Packaging development study for archipelagic sea transportation

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Abstract. Reliable multimodal transportation system is absolutely necessary to maintain connectivity in a large archipelagic country such as Indonesia. A good multimodal transportation system is needed to distribute basic needs from Java Island especially to other regions in the country. With the government program “Sea Toll”, 20-ft containers are widely used to deliver basic needs. However, due to the limitations of existing infrastructure, container distribution cannot always reach the final destination (door to door service). Therefore, it is important to analyze the possibility of packaging development for multimodal transportation to enhance the efficiency of operational and cost aspects. In this respect a research has been conducted by considering the H-1 and T-5 route of Sea Toll program 2019, as well as the Pioneering ship R-33 route 2019 with the destination of Essang Port for study case. This research was conducted using a comparative method of operational and financial performance from 10 scenarios. These 10 scenarios are applied to the same route with different packaging alternatives. Where 1 packaging type is the existing packaging, 6 packaging types are from the previous research, and 3 packaging types are the new design. Results of this research suggest the combination of 20-ft container with packaging Design-1 is the best scenario. Compared to the 20-ft container only, combination of 20-ft container with packaging Design-1 can save 37.58% of logistics costs, 49.24% of repositioning costs and 19.35% of shipping time. However, for the opportunity cost, combination of 20-ft container with packaging Design-1 requires IDR 350,000 (USD 24.6) higher than the 20-ft container only.

1. Introduction

Every human being in the world must fulfill their basic needs to maintain their existence, and there is no exception for everyone who live in small islands scattered throughout the country of a large archipelagic such as Indonesia. The basic needs consist of clothing, food and housing. Nowadays, most of them, are still produced in big cities located on Java Island as the country’s central business. Those basic commodities are then distributed to other islands including the regions defined by the government as the 3T area, namely Tertinggal (Left Behind), Terdepan (Frontier), Terluar (Outermost). Under the current government priority program of Sea Toll [1], 20-ft containers are widely used to deliver basic need commodities to the 3T area.

Because Indonesia is an archipelagic country, multimodal transportation is absolutely necessary to fulfill demand of the basic needs. To provide connectivity between land transport and sea transport, and reduce the time of loading and unloading at the port, the use of packaging as a support for ease of...
transport has began. Since entering the 1970 in Indonesia 20-ft and 40-ft containers have been widely used [2]. However, the benefits of containers to make multimodal transportation easier have not been fully felt, this is due to several factors:

- Total demand does not reach the maximum capacity of standard containers for one destination. Therefore, one container usually contain goods or commodities to be transported to more than one destination
- Lots of demand variation.
- Inequality of land and sea transportation facilities. Therefore, one must change the type of vehicle, both on land and sea transportation in the shipping process.
- Imbalance of cargo to be distributed.

If the cargo is not packed properly, the transfer of cargo between modes can lead to the potential for additional costs and delivery times.

To reduce logistics costs, the Indonesian Government evaluates the Sea Toll Program annually. In 2019, the government develops freight forwarding services, from port to port scheme to end to end scheme. To realize the development, there must be improvements to the multimodal transportation system. So the government created a new program, namely Container Masuk Desa or Container Entering Villages [3,4]. This program utilizes Pelindo Marine Service and Semen Indonesia Logistik's jointly developed new product designated as MiniCont. MiniCont is a sea transport packaging that has dimensions 1/3 smaller than a 20-ft container [5,6]. This packaging was chosen because of its small size, so it could be accommodated with a 20-ft container, perintis or pioneering ships, and Colt Diesel Engkel (CDE) truck. Therefore this packaging, can reach small islands in the 3T region. On 10th April 2019, the Container Masuk Desa program has been launched. In this first operation, MiniCont transported 3 tons of rice to Essang District, Kepulauan Talaud Regency, North Sulawesi, as shown in Figure 1. By ignoring its transportation modes changing capabilities, MiniCont can reduce container capacity, from 20.8 tons, to 9 tons.

From the Container Masuk Desa program, the current research is prepared to review the possibility of using other packages to facilitate the shipment of cargo to the archipelagic area. This research also considers the change of land transportation to sea transportation in the process of shipping cargo. The case study for this research took 2 locations, Surabaya City and Essang District. Surabaya as the city of origin, while the Essang District as the destination. Cargo shipping from Surabaya City to Essang District in 2019 is served by three (3) routes, such as H-10 Sea Toll Route 2019, T-5 Sea Toll Route 2019 and R-33 Pioneering Route 2019 [7].

![Figure 1. Map of Kepulauan Talaud Regency](image)
2. Research Methodology
In this research, primary data and secondary data are applied. Primary data were collected by interviewing and field visits to related parties. Secondary data were obtained from previous researches and publications made available by several related institutions which could be openly accessed by public. In this research, some data has been explored such as cargo throughput, type of cargo, population in Talaud Regency, and fleet specifications [8].

The first stage of this research is conducting the demand analysis, then followed by analysis of packaging capacity based on type of goods and transportation modes changing capabilities [9]. After that, the scenario of packaging usage for the Surabaya-Essang shipping route was formed through the H-1 and T-5 2019 Sea Toll Routes 2019 and R-33 Pioneering Routes 2019. The next step is operational and cost analysis for each scenario. From the results of the analysis, it can then identify which aspects that can be improved from the current shipping conditions. From the results of identification, it is proposed a new design to improve the quality of the current shipping process. After the design is considered appropriate, then the analysis that has been done is iterated to come to the new packaging design which is considered as the best to meet the demand.

Results of the aforementioned analysis lead to four (4) criteria for assessing packaging performance. These criteria include operational time, logistics costs, repositioning costs and opportunity costs. Based on these criteria, all scenarios will be compared, and the most suitable packaging for shipping cargo to archipelagic area will be found [10,11].

2.1 Development of Sea Transport Packaging
To identify the types of packaging for sea cargo, they have been classified into two (2) groups, namely exterior containers and interior containers. Exterior containers, as shown in Figure 2, are tertiary packaging which can protect cargo during the transportation and loading/unloading process. From this figure, packagings which are already widely used are standard containers and nonstandard containers. Whereas the Mini Container Design 1 [12] and Mini Container Design 2 are still in the research development stage.

![Figure 2. Exterior Containers](image)

The interior containers, as shown in Figure 3, are packaging which are necessary and can be put in a standard container in the transportation process. In this figure a number of interior container types are illustrated. The Pelra Packaging A, B, and C are still in the research development stage [13].

![Figure 3. Interior Containers](image)

2.2 Type of Cargo and Cargo Throughput
Not all cargo can be sent using sea toll vessels and get shipping cargo subsidized. The types of cargo permitted are already regulated in Minister of Trade Republic of Indonesia Regulation Number 38 year 2018 and circular letter of the Ministry of Transportation Number: AL.307 / I / I / DTPL-18 concerning
list of types of sea toll vessel cargo in 2018. For types of cargo regulated in the Minister of Trade Regulation of the Republic of Indonesia No 38 year 2018 shown in Table 1 below.

| Mineral Water | Milk | LPG gas 12kg |
|---------------|------|--------------|
| White Onion   | Tea  | Animal feed/ Fish |
| Salt          | Cofe | feed         |
| Soybean       | Canned fish | Asbestos/ Gypsum |
| Peanuts       | Biscuits | Nail |
| Margarine     | Clothes | Zinc sheet |
| Instant Noodle| Baby and adult diapers | Asphalt |
| Soft Drink    | Detergent/Soap/Tooth Paste | Vegetable |
| Medicine      | Stationary | 

Source : Minister of Trade Republic of Indonesia

For types of cargo regulated in the circular letter of the Ministry of Transportation Number: AL.307/I/I/DTPL-18 concerning list of types of sea toll vessel cargo in 2018 shown in Table 2 below.

| First Priority Cargo | Basic Needs | Important Cargo |
|----------------------|-------------|-----------------|
| 1. Rice              | 1. Soybean  | 1. Seed (Rice, Corn, Soybean) |
| 2. Sugar             | 2. Chili    | 2. Fertilizer   |
| 3. Cooking Oil       | 3. Red Onion| 3. LPG gas 3kg |
| 4. Wheat Flour       | 4. Beef     | 4. Plywood      |
| 5. Cement            | 5. Chicken Meat | 5. Iron and steel construction |
|                      | 6. Chicken Egg | 6. Light Steel |
|                      | 7. Fresh Fish (Bandeng, Kembung, and Tongkol /Tuna/Cakalang) | |

Source : Minister of Transportation Republic of Indonesia

Based on sample manifest data from PT. Sarana Bandar Nasional, one of logistics companies in Indonesia, type of cargo which are often transported in sea toll vessels can be seen in Table 3. Notation FCL and LCL denote, respectively Full Container Load and Less than Container Load.

| Number | Type of Demand Cargo | Container Status | Type of Cargo Back | Container Status |
|--------|----------------------|------------------|--------------------|------------------|
| 1      | Mineral Water        | FCL              | Scrap Metal        | FCL              |
| 2      | Seed                 | FCL              | Coconut Wood       | FCL              |
| 3      | Rice                 | FCL/LCL          | Frozen Fish        | FCL              |
| 4      | Biscuit              | LCL              |                    |                  |
| 5      | Milk                 | LCL              |                    |                  |
| 6      | Margarine            | LCL              |                    |                  |
| 7      | Sugar                | FCL/LCL          |                    |                  |
| 8      | Instant Noodle       | FCL/LCL          |                    |                  |
| 9      | Softdrink            | FCL/LCL          |                    |                  |
| 10     | Cooking Oil          | LCL              |                    |                  |
| 11     | Soap                 | LCL              |                    |                  |
| 12     | Cement               | FCL              |                    |                  |

Source : PT. Sarana Bandar Nasional Surabaya Branch, Reprocessed
For the manifest sample, 66 boxes are full homogeneous containers, 9 boxes are full heterogeneous, and the rest are empty containers. For type of cargo in full heterogeneous containers are shown in Table 4.

| No | Cargo Variation                                      |
|----|-----------------------------------------------------|
| 1  | Rice, Biscuits, Milk                                |
| 2  | Biscuits, Margarine                                 |
| 3  | Sugar, Instant Noodle                               |
| 4  | Sugar, Instant Noodle, Biscuits                      |
| 5  | Sugar, Instant Noodle, Biscuits                      |
| 6  | Sugar, Softdrink                                    |
| 7  | Softdrink, Cooking Oil                              |
| 8  | Cooking Oil, Soap, Biscuits                         |
| 9  | Cooking Oil, Sugar, Biscuits                         |

Source: PT. Sarana Bandar Nasional Surabaya Branch, Reprocessed

Before the cargo is sent to Essang District, from Surabaya the cargo will be transhipped first to Port of Tahuna. Port of Tahuna itself is a feeder port for cargo destined to three archipelagic regencies located in North Sulawesi, one of them is Kepulauan Talaud Regency. Figure 4 in the following depicts the container throughput at Port of Tahuna. A moderate increase of throughput of cargo in took place from 2016 to 2017 amounted of some 250 TEUs to 300 TEUs, and higher increase occurred from 2017 to 2018 amounted of 300 TEUs to 550 TEUs. It could be expected more increases of cargo in would happen in the oncoming years. Unfortunately the increase of cargo out is notably small, which means local products are still much insignificant.

![Figure 4. Container throughput at Port of Tahuna](image)

### 3. Results and Discussions

#### 3.1 Problem Solution

The problem faced by most of the small islands scattered in Indonesia is the high price of basic needs. This high price is due to small demand and unbalanced cargo. Because the amount of cargo is small and varied, shipping companies are reluctant to facilitate cargo shipping which destined to small islands. Until 2015, the government launched the sea toll program aimed to strengthen shipping in Indonesia’s remote, foremost and outermost regions. Sea toll vessels are programmed to serve regular and scheduled shipments.

In its realization, sea toll program uses container ships, to deliver sea cargo, therefore the cargo will be packed in ISO containers. The use of these ISO containers has the advantage of being able to facilitate
multimodal transportation. However, this advantage can only be felt in areas which have good infrastructure conditions [14]. Good infrastructure means that containers can be shipped to the final destination. To deliver goods to small islands, it is necessary to make adjustments to transportation modes, both land and sea. The available modes of transportation to facilitate shipment in small island, such as Pioneering shipping vessels, traditional ships, CDE trucks, and pickup trucks.

Transportation mode changing, will affect cargo handling process. When the cargo is in the container, the cargo is well protected, but due to modal changes, the cargo has the risk of damage because the shipment to small and remote islands may be continued without using the containers.

3.2 Cargo Analysis
To assess the function of the packaging, one should know the cargo demand and the related shipping route to calculate cargo throughput. However, the shipping route to archipelagic regions in North Sulawesi always changing from year to year. Although the route is always changing, Port of Tahuna always be a feeder port to continuing the shipment until cargoes reach the port of destination in the small island. Therefore the cargo throughput at Port of Tahuna illustrates the demand for cargoes supplied to three regencies in North Sulawesi archipelagic area. In this regards the demand in Essang District is estimated by comparing the percentage of the population [13,14]. From the results of the calculation that has been done, it is obtained the percentage of cargo demand as in Table 5.

**Table 5. Percentage cargo demand in every port located in Kepulauan Talaud Regency**

| Name of Ports       | Cargo Percentage |
|---------------------|------------------|
|                     | 2015  | 2016  | 2017  | 2018  | 2019  |
| Port of Mangaran    | 3.50% | 3.53% | 3.52% | 3.53% | 3.55% |
| Port of Lirung      | 6.61% | 6.64% | 6.62% | 6.62% | 6.63% |
| Port of Melonguane  | 4.75% | 5.03% | 5.25% | 5.50% | 5.74% |
| Port of Sawang      | 1.10% | 1.12% | 1.12% | 1.13% | 1.13% |
| Port of Beo         | 5.25% | 4.53% | 4.51% | 4.02% | 3.65% |
| Port of Rainis      | 4.92% | 4.97% | 4.98% | 5.00% | 5.02% |
| Port of Essang      | 2.38% | 2.39% | 2.38% | 2.37% | 2.38% |
| Port of Gême        | 1.89% | 1.85% | 1.83% | 1.79% | 1.76% |
| Port of Kakorotan   | 0.57% | 0.55% | 0.54% | 0.53% | 0.52% |
| Port of Karatung    | 0.34% | 0.33% | 0.33% | 0.32% | 0.31% |
| Port of Mamput      | 0.23% | 0.22% | 0.22% | 0.21% | 0.21% |
| Port of Miangas     | 0.27% | 0.28% | 0.28% | 0.28% | 0.28% |

Furthermore, from the calculation of the sample manifest, it has been attained the number of cargo in every type with Port of Essang as the destination. This calculation results as shown in Table 6 will be used in the subsequent calculation analysis.

**Table 6. Weight cargo based on type of cargo with Port of Essang as final destination**

| No | Type of Cargo  | Weight/Secondary Packaging | Number of Secondary Packaging | Total Weight (kg) |
|----|----------------|-----------------------------|------------------------------|-------------------|
| 1  | Instant Noodle | 3.46                        | 67.72                        | 234.66            |
| 2  | Softdrink      | 4.83                        | 323.04                       | 1,561.88          |
| 3  | Soap           | 6.30                        | 50.07                        | 315.44            |
| 4  | Biscuit        | 12.10                       | 15.32                        | 185.34            |
| 5  | Margarine      | 12.30                       | 29.95                        | 369.94            |
| 6  | Mineral Water  | 14.70                       | 209.13                       | 3,074.14          |
| 7  | Cooking Oil    | 15.50                       | 43.69                        | 677.25            |
| 8  | Milk           | 18.26                       | 3.57                         | 65.16             |
| 9  | Seed           | 20.05                       | 43.16                        | 865.30            |
| 10 | Sugar          | 24.35                       | 55.73                        | 1,357.08          |
3.3 Packaging Evaluation in Operational and Cost Side

Packaging evaluation aims to determine the weaknesses and strengths of each package in terms of operational and cost. Furthermore, this evaluation also aims to determine additional costs from each scenario. In all scenarios Surabaya is taken as the city of origin and Essang District as destination, and cargoes will be transported by sea. To reach Essang District, cargoes must pass three sea routes, such as H-1 and T-5 Sea Toll Route 2019 and R-33 Pioneering Route 2019. Scenario #1 is defined as the existing condition, where ISO 20-ft containers are used, for Scenarios #2 and #3 the exterior containers are used, and for Scenarios #4 to #7 interior containers are used. Figure 5 illustrate the aforementioned scenarios.

Before evaluation of the packaging is performed, the number of containers needed for shipping at weight of 28.63 tons and volume of 28.865 m³ should be identified. The results of this evaluation, as contained in Table 7, will have a major effect on logistics costs.

![Figure 5. Scenario Illustration](image)

| No | Type of Cargo | Weight/Secondary Packaging | Number of Secondary Packaging | Total Weight (kg) |
|----|---------------|-----------------------------|-------------------------------|------------------|
| 11 | Rice          | 50.15                       | 346.15                       | 17,359.23        |
| 12 | Cement        | 50.13                       | 51.18                         | 2,565.74         |
| Total |             |                              | 1,238.70                     | 28,631.17        |

Table 7. Number of packaging

| Scenario | Packaging | Number of 20-ft Container | Number of Tertiary Packaging |
|----------|-----------|---------------------------|------------------------------|
| 1        | 20-ft Container | -                        | 1.31                         | -                |
| 2        | Mini Container Design 1 | -                     | 9.54                         | 28.63            |
| 3        | Mini Container Design 2 | -                     | 20.45                        | 81.80            |
| 4        | 20-ft Container | MiniCont              | 3.18                         | 10.00            |
| 5        | 20-ft Container | Pelra A Packaging      | 1.62                         | 30.00            |
| 6        | 20-ft Container | Pelra B Packaging      | 3.58                         | 29.00            |
| 7        | 20-ft Container | Pelra C Packaging      | 3.58                         | 29.00            |

On the operational side, the evaluation is related to the amount of time spent in each scenario to reach the destination or shortly termed as the delivery time. There are three major stages in the calculation of delivery time, include the door to port, port to port and port to door. Table 8 reveals the total time of each scenario.
### Table 8. Summary of delivery time in each scenario

| Scenario | 1st Packaging | 2nd Packaging | Total Time (day) |
|----------|---------------|---------------|------------------|
| 1        | 20-ft Container | -             | 18.95            |
| 2        | Mini Container Design 1 | - | 14.23            |
| 3        | Mini Container Design 2 | - | 14.49            |
| 4        | 20-ft Container | MiniCont      | 14.10            |
| 5        | 20-ft Container | Pelra A Packaging | 14.67 |
| 6        | 20-ft Container | Pelra B Packaging | 17.90 |
| 7        | 20-ft Container | Pelra C Packaging | 14.15 |

Cost calculation is derived from the operational activities of each scenario. The total costs generated by each scenario are shown in Table 9 below.

### Table 9. Summary of Total Cost in Each Scenario

| Scenario | 1st Packaging | 2nd Packaging | Total Cost (IDR \times 10^6) |
|----------|---------------|---------------|------------------------------|
| 1        | 20-ft Container | -             | 87.40                        |
| 2        | Mini Container Design 1 | - | 141.47                       |
| 3        | Mini Container Design 2 | - | 221.37                       |
| 4        | 20-ft Container | MiniCont      | 126.86                       |
| 5        | 20-ft Container | Pelra A Packaging | 59.96 |
| 6        | 20-ft Container | Pelra B Packaging | 98.63 |
| 7        | 20-ft Container | Pelra C Packaging | 111.94 |

#### 3.4 Proposed Packaging Design-1

Packaging Design-1 is established by considering the idea from Pelra C and Pelra B packages [13,15]. Adjustments are added at the height of the packaging and extra flexibility at the base. Two (2) stacks of this package will fit in standard container height, thus reducing broken stowage when arranged in 20-ft container. This packaging use wood an hollow aluminium for materials. The feature and dimensions of Design-1 are shown in Figure 6 and Table 10.

A simulation has been conducted to arrange the number of various products in the packaging Design-1. Results of the simulation is summarized in Table 11. Further, the graph of Design-1 broken stowage of each cargo type is presented in Figure 7.

This package can be accommodated by 20-ft containers, CDE trucks, pickup trucks and Pioneering ships. One 20-ft container can hold 20 packages of Design-1, CDE trucks can accommodate 4 units of packaging Design-1, while pickup trucks can carry 2 units of packaging Design-1 and a Pioneering ship is able to transport 105 units of packaging Design-1 in every shipment.
Figure 6. Packaging Design-1

Table 10. Dimensions of Design-1

| Outer Dimension:                      |         |
|--------------------------------------|---------|
| Length                               | 1,200   mm |
| Width                                | 800     mm |
| Total Height                          | 1,170   mm |
| Foot Height                           | 120     mm |
| Pole Height                           | 1,000   mm |
| Lock Height                           | 50      mm |
| Stacking Height                       | 2,240   mm |
| Outside Volume                        | 1.12    m$^3$ |

| Inner Dimensions:                     |         |
|---------------------------------------|---------|
| Length                                | 1,180   mm |
| Width                                 | 780     mm |
| Total Height                          | 1,000   mm |
| Outside Volume                        | 0.92    m$^3$ |
| Capacity                              | 1       ton |
| Stackable                             | yes     |

Table 11. Number and type of products contained in packaging Design-1

| Type of Cargo | Number of Product |
|---------------|-------------------|
| Instant Noodle| 48.00 Box         |
| Softdrink     | 81.00 Box         |
| Soap          | 54.00 Box         |
| Biscuit       | 16.00 Box         |
| Margarine     | 36.00 Box         |
| Mineral Water | 27.00 Box         |
| Cooking Oil   | 45.00 Box         |
| Milk          | 15.00 Box         |
| Seed          | 12.00 Box         |
| Sugar         | 20.00 Box         |
| Rice          | 12.00 Box         |
| Cement        | 12.00 Bag         |

Figure 7. Design-1 broken stowage of each cargo type

3.5 Proposed Packaging Design 2

In packaging Design-2 an improvement is made from Design-1. In Design-2 walls are added to protect goods from water and the pressure from one side to the other side. From the simulation on packaging Design-2, the number and type of products that can be arranged in packaging Design-2 are listed in
Table 12. This packaging utilize HDPE for materials, with the feature as illustrated in Figure 8 and dimensions are listed in Table 13. In this regards the graph of packaging Design-2 broken stowage of each cargo type can be seen in Figure 9.

Table 12. Number and type of products contained in packaging Design-2

| Type of Cargo | Number of Product |
|---------------|-------------------|
| Instant Noodle | 18.00 Box         |
| Softdrink     | 63.00 Box         |
| Soap          | 54.00 Box         |
| Biscuit       | 12.00 Box         |
| Margarine     | 18.00 Box         |
| Mineral Water | 18.00 Box         |
| Cooking Oil   | 36.00 Box         |
| Milk          | 15.00 Box         |
| Seed          | 10.00 Box         |
| Sugar         | 20.00 Box         |
| Rice          | 5.00 Box          |
| Cement        | 5.00 Bag          |

Table 13. Dimensions of Design-2

| Exterior Dimensions |  |
|---------------------|--|
| Length              | 98 cm |
| Width               | 78 cm |
| Height              | 105.5 cm |
| Foot Height         | 15 cm |
| Cargo Hold Height   | 95 cm |
| Upside Cover Height | 5 cm |
| Wall Thickness      | 1 cm  |

| Foot Dimension      |  |
|---------------------|--|
| Foot Height         | 15 cm |
| Foot Length         | 12 cm |
| Foot Width          | 12 cm |

| Upside Cover        |  |
|---------------------|--|
| Upside Cover Height | 5 cm |
| Upside Cover Length | 100 cm |
| Upside Cover Width  | 80 cm |

| Interior Dimensions |  |
|---------------------|--|
| Length              | 96 cm |
| Width               | 76 cm |
| Height              | 87 cm |

Figure 8. Packaging Design-2
This package can accommodated by 20 ft containers, CDE trucks, pickup trucks and Pioneering ships. The 20-ft container can hold 34 packages Design-2, CDE trucks can accommodate 6 units of packaging Design-2, while pickups can carry 2 units of packaging Design-2, and the Pioneering ship is able to transport 184 units of packaging Design-2 in any single shipment.

3.6 Proposed Packaging Design-3
In packaging Design-3 improvement is made from Design-1 and -2. In Design-3 improvement is made in the wall design, which consider repositioning packages. This package is designed by following the principle of pile bucket, so it can save loading space when the packaging is empty. This packaging use HDPE for materials. The packaging Design-3 can carry up to 384 kilograms of cargo. Figure 10 shows the packaging Design-3 in a single configuration (a), stacked empty packages (b), and stacked packages when fully loaded (c). The dimensions of packaging Design-3 are given in Table 14.

![Figure 9. Design-2 broken stowage of each cargo type](image)

![Figure 10. Packaging Design-3](image)

| Base Dimension | Wall Dimension | Cover Dimension |
|----------------|----------------|-----------------|
| **Length**     | 960 mm         | - Side 1        |
| **Width**      | 640 mm         | **Base Width**  | 960 mm | **Length 1** | 780 mm |
| **Foot Dimension** |                | **Height**      | 950 mm | **Length 2** | 760 mm |
| **Foot 1**     | 6 unit         | **Upside Width**| 960 mm |                |
| **Width**      | 120 mm         | **Thickness**   | 10 mm  | **Thickness** | 10 mm  |
| **Length**     | 60 mm          | **Wall 1**      |        | **Side 2**    |
| **Height**     | 150 mm         | **Base Width**  | 656 mm | **Length 1** | 980 mm |
| **Foot 2**     | 3 unit         | **Upside Width**| 760 mm | **Length 2** | 960 mm |
From the simulation that has been conducted the type and number of products that can be arranged in packaging Design-3 are revealed in Table 15. Subsequently the graph of packaging Design-3 broken stowage of each cargo type can be seen in Figure 11.

**Table 15. Number of Product in Design-1 Packages**

| Type of Cargo      | Number of Product |
|--------------------|-------------------|
| Instant Noodle     | 16.00 Box         |
| Softdrink          | 72.00 Box         |
| Soap               | 36.00 Box         |
| Biscuit            | 8.00 Box          |
| Margarine          | 16.00 Box         |
| Mineral Water      | 16.00 Box         |
| Cooking Oil        | 24.00 Box         |
| Milk               | 12.00 Box         |
| Seed               | 18.00 Box         |
| Sugar              | 15.00 Box         |
| Rice               | 6.00 Box          |
| Cement             | 6.00 Bag          |

**Figure 11.** Design-3 broken stowage of each cargo type

As in the case of packaging Design-1 and Design-2, the packaging Design-3 can be accommodated within 20-ft containers, CDE trucks, pickup trucks and Pioneering ships. A 20-ft container, a CDE truck, a pickup truck, and a Pioneering ship can hold, respectively, 34 units, 6 units, 2 units, and 184 units of packaging Design-3.

### 3.7 Comparison of Packaging Performance

This section will discuss the comparison of all scenarios in packaging. There are 10 scenarios accounted in this study. Three scenarios using the proposed packaging developed in the current research. All scenarios are analyzed in with the same procedure. Summary of the total delivery time, total logistics cost, opportunity cost and repositioning cost of those scenarios are shown Table 16.
### Table 16. Summary of total time and costs in all scenarios

| Scenario | Packaging | 1st Packaging | 2nd Packaging | Total Time (day) | Total Logistic Cost (IDR × 10⁶) | Opportunity Cost (IDR × 10⁶) | Repositioning Cost (IDR × 10⁶) |
|----------|-----------|---------------|---------------|-----------------|---------------------------------|-----------------------------|-------------------------------|
| 1        | 20-ft Container | 87.40         | -             | 82.99           | 18.95                           |                             |                               |
| 2        | Mini Container Design 1 | 141.47        | 357.22        | 603.03          | 14.23                           |                             |                               |
| 3        | Mini Container Design 2 | 221.37        | 727.56        | 1,292.21        | 14.49                           |                             |                               |
| 4        | 20-ft Container MiniCont | 126.86        | 103.32        | 210.62          | 14.10                           |                             |                               |
| 5        | 20-ft Container Pelra A Packaging | 59.96        | 18.81         | 105.31          | 14.67                           |                             |                               |
| 6        | 20-ft Container Pelra B Packaging | 98.63        | -             | 57.26           | 17.90                           |                             |                               |
| 7        | 20-ft Container Pelra C Packaging | 111.94       | 150.76        | 229.05          | 14.15                           |                             |                               |
| 8        | 20-ft Container Pckging Design-1 | 54.55        | 0.35          | 42.12           | 14.77                           |                             |                               |
| 9        | 20-ft Container Pckging Design-2 | 56.36        | 2.09          | 94.78           | 18.32                           |                             |                               |
| 10       | 20-ft Container Pckging Design 3 | 78.36        | 54.59         | 41.50           | 19.03                           |                             |                               |

### 4. Conclusions

A study on the development of alternative packaging for archipelagic sea transportation has been described. Some conclusions that can be drawn from this study are as follows:

1. The most widely used sea cargo packages is 20-ft container (Scenario #1). From the calculation results on the operational side of Surabaya to Essang shipment, Scenario #1 spends 18.95 days for shipping time and requires IDR 87.40 millions (USD 6,144) for total logistics cost and IDR 82.99 millions (USD 5,834) for the repositioning, but no opportunity cost is required.

2. Evaluation for interior container is to adjust dimensions with standard containers, and make the gross weight of the packaging as light as possible. The results of the evaluation in terms of...
operational and cost for shipping 28.63 tons of cargo from Surabaya to the Essang District including:

a. Operational side evaluation reveals:
   - Scenario #4 is the fastest scenario, using a combination of 20-ft containers and MiniCont, takes some 14.1 days.

b. Cost side evaluation reveals:
   - Scenario #8 (combination of 20-ft container and packaging Design-1) is the scenario with the lowest logistic cost, namely IDR 54.55 millions (USD 3,835).
   - Scenario #6 (combination of 20-ft container and Pelra B Packaging) is the scenario with the lowest opportunity cost, that is zero similar to Scenario #1.
   - Scenario #10 (combination of 20-ft container and packaging Design-3) is the scenario with the lowest repositioning cost, namely IDR 41.50 millions (USD 2,917).

3. Scenario #8 (combination of 20-ft container and packaging Design-1) is the best scenario. Compared to the 20-ft container, Scenario #8 can save about 37.58% of logistics costs, 49.24% of repositioning costs, and 19.35% of shipping time. However, Scenario #8 requires opportunity cost in the order of IDR 0.35 millions (USD 24.6) which is higher than Scenario #1 and Scenario #6.

References

[1] Kusuma, L.T.W.N. and Tseng, F.S. (2019). “Analysis of the impact of the “Sea Toll” program for seaports: resilience and competitiveness”. J. of Applied Sciences 9(16):3407.
[2] Nugroho, S. (2005). “A case-based stowage planning system. WIT Transactions on The Built Environment”. 79:1-10
[3] Direktorat Jendral Perhubungan Laut (2019). Info Maritim Edisi IV, Jakarta.
[4] Mustakim, A. and Hadi, F (2018). “Innovated conceptual design of loading unloading tool for livestock at the port”. IOP Conf. Series: Journal of Physics 979:012061.
[5] Nur, H.I., Lazuardi, S.D., Hadi F. and Hapis M. (2018). “Determining domestic container shipping as an enforcement of Indonesian international hub port”. IOP Conf. Series: Earth and Environmental Science 135:012012.
[6] PT. Pelabuhan Indonesia III (Persero) (2018). Dermaga Edisi 238- September, Surabaya.
[7] Bappenas (2015). Implementation of Sea Toll 2015-2019, Jakarta.
[8] Badan Pusat Statistik Kabupaten Kepulauan Talaud (2018). Kabupaten Kepulauan Talaud Dalam Angka. Melonguane.
[9] Funke, J. and Kopfer, H. (2015). “A neighborhood search for a multi-size container transportation problem”. IFAC-PapersOnLine 48(3):2041-2046.
[10] Mulyono, Manfaat, D. and Achmadi, T. (2016). “Applying theory of constraint to identify the constraint of marine transportation system”. Int. J. of Oceans and Oceanography 10(2):173-190.
[11] Manfaat, D. Achmadi, T. and Mulyono (2016). “Implementing the theory of constraint to optimize the marine transportation system productivity: A case study of company ‘X’ ”. J. of Eng. And Applied Sciences 11(9):2085-2093.
[12] Wiwaswan, D.L. (2019). Conceptual Design of Mini Container For Door to Door Services in Archipelagic Regions: a Case Study of Nusa Tenggara Timur. Final Year Project, Dept. of Sea Transportation – ITS, Surabaya.
[13] Izza, F.F. (2017). Conceptual Design of Container Packaging for Traditional People Shipping: A Case Study of People Shipping at Kalimas Port Surabaya. Final Year Project, Dept. of Sea Transportation – ITS, Surabaya.
[14] Tukan, M., Achmadi, T., and Widjaja, S. (2015). “Seaport dimensional analysis towards economic growth in archipelagic regions”. Int. J. of Technology 6(3):422-431.
[15] Nugroho, S., Zulkarnaen, F., and Arizal J.F. (2018). “Intelligent transportation architecture to address challenges of traditional shipping operations (PELRA)”. J. of Eng. and Applied Sciences, 13(8):2114-2119.