Transportation Distances Reduction at Surabaya Distribution Center Using Anylogistix Software

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ABSTRACT

The delivery method of finished goods by the company Surabaya Distribution Center is to deliver to one customer location (single drop), and the truck size used will be adjusted based on the demand. The company considers the single drop inefficient since the usage of small trucks is significantly higher than that of larger trucks. Therefore, it is essential to change finished goods previously delivered using small modes of transportation to large ones. Since customer demand cannot be controlled, increasing the truck size could be achieved by merging several destinations in a truck (multidrop), reducing transportation distance. The problem of determining the optimal route to reduce the delivery route distance by considering the vehicle capacity is included in the Capacitated Vehicle Routing Problem with Time Windows (CVRPTW), which can be solved using Anylogistix. Anylogistix software was selected as a software tool for applying the simulation modeling approach based on the functionality, accessibility, simplicity, and convenience of use, as well as the degree of suitability of the models to the conditions of reality. The simulation begins with selecting the appropriate type of simulation, inputting data, applying research assumptions, and verifying and validating until a verified and validated simulation is obtained. Through a systematic approach, the Anylogistix simulation can reduce the distance of the routes, initially 280,258.7 km to 203,905.93 km (27.2% distance reduction). In addition, the results showed that the delivery of goods from small modes of transportation allocated to large modes of transportation was 181 shipments with optimal utilization of >70%.

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1. Introduction

Distribution Center (DC) is a warehouse owned by a Fast-Moving Consumer Goods (FMCG) company that stores and distributes products to its various distributors. In 2016 alone, Surabaya DC, which is located in Indonesia, carried out 986 deliveries by land using the Built Up, Colt Diesel Engkel (CDE), Engkel, Tronton, and Colt Diesel Double (CDD) truck transportation modes. The choice of truck transportation mode was chosen because of the ease of access to various locations and the flexibility of delivery frequency (Puspitasari et al., 2021). An effective delivery network is beneficial for achieving all supply chain needs, such as minimizing costs and providing a high response to consumer demand (Chopra & Meindl, 2007). The delivery method used by DC Surabaya is a single drop, i.e., shipments made from DC for a single destination. With the single drop method, the total distance that must be taken for shipping by land is 280,258.76 km. Surabaya Distribution Center expects delivery to be carried out using large modes of transportation or upsizing trucks and a multidrop delivery system, where delivery in the same week can be made in one delivery to several destination locations.

Anylogistix is a tool that can help the delivery strategy of goods become more effective and efficient. This tool can create simulations of shipping goods with optimal distances and routes, considering the capacity of the mode of transportation and the utility level of the vehicle. This study aims to determine the allocation of goods from small modes of transportation to large modes of transportation (truck upsizing) and determine multidrop shipping routes

in Surabaya DC, which can reduce delivery distance. The limitations applied in this study are that the data used is 2016 data, the maximum total vehicle mileage is 1,800 km per day, the delivery and receipt of goods is only carried out on the same day starting at 8 am – 5 pm, and this research does not consider road density, weather, road changes, and road operating hours. The assumptions used are that the loading and unloading time at the destination location is assumed to be 3,600 seconds, the number of vehicle fleets in the simulation is unlimited, the vehicle speed is constant with a speed of 70 km/hour, and delivery from Surabaya DC is assumed to be sent simultaneously at 08.00 WIB.

AnyLogistix software was selected as a software tool for applying the simulation modeling approach based on the functionality, accessibility, simplicity, and convenience of use, as well as the degree of suitability of the models to the conditions of reality (Zhukovskaya et al.,2022).

2. Theoretical Background

2.1 Capacitated Vehicle Routing Problem with Time Windows (CVRPTW)

Capacitated Vehicle Routing Problem with Time Windows (CVRPTW) is a modified form of the Capacitated Vehicle Routing Problem. CVRPTW is a type of VRP resulting from a combination of the general types of capacitated vehicle routing problems and vehicle routing problems with time windows, which aims to optimize delivery routes to meet customer demand with capacity constraints and specific service periods so that minimum time is obtained. Customer service begins within the specified period, and the vehicle must also arrive at the customer's location within the specified period. When the vehicle arrives at the location, but the customer is not ready for service, the vehicle must wait (Confessore et al., 2008).

2.2 Simulation

Simulation is an operation-research technique that is widely used. To perform a simulation, the model is numerically exercised for the inputs to observe how the inputs affect the output performance metrics (Law, 2015). Simulation is an imitation of a real system and can be done manually or with computer technology, which can then be observed for learning purposes. Simulation is also a method in which the reproduction or replication of a condition and situation is carried out using a model as testing material (Giyantoro, 2018). Simulation may be applicable in a highly complex system in which an analytical solution may not accurately describe a real-world system.

2.3 Anylogistix

Anylogistix is a tool that can be used to overcome various Supply Chain Management problems. It utilizes two technological bases —logistics system simulation and optimization—to provide answers to a range of decision-making issues in real-world logistics systems (Ivanov, 2020). By using Anylogistix, companies can be helped to ensure their business supply chains are structured and robust. Anylogistix can create a plan by optimizing the network using simulation modeling to test and develop it. Anylogistix has one of the Capacitated Transportation Optimization with Time Windows modules in the software. In this module, Anylogistix will be a tool for learning how to determine customer time intervals or operating hours and create delivery routes for customers who are visited in a specific order. Factors that need to be considered are customer demand and vehicle capacity. The experiments' results will contain a set of optimal routes obtained for each delivery considering all the specified constraints.

Anylogistix computational tool has been widely applied in the simulation of supply chain and logistics solutions in various contexts, such as examining the impact of the COVID-19 pandemic on food retail supply chain (Burgos & Ivanov, 2021), reducing medicine shortage in epidemic outbreaks (Lozano-Diez et al., 2020), designing immunization supply chain network (Prosser et al., 2021), and identifying possible DC for food distribution (Vitorino et al., 2022).

2.4 Previous research

In the previous study, Kurniawan et al. (2023) found optimal routes for solving capacitated vehicle routing problems with time windows. Using Anylogistix software can save more than 20% of the distances. Their research was conducted using the Anylogistix software to obtain an optimal delivery route design in solving capacitated vehicle routing problems with time windows.The previous study by Kurniawan et al. (2023) obtained three delivery route designs and route visualization results. Kurniawan et al. (2023) and Wijanarko and Sepadyati (2022) examine the delivery of products from the gas (energy) industry. Meanwhile, this research takes a case study from the

Distribution Center, a fast-moving consumer goods (FMCG) company, which makes a more significant number of deliveries and a larger number of customers who wish to re-examine the effectiveness of using Anylogistix in reducing delivery distances.

Yuliza et al. (2020) aim to determine the optimal route for overcoming Capacitated Vehicle Routing Problem (CVRP) route problems using optimization methods and with the help of Clarke's Algorithm and LINGO. Meanwhile, others discuss genetic algorithms with cluster-first route-second, which can design a minimal distribution path in overcoming the CVRPTW routing problem using the P-Median method (Putri et al., 2021). Nurlathifah et al. (2020) aim to optimize fuel distribution routes by applying CVRP using optimization methods and with the help of solver add-ins in Ms. Excel.

3. Methodology

The first step in this research method is identifying and formulating the problem, which is carried out to detect the existence of a problem that occurs in a company. From the results of identifying and formulating the problem using interviews, it was found that the mode of transportation for product distribution could have been more optimal because the company still used small trucks on a single drop basis, so the delivery distance traveled could have been more optimal. Furthermore, a literature study is carried out to find reference sources that can be used in solving problems and providing suggestions for improvements. Literature studies can come from journals, theses, or books that optimize distribution/delivery routes using the Capacitated Vehicle Routing Problem with Time Windows (CVRPTW) approach.

After obtaining and collecting 2016 Customer Sales data, which contains information on Plant, Shipment Date, Vendor Name, ID Route, Pick-up Area, Delivery Area, Cases, Weight, and Volume, the data will be entered into Ms. Excel. In addition, data is needed on the type of transportation mode selected and used for each shipment. The newer data can not be obtained, yet the data is still relevant since the customer locations are still relatively fixed. Moreover, the data entered in Ms. Excel will be sorted according to the delivery date requirements. Then, it is calculated and summarized based on the type and volume of transportation modes used and the location of the delivery destination using the help of the PivotTable feature in Ms. Excel. From the data, there is a high frequency of small trucks (<40 cbm), which is seen as a problem because of the higher cost/case compared to bigger trucks. Therefore, multidrop delivery is needed to accommodate high truck utilization and avoid small truck usage at once. Multidrop is something that could be done using the Transportation Optimization capability in Anylogistix Software.

Anylogistix has several modules, and the module used in this research is TO Capacitated Transportation Optimization with Time Windows, which emphasizes calculating the distance of many routes by considering the company's transportation capacity and working hours.

There are several assumptions and limitations in this study. The research will limit its study to land transportation since it will focus on delivery that is being delivered and arrives at customers within the same day. The working hours are 8 am to 5 pm, which is the regular hours for most transporters. Based on the interview with the logistics department, the maximum distance agreed by the transporter would be 1800 km. Since the trucks could be ordered from several third-party logistics providers, the number of trucks is assumed to be infinite. Moreover, it is estimated that an hour is needed to unload at the customer's warehouse. Lastly, the speed of trucks is assumed to be constant at 70 km/h. All these assumptions are put in the software, shown in Figure 1 and Figure 2 below.

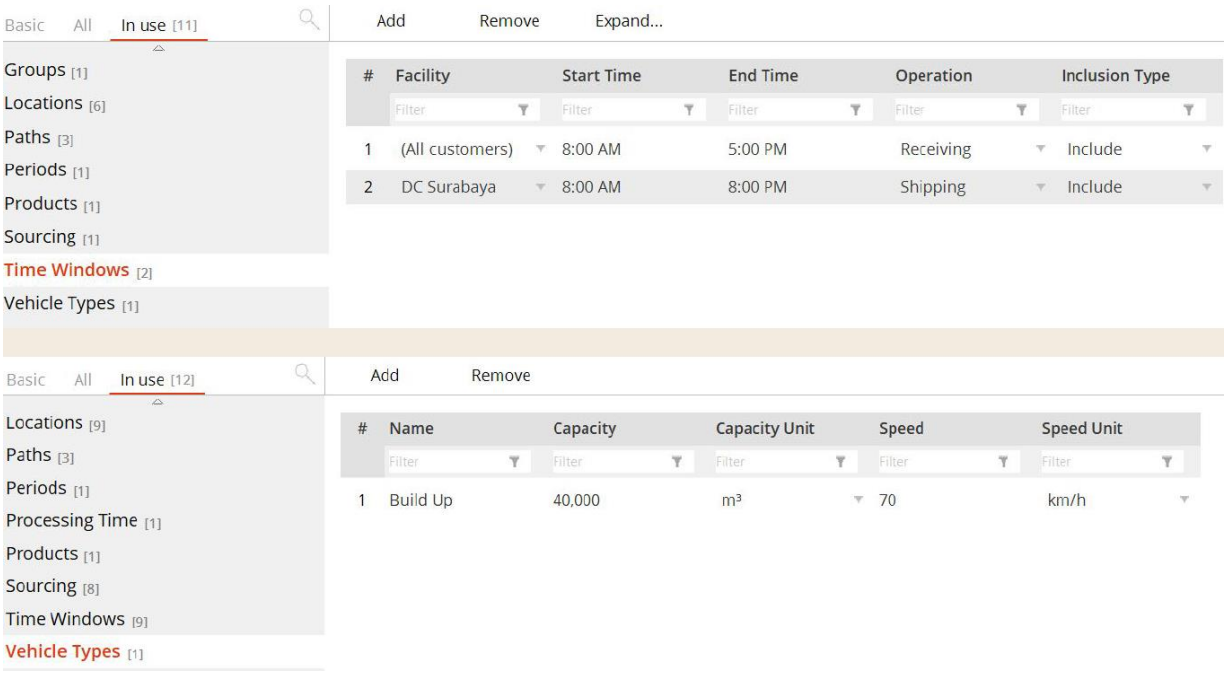

Figure 1. Time Windows and Vehicle Types Input

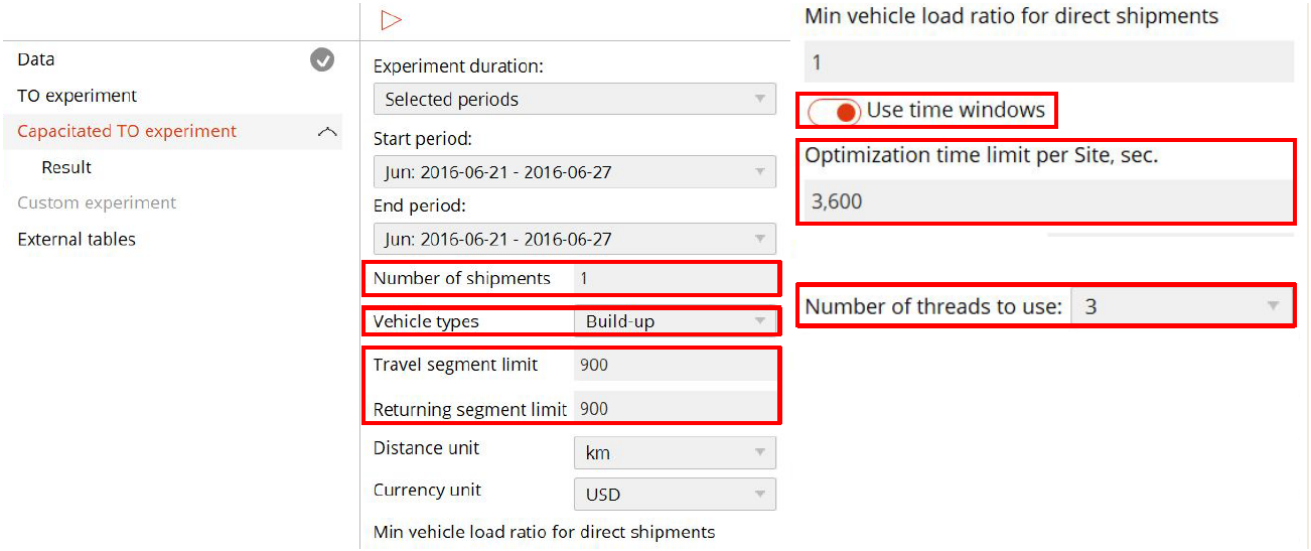

Figure 2. Daily Maximum Distance and Unloading Time Input in Anylogistix

All information gathered from the company inputted to software, resulting using 13 tables in Anylogistix, as in Figure 3 below.

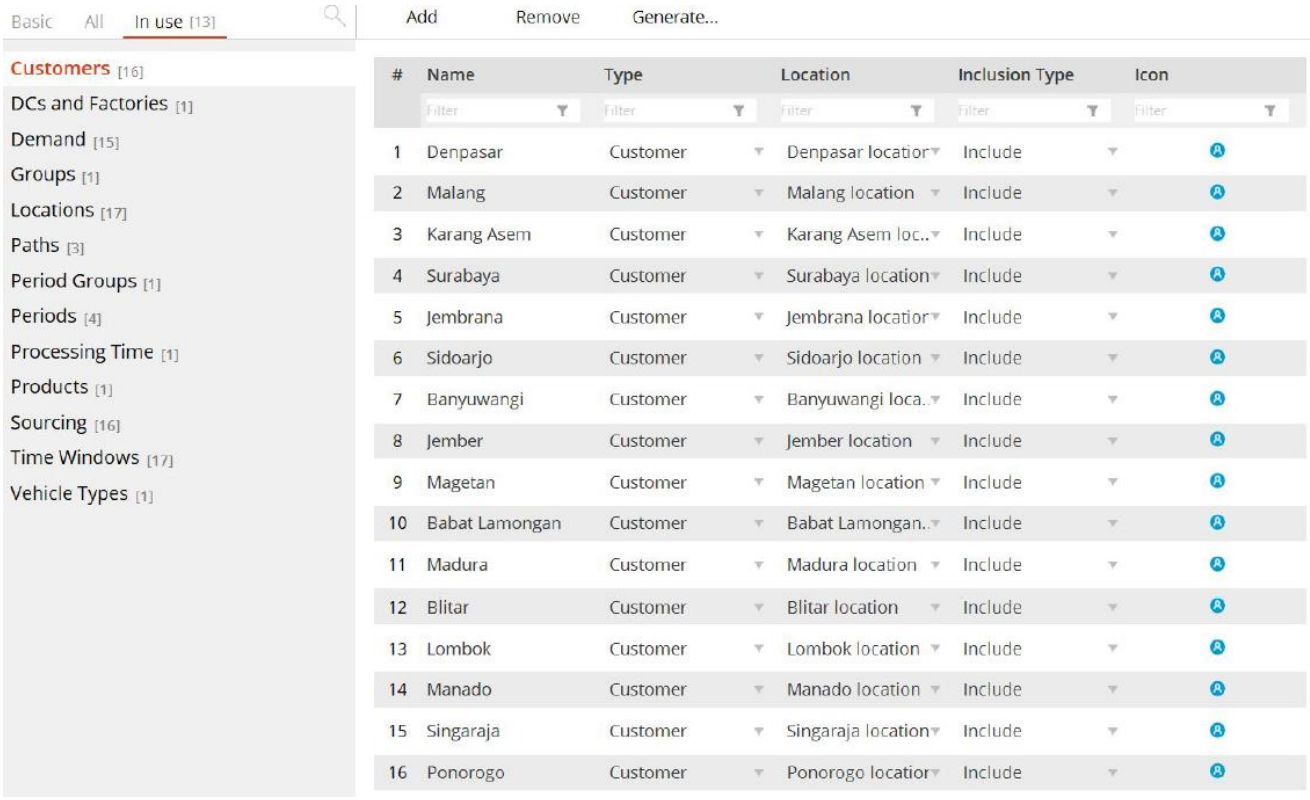

Figure 3. Tables used in Anylogistix to simulate current condition

The next step is to carry out a simulation to determine the optimal delivery route to each destination (delivery area), which will then be able to reduce the delivery distance from Surabaya DC. Software simulation results Anylogistix will show data on the target customer, delivery period, mode of transportation used, DC location, distance traveled, and volume or capacity transported. Apart from that, Anylogistix can also show simulation results visually in the form of delivery routes from one location to another on a map. The results of determining the delivery route are also equipped with data on the arrival time of the delivery truck at the destination location. The next stage is verification after the simulation stage has been successfully carried out.

At the verification stage, the results of the simulation or modeling that have been carried out by the software Anylogistix will be checked for truth and accuracy. The verification stage aims to see and analyze whether the simulation results using the software are following the conceptual model. The verification stage can be tested by changing the maximum limit of delivery locations one driver makes. The greater the determination of the maximum distance for a delivery location that one driver can take, the less the frequency of delivery and the number of vehicles used in one week. The less the determination of the maximum distance for a delivery location that one driver can take, the more the frequency of delivery and the number of vehicles used in one week. After the verification stage is appropriate, the next stage is validation. The validation stage is carried out to see whether the simulation that the Anylogistix software has made is based on the actual conditions that occur. The validation stage is carried out by comparing shipping routes and distances between the Anylogistix simulation results and the simulation results using Google Maps. The simulation results are considered valid when the delivery routes and distances from Anylogistix's simulation results are similar and close to the distance shown on Google Maps.

An analysis will be carried out based on a comparison of the total distance traveled before and after the simulation is carried out, analyzing the level of vehicle utilization after delivery by truck upsizing and analyzing shipments that have been combined (multidrop). In Anylogistix, for every generated path for multidrop, there are several outputs that could be traced, such as arrival time, cost, and distance.

Although minimization of cost and time are the most commonly used in Location Routing Problem (Bombang, 2023), there are a lot of factors contributing to arrival time difference, such as road traffic, weather, route diversion, or truck time restrictions. Moreover, the cost has a high fluctuation over time. Therefore, distance is seen as more reliable data, which is also used by other popular methods such as Saving Matrix (Yuniarti & Astuti, 2013).

Then, suggestions will be provided based on an analysis of the simulation results, which will provide various important information. Lastly, a conclusion is drawn to make it easier for the reader to understand the main issues and inform what proposals the company can implement (Figure 4).

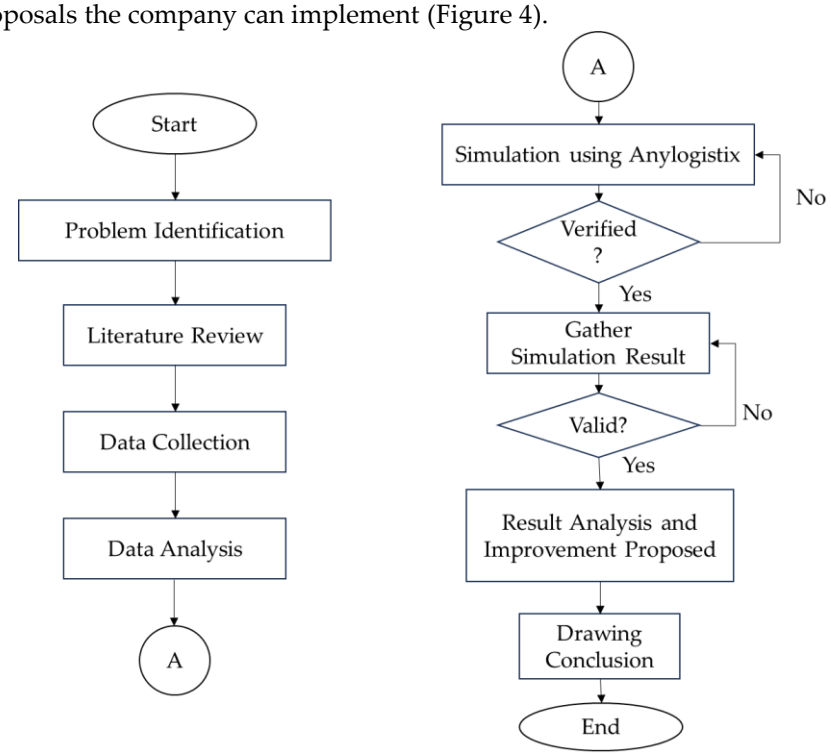

Figure 4. Research Methods

4. Results and Discussion

4.1 Verification

Simulation results that have been carried out by the software Anylogistix will be checked for accuracy. At this verification stage, a verification test will be carried out in the second week of March. Verification is done by changing the travel and returning segment limit values in the Anylogistix simulator. Table I shows the simulation results using the travel and returning segment limit values used for the simulation, namely 900 km each. Ten deliveries were made in the second week of March, with three combined deliveries to more than one different location (multidrop deliveries).

Table 1. Route Simulation Results of the Verification Stage on Anylogistix

	Site	Vehicle Type	Destinations	Distance, km
1	DC Surabaya	Build-up	Denpasar, Banyuwangi	870.81
2	D.C. Surabaya	Build-up	Malang, Klungkung	975,995
3	DC Surabaya	Build-up	Singaraja	774,674
4	DC Surabaya	Build-up	Blitar, Tripe Lamongan	343,198
5	DC Surabaya	Build-up	Jember	404,484
6	DC Surabaya	Build-up	Madurese	187,075
7	DC Surabaya	Build-up	Ponorogo	379,825
8	DC Surabaya	Build-up	Magetan	367,679
9	DC Surabaya	Build-up	Madurese	187,075
10	DC Surabaya	Build-up	Denpasar	853,341

[1] Tables may have a footer.

4.1.1 Verify with Extreme Low Travel Segment Limit

By reducing the travel segment limit and returning segment limit to 200 km each, Anylogistix could not find an optimal travel route solution because no destination location could be reached within a distance of 400 km round trip. Therefore, almost all customers will be on the Skipped Customers results tab after the limit is reduced. Therefore, the smaller the distance that can be traveled, the more customers or deliveries that cannot be served (skipped customers).

4.1.2 Verify with Extreme High Travel Segment Limit

By increasing the travel segment limit and returning segment limit to 3,000 km each, Anylogistix can find more optimal travel route solutions because the distance limit to travel to the destination location is greater, with a total distance of 6,000 km for a round trip. Therefore, there was a reduction in the number of shipments from ten to eight shipments. There was a merging of shipping routes from what was originally only three multidrop shipments to five multidrop shipments. To conclude, the greater the distance limit that can be traveled, the fewer the number of deliveries in one week. The greater the distance limit, the more deliveries from different destination locations can be combined in one delivery.

4.2 Validation

Anylogistix simulation results have been verified. Validation is carried out to see whether the simulation has been created by the software Anylogistix following the actual conditions that occur. Figure 5 shows the route from the Anylogistix simulation results. The route formed is from Surabaya DC to Denpasar, then to Banyuwangi, and then return to DC Surabaya with a total distance traveled of 870.81 km.

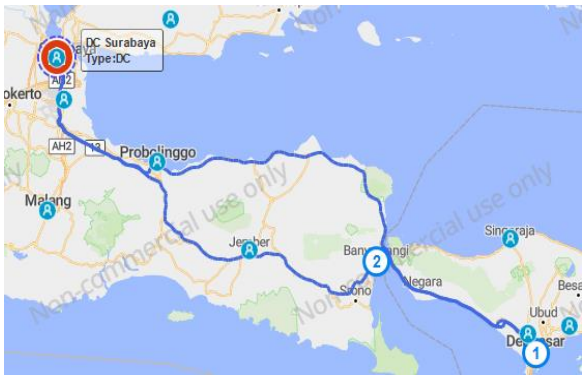

Figure 5. Anylogistix simulation route for delivery to Denpasar and Banyuwangi

Figure 6 shows the travel route obtained from Google Maps from Denpasar to Banyuwangi. The destination location inputted into Google Maps is the same as that simulated by Anylogistix, namely from Surabaya DC to Denpasar, then to Banyuwangi, and then to Surabaya DC. The total distance traveled from this route is 879 km, so the difference in distance between the Anylogistix simulation and Google Maps is 9.81 km. There is a difference in determining the route between Google Maps and Anylogistix.

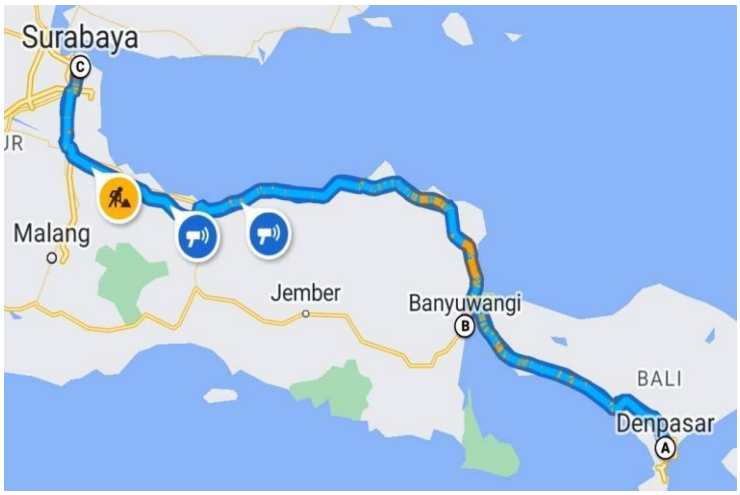

Figure 6. Google Maps route results for deliveries to Denpasar and Banyuwangi

Figure 7 shows the route from the Anylogistix simulation results. The route formed was from Surabaya DC to Malang, then Klungkung, and then back to Surabaya DC with a total distance of 975.995 km.

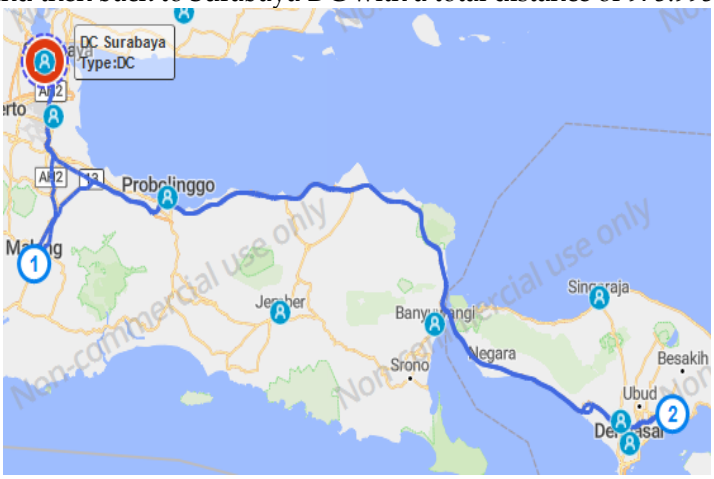

Figure 7. *Anylogistix* simulation results for delivery to Malang and Klungkung

Figure 8 shows the travel route obtained from Google Maps. The destination location entered into Google Maps is the same as that simulated by Anylogistix, namely from Surabaya DC to Malang, then to Klungkung, and then back to Surabaya DC. The total distance covered by this route is 997 km, so the difference in distance between the Anylogistix simulation and Google Maps is 21 km, with a slight difference in determining the route taken between Google Maps and Anylogistix.

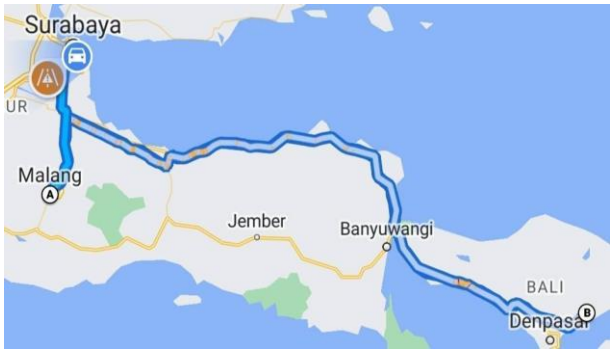

Figure 8. *Google Maps* route results for deliveries to Malang and Klungkung

From several validation tests, it can be concluded that the Anylogistix simulation results are valid because the Anylogistix simulation results are almost close to the Google Maps results, which represent reality conditions. The difference in distance and route determination to the destination location could be due to Anylogistix's limitations in knowing real-time road conditions. At the same time, Google Maps can find out if there are repairs or road closures and so on so that Google Maps can find another travel route. Apart from that, the determination of location points between Anylogistix and Google Maps can be less than 100% the same, so there may be differences in determining location points, which cause slight differences in distance and travel routes. The Anylogistix simulation results are the same as the actual conditions.

4.3 Discussions

Table II shows delivery data before determining the delivery route using the Anylogistix simulation. In the third week of January, there were 15 deliveries to 12 different destination locations daily. The vehicle modes used are Engkel, CDD, and Build-up, with less than 100% utilization. The total distance traveled before the simulation was carried out was 6,706.14 km.

Table 2. January Delivery Data Week-3 Before Simulation

Single Drop Shipping				
Shipment Date	**Delivery Area**	**Volume (m^3)**	**Truck Type**	**Distance (km)**
20-Jan-16	Magetan	23,211,205	Engkel	367,679
21-Jan-16	Tripe, Lamongan	24,802,000	Engkel	130,281
21-Jan-16	Klungkung	23,928,283	Engkel	892,557
21-Jan-16	Singaraja	24,070,904	crank	774,674
22-Jan-16	Kediri	36,620,230	Build up	226,056
22-Jan-16	Blitar	12,683,330	CDD	303,714
22-Jan-16	Sidoarjo	11,783,770	CDD	64,644
22-Jan-16	Magetan	14,028,928	CDD	367,679
22-Jan-16	Banyuwangi	17,184,000	CDD	612,765
22-Jan-16	Surabaya	23,941,690	crank	0
25-Jan-16	Boat	13,950,000	CDD	828,131
25-Jan-16	Klungkung	22133,920	crank	892,557
25-Jan-16	Probolinggo	24,155,810	Stiff	228,151
25-Jan-16	Jember	29,267,875	Stiff	404,484
25-Jan-16	Banyuwangi	20,217,370	Stiff	612,765
Total Distance (km)				6,706.14

Table 3 is the result of the Anylogistix software determining the goods' delivery route in the third week of January. The delivery frequency, which was initially made every day, was simulated into deliveries per week so that deliveries made 15 times could be reduced to 9 times a week. There is an allocation of deliveries from small to large modes of transportation (truck upsizing) so that several deliveries can be combined at the exact location or at different locations (multidrop). Delivery with a comma (,) is the result of a simulation of truck upsizing delivery at several different locations at once (multidrop). Meanwhile, deliveries with an asterisk (*) result from a truck upsizing simulation combining two or more deliveries at the exact destination. Therefore, the total distance traveled using software simulation assistance Anylogistix is 4,517.1 km in the third week of January. The simulation result minimized the distance to 32.64%. Based on its utility, only one shipment in the third week of January had low utilization (below 70%), which is the delivery area in Surabaya, utilize 59.85% of its capacity.

Table 3. Delivery Route Determination Simulation Results for January, Third Week

Anylogistix Software Simulation				
Delivery Area	**Volume (m^3)**	**Utilization**	**TruckType**	**Distance (km)**
Ship, Singaraja	38,020.9	95.05%	Build-up	869.5
Probolinggo, Blitar	36,839.1	92.10%	Build-up	442.6
Surabaya	23,941.7	59.85%	Build-up	0
Sidoarjo, Babat Lamongan	36,585.8	91.46%	Build-up	193.7
Jember, Klungkung	35,330.1	88.33%	Build-up	912.1
Kediri*	36,620.2	91.55%	Build-up	226.1
Banyuwangi*	37,401.4	93.50%	Build-up	612.8
Magetan*	37,240.1	93.10%	Build-up	367.7
Klungkung*	40,000.0	100.00%	Build-up	892.6
			Total distance traveled	4,517.1

Figure 9 is several images of the visualization results of multi-drop delivery routes in Anylogistix. The red circle symbol in the image is the location of Surabaya DC. Then, numbers 1 and 2 are the sequence numbers for stops on the goods distribution route. Delivery will be made from DC Surabaya to destination number 1, then to destination number 2 before returning to Surabaya DC.

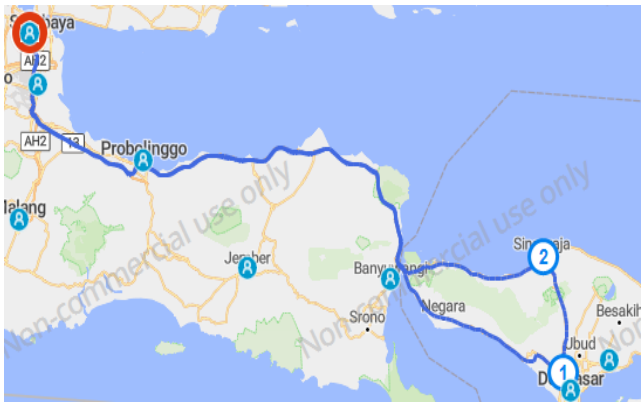

Figure 9. Visualization of Simulated Delivery Routes to Ships and Singaraja

Table 4 is a recapitulation table of the Anylogistix simulation results for one year. For a year, there are 7 weeks that do not experience combined delivery, so that in those 7 weeks there is no distance reduction. The total distance reduction that has been carried out by Anylogistix is 76,352,773 km/year or 27.2% of its total distance. The vehicle utilization rate of 47,75% deliveries was more than 70% (181 deliveries in total), while the remaining deliveries, which is 198 deliveries, were under 70% utilization (utilization <70%).

Table 4. Table of Summary of Simulation Results for January-December 2016

Month and Week		**Distance Difference (Simulation results vs current conditions in km)**	**Distance reduction from simulation results vs current conditions (%)**	**Number of Delivery from Simulation with utilization ≥70%**	**Total Delivery Amount Simulation Results**
January	Week 1	455.13	14.32	4	6
	Week 2	1034.16	27.8	4	8
	Week 3	2200.4	32.64	8	9
	Week 4	488.01	10.3	4	8
February	Week 1	117.43	2.54	4	8
	Week 2	1545.73	20.27	5	15
	Week 3	625.21	27.31	2	4
	Week 4	7715.51	23.81	5	11

Table 4. Table of Summary of Simulation Results for January-December 2016

Month and Week		Distance Difference (Simulation results vs current conditions in km)	Distance reduction from simulation results vs current conditions (%)	Number of Delivery from Simulation with utilization ≥70%	Total Delivery Amount Simulation Results
March	Week 1	1602.43	29.12	3	7
	Week 2	803.61	13.07	5	10
	Week 3	465.68	7.52	6	9
	Week 4	2041.85	27.1	3	7
	Week 5	88	2.83	3	5
April	Week 1	666.67	12.46	5	9
	Week 2	175.82	4.01	2	7
	Week 3	800.32	14.32	4	7
	Week 4	220.8	5.35	2	7
May	Week 1	No merger occurred		0	3
	Week 2	734.6	14.21	3	6
	Week 3	29.94	1.22	2	4
	Week 4	599.26	29.33	3	6
June	Week 1	404.48	9.07	1	6
	Week 2	303.71	5.24	4	11
	Week 3	858.01	15	4	10
	Week 4	No merger occurred		0	2
July	Week 1	No delivery			
	Week 2				
	Week 3	359.23	10.05	4	8
	Week 4	2.81	0.37	2	4
	Week 5	1957.55	25.34	5	9
August	Week 1	No merger occurred		0	3
	Week 2	4246.54	52.29	4	7
	Week 3	5752.24	47.09	8	11
	Week 4	3599.87	35.85	5	14
September	Week 1	689.86	20.06	2	3
	Week 2	916.3	15.66	2	8
	Week 3	2599.98	40.41	4	9
	Week 4	5021.18	62.78	8	8
	Week 5	3497.83	42.42	5	9
October	Week 1	3988.5	40.34	6	8
	Week 2	2942.57	38.9	5	8
	Week 3	2951.78	52.88	3	7
	Week 4	1172.33	23.17	3	6
November	Week 1	No merger occurred		0	4
	Week 2	3552.34	48.8	4	8
	Week 3	853.34	15.39	4	11
	Week 4	1751.62	27.91	6	9
	Week 5	No merger occurred		0	3
December	Week 1	675.26	14.49	1	5
	Week 2	1081.49	14.54	5	14
	Week 3	2754.31	33.87	6	12
	Week 4	2009.54	33.25	3	6
Total				181	379

5. Conclusion

Based on the results of research that has been carried out to solve the Vehicle Routing Problem (VRP) problem, Anylogistix software allocated goods shipments from small to large transportation modes for 181 shipments, 47.75% of total deliveries, with optimal utilization of ≥ 70%. Shipments with low utilization should still use small modes of

transportation according to the capacity of the goods being transported, even though the simulation has been carried out. Software Anylogistix can produce routes that reduce delivery distances by 27.2% of its total distance at the Surabaya DC by combining deliveries directly to several customer destination locations (multidrop).

Further research should be carried out with several different simulation software to obtain more optimal results per the Vehicle Routing Problem (VRP) problem. The application of the land route simulation that has been carried out will also be valid for simulating sea route shipping. Moreover, this research has not considered factors such as road traffic, weather, route diversion, or truck time restrictions.

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