the land cranes used to lift and move goods. Land cranes, as the main tool in the loading and unloading process, have a very crucial role. Any damage that occurs to a land crane, especially one that is unpredictable, can immediately hamper the smooth running of the entire operational process, cause significant delays in moving goods, and even delay the departure of ships. Given that the goods transported at this port often have very large weights and require special equipment such as cranes to move, damage to the crane can worsen the situation by hampering the scheduled loading or unloading time.

In addition, inadequate crane operator skills are also a factor that greatly affects operational safety. Crane operators who are not well trained or do not have sufficient understanding of crane operating procedures can make mistakes in setting loads or operating the equipment, which increases the possibility of accidents. Operators who are not familiar with a particular crane or who do not have sufficient experience are also at greater risk of human error, such as unsafe lifting of loads, unsafe crane operation, or even failure to recognize signs of damage to the crane being used. These errors, although sometimes seemingly minor, can lead to major incidents that damage goods, damage equipment, or even cause serious injury to workers.

Another factor that contributes to increased risk of accidents is poorly managed scheduling congestion. In ports with high loading and unloading volumes, tight and poorly coordinated scheduling can put undue stress on operators and equipment. When schedules are too tight or schedule changes are not well prepared, workers and crane operators are forced to work in a rushed manner and sometimes without enough time to check and ensure everything is functioning properly. This time pressure can lead to carelessness or hasty decision-making, which ultimately increases the potential for accidents. In addition, scheduling congestion also increases the likelihood of queues or delays, which can make the work area busier and potentially endanger worker safety.

The data below is a summary of work accidents that occurred while the PT Samudera Maritime Indonesia fleet was carrying out the loading/unloading process at the Nusantara Jetty.

**Tabel 1. Work Accidents**

No	Ship Name	Date	Accident Light	Accident Currently	Accident Heavy
1	Archipelago Lantern	12-15/09/2023	V		
2	Grace Archipelago	24-27/09/2024		V	
3	Archipelago of Light	10/28-30/2024	V		
4	Prosperous Ocean 06	11/20-23/2024	V		
5	Prosperous Ocean 06	04-06/12/2024		V	
6	Prosperous Ocean 06	04-06/12/2024	V		

Source: DPA Data from PT Samudera Maritime Indonesia

Based on the data listed in Tabel 1. regarding work accidents that occurred during the loading and unloading process of PT Samudera Maritime Indonesia's fleet at Jetty Nusantara, there were several incidents recorded. The accidents that occurred varied in severity, with most accidents recorded as minor and moderate accidents. For example, the Nusantara Lentera ship experienced a minor accident on September 12-15, 2023, while Grace Nusantara experienced a moderate accident between September 24-27, 2024. The Samudera Makmur 06 ship was recorded as having an accident with varying severity, including minor and moderate accidents on December 4-6, 2024. In addition, the Nusantara Cahaya ship was also recorded as having a minor accident in the period October 28-30, 2024. These data show that there were a number of work accidents that occurred during the loading and unloading process, indicating the importance of further efforts to improve work safety at the port.

Based on various problems that arise and the explanations that have been presented regarding the importance of land crane maintenance and crane operator skills in supporting the smoothness and safety of loading and unloading operations at PT Samudera Maritime Indonesia, the researcher is interested in compiling a thesis research entitled *The Effect of Land Crane Maintenance and Land Crane Operators on Scheduling and its Implications on Operational Safety of Loading and Unloading at PT Samudera Maritime Indonesia*.

## METHOD

This type of study refers to its type, namely quantitative research with surveys. Quantitative research is classified as a study that uses a measurable data analysis process with clear and detailed stages, and uses certain statistical calculations to draw conclusions objectively. (Sekaran & Bougie, 2020). Survey research is a non-interventional study: not treated specifically or subjects are not intervened in the research period/ data is simply obtained from surveys, namely observing respondents, data is obtained from questionnaires as data collection instruments. This research is also a case study, where data is taken from one case, namely the operational safety of loading and unloading from one agency only in a certain period, namely PT Samudera Maritime Indonesia. Case study research allows for homogeneity of respondents and provides the benefit of respondents having an assessment of the same object, namely PT Samudera Maritime Indonesia.

The population in this study includes all elements involved in loading and unloading operations using land cranes at Jetty Nusantara, Ship Party, Pbm Party, Shipper/Renter, Crane Operator, assumed in a loading/unloading activity the population involved is 85 people.

(Suliyanto, 2018) also emphasized that the sampling procedure is very crucial in research, because it determines who will be part of the sample. This process is used to select certain members of the relevant population and meet certain predetermined criteria. To ensure that this

process runs smoothly and the research results can be accounted for, researchers need to provide a clear and detailed explanation of the sampling technique used. In this study, researchers used the purposive sampling method, which means that participants were selected based on certain considerations that are relevant to the research objectives. With this technique, researchers can select individuals who have special experience or knowledge that will contribute more to answering research problems, as well as ensuring that the selected sample has high relevance to the topic being studied.

Calculation and sampling can be formulated using the problem from (Taro Yamane, 1973) with the following formula:

$$n = \frac{N}{N \cdot d^2 + 1}$$

Where:

- n = Number of samples
- N = Population size
- d = Set precision (desired accuracy limit)

With a population size of N: 85 populations, and a precision level set at 5%, using the formula from (Taro Yamane, 1973) we get:

The sample selection criteria use purposive sampling techniques, namely sampling techniques to obtain data sources with certain considerations regarding the relevance of the research being conducted (Sugiyono, D. (2013)), the sample size is:

$$n : \frac{85}{85(0.05)^2+1}$$

$$n : \frac{85}{85(0.0025)+1}$$

$$n : \frac{85}{1.2225}$$

$$n : 69.52$$

With the above approach, the total research sample can be rounded up to 70 respondents covering all the categories mentioned, allowing for a comprehensive and representative analysis of the existing population.

- 1. Ship's side : 15 crew members of the general cargo ship PT SMI
- 2. PBM Party : 15 people
- 3. Shipper/renter : 20 people
- 4. Crane operator : 20 people

In this study, a sample refers to a small portion of a population selected to represent the characteristics and numbers in that population, according to the explanation given by (Sugiyono, 2017:62). To determine the sample, the researcher used a simple random sampling technique, which allows for random selection of sample members without considering the strata or categories that may exist in the population. This approach is suitable for use when population members are considered uniform, so that random sample selection is considered sufficient to represent the entire population. This is in line with the explanation from (Sugiyono, 2017:64), which states that the simple random sampling technique can be used

when the population is considered homogeneous. This opinion is also reinforced by (Bambang & Ricky, 2022:35), which states that the use of this technique provides the possibility for each member of the population to have an equal chance of being selected as part of the sample.

### **Data Processing and Data Analysis Techniques**

The data obtained is then processed using SmartPLS 4. The software is used to facilitate data processing, so that the results are faster and more precise. Where editing and coding are carried out. Editing is the first stage in processing data obtained by researchers from the field by checking the possibility of errors in respondent answers and the uncertainty of respondent answers. Coding is giving or certain signs or codes to similar alternative answers or classifying them so that it can facilitate researchers regarding tabulation.

In this study, the data collected is presented in the form of a Tabel to make it easier to analyze and understand the data so that the data presented is more systematic. Where tabulation is done. Tabulation is the calculation of data that has been collected in each category until it is arranged in a Tabel that is easy to understand.

The data obtained, after being processed and sorted, will be used for statistical analysis of data in accordance with the research objectives. The data analysis used is path analysis and hypothesis testing.

## **RESULTS AND DISCUSSION**

### **Research Data**

#### **Respondent Description**

Sampling comes from ship ABK general cargo ship PT SMI. PBM party, Shipper party and crane operator. Sample selection was carried out first. Attached is a review of the characteristics of the respondents which are clarified into a tabulation of the identity of 70 respondents, where the questionnaire statements were given through the Google Form application which was distributed via WhatsApp web. Presentation of data regarding the respondent's personal data to describe the condition of the respondents. Several characteristics of the research respondents were obtained based on gender, age, last education, profession and length of service. Based on the distribution of respondent characteristic data totaling 70 respondents. Respondents with male gender are 63 people (90%), while females are 7 (10%). In other words, the most respondents are male. In terms of age, the largest number is obtained with the age of 21-30 years, amounting to 37 respondents (52.8%). In addition, a picture of the respondents' education is obtained, the dominant respondents are respondents with a Bachelor's degree major, amounting to 26 people (37.1%).

Based on the profession, most respondents are private employees totaling 24 people (34.3%). With the length of service, the respondents who dominate are respondents who have worked for 1-5 years totaling 33 people (47.1%).

#### **Research result**

In carrying out a series of statistical analyses, data will be divided into several parts consisting of analyses as described below:

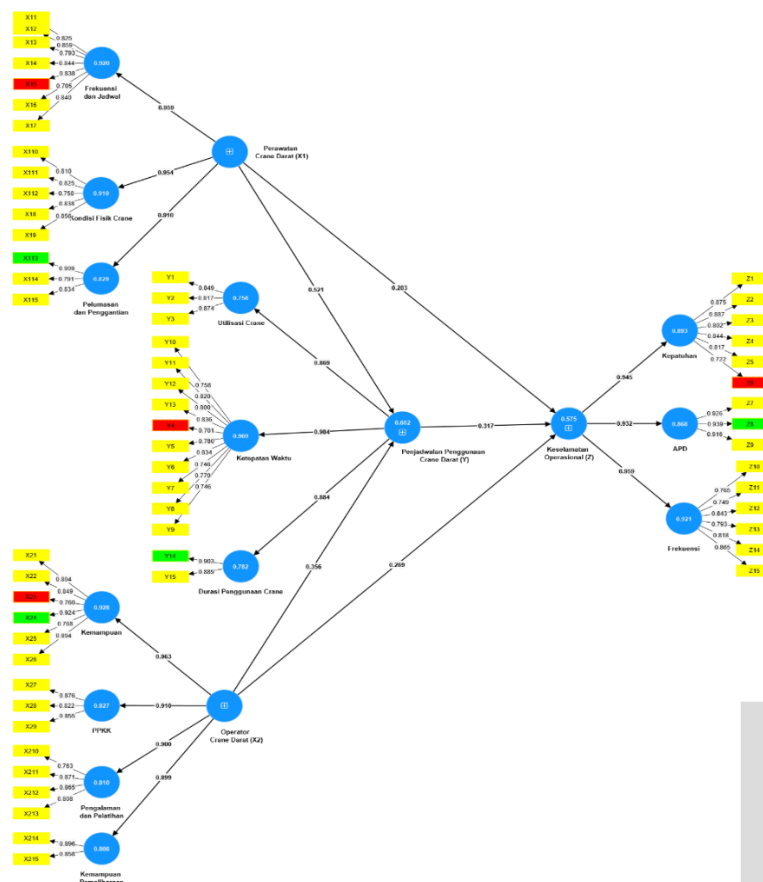
#### **Evaluation of Measurement (Outer) Model**

Measurement model (outer model) is a theoretical framework that builds relationships between latent variables and manifest variables. The assessment of the measurement results of the measurement model (outer model) is carried out using confirmatory factor analysis (CFA) to test the validity and reliability of the underlying constructs. The assessment of the measurement model includes three component tests: convergent validity, discriminant validity, and reliability.

Testing first-order and second-order constructs in SEM PLS (Partial Least Squares

Structural Equation Modeling) involves a systematic approach to ensure the validity and reliability of constructs at various levels. First-order constructs are basic-level constructs that are directly measured by related indicators, while second-order constructs are constructs formed by several first-order constructs. To test first-order constructs, the analysis usually begins by evaluating convergent validity, discriminant validity, and internal reliability, such as looking at the outer loadings of each indicator against its construct, where values above 0.7 are generally considered adequate, although for applied research 0.5 is sufficient (Ghozali, 2020). Internal reliability can be measured by Cronbach's Alpha or Composite Reliability, while convergent validity can be evaluated through Average Variance Extracted (AVE), with values above 0.5 usually considered adequate.

Next, in the second-order construct, the analysis approach continues by evaluating the relationship between the second-order construct and the first-order construct that forms it. This approach is called the Hierarchical Component Model (HCM) and has several methods, such as the repeated indicators approach and the two-stage approach (Pico-Saltos et al., 2023). In the repeated indicators approach, the indicators in the first-order construct are repeated in the second-order construct, allowing SEM PLS to calculate the overall construct validity. On the other hand, the two-stage approach is carried out by testing the first-order construct first, then using the score of this construct as an indicator of the second-order construct in the second stage. This two-stage approach is useful if the second-order construct has many indicators, because it reduces the complexity of the model. After that, the validity and reliability evaluation is carried out on the second-order construct, similar to the procedure for the first-order construct. With this systematic approach, researchers can ensure that each level of the construct, both first-order and second-order, has adequate validity and reliability for SEM PLS analysis.



Source: SEMPLS Processing (2025)  
**Figure 1. Outer Model Measurement Model**

From the image above, the variables that have validity because in general for research from the initial measurement stage of 0.7 are still categorized as having exceeded it so that it is said to be valid for further analysis.

**Validity Testing (*Convergent Validity*)**

*Convergent validity* conducted to test the level of accurate items to measure the research object. In this study using the loading factor test. According to Hair et al in Indrawati (2015), an item can be said to have convergent validity if the loading factor score is more than 0.6. The following are the results of the loading factor scores.

**Tabel 2. Convergent Validity Test**

Variables	Dimensions	Outer Loding Dimension	Item	Outer Loading Indicator	Information
Land Crane Maintenance (X1)	Frequency and Schedule of Inspections	0.959	X11	0.825	valid
			X12	0.859	valid
			X13	0.793	valid
			X14	0.844	valid
			X15	0.838	valid
			X16	0.705	valid
	Crane Physical Condition	0.954	X17	0.840	valid
			X18	0.838	valid
			X19	0.856	valid
			X110	0.810	valid
			X111	0.825	valid
	Lubrication and Component Replacement	0.910	X112	0.758	valid
			X70	0.909	valid
			X114	0.791	valid
	Land Crane Operator (X2)	Ability to Operate Crane	0.963	X115	0.834
X21				0.804	valid
X22				0.849	valid
X23				0.760	valid
X24				0.924	valid
X25				0.768	valid
Understanding of Work Safety Procedures		0.910	X26	0.894	valid
			X27	0.876	valid
			X28	0.822	valid
Experience and Training		0.900	X29	0.855	valid
			X210	0.763	valid
			X211	0.871	valid
			X212	0.865	valid
Ability in Basic Crane Maintenance		0.899	X213	0.808	valid
			X214	0.896	valid
	X215		0.858	valid	
Land Crane Usage Scheduling (Y)	Crane Utilization	0.869	Y1	0.849	valid
			Y2	0.817	valid
			Y3	0.874	valid

Variables	Dimensions	Outer Loading Dimension	Item	Outer Loading Indicator	Information
	Timeliness of Crane Use	0.984	Y4	0.701	valid
			Y5	0.780	valid
			Y6	0.834	valid
			Y7	0.746	valid
			Y8	0.770	valid
			Y9	0.746	valid
			Y10	0.758	valid
			Y11	0.820	valid
			Y12	0.800	valid
	Y13	0.836	valid		
	Crane Usage Duration	0.884	Y14	0.903	valid
			Y15	0.889	valid
	Operational Safety (Z)	Compliance with Safety Procedures	0.945	Z1	0.875
Z2				0.887	valid
Z3				0.802	valid
Z4				0.844	valid
Z5				0.817	valid
Z6				0.722	valid
Use of Personal Protective Equipment (PPE)		0.932	Z7	0.926	valid
			Z8	0.939	valid
			Z9	0.916	valid
Crane Inspection and Maintenance Frequency		0.959	Z10	0.765	valid
			Z11	0.749	valid
			Z12	0.843	valid
			Z13	0.793	valid
			Z14	0.818	valid
			Z15	0.865	valid

Source: SEMPLS Processing (2025)

Based on the results of the second-order dimension loading factor analysis, each variable shows the dimensions with the highest and lowest contributions to the main variable. In the Land Crane Maintenance variable (X1), the dimension with the highest loading factor is the Frequency and Schedule of Inspection (0.959), which shows that the schedule and frequency of routine crane inspections have a very large influence on the quality of land crane maintenance. This reflects the importance of scheduled and ongoing inspections to ensure that the crane remains in optimal condition. In contrast, the dimension with the lowest value is Lubrication and Component Replacement (0.910), which shows that although lubrication and component replacement are very important, their contribution to land crane maintenance is slightly lower compared to the frequency and schedule of inspections.

For the Land Crane Operator variable (X2), the dimension with the highest value is Crane Operating Ability (0.963), which indicates that crane operating skills have the greatest influence on crane operator effectiveness. Conversely, the dimension with the lowest value is Basic Crane Maintenance Ability (0.899), which indicates that although basic crane maintenance ability is also important, its influence on the overall quality of land crane operators

is slightly lower than crane operating ability.

In the variable of Land Crane Utilization Scheduling (Y), the dimension with the highest loading factor is Crane Utilization Punctuality (0.984), which shows that the punctuality in crane usage has a very large influence on the effectiveness of land crane usage scheduling. This confirms the importance of crane usage on schedule to improve operational efficiency. In contrast, the dimension with the lowest value is Crane Utilization (0.869), which shows that although crane utilization is important, its contribution to crane usage scheduling is slightly lower compared to the punctuality of crane usage.

For the Operational Safety variable (Z), the dimension with the highest loading factor is the Frequency of Crane Inspection and Maintenance (0.959), which indicates that routine crane inspection and maintenance greatly influences operational safety. Timely and regular maintenance can reduce the potential for damage and accidents. Meanwhile, the dimension with the lowest value is the Use of Personal Protective Equipment (PPE) (0.932), which although very important in supporting safety, has a slightly lower contribution compared to the frequency of crane inspection and maintenance in maintaining overall operational safety.

Based on the results of the first order indicator analysis, it shows that in the Operational Safety of Loading and Unloading (Z) variable, the indicator with the highest loading value is Z8 (0.939), which states "Safety signs and warning signs must always be available and easy to see in the work area." This shows that the existence and visibility of safety signs are very important to maintain safety in the work area. Conversely, the indicator with the lowest loading value is Z10 (0.765), which is "Safety evaluations are carried out periodically". Although safety evaluations are important, these data show that safety evaluations need to be carried out more frequently to improve overall work safety.

In the Land Crane Maintenance variable (X1), the indicator with the highest loading value is X70 (0.909), which states "Routine checks are carried out to ensure the crane is in good condition." This reflects that routine checks carried out on a scheduled basis play a major role in maintaining optimal crane performance. On the other hand, the indicator with the lowest loading value is X16 (0.705), which is "Lubrication and component replacement are carried out periodically". Although lubrication and component replacement are important, these data indicate that this aspect still needs further attention to improve the effectiveness of crane maintenance.

In the Land Crane Operator variable (X2), the indicator with the highest loading value is X24 (0.924), which states "Land crane operators must be able to operate land cranes accurately and efficiently during the loading and unloading process." This shows that the operator's skills in operating cranes efficiently and accurately greatly affect operational safety and success. Conversely, the indicator with the lowest loading value is X23 (0.760), which is "Crane operators always follow SOPs in operating land cranes during loading and unloading activities." Although following SOPs is important, these data show that compliance with SOPs needs to be improved among operators to minimize the risk of accidents.

In the variable of Land Crane Usage Scheduling (Y), the indicator with the highest loading value is Y14 (0.903), which states "Land crane usage scheduling always minimizes downtime and unexpected damage during loading and unloading." This shows that effective scheduling greatly affects efficiency and minimization of damage during loading and unloading activities. In contrast, the indicator with the lowest loading value is Y6 (0.746), which is "Land crane usage scheduling is arranged by considering routine maintenance time according to PMS." Although important, this data shows that scheduling that takes routine maintenance into account needs more attention to be better coordinated with other operational needs.

Tabel 2. presented presents data on the loading factor values related to each manifest variable. All indicators entered into the latent variable show a loading factor value of more than 0.6, thus confirming the validity of all indicators.

### Discriminant Validity Testing

*Discrimination validity period* in a test, each item in a variable has no correlation with other variables. The method used to conduct the discriminant validity test in this study is by measuring the cross loading value.

**Tabel 3. Fornell-Larcker Criterion between Variables**

	Operational Safety (Z)	Land Crane Operator (X2)	Scheduling of Land Crane Usage (Y)	Land Crane Maintenance (X1)
Operational Safety (Z)	<b>0.794</b>			
Land Crane Operator (X2)	0.628	<b>0.780</b>		
Scheduling of Land Crane Usage (Y)	0.692	0.642	<b>0.765</b>	
Land Crane Maintenance (X1)	0.658	0.550	0.717	<b>0.779</b>

Source: SEMPLS Processing (2025)

The results of the Fornell-Larcker Criterion between all latent variables with indicator variables that have been shown in the Tabel above that the value of an indicator is greater in calculating variables from other constructs. Based on these results, it can be stated that each indicator used has good discriminant validity to form its respective variables.

The next criterion in the discriminant validity test is to use the Heterotrait-Monotrait Ratio (HTMT) value using the maximum HTMT value limit of 0.90. The results of the Heterotrait-Monotrait discriminant validity test can be reviewed in the following Tabel.

**Tabel 4.Heterotrait-Monotrait Ratio (HTMT)**

	Operational Safety (Z)	Land Crane Operator (X2)	Scheduling of Land Crane Usage (Y)	Land Crane Maintenance (X1)
Operational Safety (Z)				
Land Crane Operator (X2)	0.659			
Scheduling of Land Crane Usage (Y)	0.721	0.677		
Land Crane Maintenance (X1)	0.687	0.578	0.750	

Source: SEMPLS Processing (2025)

According to the description above, it is stated that the variables used in this study already have good discriminant validity in the preparation of each variable. The recommended measurement value in HTMT analysis in PLS has been set below 0.85, although there are values above 0.85 to a maximum of 0.90, which is still considered sufficient. In the HTMT criteria Tabel, it is <0.9, so it has met the discriminant validity test criteria.

After conducting validity testing using the outer loading value, the next step is conducting discriminant validity testing using the average variance extracted (AVE) value. The following are the results of the discriminant test.

**Tabel 5. Average Variance Extracted (AVE)**

Variables	Average variance extracted (AVE)	Information
Land Crane Maintenance (X1)	0.607	Valid
Land Crane Operator (X2)	0.608	Valid
Scheduling of Land Crane Usage (Y)	0.585	Valid
Operational Safety (Z)	0.631	Valid

Source: SEMPLS Processing (2025)

This test is conducted to see how big the difference is between variables. The value seen in this test is the value of the average variance extracted (AVE) overall all variables have an AVE value  $> 0.5$  so that it is declared valid.

### Reliability Testing

PeThis test uses the analysis of Cronbach's alpha (CA) and Composite reliability (CR) values. The rule of thumb for good CA and CR values is  $\geq 0.6$  and  $0.7$ , so this study uses these values as indicators. The following are the results of reliability processing on 70 respondents:

**Tabel 6. Reliability Testing**

Variables	Cronbach's alpha	Composite reliability	Information
Land Crane Maintenance (X1)	0.953	0.954	Reliable
Land Crane Operator (X2)	0.953	0.955	Reliable
Scheduling of Land Crane Usage (Y)	0.949	0.950	Reliable
Operational Safety (Z)	0.958	0.960	Reliable

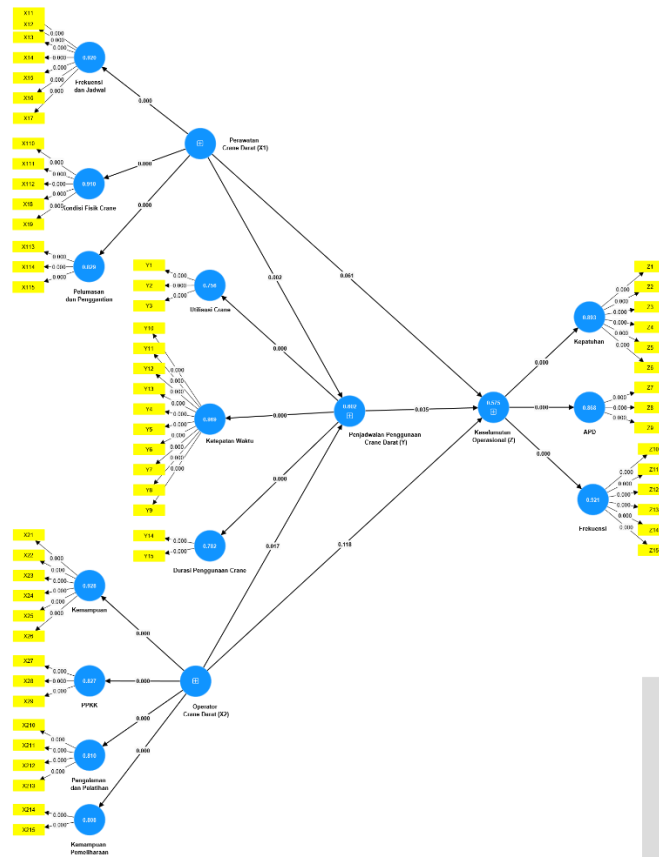
Source: SEMPLS Processing (2025)

Based on the Tabel above, it can be concluded that the constructs for all variables meet the reliable criteria. This is indicated by the Cronbach's Alpha and composite reliability values obtained from the SmartPLS estimation results. The resulting value is  $> 0.70$  as recommended criteria.

Based on the four parameters of the test results on the validity and reliability of the outer model that have been described above, namely discriminant validity (with Cross Loadings, Fornell-Lacker, HTMT values) and indicator reliability (with outer loading values), construct reliability (with Cronbach's alpha and composite reliability values), construct validity (with average variance extracted or AVE values) can draw general conclusions. This means that in the measurement model of this study, all indicators are reliable and useful for the targeted measurement of each component. With these results, it is feasible to continue this research stage to the next analysis stage, namely testing the inner model (structural model).

### Structural Model Evaluation (Inner Model)

The purpose of this quantitative analysis is to test the influence of a particular latent variable on other latent variables in the structural model. The examination is carried out by assessing the path value to determine the significance of the influence, which can be determined by calculating the t value of the path value (which can be obtained by Bootstrapping). Below is an illustration that describes the results of the Bootstrapping used:



Source: SEMPLS Processing (2025)

Figure 2. Bootstrapping

The Inner Model according to Ghozali and Latan (2015) is a structural model (inner model) that describes the causal relationship between variables based on theory. The inner model will conduct an analysis where the causal relationship between variables will be examined. In this section, several things that will be tested are VIF or multicollinearity, coefficient of determination or R-Square (R2), effect size (f2), predictive value (Q2), T-Statistics, indirect effect.

**Multicollinearity test**

The results of the multicollinearity test are shown in the Tabel below:

Tabel 7. Multicollinearity Test Results (VIF)7

	Operational Safety (Z)	Land Crane Operator (X2)	Scheduling of Land Crane Usage (Y)	Land Crane Maintenance (X1)
Operational Safety (Z)				
Land Crane Operator (X2)	1,751		1,433	
Scheduling of Land Crane Usage (Y)	2,510			
Land Crane Maintenance (X1)	2.115		1,433	

Source: SEMPLS processed data (2025)

From the Tabel above, the results of the Variance Inflation Factor (VIF) test in this research model where the VIF values of all variables are found to be less than 5. Therefore, it can be interpreted that all variables in the research model have an ideal inner VIF value. Based on this, it can be said that there is no multicollinearity problem between the variables in the

research model. These results indicate that the quality of the research model has been accepted in terms of there being no multicollinearity issues.

**Effect size-f-square (f<sup>2</sup>)**

Effect size value f<sup>2</sup> shows how much the independent variable influences the dependent variable. According to Cohen's explanation (1998), there are three classifications of f<sup>2</sup> values, namely:

1. 0.02 : weak
2. 0.15 : currently
3. 0.35 : strong

**Tabel 8. Results f-square**

Influence	Effect Size Value	Information
Land Crane Maintenance (X1) -> Land Crane Usage Scheduling (Y)	0.475	Strong Influence
Land Crane Operator (X2) -> Land Crane Usage Scheduling (Y)	0.222	Strong Influence
Land Crane Maintenance (X1) -> Operational Safety (Z)	0.089	Weak Influence
Land Crane Operator (X2) -> Operational Safety (Z)	0.097	Weak Influence
Land Crane Usage Scheduling (Y) -> Operational Safety (Z)	0.094	Weak Influence

Source: SEMPLS processed data (2025)

Based on the results shown in Tabel 4.14, the influence of the Land Crane Maintenance variable (X1) on the Scheduling of Land Crane Use (Y) shows a fairly large effect size value, namely 0.475, which is included in the category of strong influence. This indicates that land crane maintenance has a significant impact on the efficiency and effectiveness of land crane usage scheduling. With good maintenance, the machine will operate more optimally, so that usage scheduling can be arranged more precisely and effectively, avoiding unnecessary downtime, and increasing overall productivity. Meanwhile, although there is a strong influence of the Land Crane Operator variable (X2) on the Scheduling of Land Crane Use (Y) with an effect size value of 0.222, this influence is still smaller than the influence of maintenance. This indicates that the skills and operation of the crane by the operator are indeed important, but the crane maintenance factor is more decisive in influencing the overall performance of crane use. Meanwhile, other variables such as Land Crane Maintenance on Operational Safety (Z), as well as the influence of Land Crane Usage Scheduling on Operational Safety, show a weaker influence, with very low effect size values, indicating that these factors do not have a significant impact on operational safety in this context.

**Predictive Relevance (Q-Squared)**

The model makes a significant contribution in explaining the variation in the dependent variable, and has strong predictive ability.

**Tabel 9. Q Squared Results**

Variables	Q <sup>2</sup> Square	Information
Scheduling of Land Crane Usage (Y)	0.337	Medium Predictive Relevance
Operational Safety (Z)	0.339	Medium Predictive Relevance

Source: SEMPLS processed data (2025)

According to the Tabel above, the Land Crane Usage Scheduling variable has a Q<sup>2</sup> value of 0.337, this Q-squared value is between 0.25-0.50, so it is said that its predictive ability is medium (medium predictive relevance). Likewise, the Operational Safety variable has a Q<sup>2</sup>

value of 0.339, the Q-squared value is between 0.25-0.50, so it can be considered that its predictive ability is medium (medium predictive relevance).

**R-Square (Coefficient of Determination)**

According to Hair et al. (2019) the R2 or R-Square test is a way to find out how much percentage of endogenous constructs can be explained by their exogenous constructs. The coefficient of determination (R2) value is expected to be between 0 and 1. R2 values of 0.75, 0.50, and 0.25 indicate that the model is strong, moderate, and weak.

**Tabel 10.R-Square (R2) Test Results**

Variables	R-square
Scheduling of Land Crane Usage (Y)	0.602
Operational Safety (Z)	0.575

Source: SEMPLS processed data (2025)

The Tabel above can be seen that the variable Scheduling of Land Crane Use has a large R2 value, the R2 value is 0.602 indicating that the contribution of the variables Land Crane Maintenance and Land Crane Operator is 60.2% while the remaining 39.8% is the influence of other variables not used in this study. The Operational Safety variable has a large R2 value, the R2 value is 0.575 indicating that the contribution of the variables Land Crane Maintenance, Land Crane Operator and Scheduling of Land Crane Use to Operational Safety is 57.5% while the remaining 42.5% is the influence of other variables not used in this study.

**Research Hypothesis**

The following are the results *Path Coefficients* direct influence:

**Tabel 11. Direct Influence and Indirect Influence**

Hypothesis	Influence	Original sample (O)	T statistics ( O/STDEV )	P values	Caption
H1	Land Crane Maintenance (X1) -> Land Crane Usage Scheduling (Y)	0.521	2,846	0.002	Significant
H2	Land Crane Operator (X2) -> Land Crane Usage Scheduling (Y)	0.356	2.119	0.017	Significant
H3	Land Crane Maintenance (X1) -> Operational Safety (Z)	0.283	1,653	0.050	Significant
H4	Land Crane Operator (X2) -> Operational Safety (Z)	0.269	1,683	0.028	Significant
H5	Land Crane Usage Scheduling (Y) -> Operational Safety (Z)	0.317	1,813	0.035	Significant
H6	Land Crane Maintenance (X1) -> Land Crane Usage Scheduling (Y) -> Operational Safety (Z)	0.461	2,740	0.003	Significant
H7	Land Crane Operator (X2) -> Land Crane Usage Scheduling (Y) -> Operational Safety (Z)	0.350	2.111	0.017	Significant

Source: SEMPLS Processing (2025)

Based on the Tabel above, it can be concluded that the seven hypotheses tested show significant direct and indirect effects. This can be seen from the T-Statistics value which is greater than 1.64 and the p-value which is less than 0.05, which indicates that the hypotheses are accepted. Thus, all relationships tested in this study have a significant impact both directly and indirectly.

## CONCLUSION

There is a direct positive and significant influence of Land Crane Maintenance on Land Crane Usage Scheduling. This means that the better the maintenance performed on the land crane, the more effective the scheduling of the use of the land crane. Proper maintenance ensures the crane is in optimal condition, which supports the use of the crane on schedule and reduces operational disruptions.

There is a direct positive and significant influence of Land Crane Operators on Land Crane Usage Scheduling. This means that the skills and abilities of the land crane operator have a direct impact on the scheduling of the use of the land crane. A skilled operator can operate the crane efficiently and minimize downtime, which allows for better and more organized crane scheduling.

There is a direct positive and significant influence of Land Crane Maintenance on Operational Safety. These results indicate that good maintenance of land cranes has a positive impact on operational safety. Well-maintained cranes are less likely to experience damage or mechanical failure that could compromise worker safety, thereby improving overall operational safety.

There is a direct positive and significant influence of Land Crane Operators on Operational Safety. This means that the skills of land crane operators have a positive impact on operational safety. Well-trained operators can operate cranes safely, follow safety procedures, and reduce the risk of accidents that occur during loading and unloading activities.

There is a direct positive and significant influence of Land Crane Usage Scheduling on Operational Safety. This indicates that effective scheduling of land crane usage also contributes to operational safety. Proper scheduling ensures that cranes are used in safe conditions, by avoiding overuse and ensuring sufficient maintenance time, which has the potential to reduce accidents.

Land Crane Maintenance has a significant impact on Operational Safety through Scheduling of Land Crane Use. This means that ground crane maintenance plays a significant role in improving operational safety, not only directly, but also through its influence on the scheduling of ground crane use. With good maintenance, crane scheduling becomes more efficient, which in turn supports better operational safety.

Land Crane Operators have a significant influence on Operational Safety through Scheduling the Use of Land Cranes. This shows that the skills of land crane operators not only directly affect operational safety, but also through their influence on the scheduling of land crane use. Skilled operators can manage crane scheduling more effectively, which has an impact on reducing the risk of accidents and increasing safety in the field.

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