Determining The Optimal Location of Central Spare Part Warehouse for The Leading Taxi Company in Indonesia

Aziz Syam[1], Muh'amat Arifin[2], Humiras Hardi Purba[3]
[1](Student, Industrial-Engineering Department, Mercu Buana University, Jakarta, Indonesia,email: azizsyam8@gmail.com)
[2] (Student, Industrial-Engineering Department, Mercu Buana University, Jakarta, Indonesia, email: arifinragil@yahoo.co.id)
[3] (Lecturer, Industrial-Engineering Department, Mercu Buana University, Jakarta, Indonesia, email: humiras.hardi@mercubuana.ac.id)

ABSTRACT
As the largest taxi company in Jakarta and Indonesia, Blue Bird taxi has a central spare parts warehouse that serves 31 taxi pool points in Jakarta and surrounding satellite cities. The center of gravity analysis method is used to find the optimal central spare part warehouse location which will have an impact on saving the entire pool of the warehouse. The calculation results obtained the optimal location at the coordinates x (655) and y (377) where the location of the excitation is in the area of Mampang Prapatan. The best recommendation is to place the warehouse location in the nearest pool from the coordinates, the Warung Buncit or Kalibata pool.

Keywords *-Center of gravity, Warehouse, Taxi*

I. INTRODUCTION

Higher than New York, which is only 1.6, the availability of taxis in Jakarta reaches 2.65 per 1,000 population as reported by the BBC. Singapore is the benchmark for the taxi industry in Jakarta, where Singapore has a figure of 5.2 taxis per 1,000 residents. The increasing level of economic growth has affected the need for the taxi in Indonesia, especially for people in the city with poor public transportation. Taxi business in Indonesia is predicted not to experience saturation even though the development of online taxis is also increasingly stretching.

Blue Bird Group is a leading and most popular transportation company, which has reputation for high standards in providing taxi services to major cities throughout Indonesia. It has 61 depots located in various cities such as Jakarta, Banten, Bandung, Semarang, Surabaya, Bali, Lombok, Medan, Padang, Batam, Pekanbaru, Palembang, Makassar, and Manado, making this company that has a blue bird logo continues to grow and innovate with reliable technology and management systems.

Distribution center or warehouse location decisions are one part of the supply chain management. Functional distribution center locations can decrease organization's transportation costs and cut down inbound and outbound lead times. Leadtime shortenings, consequently, make inventory control easier and thus most likely increase service level [1]. The nature of spare parts business adds its own characteristics to warehousing and thus also to location decision. The volatile demand of spare parts increases the need for effective operation[2].

In order to support supply chain effectiveness, determine the location of a spare part warehouse for 31 Blue Bird taxi depots in the Jakarta area to be a decision that will have an impact on efficiency to increase company profit which is the case study of this research.

A spare part warehouse will later serve all depots in Jakarta area that were previously served by each pool location. The company's policy to make those warehouses become one is the basis of the purpose of this research so that the final result will be a recommendation for the implementation of the policies that have been made.

II. LITERATURE REVIEW

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but are not limited to, new product development, marketing, operations, distribution, finance and customer service[3]. Supply Chain Management (SCM) refers to "a set of systematic, strategic coordination, and methods used to effectively coordinate suppliers, producers, depots, and stores, so that commodity is produced and distributed at the correct quantities, to the correct locations, and at the correct time, in order to reduce system cost while satisfying service level requirements. The fundamental notion of these definitions is that a Supply Chain must be controlled in order to be fast and trustworthy, cost-effective, and flexible enough to meet customers' requirements [4].

Location in each facility has an impact on costs and activities, in order to deliver products with efficient services. The center of gravity method used to determine the location of a facility such as a warehouse or a factory is part of the development strategy of the Supply Chain Management network.

The gravity location model is based on the selection of coordinate points for distribution center that gives the totalshortest distance to the production zone or customer that must be supplied. This model uses several assumptions, namely: 1) The cost of transportation costs is assumed to increase in proportion to the volume transferred. 2) Good supply sources and the location of the production can be located on a map with clear X and Y coordinates [5].

If there are i demand regions (i=1, …n) with coordinates x_i and y_i with weights or demand density at each region i represented by ω_i , then center of gravity give everage weighted coordinate. The center of gravity coordinates x_g and y_g will not minimize the distance travelled by the customer but will give average of weighted customer located in different regions with varying demand density

$$x_g = \frac{\sum_{i=1}^{n} \omega_i x_i}{\sum_{i=1}^{n} \omega_i} \quad (1)$$

$$y_g = \frac{\sum_{i=1}^{n} \omega_i y_i}{\sum_{i=1}^{n} \omega_i} \quad (2)$$

In 2015, Onnela conducted research to determine the optimal location for Kalmar's European Distribution Center with a qualitative and quantitative approach. Research which is a combination of case study and action-oriented study aims to cover the most important themes of warehousing and location decision with respect to the case company's situation. Even though changing the location is not recommended action of that research, but the result of the center of gravity analysis was a point in the western part of Germany[6].

The study used the Center of Gravity (COG) method to determine the location pf the warehouse previously in Bogor in the case of a tire company conducted by Rully and Aldenia, who obtained a new location which was more optimal for the company, which was moved in the city of Solo [7].

The network development strategy of supply chain management research in 2015 by Yunitasari used Gravity Location Models method to determine the optimal location or local warehouse position of a company. This study produces the optimal coordinates of the method of narrative with the most minimal transportation cost [8].

Summarizing the various studies that have been conducted in relation to the determination of locations with the Center of Gravity method, there has not yet been found a study with a case study of taxi companies with spare part warehouse that serves demand or purchases from a pool point in a city.

III. RESEARCH METHODOLOGY

The methodology used in this analysis refers to the center of gravity method for location determination by using data from the Blue Birdtaxi companyin Jakarta area.

As shown in figure 1, the flow of this research begins with identifying problems, followed by literature studies. Datacollection methods in this study are divided into two parts, namely data sources and data collection. Data sources related to this research are primary and secondary data. Primary data is collected through data collection methods from report documents related to the number of spare parts purchased from various taxi depots in the Jakarta area. Secondary data is obtained from the internet as a reference for the coordinates of each depot on a city scale.

Data collection is done by determining the location of the sample from *google maps* to find out the coordinates of the location of the taxi depot which totaled 31 points in five Jakarta's region and some in its satellite cities such as Tangerang, Depok, and Bekasi. Customer demand data is obtained from the total purchase of all depots served by three existing spare part warehouse.

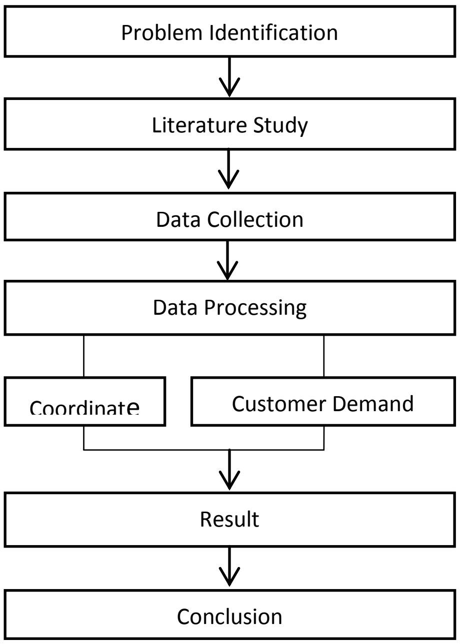

Figure 1: Research Flow

IV. DATA COLLECTION

Data processing to determine the location point of the Blue Bird taxi company spare part warehouse in the Jakarta area is divided into two parts. The first part is the coordinates of the location of the taxi pool spread over 31 points. The second data which in this case is interpreted as the spare part demand data from 31 taxi pools.

A. Coordinate

Coordinate points spread across the 31 existing pool points of the Blue Bird taxi company are placed on the Jakarta map which has been divided into 12 parts on the X-axis and 7 parts on the Y-axis as shown in figure 2. The broad scope of the existing taxi pool points distribution, boundary data obtained from the farthest node of the four wind direction. The west side is the Curug pool at coordinates (20,420), the northernmost side is the Kelapa Gading pool (790,620), Tambun pool is the easternmost node (1130,360), and the southernmost is the Siliwangi Depok pool node (610,50).

B. Demand

The number of demand obtained from the results of real data from the total purchase of spare parts in the existing five warehouses. The existing warehouse serves 31 points that have been describing in the previous discussion. The data obtained is the number of spare parts purchased in each taxi pool for one year in rupiah, as shown in table 1.

Table 1: Demand Data of Blue Bird Taxi Pool

CODE	POOL	DEMAND (Rupiah)
A	Garuda	85,258,268
B	Wr. Buncit	2,105,073,957
SY	Sutoyo	122,843,755
C	Ciputat	1,317,255,311
D	Kramat Jati	250,441,964
CJ	Cijantung	276,732,624
E	Daan Mogot	333,164,665
CD	Cipondoh	46,461,534
CU	Curug	32,077,798
F	Puri Indah 2	151,971,239
G	Narogong	264,017,016
H	Cimanggis	444,625,906
KA	Kranggan	58,852,509
SD	Siliwangi Depok	91,277,712
J	Bintaro	602,990,450
BD	BSD	130,885,702
K	Kelapa Gading	506,609,519
L	Pondok Cabe 2	458,345,770
T	Pondok Cabe 1	89,571,886
M	Japos	174,869,242
JO	Joglo	87,247,962
MM	Marga Mulya	99,096,587
TB	Tambun	68,820,142
MW	Margasatwa/Pinang	104,806,397
N	Penggilingan	299,492,755
O	Ciputat 2	101,027,120
LB	Lebak Bulus	101,115,124
P	Puri Indah 1	405,921,079
R	Radin Intan	545,660,254
S	Halim	125,335,569
X	Kalibata	400,362,477

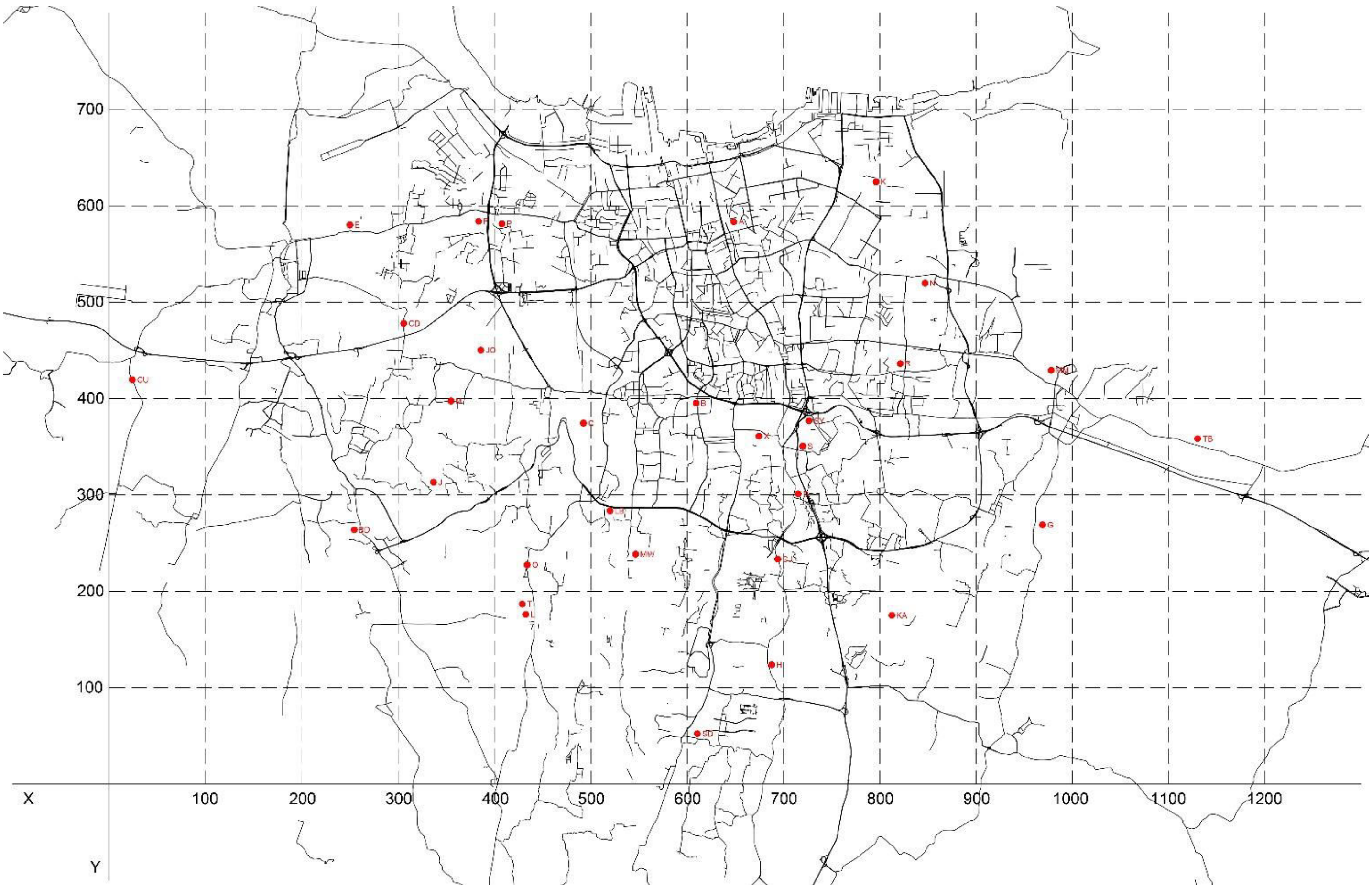

Figure 2: Map of Location Points of Blue Bird Taxi Pool in Jakarta Area

V. RESULT

Simplify the calculation of the desired gravity point weight (ω) in each taxi pool, the number on demand is divided equally, which is equal to 500.000. In Table 2 the data consisting of coordinate points (x, y) and synchronized demand will be processed to be included in the as mathematical equation in (1) and (2) from the Center of Gravity formula.

Table 2: Font Sizes for Papers

CODE	POOL	x	y	ω
A	Garuda	65	590	171
B	Wr. Buncit	610	390	4210
SY	Sutoyo	730	380	246
C	Ciputat	490	380	2635
D	Kramat Jati	720	300	501
CJ	Cijantung	690	230	553
E	Daan Mogot	250	580	666
CD	Cipondoh	310	480	93

CU	Curug	20	420	64
F	Puri Indah 2	380	580	304
G	Narogong	970	270	528
H	Cimanggis	690	130	889
KA	Kranggan	810	170	118
SD	Siliwangi Depok	610	50	183
J	Bintaro	340	310	1206
BD	BSD	250	265	262
K	Kelapa Gading	790	620	1013
L	Pondok Cabe 2	430	180	917
T	Pondok Cabe 1	430	185	179
M	Japos	360	400	350
JO	Joglo	385	450	174
MM	Marga Mulya	980	430	198
TB	Tambun	1,130	360	138
MW	Margasatwa /Pinang	550	240	210
N	Penggilingan	850	520	599
O	Ciputat 2	430	230	202
LB	Lebak Bulus	510	280	202
P	Puri Indah 1	410	580	812
R	Radin Intan	620	440	1091
S	Halim	720	350	251
X	Kalibata	670	360	801

Getting the desired x and y coordinates, the center of gravity formula in equations (1) and (2) is used. The first step to get the most optimal coordinate point is to calculate the total (ω) multiplied by the axis (x) which is 31 points divided by the total number of total weight at 31 points.

$$x_g = \frac{\sum_{i=1}^{n} \omega_i x_i}{\sum_{i=1}^{n} \omega_i} \quad (1)$$

$$x_g = \frac{(\omega_1 x_1) + (\omega_2 x_2) + (\omega_3 x_3) + \ldots + (\omega_{31} x_{31})}{\omega_1 + \omega_2 + \omega_3 + \ldots + \omega_{31}}$$

$$x_g = \frac{(171\,.65) + (4210\,.610) + (246\,.380) + \ldots + (801\,.670)}{171 + 4210 + \ldots + 801}$$

$$x_g = \frac{11268465}{17200}$$

$$x_g = 655$$

Equation (1) shows that the *x*-axis result is 655 which is obtained from the division between the total numbers of loads multiplied by 31 points *x* divided by the total number of loads which is 17200. After obtaining the *x*-axis, then determine the *y*-axis with equation (2).

$$y_g = \frac{\sum_{i=1}^{n} \omega_i y_i}{\sum_{i=1}^{n} \omega_i} \quad (2)$$

$$y_g = \frac{(\omega_1 y_1) + (\omega_2 y_2) + (\omega_3 y_3) + \ldots + (\omega_{31} y_{31})}{\omega_1 + \omega_2 + \omega_3 + \ldots + \omega_{31}}$$

$$y_g = \frac{(171\,.590) + (4210\,.390) + (246\,.380) + \ldots + (801\,.360)}{171 + 4210 + 246 + \ldots + 801}$$

$$y_g = \frac{7451275}{17200}$$

$$y_g = 377$$

Based on the calculation above, the optimal point on the *y* axis is found at point 377. The point is obtained from the result of the division between the *y* coordinates multiplied by the load as a whole

VI. CONCLUSION

The application of the center of gravity method in determining the optimal location of the central spare part warehouse for the largest taxi company in Indonesia was obtained coordinates *x* (655) and y coordinates (377) which are shown in figure 3. At the existing condition point (655, 377) in the area Mampang Prapatan, South Jakarta.

The recommendation given to make this point optimal for actual conditions is the use of the closest pool that is still within the area of the point. The choice of pool that can be developed to become the central spare parts warehouse without buying a new land is at the Warung Buncit pool or the Kalibata pool.

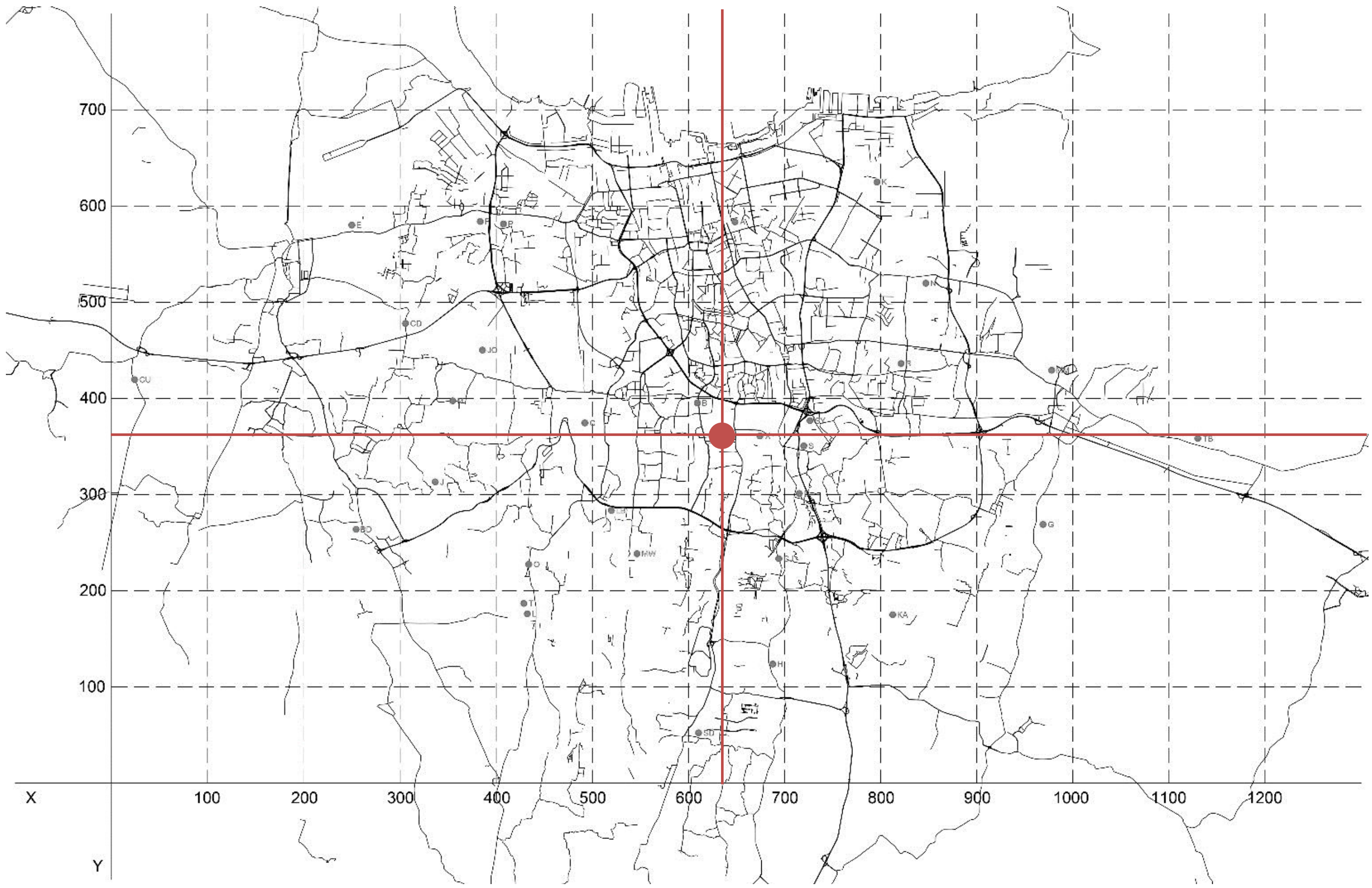

Figure 3: Map of Location Points of The Optimal Central Spare Part Warehouse

REFERENCES

[1] F. Gallmann and V. Belvedere, "Linking service level, inventory management and warehousing practices: A case-based managerial analysis," *Oper. Manag. Res.*, vol. 4, no. 1–2, pp. 28–38, 2011.

[2] J. Huiskonen, "Maintenance spare parts logistics: Special characteristics and strategic choices," *Int. J. Prod. Econ.*, vol. 71, no. 1–3, pp. 125–133, 2001.

[3] B. Columbus *et al.*, *Supply Chain Management Strategy , Planning, and Operation Sixth Edition*. 2016.

[4] J. T. Mentzer, J. S. Keebler, N. W. Nix, C. D. Smith, and Z. G. Zacharia, "JOURNAL OF BUSINESS LOGISTICS, Vol.22, No. 2, 2001 1," *J. Business, Defin. Supply Chain Manag.*, vol. 22, no. 2, pp. 1–25, 2001.

[5] W. Keller and S. Yeaple, "Gravity in the weightless economy," *NBER ITO Conf.*, pp. 1–57, 2009.

[6] N. Onnela, "Nona Onnela Determining the Optimal Distribution Center Location," no. February, p. 89, 2015.

[7] T. dan D. C. A. Rully, "Penggunaan Metode Center of Gravity dalam Penentuan Lokasi Gudang terhadap Meminimkan Biaya Transportasi pada PT Elangperdana Tyre Industry," pp. 64–69, 2014.

[8] Elly Wuryaningtyas Yunitasari, "Metode Gravity Location ABC.pdf." Surakarta, 2015.