The Effectiveness of Warehouse Utilization at Soekarno-Hatta Internasional Airport

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ABSTRACT

In order to improve the performance of cargo warehouse owned by PT JAS, layout redesigning is carried out. It is to facilitate the operator in storing, moving, and carrying cargo so that these activities can run quickly and systematically with relatively low cost. By using the method of Cube per Order Index (COI) that refers to the data of import cargo movement in 2010, it is found that the utilization of PT JAS warehouse at Soekarno-Hatta international airport can still be optimized up to a hundred percent from the current condition.

Key words: Warehouse layout, effectiveness of warehouse, and method of cube per order index

Introduction

For large scale companies, a warehouse has a significant meaning for storing the cargo that will be exported and imported as well as for storing the newly received cargo to be delivered. Therefore, the main function of a warehouse is for cargo receiving, storage, and delivery. Since warehouse is one of supporting factors in the production process, thus cargo piling-up should be carried out in such a way that makes easy for taking out, as shown in Figure 1 and Figure 2. Carefulness becomes a main factor to prevent any accident in cargo piling-up, labelling, and delivery or to avoid mistakes in cargo receiving. Since a warehouse is a facility for cargo storage, then its activities have a role like distributor. Therefore, warehousing system can be said effective and efficient if it is able to meet the speed of processes from receiving, storage to delivery.

Figure 1 & 2. Cargo racks in an import warehouse

One way to avoid mistakes is analyzing the cost of cargo flow from one department to another, or conducting storage according to the classifications: most frequently used, taken out, stored based on the distance of movement, storage, and cargo taking-out. In an other word, the cargoes are classified in order to facilitate the operator and to shorten the time and distance (Warman, 1995, Wignosoebroto, 2000).

According to Lasse (2012), warehouses at a port are differentiated according to their function: Line 1 warehouse for general/breakbulk cargo and CFS (*Container Freight Station*); while Line 2 warehouse, which is the extention of Line 1 warehouse, serving as transit warehouse and treated the same as Line 1 warehouse, and at the same time as a support for some other activities such as *marking, sorting, labelling, bagging* and *palleting*.

The role of Line 1 warehouse is to smoothen the activities of loading and discharging ship's cargo without having to wait for the receiver or cargo arrival, so that the vessel can finish its berthing time as efficiently as possible (Lasse, 2012). The two theories mentioned above apply similarly for Line 1 and Line 2 warehouses at an airport.

According to Render and Heizer (2009) the aim of warehouse layout is to find the optimum point of the cost for material handling and the costs related to the size of warehouse. Furthermore, layout is an important decision to determine the efficiency for a long term operation because it has many strategic impacts, layout determines the competitiveness of a company in terms of capacity, process, flexibility, cost, quality of work

environment, contact with customer, and company image.

Beside layout arrangement, adding product value can be done through customization which is the best way in competitive advantage because of rapid product changing in the market (Barry Render and Jay Heizer, 2009).

As one of the companies managing cargo warehouse at Soekarno-Hatta International Airport, Cengkareng, PT Jasa Angkasa Semesta (JAS) manages cargo warehouse of 1.000 m^2. In addition to poorly-ordered cargo placement and information system which has not been partly computerized, it still needs fairly long time to find the cargo. In fact, the cargo managed by PT JAS consists of various types and sizes. Therefore, a systematic cargo arrangement is necessary. Accordingly, warehouse redesigning or layouting can be done using *algoritma computerized relative allocation of facilities tehnique* (CRAFT)—based on the analysis on the cost of cargo flow from one place to another, or the cargo is arranged based on the lowest cost for storage, taking out, and delivery.

So far, the system or method of cargo arrangement implemented by PT JAS has been *racking/specific storage* system—placed on warehouse racks based on the type and size of cargo combined with the last serial number of Air Way Bill (AWB). Whereas for export cargo, the arrangement is based on the spesific type/size of cargo combined with the airlines that will carry it. So far, this system is considered effective and efficient enough. Meanwhile, there is an obstacle for import cargo, especially the cargo that is settled and not taken out by the consignee. In order to overcome this problem, the company coordinates with related agency, i.e. Customs office, so that the cargo taking out can run smoothly. The other effort is to approach the consignee to immediately take their cargo.

During 2000, PT JAS started to provide *cargo handling* and *warehousing* services after PT Cardig Air has handed over the business to PT JAS This business expansion supports the company in serving more than 25 airlines throughout Indonesia, making PT JAS as the first *ground handling* company in Indonesia that offers one-stop service to its customers. To support its activities, PT JAS has four categories of warehouse, namely export warehouse, import warehouse, domestic warehouse, and rush warehouse for cargo that needs fast handling (such as vegetables, fresh fish, corpse, and live animal). These variative categories of warehouse enable the company to survive and have high competitiveness, both in Indonesia and internationally.

The main problem in this research is how to improve the performance of cargo warehouse of PT JAS by rearranging the layout for cargo in order to facilitate the operator to move, carry, and store quickly and systematically with relatively low cost.

This research uses primary data obtained through an interview with senior staff who have a direct relation with warehouse management and also uses quantitative data taken from the record of the research object, cargo warehouse of PT JAS at the cargo area of Soekarno-Hatta International Airport in April 2010.

Data analysis is done to determine: 1) warehouse capacity; to optimize the cargo storage, 2) distance; to know the distance of cargo storage place from the door, and 3) to make *Activity Relationship Diagram* (ARD) and *Area Allocation Diagram* (AAD) for arranging the cargo placement based on the frequency of cargo withdrawal. Meanwhile, the existing warehouse layout for comparison with the new one is made using the method of *Cube per Order Index (COI)* (Manzini, 2011).

Total Model System

a. The Implementation of Cube per Order Index Method

Cube per Order Index is a method used for determining the right layout with the following steps. The first is to calculate the cost of cargo movement per unit based on the frequency of cargo inward/outward, size of warehouse for each unit, then make a descending order. Next, is to calculate the index of distance based on the value of proportion for each inward/outward cargo and the distance of inward/outward movement from each area. After that, an index of distance in an ascending order is performed and finally is to locate the cargo in accordance with the cost of movement and the index of distance.

b. Analysis on the Layout for Cargo

Based on the layout and cargo storage, the following steps are carried out. First is designing racks according to the cargo need and followed by analyzing the activities in the warehouse that need improvement and finally determining the warehouse layout based the method of *Cube per Order Index* using the following formula (Manzini, 2011):

$$COI_{i,T} = \frac{v_{i,T}}{\sum_{\substack{order\ j \\ in\ period\ T}} x_{ij}}$$

Where;

$v_{i,T}$

average storage level of sku i in time period T.

Results and Discussion

Analysis on the Growth of Import Cargo Volume

The following is the growth of import air cargo volume as seen in Table 1.

Table 1. Growth of Import Cargo Volume in 2010

Month	Cargo Volume	Growth	Percentage	Average Volume Per Day (Kg)
January	6,190,751	0	0%	199,701.65
February	5,942,929	-247,822	-4%	212,247.46
March	8,044,655	2,101,726	35%	259,504.98
April	7,368,020	-676,635	-8%	245,600.65
May	7,832,487	464,467	6%	252,660.88
June	7,666,567	-165,920	-2%	255,552.23
July	7,816,797	150,231	2%	252,154.74
August	8,194,156	377,359	5%	264,327.61
September	4,318,926	-3,875,230	-47%	143,964.21
October	6,863,406	2,544,479	59%	221,400.19
November	7,885,363	1,021,958	15%	262,845.44
December	7,628,330	-257,034	-3%	246,075.16
	85,752,386			2,816,035.20

Source: PT Jasa Angkasa Semesta, CS Import Section (2010)

From the above table, it can be explained that in January 2010 there was not either any decrease nor increase because January 2010 is the beginning of the research and as the base for analysis with the total volume of 6,190,751 kilograms.

The cargo volume in January 2010 was 6,190,751 kg, and in February 2010 it became 5,942,929 kg. Thus, in February 2010 the cargo volume decreased 5,942,929 kg - 6,190,751 kg = - 247,822 kg, and the percentage is -4%.

$$\text{Percentage} = \frac{\text{Cargo volume in February} - \text{Cargo volume in January}}{\text{Cargo volume in January}} \times 100\ \%$$

$$\text{Percentage} = \frac{5{,}942{,}929\ \text{kg} - 6{,}190{,}751\ \text{kg}}{6{,}190{,}751\ \text{kg}} \times 100\ \%$$

$$\text{Percentage} = \frac{-\ 247{,}822\ \text{kg}}{6{,}190{,}751\ \text{kg}} \times 100\% = -4\%$$

To enable the analysis, the above formula is also applied for the subsequent months in a year. From the calculation, it is found that the average vargo volume in 2010 is 7,146,032 kg, while the average volume per day is 2,816,035 kg.

The growth of cargo volume in 2010 can be seen in the following graphs:

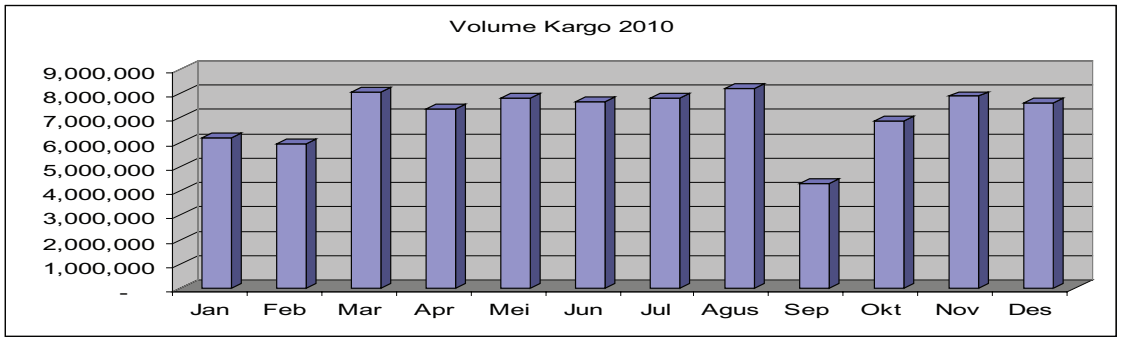
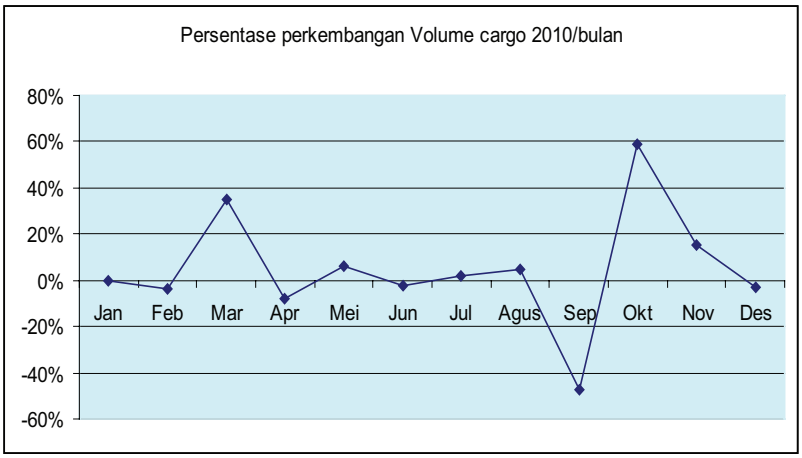


Figure 3. Graphic of the Growth of Import Cargo Volume of PT JAS (2010)



Source: Secondary Data processed, 2011
Figure 4. Percentage of the Growth of Cargo Volume

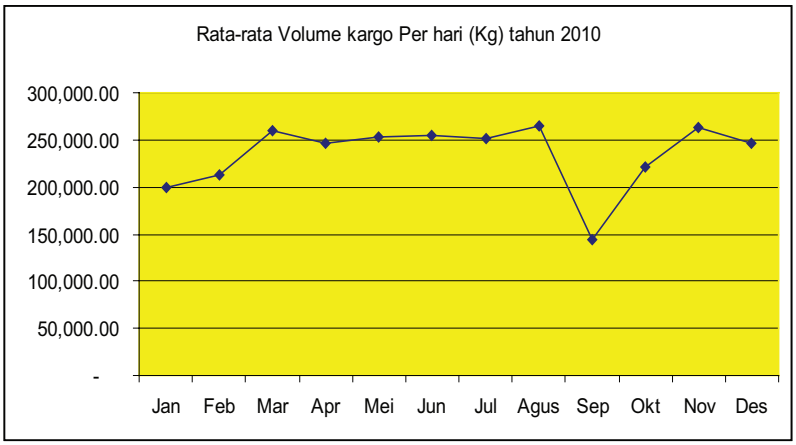


Figure 5. Average of Cargo Volume

The above figures show that the both decrease and increase of cargo volume are caused by several factors such as the growing economy of Indonesia**,** the prevailing free market of AFTA**,** the government policy in the industry and trade sector for consumer goods procurement, and the technology for handling air cargo (Kemenperin, 2012).

Analysis on the Effectiveness of Import Warehouse Utilization

PT JAS, located at the cargo area of Soekarno–Hatta International Airport, has three types of warehouse, namely export warehouse, import warehouse, and *rush handling* warehouse. Import warehouse has several places to store goods or cargo, including general cargo. Furthermore, the effectiveness meant in this article is about the effectiveness of warehouse utilization for the goods categorized as *general cargo* in the form of three-layer racks. With the size of import warehouse 9,854 meter per square in total, including *rush handling* warehouse of 1,386 meter per square, however, not all of the space in the import warehouse can be used. Around 15 to 25 percent of its capacity is used for Customs office, ground handling and for spare parts. Therefore, the capacity of import warehouse that can be used is only around

7,390 meter per square or around 7,569,000 kgs per month—and the capacity utilized per day is 248,843.84 kgs.

The capacity of warehouse utilization (per day):

$$= \frac{\text{Capacity per month x 12 months}}{365}$$

$$= \frac{\text{7,569,000 kgs x 12 months}}{365} = 248{,}843.84$$

While for the assessment on the effectiveness of warehouse utilization, each percentage of 10%-100% will be given point 1-10, and if more than 100 %, it will be given point 11. Table 2 shows the criteria or standard for assessing the effectiveness of warehouse the author uses in this research as reference.

Table 2. Assessment on the Effectiveness of Warehouse

PERCENTAGE (%)	POINT
1.00 – 10.00	1
10.01 – 20.00	2
20.01 – 30.00	3
30.01 – 40.00	4
40.01 – 50.00	5
50.01 – 60.00	6
60.01 – 70.00	7
70.01 – 80.00	8
80.01 – 90.00	9
90.01 – 100.00	10
>100	11

Source: Silviana Karnita, 2010

The following is a calculation to find the effectiveness of warehouse utilization by PT Jasa Angkasa Semesta in 2010:

From the above table, it can be explained that in January 2010, the volume of warehouse utilization was 199,701.65 kg, less than the available capacity of the warehouse; 248,843.84 kg. Therefore in January 2010, the utilization percentage of the available warehouse capacity is 80%, and based on dan Table 3, its effectiveness is 9.

$$\text{Percentage} = \frac{\text{Volume of warehouse utilization in January 2010}}{\text{warehouse Capacity}}$$

$$\text{Percentage} = \frac{199{,}701.65 \text{ kg}}{248{,}843.84} = 80\%$$

For the subsequent months until the end of 2010, this formula will be used in the calculation, so that it will be found that the highest utilization occured in August 2010 with the volume of warehouse utilization as many as 264,327.61 kg or 106% of the available volume, i.e. 248,843.84 kg. Next, the lowest warehouse utilization happened in September 2010, with the utilization for as many as 143,964.21 kg or 58% of the available volume.

Furthermore, the warehouse utilization is much influenced by the duration of goods storage. Principally, the duration of the cargo in the warehouse is influenced by the following several factors:

Documentation process; if the document used to take out the cargo is not complete, changed or containing other things related to the cargo document, thus the cargo can not be taken out before the documentation process finishes.

Mistake in delivering cargo, usually called *mis-routing*. This happens because of a mistake in the delivery. In other words, the cargo goes not to the addressee. For a while, the cargo should be piled up before being sent to the right address. Consequently, the cargo can influence the volume of utilized warehouse.

Table 3. The Effectiveness of Warehouse Utilization by PT Jasa Angkasa Semesta in 2010

Year	Month	Average Volume of warehouse utilization per day (Kg)	Capacity of warehouse per day (Kg)	Percentage (%)	Effectiveness
2010	January	199,701.65	248,843.84	80%	9
	February	212,247.46	248,843.84	85%	9
	March	259,504.98	248,843.84	104%	11
	April	245,600.65	248,843.84	104%	11
	May	252,660.88	248,843.84	102%	11
	June	255,552.23	248,843.84	103%	11
	July	252,154.74	248,843.84	101%	11
	August	264,327.61	248,843.84	106%	11
	September	143,964.21	248,843.84	58%	6
	October	221,400.19	248,843.84	89%	9
	November	262,845.44	248,843.84	106%	11
	December	246,075.16	248,843.84	99%	10
Total	12	2,816,035.20	-	-	120.00

Source: PT Jasa Angkasa Semesta (2010), data is processed by the author

Damaged goods. If the goods or cargo is damaged, the customer usually makes a claim. During the claim process, the cargo stays in the warehouse.

Goods restricted to enter. If the goods received by the company's employee are the ones restricted to enter the Indonesian territory, such as narcotics, fire arms, etc., so while waiting for the decision from Customs Office, the goods will be in the warehouse.

Warehouse rent. The fee of warehouse rent can also determine whether the goods can be taken out or not. It is usually because the price of the goods is not equal with the fee that should be paid.

In line with that, the duration of goods storage in the warehouse has both advantage and disadvantage for the company. The advantage is that the company gets more fee from the rent. Whereas the disadvantage is that the longer the goods are stored the less capacity of warehouse will be available. Thus, the goods circulation does not run well.

Then the storage period in the warehouse is 30 days. If in 30 days there are no claims, there will usually be a 10-day extension. If there are still claims, the goods are considered as free goods.

Warehouse Data

Size of warehouse is 697.5 m^2, including office room, information room, and goods piling-up area.

1. Beginning condition

From the observation and the information obtained, the warehouse condition can be described as follows:

Cargo storage takes any place that is still empty, so the cargo location is changing according to its arrival. Consequently, it will take fairly long time to find the cargo to get it out from the warehouse.

Data System only records the number of inward/outward cargo and the rest of each type of cargo.

The equipment used is only *trolley* and *forklift*.

2. Racks Design

a. Length of Girder

The length of girder is based on the size and the interval space betwen the rack's vertical part and the pallet. The size of pallet used is 1300 mm x 1100 mm x 150 mm with maximum capacity of 625 kilograms. The interval space between the rack's vertical part and the pallet and the space between a pallete and another is at least 3c = 3 x 101.6 mm = 304.8 mm

Width of burden (W) = 1,100 mm atau 2W =2,200 mm

The length of girder used is 3c + 2W = 304.8 + 2,200 mm = 2,504.8 = 2,590.8 mm

The weight received by girder = twice the maximum weight on pallet = 2 x 625 = 1,250 kg

Height of burden = 76.2 mm

Based on girder's burden, girder with steel code C3X3.5 is needed because it can accommodate the weight up to 1,601.1 kg.

3. Height of Rack

The height of rack is based on the space between the load and girder + the height of girder + the maximum height of pallet plus cargo.

Space inter-load = 1,152.4 mm,

Height of girder = 76.2 mm,

Maximum height of pallet plus cargo = 1,250 mm,

Height of rack = 1,250 + 152.4 + 76.2 = 1,478.6 = 1,524 mm = 1.524 m.

4. Height and Depth of Rack Frame

The depth of rack frame is based on:

Excess of 1 side of pallet = 40.4 mm,

Depth of rack frame = length of pallet – (2 x excess of pallet side),

= 1,300 mm – 76.2 = 1,219.2 mm,

Height of rack frame = 2 x height of rack = 2 x 1,524 = 3,408 mm = 3,408 m.

Based on the height of rack frame, forklift with maximum lifting 3,450 mm is needed.

5. Proposed Design of Warehouse Layout

To redesign the layout, it is necessary to know the beginning and final stock and maximum stock of goods in the warehouse, goods package, frequency of transportation, need for size of floor, distance from the entrance and exit to the storage location, cost of cargo movement, and determination of goods layout.

6. Calculation of pallet stock

From the table 6 it can be seen that the maximum pallet stock is 47 pallets.

7. Total Frequency of Transportation

The total frequency of transportation is calculated based on the number of cargo received and cargo delivered as well as the load capacity of trolley and forklift.

Frequency of Receiving

Sample calculation for the 17th week (maximum need of pallet)

Load capacity of forklift = 1 pallet,

Number of pallet needed for cargo receiving = 41 pallets,

Frequency of goods transportation to be received = 41 times,

Load capacity of forklift = 10 boxes,

Number of boxes received = 48 boxes,

Table 5. Calculation of Maximum Stock in the Warehouse

Week	Beginning stock	In	Out	Final stock	Week	Beginning stock	In	Out	Final stock
1	24,600	0	5,400	19,200	11	20,400	0	6,000	14,400
2	19,200	0	6,000	13,200	12	14,400	0	6,000	8,400
3	13,200	0	6,000	7,200	13	8,400	24,600	6,600	26,400
4	7,200	25800	6,000	27,000	14	26,400	0	4,200	22,200
5	27,000	0	6,000	21,000	15	22,200	0	4,800	17,400
6	21,000	0	7,200	13,800	16	17,400	0	7,200	10,200
7	13,800	0	4,200	9,600	17	10,200	24,600	6,600	28,200
8	9,600	0	4,200	5,400	18	28,200	0	600	22,200
9	5,400	25800	4,800	26,400	19	22,200	0	7,800	14,400
10	26,400	0	6,000	20,400	20	14,400	0	6,600	7,800

Table 6. Calculation of pallet stock (Package per Pallet 600)

Week	Beginning stock	In	Out	Final stock
1	41	0	9	32
2	32	0	10	22
3	22	0	10	12
4	12	43	10	45
5	45	0	10	35
6	35	0	12	23
7	23	0	7	16
8	16	0	7	9
9	9	43	8	44
10	44	0	10	34
11	34	0	10	24
12	24	0	10	14
13	14	41	11	44
14	44	0	7	37
15	37	0	8	29
16	29	0	12	17
17	17	41	11	47
18	47	0	10	37
19	37	0	13	24
20	24	0	11	13

Frequency of loading by forklift = 48/10 = 4,8 = 5 kali.

Frequency of Outward Transportation

Frequency of transportation is calculated based on the number of cargo delivered and the load capacity of trolley and forklift.

Sample calculation for the 17th week (maximum need of pallet)

Load capacity of forklift = 1 pallet,

Number of pallet needed for taking out the goods = 11 pallets,

Frequency of goods transportation to be taken out = 11 times,

Load capacity of forklift = 8 boxes,

Number of boxes taken out = 10 boxes,

Frequency of loading by forklift = 8/10 = 0,8 = 1 time.

The total frequency of transportation is shown in Table 7.

8. Need for Size of Floor

The size of floor needed is calculated based on the size of area for rack.

Dimension of Rack Area for Goods

Based on the dimensional picture of the rack area for goods it is found:

Length of rack area = 2,667 mm.

Width of rack area = 3,400 mm.

Size of rack area = 9.0678 $m^{2.}$

Number of Pallet per Rack Column

Table 7. Total Frequency of Transportation.

Week	In Frequency	Out Frequency	Total frequency of transportation
1	0	9	9
2	0	10	10
3	0	10	10
4	43	10	53
5	0	10	10
6	0	12	12
7	0	7	7
8	0	7	7
9	43	8	51
10	0	10	10
11	0	10	10
12	0	10	10
13	41	11	52
14	0	7	7
15	0	8	8
16	0	12	12
17	41	11	52
18	0	10	10
19	0	13	13
20	0	11	11
Total	168	194	362
Average	84	97	18

Table 8. Distance of Rack Column to the Entrance/Exit

Location Area	Distance from door to Entrance (m)	Distance from door to Exit (m)	Location Area	Distance from door to Entrance (m)	Distance from door to Exit (m)	Location Area	Distance from door to Entrance (m)	Distance from door to Exit (m)	Location Area	Distance from door to Entrance (m)	Distance from door to Exit (m)
1	19.7	9.2	23	12.4	16.5	12	5	23.8	34	19.8	9
2	18.4	10.5	24	11	17.8	13	3.7	25.2	35	18.5	10.4
3	17	11.8	25	9.8	19.	14	2.4	26.5	36	17.2	11.7
4	15.7	13.2	26	8.5	20.5	15	23	5.8	37	15.8	13
5	14.4	14.5	27	7.2	21.8	16	21.7	7.2	38	14.5	14.4
6	13	15.8	28	5.8	23.2	17	20.4	8.5	39	13.2	15.7
7	11.7	17.2	29	26.5	2.4	18	19	9.8	40	11.8	17
8	10.4	18.5	30	25.2	3.8	19	17.7	11	41	10.5	18.4
9	9	19.8	31	23.8	5	20	16.4	12.5	42	9.2	19.7
10	7.7	21.2	32	22.5	6.4	21	15	13.8	43	30	2.4
11	6.4	22.5	33	21.2	7.7	22	13.7	15.2	44	28.5	3.7

1 rack column consis**ts of 3 layers, 1 layer contains 1 pallet, so the number of pallet per rack column =3 pallets.**

Maximum number of pallet = 47 pallets.

Number of column needed = 47/3 = 16 rack column.

Remainder Size of Warehouse

Size of warehouse needed for rack column = Size of rack area x number of rack =

9.0678 x 16 =155,085 $m^{2.}$

Size of warehouse for office = 17.5 $m^{2.}$

Size of *main board area* = 5 $m^{2.}$

Size of warehouse needed 155,085 m^2.

Remainder Size of Warehouse = Size of warehouse – Size of warehouse for office –size of *mainboard area* – Size of warehouse needed = 697.5 - (17.5 + 5 + 155.85) = 519.15 m^2

Because the size of warehouse needed is smaller, then the rack layout can be redesigned as follows:

Calculation of the distance of Entrance/ Exit to the Storage Location

1 rack consists of 2 columns.

1 column consists of 3 layers.

1 layer contains 1 pallet.

Number of pallet per column = 3 pallets. Number of pallet per rack = 6 pallets.

Length of rack = 2,667 mm.

Length of column = 2,667/2 = 1.3335 m.

The distance of column location to the Entrance/Exit is shown in Table 8.

Cost of Cargo Movement

The cost of cargo movement is calculated based on the operational cost/ distance in 1 hour. Operational cost is the depreciation cost of equipment + fuel cost + cost of operator per hour broken down as follows:

a. Depreciation cost of equipment

Depreciation cost of trolley = IDR 22,500/month = IDR140.625/hour

Depreciation cost of forklift = IDR 1,500,000/moth = IDR 9375/hour

b. Fuel cost

For trolley = IDR 0/hour, and for forklift = IDR 3,500/hour

c. Cost of operator

For trolley = IDR 5000/hour, and for forklift = IDR 10,000/hour

d. Average distance

Average distance = distance per month/ working hour per month

For *trolley* = 5,000/160 hours = 31.25m/ hour

For *forklift* = 28,000/160 hours = 175 m/hour

e. Transporting cost

For *trolley* = (140.625 + 5,000)/31.25 m = IDR 164.5/m

For *forklift* = (9,375 + 35,000 + 10,000)/175 m = IDR 310.72/m

9. Calculation by Warehouse Layout Method (for location 42)

Number of column needed = 16 columns,
Frequency of inward movement = 10 times,
Frequency outward movement = 10 times,
Total frequency of movement = 20 times,
Transporting cost by forklift = IDR 310.72/m,
Distance from Exit (outward door) to rack column = 19.7 m,
Distance from Entrance (inward door) to rack column = 9.2 m

$$\text{Transporting cost} = \frac{(310.72 \times 10 \times 19.7) + (310.7 \times 10 \times 9.2)}{16} = \text{IDR } 5{,}606$$

In order to facilitate the calculation of

transporting cost and the location of goods in each column, WinQsb program is used.

The result of calculation using WinQsb program is shown in Table 9.

In addition to the cost, cargo placement can also be determined by using Winqsb program as shown in Table 10. below.

10. Cargo placement on the rack column based on *dedicated storage*

See Table 10. Cargo Placement on Rack Column Based on Dedicated Storage

The cost of cargo movement using *Cube per Order Index Storage* method is calculated based on frequency (Fi), cost (Ci), and distance (Si). Table 11 shows the cost of cargo movement.

11. Cost of Cargo Movement

See Table 11. Cost of Cargo Movement

12. Data on Cargo Inward/Outward Movement in Import Warehouse

Calculation for Material A

See Table 12. Data on Cargo Inward/ Outward Movement in Import Warehouse for Material A in the Period of 25 Months

13. Data on the Number of Pallets in Inward/Outward Movement in Import Warehouse for Material A during 25 Months

If the maximum cargo per plastic pallet is 31 kg, then the number of pallets needed during the inward/outward movement of cargo A is shown in Table 13.

Table 13. Data on the Number of Pallets in Inward/Outward Movement in Import Warehouse for Material A during 25 Months

14. Data on the Frequency of Inward/ Outward Transportation of Cargo A (fi)

If the load capacity of forklift = 1 pallet, then the frequency of in/out movement of forklift is shown in Table 14.

Table 14. Data on the Frequency of Forklift Movement in Warehouse for Material A during 25 Months

Total average of the movement frequency of cargo A during 25 months = 518,038 times.

15. Determining Maximum Number of Pallets Needed

The maximum number of pallets needed is calculated based on the total number of pallets needed; in period 22 there are 89,218 pallets. It means that import cargo needs 89,218 plastic pallets.

16. Determining the Column and Rack Needed

A rack consists of 1,053 columns. Each column has 3-4 layers, each layer contains 1 pallet, and 1 rack can be loaded with 2 pallets per column.

The number of columns in the import warehouse is only 1,386, it is multiplied by 2; or only 2,773 pallets can be accommodated in the import warehouse area (the size of area is 2,722 cubic meter). If the maximum number of pallets needed for import cargo is 89,218, then in order to determine how many columns needed we can calculate 89.218 pallets is divided by 2, so that we find the number of columns; i.e. 44,609 columns.

Since the import warehouse of PT JAS still needs as many as 43,223 columns, it can be overcome by applying *open storage* and utilizing other warehouses—moreover, not all general cargo has the size that is in accordance with the size of plastic pallet.

In other words, half of the area can

Table 9. Result of Cost Calculation and Cargo Layout using WinQsb program

No	From	To	Shipment	Unit Cost	Total Cost	Reduced
1	Source 12	1	1	6	6	0
2	Source 15	2	1	6.7	6.7	0
3	Source 15	3	1	6.7	6.7	0
4	Source 15	4	1	6.7	6.7	0
5	Source 15	5	1	6.7	6.7	0
6	Source 13	6	1	6.7	6.7	0
7	Source 13	7	1	6.7	6.7	0
8	Source 13	8	1	6.7	6.7	0
9	Source 13	9	1	6.7	6.7	0
10	Source 12	10	1	6	6	0
11	Source1 2	11	1	6	6	0
12	Source 11	12	1	6.7	6.7	0
13	Source 11	13	1	6.7	6.7	0
14	Source 11	14	1	6.7	6.7	0
15	Source 11	15	1	6.7	6.7	0
16	Source 2	16	1	5.6	5.6	0
17	Source 2	17	1	5.6	5.6	0
18	Source 2	18	1	5.6	5.6	0
19	Source 2	19	1	5.6	5.6	0
20	Source 3	20	9	9	9	0
21	Source 3	21	9	9	9	0
22	Source 3	22	9	9	9	0
23	Source 4	23	1	6.7	6.7	0
24	Source 4	24	1	6.7	6.7	0
25	Source 4	25	1	6.7	6.7	0
26	Source 4	26	1	6.7	6.7	0
27	Source 2	27	1	5.6	5.6	0
28	Source 2	28	1	5.6	5.6	0
29	Source 2	29	1	5.6	5.6	0
30	Source 2	30	1	5.6	5.6	0
31	Source 2	31	1	5.6	5.6	0
32	Source 6	32	1	6.7	6.7	0
33	Source 6	33	1	6.7	6.7	0
34	Source 6	34	1	6.7	6.7	0
35	Source 6	35	1	6.7	6.7	0
36	Source 7	36	1	6.7	6.7	0
37	Source 7	37	1	6.7	6.7	0
38	Source 7	38	1	6.7	6.7	0
39	Source 8	39	1	6.7	6.7	0
40	Source 9	40	1	6	6	0
41	Source 9	41	1	6	6	0
42	Source 9	42	1	6	6	0
43	Source 2	43	1	6	6	0
44	Source 5	44	1	6	6	0

Table 10. Cargo Placement on Rack Column Based on *Dedicated Storage*

Location of rack column	Cargo Number	Location of rack column	Cargo Number
1	12	23	4
2	15	24	4
3	15	25	4
4	15	26	4
5	15	27	2
6	13	28	2
7	13	29	2
8	13	30	2
9	13	31	2
10	12	32	6
11	12	33	6
12	11	34	6
13	11	35	6
14	11	36	7
15	11	37	7
16	2	38	7
17	2	39	7
18	2	40	9
19	2	41	9
20	3	42	9
21	3	43	2
22	3	44	5

Table 11. Cost of Cargo Movement

Cargo Number	Cargo Name	Fi	Ci	Si	CiFi/Si
1	A	2	310.72	2	310.72
2	B	20	310.72	16	388
3	C	6	310.72	3	621
4	D	6	310.72	4	466
5	E	6	310.72	5	372
6	F	6	310.72	4	466
7	G	6	310.72	4	466
8	H	2	164.5	1	329
9	I	4	310.72	3	414
10	J	2	164.5	1	329
11	K	6	310,72	4	466
12	L	4	310,72	3	414
13	M	6	310,72	4	466
14	N	18	310,72	16	349
15	O	6	310,72	4	466

Table 12. Data on Cargo Inward/Outward Movement in Import Warehouse for Material A in the Period of 25 Months

No	Period	Cargo Beginning Stock	In	Out	Cargo Final Stock
1	Jan-10	495,292.50	6,190,751.23	5,885,359.33	1
2	Feb-10	800,684.40	5,942,928.83	5,225,110.93	2
3	Mar-10	1,518,502.30	8,044,654.64	7,291,107.24	3
4	Apr-10	2,272,049.70	7,368,019.58	7,890,657.57	4
5	May-10	1,749,411.71	7,832,487.06	7,888,839.41	5
6	Jun-10	1,693,059.36	7,666,566.64	7,787,397.14	6
7	Jul-10	1,572,228.86	7,816,797.21	7,969,652.81	7
8	Aug -10	1,419,373.26	8,194,156.00	7,353,039.80	8
9	Sep-10	2,260,489.46	4,318,926.30	4,914,779.50	9
10	Oct-10	1,664,636.26	6,863,405.70	5,953,681.20	10
11	Nov-10	2,574,360.76	7,885,363.40	7,944,295.00	11
12	Dec-10	2,515,429.16	7,712,805.20	8,332,747.40	12
13	Jan-11	1,895,486.96	7,866,778.80	7,614,305.90	13
14	Feb-11	2,147,959.86	6,604,426.00	6,439,054.50	14
15	Mar-11	2,313,331.36	8,988,234.80	9,119,516.60	15
16	Apr-11	2,182,049.56	8,487,566.50	8,516,588.20	16
17	May-11	2,153,027.86	8,743,157.70	8,578,692.70	17
18	Jun-11	2,317,492.86	9,083,472.10	8,857,177.80	18
19	Jul-11	2,543,787.16	9,423,626.00	9,455,165.30	19
20	Aug -11	2,512,247.86	8,145,396.60	8,668,779.10	20
21	Sep-11	1,988,865.36	8,976,792.60	8,655,412.90	21
22	Oct-11	2,310,245.06	9,629,127.50	9,173,615.30	22
23	Nov-11	2,765,757.26	9,961,973.20	10,154,105.50	23
24	Dec-11	2,573,624.96	11,148,009.20	11,298,080.20	24
25	Jan-12	2,423,553.96	8,802,784.60	8,813,939.60	25

Table 13. Data on the Number of Pallets in Inward/Outward Movement in Import Warehouse for Material A during 25 Months

NO	Period	Beginning Stock of Pallet	In	Out	Final stock of Pallet
1	Jan-10	15.977	199.702	189.850	25.829
2	Feb-10	25.829	191.707	168.552	48.984
3	Mar-10	48.984	259.505	235.197	73.292
4	Apr-10	73.292	237.678	254.537	56.433
5	May-10	56.433	252.661	254.479	54.615
6	Jun-10	54.615	247.309	251.206	50.717
7	Jul-10	50.717	252.155	257.086	45.786
8	Aug 10	45.786	264.328	237.195	72.919
9	Sep-10	72.919	139.320	158.541	53.698
10	Oct-10	53.698	221.400	192.054	83.044
11	Nov-10	83.044	254.367	256.268	81.143
12	Dec-10	81.143	248.800	268.798	61.145
13	Jan-11	61.145	253.767	245.623	69.289
14	Feb-11	69.289	213.046	207.711	74.624
15	Mar-11	74.624	289.943	294.178	70.389
16	Apr-11	70.389	273.792	274.729	69.453
17	May-11	69.453	282.037	276.732	74.758
18	Jun-11	74.758	293.015	285.715	82.058
19	Jul-11	82.058	303.988	305.005	81.040
20	Aug 11	81.040	262.755	279.638	64.157
21	Sep-11	64.157	289.574	279.207	74.524
22	Oct-11	74.524	310.617	295.923	89.218
23	Nov-11	89.218	321.354	327.552	83.020
24	Dec-11	83.020	359.613	364.454	78.179
25	Jan-12	78.179	283.961	284.321	77.819

Table 14. Data on the Frequency of Forklift Movement in Warehouse for Material A during 25 Months

NO	Period	In	Out	Total
1	Jan-10	199.702	189.850	389.552
2	Feb-10	191.707	168.552	360.259
3	Mar-10	259.505	235.197	494.702
4	Apr-10	237.678	254.537	492.215
5	May-10	252.661	254.479	507.140
6	Jun-10	247.309	251.206	498.515
7	Jul-10	252.155	257.086	509.240
8	Aug-10	264.328	237.195	501.522
9	Sep-10	139.320	158.541	297.861
10	Oct-10	221.400	192.054	413.454
11	Nop-10	254.367	256.268	510.634
12	Des-10	248.800	268.798	517.598
13	Jan-11	253.767	245.623	499.390
14	Feb-11	213.046	207.711	420.757
15	Mar-11	289.943	294.178	584.121
16	Apr-11	273.792	274.729	548.521
17	May-11	282.037	276.732	558.769
18	Jun-11	293.015	285.715	578.731
19	Jul-11	303.988	305.005	608.993
20	Aug-11	262.755	279.638	542.393
21	Sep-11	289.574	279.207	568.781
22	Oct-11	310.617	295.923	606.540
23	Nov-11	321.354	327.552	648.906
24	Dec-11	359.613	364.454	724.067
25	Jan-12	283.961	284.321	568.281
Total		6.506.394	6.444.552	12.950.945
Average		**260.256**	**257.782**	**518.038**

be converted; i.e. 1,300 columns multiplied by 2, then it results 2,600 as the number of pallets needed, or it equals the space of 2,519 cubic meter. Now, the total number of columns in the import warehouse becomes 2,686 which is obtained from the calculation 1,386 + 1,300 columns, so that the lack for column is 41,923. If 41,923 columns are converted to the number of racks, then the import warehouse needs 3,494 racks (note: each rack has 12 columns).

17. Determining the size of area for Cargo A (Si)

The size of warehouse area needed for import cargo storage is: total rack x size of rack (square meter); if the size of rack is 149.35 cubic meter and the number of rack needed is 1 (4 layers and 12 columns), then 3,494 racks x 149.35 cubic meter = 521,828.9 cubic meter.

Calculating the size of area needed for other goods that are stored:

The calculation of the total area needed for storing all cargo is 2,722 cubic meter (the existing racks) plus 2,519 cubic meter (warehouse area conditioned as racks), plus 521,828.9 cubic meter (lack space), so that the total area needed for maximization is 527,069.9 cubic meter. If converted into percentage, the existing racks is 0.52% and the warehouse area conditioned as rack is 0.48%, and additional space needed is 99.01%.

As a solution, some types of cargo frequently handled by warehouse have been converted; namely 1) long or unsymetric (*odd size*) cargo, 2) *heavy cargo*, 3) *bale cargo*, since the portion of the three types of cargo is 25% of the total tonnage stored in the warehouse during October 2011 (as the biggest total tonnage). Subsequently, the 25% of total tonnage can be equalized or converted with 99,01% as the space filler that is counted as lack/shortage or with no rack utilization. Therefore, warehouse maximizataion can be done using the right layout as well as the calculation using the above *cub per index* method and as explained in Figure 5, 6, 7, and 8 below.

To maximize the space, during the

Total Space

Label	Available (m^3)
Rack 520	1,808
Rack DG	33
Open Storage	583
Cool Storage	1,011
Open DG	54
Strong Box	45
Kerangkeng Barang Kecil	369
Ruang Periksa I	
Ruang Periksa II	
Preparation Area 520	
Cantilever	166
Total Space	4.070

Additonal 521

Label	Available (m^3)
Rack 521	927
VAL/VUN	363
Total Space	1.290

The total size of building 520 + 521 has been calculated on a 2,722 cubic meter space and additional space = 2,519 cubic meter (for dangerous cargo rack 53, cooling room 1,011, open dangerous cargo storage 54 , security room 45, verification room 369, and valuable goods space 363 + space for preparing area 624) = 5,241 cubic meter, while the space in the nexty table calculated that the total size of building 520 + 521 becomes 4,070 + 1,290 = 5,360 cubic meter. Therefore the rest of the available space 5,360 – 5,241 = 119 cubic meter, 119 cubic meter is only sufficient for heavy cargo in big package and cylinder or the size of log about 6 tons/cubic meter. Thus, the total cargo can be converted is 714 tons or 714,000 kilograms or 25% of the total cargo (calculated from the final goods stock in October 2011), and this calculation matches the average of – cargo size which enter at the observation, in percentage as follows: 1% + 9% + 15% = 25%, (long, heavy, and log)

Source: Proyek London PT JAS, ODP 2012

Figure 5. Total warehouse Space of PT Jasa Angkasa Semesta Tbk, Building 520 and 521.

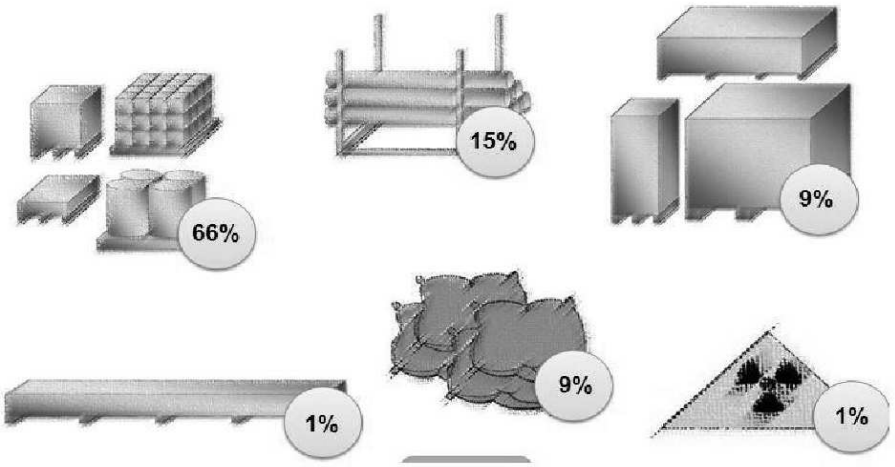


Figure 6. The contribution of cargo based on the dimension in the PT JAS warehouse (2010)v

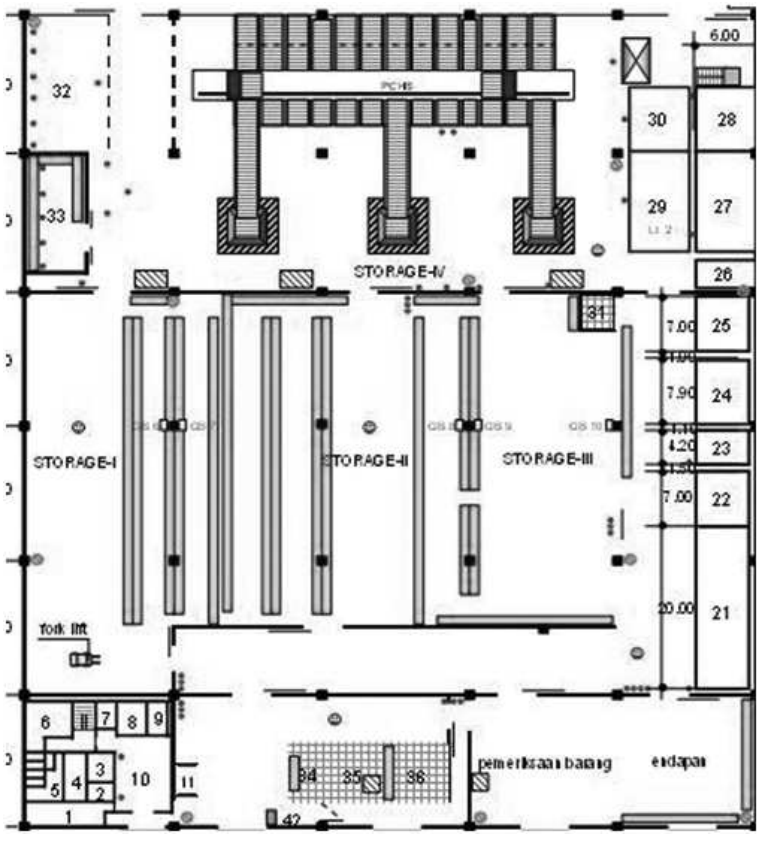


Figure 7. Previous layout of Import Warehouse in 2009

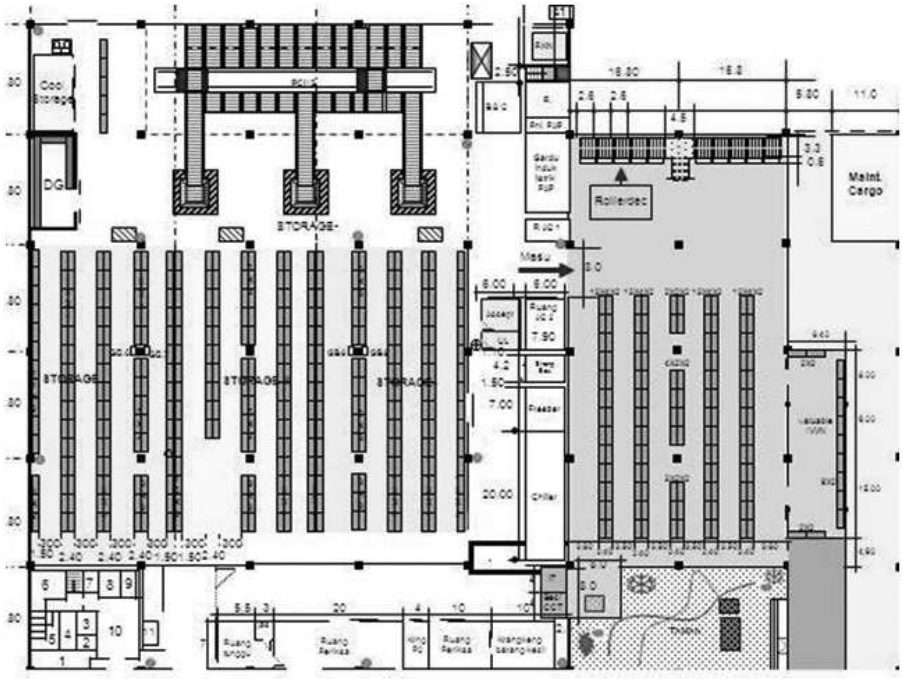


Figure 8. The layout proposed for Import Warehouse in 2010, to be used in 2011

peak season of cargo, Building 520 with 1,796 racks (1,038 columns and Building 521 with 927 racks (348 columns) = totally 2,722 racks (1,386 columns), however, it still needs 3,494 racks more (41,923 columns).

Conclusion

During 2010, the growth of import cargo volume in PT JAS experiences six times increase, and at least five times decrease. The increase occured in March, May, June, July, August, October and November, whereas the decrease happens in February, April, June, September dan December. For one year, in the periode of Januari up to December 2010, the volume of import cargo received by PT Jasa Angkasa Semesta was 85,752,386 kilograms. The highest volume of import cargo in 2010 happens in August with total volume 8,194,156 ... **tidak jelas** .. and the percentage 5% of the total volume of import cargo received by PT Jasa Angkasa Semesta for one year; that is 85,752,386 kilograms. The lowest volume of import cargo in 2010 happens in September with total volume of import cargo as much as 4,318,926 with percentage of -47% from the total volume of import cargo received by PT Jasa Angkasa Semesta for one year; that is 85,752,386 kilograms.

In the meantime, the effectiveness of import warehouse utilization has recorded the highest effectiveness happening in March, April, May, June, July, August, November, as manay as 11 points. The highest utilization of warehouse happens in August 2010 with the volume of warehouse utilization 264,327.61 kilograms, or 106% of the available volume; 248,843.84 kilograms. While the lowest utilization of warehouse happens in January 2010, as many as 143,964.21 kilograms, or 58% of the available volume, as many as 248,843.84 kilograms.

The layout redesigning of import warehouse of PT JAS at Soekarno-Hatta International Airport branch using *Cub per Order Index* (COI) method is based on the

cost of cargo flow related to the current condition, especially in 2010, by regarding the various types of goods managed by PT JAS, the volume of inward cargo, and the effectiveness of utilization. Therefore, by redesigning the layout of import warehouse, it will be able to maximize the utilization of warehouse space a hundred percent.

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