

MULTIMODAL TRANSPORTATION MODEL FOR HEAVY LIFT CARGO: A CASE STUDY OF EXPORT RAILWAY CARRIAGES

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ABSTRACT

Railway carriage as one type of heavy lift cargo, has different handling method compared with others. The dimension of the carriage is the most important factor that affects the handling process substantially. Mostly the capacity of the vessel selected is not fully occupied. In addition, shipment time should be planned effectively, so it can meet the predetermined schedule. Therefore this study aims to design exporting scheme for railway carriage which can be minimizes the cost of transport and the delivery times, by comparing availability of multimodal transportation. The most appropriates land transportation mode is multi-axle trailer that provides unit cost of 27.7 Million-Rupiah/carriage, while the selected sea transportation mode is a 27,926 DWT general cargo vessel with unit cost of 194.4 Million-Rupiah/carriage. The Total unit cost is 222.2 Million-Rupiah/carriage and the total time of delivery is 142 days.

Keywords: Multimodal, Export, Heavy Lift Cargo, Railway Carriage.

INTRODUCTION

Indonesia's export commodities mostly come from agriculture and oil & gas, but are now increasingly turning to manufacturing products such as heavy lift cargo which is have a high value. One of the heavy lift cargo product is the railway carriage. Production of railway carriage in Indonesia in the next few years was predicted to increase. The only one company which produce railway carriages and its' related products is PT Industri Kereta Api (Persero) or hereafter referred to PT INKA. In addition to fulfilling domestic needs, PT INKA also produces railway carriages for export to several countries, such as Malaysia, Philippines, Thailand, Singapore, Australia and Bangladesh.

Bangladesh trying to improve their intercity transport infrastructure by increasing the fleet of railways, in this cases Bangladesh become one of the export destinations for PT INKA, which has 150 railways carriages have been delivered in year of 2016. Furthermore, in the year of 2017 PT INKA has won contracts to produce and sent 250 railway carriages to this countries [2].

Delivery of carriages has been using multimodal transportation with door to door terms of shipment, starting from PT INKA production warehouse to final destination at Bangladesh. Shipment process using freight forwarder services usually meet several problems, include delivery schedule which has didn't match by previous additional cost estimation for carriages shipment, and include the availability level of conveyance who causes several goods are stay in warehouse and stacking fields.

Nowadays issues who related to conveyance was the capacity of vessels and the number of multi-axle trailers who not appropriates for shipment. This condition causes less of optimal logistics cost and less streamlined shipment time needs.

Therefore this study aims to design exporting scheme for railway carriage which can be minimizes the cost of transport and the delivery times, by comparing availability of multimodal transportation. Some delivery scenarios need to be developed with note capacity of each mode resulting the minimum logistics costs and the right time.

EXPERIMENTAL SET UP

Research Methodology

Data collection method in this research are divided into direct data collection method (primary) and indirect (secondary). This data collection has done by taking data from several related companies to know the specifications of research objects and assist in terms of basic assumptions in a calculation.

Data on the condition of railway carriage delivery is currently used to analyze the comparison of available multi-modal transportation and in accordance with the demand of railway carriage requests. Land transport vehicle comparison in this research is between multi-axle trailers and trains, while for sea transport vehicle comparison is using general cargo ships, heavy lift ships, Ro-Ro ships, and barges. Each type of vessel will be varied based on a range of 5,000 - 10,000 DWT; 10,001 - 20,000 DWT; and 20,001 - 35,000 DWT. There are 3 (three) cost components to be analyzed: land transport cost, cargo handling cost, and sea transport cost. From the analysis, the chosen multi-modes is the most produces lowest unit cost (Rupiah/carriage) and the total time corresponding to the delivery deadline. Furthermore, sensitivity analysis will be conducted on the effect of demand changes with unit cost as well as the delivery time. And also the changing demand for alternative land base transport modes.

Overview of the Current Conditions

A total of 150 railway carriages of BG Coaches and MG Coaches types, were delivered in 2016 through North Jamrud Wharf, Port of Tanjung Perak. In this conditions, multi-axle trailer used for land transport modes, while general cargo ship used for sea transport modes with different deadweight tonnage (DWT) on each shipment.

The trailer departs from the production warehouse at PT INKA Madiun to Tanjung Perak Port with 180 Km distance. After the carriages were loaded at Tanjung Perak Port, the vessel sailed to the unloading port of Chittagong Port. The shipping distance is 2,744 Nm. The delivery deadline in accordance with the contract is 30 months, that's means before May 2017, all railway carriages should be delivered and arrived in Bangladesh. This shipment has been made within the prescribed deadline starting from March 23rd, 2016 to September 21st, 2016. This shipment divided into 7 times, where each delivery has a different amount of cargo (see Table 1).

Table 1 Shipment of 150 Railway Carriages to Bangladesh

Date of Delivery	Shipment	Unit	Weight (Ton)	Volume (MT)
23/03/2016	1	15	654	2.667
27/04/2016	2	22	959	3.916
14/06/2016	3	22	959	3.912
08/08/2016	4	21	915	3.737
27/08/2016	5	20	872	3.551
15/09/2016	6	25	1.090	4.443
21/09/2016	7	25	1.090	4.443
TOTAL			6.540	26.670

Delivery of railway carriages requires good coordination between ship owner, freight forwarders, loading and unloading companies, consignee, and port authorities. From the price offered and approved by the parties concerned, finally obtained the total logistics costs for 150 train carriages is 58.7 Billion-Rupiah/carriage. The unit cost for each land transport and sea transport modes are 50 Million-Rupiah/carriage and 181.3 Million-Rupiah/carriage, respectively. The general cargo ship used in 7 shipment between 10,000 - 17,000 DWT (see Table 2).

Table 2 Sea Transport Modes for 150 Railway Carriages in 2016

Name of Ships	Year	Class	Flag	DWT
MV Seiyo Spring	2003	NKK	Panama	9.999
MV Corebright OL	2012	NKK	Panama	14.226
MV Brilliant Pescadores	2005	NKK	Panama	12.004
MV Miike	2011	NKK	Panama	14.041
MV Matsumae	2007	NKK	Panama	13.801
MV Thorco Lily	2013	NKK	Hongkong	16.956
MV Honor Pescadores	2003	BV	Panama	11.982

Deliveries in 2016 show that the capacity of ships and the number of multi-axle trailers used are not yet appropriate. This resulted in the logistics costs issued is not optimal and less efficient time needed. Facing the increasing demand every year, it's required a research related to effective time planning and minimum cost, by connecting the production capacity of railway carriages as well as taking into other related factors.

It can be used to do a comparative analysis of several alternative modes of transportation. Selected land transport modes are multi-axle trailers and trains, while sea transport are general cargo ships, heavy lift ships, Ro-Ro ships, and barges, which the type of vessel has variations of 5,000 - 10,000 DWT, 10,001 - 20,000 DWT, and 20,001 - 35,000 DWT.

RESULTS AND DISCUSSION

Production Capacity

The beginning of shipment plan is to connect the capacity and production process into calculation model. Making each carriage through 3 (three) processes is fabrication with time 105.5 days, finishing 77.5 days, and testing 2.5 days [7]. In conclusion one carriage must pass through the process for 6 months. Based on survey results, every month there are 20 railway carriages out of the production warehouse. The assumption used for this calculation model is 60% of the total production to be exported to Bangladesh, it was 15 railway carriages. The production process will begins one month after the contract was agreed on July 2017 (see Figure 1).

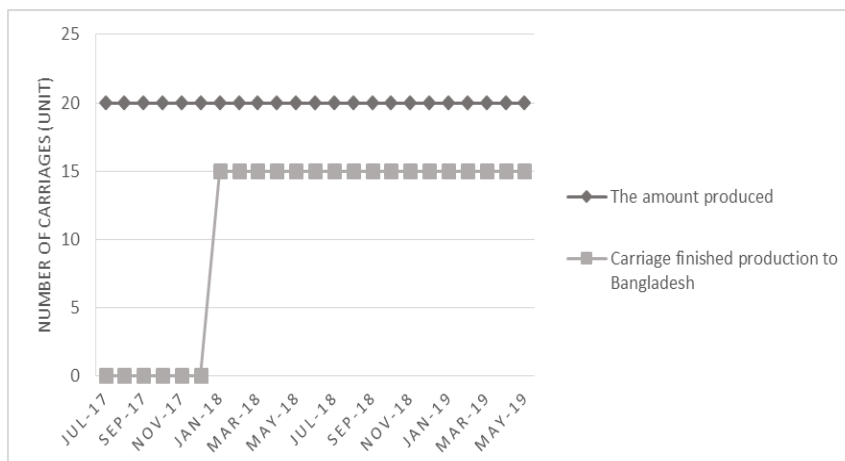


Figure 1 Production Capacity

Time Calculation

Land transport scheme in this model using 5 units of multi-axle trailers in one shipment time, by this scheme, 5 units of carriages could be delivered in same period of time. Time spent on this calculation is the loading and unloading process time, time off, shipment process from warehouse to port, and the otherwise, and shipment process from port to warehouse. The total shipment time that used by multi-axle trailer is 17.45 hours/RT (rounded to 1 day) (see Table 3).

Table 3 Time Calculation of Multi-Axle Trailer

Distance from Port to Warehouse	180 Km
Distance from Warehouse to Port	180 Km
Speed of Depart	25 km/hr
Speed of Return	30 km/hr
Load Speed in Warehouse	0,3 hr/carriage
	1,5 hr/carriage
Unloading Speed in the Stacking Field	0,15 hr/carriage
	0,75 hr/carriage
Time off, etc.	2 hr
Warehouse to the Port	7,2 hr
Port to Warehouse	6 hr
Total Time	17,45 hr/RT
Total Time (rounded up)	1 day

Second alternatives for land transport is using trains which only needs one locomotive to transport 20 carriages. Time calculation for this scheme include the duration of loading and unloading time from trains, travel time amongst stations, shipment time from stations to sea port, and loading and unloading time from trailers. As a result, total time for each carriages spent around 6.2 hours and total roundtrip times takes 5.3 days (see Table 4).

Table 4 Time Calculations of Trains

Number of Locomotives	1	unit
Number of Carriages	20	unit/locomotive
Duration of Load Time	0,5	hr/carriages
Old Station to Station (depart and return)	4	hr/locomotive
Unloading Time	0,5	hr/carriage
Delivery to Port	0,25	hr/carriage
Duration Load Time to Trailer	0,5	hr/carriage
Unloading Time from Trailer	0,5	hr/carriage
Total Time	6,25	hr/carriage
Cargo Transported	20	Carriage
Frequency By Cargo	12,5	RT
Total Time 1 RT	129	hr
Total Time 1 RT	5,375	day

In a sea transport mode, differentiation of vessel size will be affect the cargo space. This cargo space as representative from total number of carriages which can be shipped and automatically will be influenced the total frequency of shipment.

Besides the capacity of cargo spaces, speeds of ship should be takes as one of major consideration on total time calculation on sea transport mode. Every single type of vessels has different number of services speed, for instances general cargo ships has 11 and 13 knots; Ro-Ro ships has 4 and 16 knots; heavy lift ships has 11 and 14 knots; and barge 5 and 7 knots. After being able to identify the capacity of the cargo space and calculate the speed, the shipment time can be calculated as shown in Table 5. The fastest delivery time is generated by Ro-Ro ship category 3 (RR3) while the longest time has taken by category 1 (BA1).

Table 5 Time Calculation of Each Ship

Ship Codes	DWT	Frek. By Cargo	Cargo Real Transported (/RT)	Total Time (Day)	Estimated Time
GC1	7.966	25	10	495	10/10/2020
GC2	16.969	14	18	285	13/08/2019
GC3	27.926	6	46	133	14/03/2019
HL1	10.000	9	28	189	09/05/2019
HL2	14.112	9	30	190	10/05/2019
HL3	30.000	7	40	152	02/04/2019
RR1	7.440	7	37	119	28/02/2019
RR2	11.407	5	60	168	18/04/2019
RR3	25.000	3	121	112	21/02/2019
BA1	7.969	32	8	1.256	12/12/2024
BA2	12.995	14	18	558	11/02/2021
BA3	30.669	8	35	328	25/09/2019

Cargo Handling

Cargo handling cost is caused by cargo handling activity which has influenced by loading and unloading equipment. There are several vessels equipped by loading cranes named as geared vessel, and for gearless vessel usually using harbor mobile crane (HMC). Along with the size of the vessel, this activity affects the cargo handling cost.

Table 6 Activity of Each Ship Type

General Cargo (GC)	Heavy Lift (HL)	Ro-Ro (RR)	Barge (BA)
Packaging	Packaging	Packaging	Packaging
Tarpaulin	Tarpaulin	Tarpaulin	Tarpaulin
Chartering 2 Trailer Multi-Axle	Chartering 2 Trailer Multi-Axle	Chartering 2 Trailer Multi-Axle	Chartering 2 Trailer Multi-Axle
Chartering 2 Prime Mover	Chartering 2 Prime Mover	Chartering 2 Prime Mover	Temporary Support
Temporary Support	Temporary Support	Temporary Support	The Equipment for Crane
The Equipment for Crane	The Equipment for Crane	The Equipment for Crane	HMC POL
TKBM POL	HMC POL	TKBM POL	HMC POD
TKBM POD	HMC POD	TKBM POD	TKBM POL
Lashing	TKBM POL	Lashing	TKBM POD
	TKBM POD		Lashing
	Lashing		

Table 6 shows several activities of each vessels. particularly on loading and unloading activities, general cargo vessel using ships crane, while barge and heavy lift using HMC. Despite not using HMC, Ro-Ro ships use temporary support and prime movers to load carriages on a board. As a result the smallest unit cargo handling cost in units 15.5 Million-Rupiah/carriage is generated by general cargo ship category 3 (GC3), while the largest by barge category 1 (BA1) (see Figure 2).

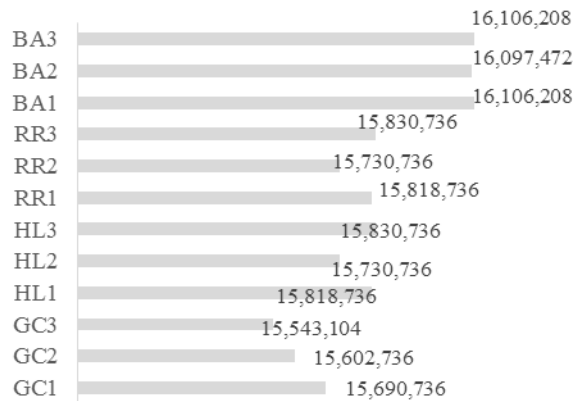


Figure 2 Cargo Handling Cost

Shipping Cost Calculation

Land transportation consists of 10 components. Figure 3 shows the percentage of each component of a multi-axle trailer cost. The highest cost is charter cost multi-axle trailer and prime mover, while the lowest cost is toll fees and repair costs. The second highest cost is fuel cost. The fuel oil requirement for trucks with a capacity of 45 tons over the age of 3 years is 1 liter of diesel for every 1.8 Km [1]. This multi-axle trailer charter using a time charter party, where the cost of transportation mode and all operations are calculated in accordance with the total frequency, which has 50 times. So the total fuel cost is 1.4 Billion-Rupiah. This fuel cost has a percentage of 36% of the total cost at 6.9 Billion-Rupiah.

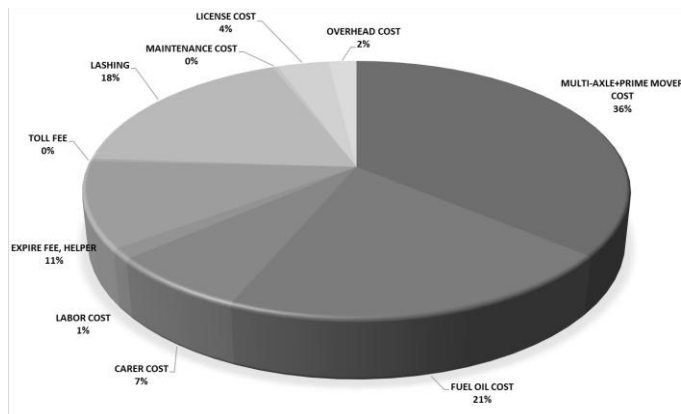


Figure 3 Multi-Axle Trailers Cost Components

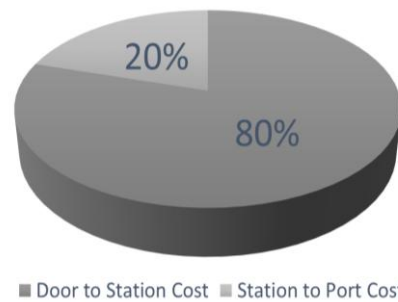


Figure 4 Railway Cost Components

When using trains mode, carriages shipment scheme from door to station then continued by multi-axle trailer from station to sea port. By this condition, there are two components for cost calculation, namely shipment cost for door to station which include trains charter fees and overhead fees. Meanwhile shipment cost from station to sea port consist of lashing charges, voyage charter, temporary support at station, crane charter fees, TKBM fees and overhead fees. In general, the percentage of costs in rail mode is shown as in Figure 4, where the station to port costs even though only 20%.

The analysis in this study based on ships operator's view. The components of shipping costs are fixed costs (capital and operational costs) and variable costs (fuel costs and port charges). Fixed costs are obtained by regulating ship prices from various sources and considering the age of vessel. The regression results are used to determine the residual life of the vessel. Capital cost per year has obtained by dividing the ship's price with its economic life after adding 2% inflation. This capital cost will be added to the daily operating cost, then all vessels can be compared in accordance with the time vessel operating.

Then, operation costs component are sum of crew salary, maintenance and repair cost, insurance, crew supplies, and lubricating oil. The next step is calculating the fuel cost. Referenced by the world fuel prices, Intermediate Fuel Oil's fuel price is \$ 367/ton and for Marine Diesel Oil is \$ 482/ton [3].

Cost of origin and destination port are calculated based on the tariff of ship services and cargo services. Then the penalty cost (PC) before meet total cost should be calculated first with the following formula:

$$\text{Unit Cost PC (Rp/Carriage)} = \text{Unit cost FC} + \text{Unit cost VC} + \text{Unit cost CHC} \quad (1)$$

$$\text{Total Penalty Cost(Rp/Total RT)} = \text{Unit Cost PC} \times \text{Frek.By Cargo} \times \text{Broken Stowage} \quad (2)$$

Shipping Cost Calculation

Total logistics cost consists of 3 (three) components namely land transportation cost, cargo handling cost, and sea transportation cost. This total cost is used to calculate unit cost in units of Rupiah per carriage as shown in Table 7.

Table 7 Unit Cost Alternative Multi-Mode

Ship Codes	Unit Cost (Trailer + Ship)	Unit Cost (Trains+Ships)
GC1	230.623.389	234.079.065
GC2	241.407.145	244.862.821
GC3	222.229.171	225.684.847
HL1	243.672.062	247.127.738
HL2	363.701.594	367.157.270
HL3	585.552.167	589.007.844
RR1	1.459.334.743	1.462.790.419
RR2	480.281.637	483.737.313
RR3	395.519.578	398.975.254
BA1	450.089.540	453.545.216
BA2	588.711.142	592.166.818
BA3	792.045.895	795.501.571

The cheapest cost alternative unit is multi-axle trailer and ship with GC3 code or general cargo ship with 25,387 DWT with unit cost at 222.2 Million-Rupiah/carriage (see Table 7).

CONCLUSION

1. Shipment frequency of 150 railway carriages in 2016 to Bangladesh is 7 (seven) times by using sea transport modes of general cargo ship of 10,000 - 17,000 DWT. The mode of land transportation is multi-axle trailer. This delivery resulted in unit cost for sea transportation is 181.3 Million-Rupiah/carriage and land transportation cost unit of 50 Million-Rupiah/carriage.
2. For delivery of export railway carriage in 2017, selected land and sea transportation modes are based on the lowest unit cost. The selected land transportation modes is multi-axle trailers, which can carry 5 (five) carriage per day and cost at 27.7 Million-Rupiah/trailers. While the selected sea transportation mode is a 27,926 DWT general cargo ship, which can carry 46 carriages and its cost reach 194.4 Million-Rupiah/car. So the combined multi-mode transportation is multi-axle trailer and general cargo ship 27,926 DWT with unit cost at 222.2 Million-Rupiah/carriage with total time 142 days.

ACKNOWLEDGEMENTS

The author would like to thank PT INKA, PT Silkargo Indonesia, PT Ampel Jaya, PT KALOG, and PT JPT for providing information and data needed in this study.

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