Implementation of Integer Programming in decision support system for operational optimize procurement of public bus transport distribution (case study: Trans Jogja)

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Abstract- Trans Jogja is a public transportation solution for balancing between supply and demand of Jogjakarta traffic. The Arise problems such as increase of fuel, spare parts that leads to Increase in operational costs, amount of bus is not ideal Because the distribution is not in accordance with the needs, etc. The problems experienced can disturb the operational performance, so it needs the system that can reduce operational costs.

One method to solve the problem is optimizing the operational cost of the fleet without reducing service. Linear programming is a method of operation research that is used as problem solving, one of the which is transportation optimization. The steps taken in this method by setting the function objectives, variables, parameters and constraints, then proceed with the design models for procurement decision makers operational modes of the bus. Variables, parameters and constraints as well as the objective function are Obtained from bus service indicators in one lane using the service indicators issued by the World Bank, 1986.

The output of this research is the decision support system for operational optimize procurement of buses for Route 1A, 1B , 2A, 2B, 3A, 3B to help the distribution amount of buses in each route Effectively, efficiently and can reduce operational cost. This system there are features of the fleet amount, bus capacity, load factor, the bus interval, average speed, reserve buses, passenger number, operational cost Whose value can be changed According to the current situation then there is distribution feature amount of buses in each route so make it Easier decision makers for distribution bus.

Key word: linear programming, supply, demand, distribution.

I. INTRODUCTION

Increased private transportation but not offset by improvements in road infrastructure, can make traffic congestion (Trans Media, 2012), as happened in Jogjakarta (growth in amount of Two-wheeled private transportation increased 9%, four-wheeled transportation increased 11.7% in 2013), The behavior of road user, mobility level of community and incresed of business centers in urban areas (DIY Dishubkominfo Office, 2014). Less public interest to use public transport because of uncomfort, unsafe, efficiency time and so on. The government began to improve the quality of public transport to reduce traffic problems that occur. Trans Jogja is present as a traffic solution. Trans Jogja is a public bus. Trans Jogja balance between *supply* and *demand.* Problems resurfaced as minimal maintenance because all the buses are operated, the increase in fuel and spare parts give rise to increases in operating costs, The distribution of the bus does not match the needs, and so on. These problems can disrupt the operational performance of its impact can reduce public interest.

Some research related to this problem as in the research of Agung Bayu Pratomo, Agus Sumarsono and Budi Yulianto (2015) discussed about the level of effectiveness and efficiency, and the standard of performance fulfillment of public transportation route Trans Jogja 4A and 4B.Through descriptive analysis with primary data collection (headway, number of passengers, load factor, travel time and passenger waiting time) and secondary data (company data and Trans Jogja route data) related to Trans Jogja's performance. on route 4A and 4B have not been fulfilled. This research using Standard Indicators Based on World Bank standards and standards of the Department of Land Transport, especially passengers waiting times. In the present study discusses the performance improvement of public transport operational level of public transport provision trans jogja to improve performance by making an operational decision-making system of procurement amount of transport used to

implement the method of *Integer* Programming. Differences in the course of a study previously conducted only measure the efficiency, effectiveness and compliance with the standards of a public transportation, so in this study discussed about the improvement of the performance in public transportation at procurement of public transportation trans Jogja to improve performance by making an operational decision-making system the amount of transportation used by implementing Integer Programming method. Differences in previous studies undertaken only measure the level of efficiency, effectiveness and conformity with the standard of a public transportation, then in this study about the improvement of the performance operational public transportation for bus procurement to improve the performance of public transportation by making an operational decision-making system procurement of transportation, especially bus. Which is used so that the expected of amount of bus distribution per route can be optimal because each location dijogja have different characteristics different and can reduce operational costs without reducing the service to the user.

II. RESEARCH METHODS

A. design

This study on the Implementation of *Integer Programming* in Operational Procurement Decision Makers bus transportation through several stages. Problems taken in this research about the optimization of bus operational cost emphasis without reducing the service by using linear programming so it is expected that the distribution amount of bus each route can be met optimally because each location dijogja have different characteristics and can reduce operational cost.

Data was collected by conducting a survey in buses and bus stops are passed along route 1A, 1B, 2A, 2B, 3A, and 3B trans jogja based on indicators of service performance buses issued by the World Bank in 1986, from survey data obtained time table of each bus fleet come and go (speed, fleet size, load factor, and head the way), the length of the line, the route, the number of buses, bus capacity and operational costs as well as the factors that influence the number of passengers on a route, among others: average speed, number of passengers, the distance mileage, transportation travel time, bus capacity, load factor, headway, frequency of transportation, etc. (Wiryanta, 2004). In Figure 1 illustration indicator trans jogja services in one path used in this study correspond bus service performance indicators issued by the World Bank in 1986 suit field conditions.

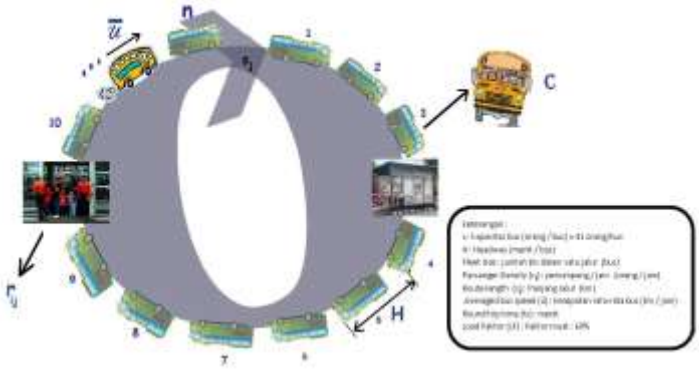

Figure 1. Illustration of the Trans Jogja Service Indicators

The next step is to design the system. Design and manufacture of decision-making systems operational optimization of transportation modes in the form of a desktop trans jogja done by applying themodel *waterfall* as shown in Figure 2. Themodel *waterfall* is a model construction of a system that performed sequentially or linearly. Each stage is done in this order until. completed without being able to be interrupted by phases sharing. This model was chosen in this study because its implementation is gradual, detailed and organized for each stage must be completed in full before advancing to the next stage of making it easier for designers to build systems.

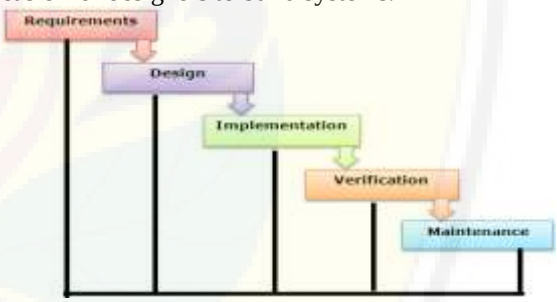

Figure 2 Waterfall Model

Data processing and analysis was performed using linear programming methods. Step traversed is by defining the objective function, variables, parameters, and constraint that affects the terms of the analysis of the operational situation Transjogja adjusted according to the standard of the Department of Land Transport and standards of the World Bank in 1986, after which it continued with the design model for system operating decision maker procurement of transport mode bus general.

Designing a model for decision-making system optimization Transjogja bus transportation procurement operations using jensen assistance lib which is one library in Microsoft Excel to assist decision-making analysis of the optimal number of transportation. Jensen lib is used to solve problems in the case of operations research. Use of jensen lib considered very easy to use than building a system from scratch because Microsoft Excel is already often used in offices that do not require adjustment before use. Here are the stages of the decision-making system design optimization of procurement

operations Trans Jogja bus transportation. In this study indicators, variables and parameters using standard assessment issued by the Ministry of Land Transportation as shown in table 1 and the standard of the World Bank as in table 2 are adapted to the situation and condition of the field when Transjogja operation.

Table 1. Performance Indicators Service Bus According to the Ministry of Land Transportation

SIZE	CRITERIA
5-10 minutes 10-20 minutes	Time between: • Average - Average • Maximum
5-10 mins	passenger waiting time
300-500 m 500-1000 m	Walking distance to the shelter • Solid Territory • less dense region of
0-1 times 2 times	Number of replacement modes: • average - average • Maximum
60-90 minutes 120 minutes	bus travel time: • average - average • Maximum
of 10-12 km / h 15-18 km / h 25 km / h	Free bus ride • dense areas • Regional bus lines • less dense area

(Source: Directorate General of Land Transportation; Ministry of Transportation, 1996)

Table 2. Key performance indicators of public transport services by the standards of the World Bank

Standard	Parameter	indicators
463-555 person / bus / day	Number of passengers transported per bus per day (person / bus / day)	Number of passengers
230-260 km / day	Average distance traveled; (km / day)	Utilization of transportation s
0.3 to 0.4 0.5 to 1.5 3-8	number of administrative staff / bus number of employees garage / bus number of employees total / bus	Productivity of employees
80-90%	ratio of the number buses that operate with the bus number overall (%)	Availability
15-25 liters / 100km	fuel consumption per bus per 100 km (liters)	fuel consumption
7-12	ratiocost of partswith operating costs of transportations	Requirement Partsper year
10 years,	average lifespan of	Age transportation s
70%	Comparison of the number of passengers with acapacity seatingper unit of time	Load factor
10-12 km / hr 10-20 min	Free bus Headway	Quality
1.05 - 1.08	the ratio between income dangan transportation operating costs	operating ratio

(Source: World Bank Policy Study, 1986)

III. RESULT AND DISCUSSION

In the development of decision-making systems operational optimization of bus transportation in this case using Transjogja as an object of research. In the development of this system has several stages include:

1. Needs Analysis System

at the early stages of this research the researchers first collecting data for the analysis of system requirements. Data collection related to the Trans Jogja. Transjogja which has spread in eight 74 bus routes. This stretch of eight Jogja divide into four regions. Each region, there are two opposing these. Each route there are several areas that bypassed two or more of these trips Transjogja but there are some areas just passed one route alone as illustrated in Figure 3. In this study only discusses the trajectory that is only six 1A, 1B, 2A, 2B, 3A and 3B.

Figure 3. These Transjogja 1A, 1B, 2A, 2B, 3A, 3B

In this study indicators and variables used using standard Department of Land Transportation and standards of the World Bank in terms of passenger demand or user. On one lap as illustrated in Figure 1 is known that among other indicators that affect the capacity of the bus, *headway*,the number of buses in one lane(*fleet*size), *passanger*density,path length, average speed bus, *round trip time* and *load*factor.

2. System Design

At the design stage of this system required a system that is able to help make decisions for the operational costs of three routes or paths Transjogja discussed, the survey results obtained eight indicators that affect the service Transjogja for the determination of the number of fleet each path an effective and efficient way to reduce costs operating without reducing the performance of services to users. These indicators include the number of total fleet, a fleet which is set as a backup, the number of passengers, operating costs,

the average bus speed, load factor has been set, the time interval between the first bus and the next. The system is used as a tool for fleet operational decision-making can be modified to change constants on indicators that can be used when there is a change in accordance with the conditions of the field.

3. Implementation

In this study using linear programming methods. Linear programming is one of the methods in operations research in the form of a mathematical model used to solve various problems such as assignment, distribution and transportation by minimizing or maximizing the objective function in order to achieve optimal results with limited resources. The objective function is dependent on a number of input variables (A. Taha, Hamdy, 1996).

Two kinds of functions Linear Program:

- The objective function: directing the analysis to detectproblem formulation
- obstacles Functionpurpose:to determine the available resources and the demand for these resources.

Determination of the objective function in this research is to optimize operating costs (US $) by specifying the size or number of bus fleet each route efficiently, so that the fleet size becomes a decision variable.

Transportation operating costs (VOC) trans jogja according SINDO news news.com 2015 Rp 6024 per kilometer for each bus, so as to determine the operational cost per each route then the operational cost per kilometer multiplied by the length of each route.

The mathematical formula for the calculation of the objective function or purpose as follows:

$\sum_{j=1}^{n} c_j x_j \sum_{j=1}^{n} c_j x_j$ ..... equation 1

where:

c: the operational costs of each route (IDR)

x: the number of buses per route (fleet size)

j: s Transjogja (1A = x_1,1B = x_2,2A = x_3,2B = x_4, 3A = x_5 and 3B = x6)

So the objective function formula obtained as follows:

$Z_{minimum}$= c_1x_1+ c_2x_2+ c_3x_3+ c_4x_4+ c_5x_5+ c_6x_6.. ..... equation 2

$Z_{minimum}$= 216.442,32x_1 222.647,04$x+_2$ + 198 189,60x_3 191.502,96$x+_4$ +198.912,48x_5 + 194.454,72x_6

in Figure 1 it can be seen the factors that may affect the Fleet size or the number of buses in a lane that is:

- the time it takes the bus in one round on one s, t_s (min)
- bus arrival time interval within the first with the second bus, *H* (min / bus)
- Long lines, s_j (km)
- average speed bus, *U* (km / min)

There are four kinds of constraint to the needs on demand passenger bus that total passenger demand, the availability of the fleet that operate, frequency of demand and passenger demand. In Figure 4 are described on the table analysis of the relationship between variables and parameters that affect the performance of the bus to determine the objective and constraint functions.

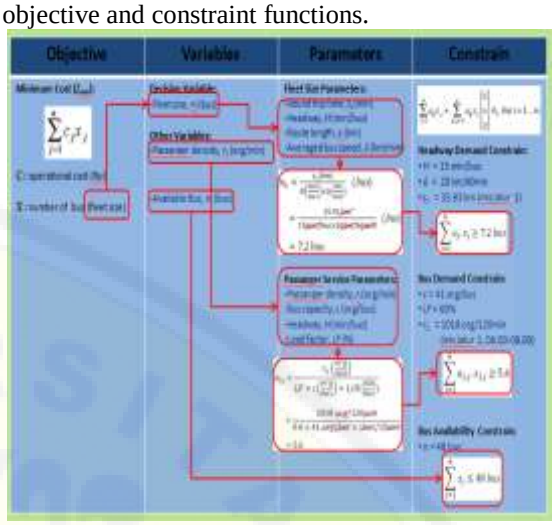

Figure 4. Table analysis of the relationship between the variables and parameters to determine the function objektive and constrains

constraint equations into mathematical equations linear programming. 1A is likened x1, 1B is x2, 2A is x3, 2B is x4, x5 3A is, 3B are x6, to facilitate the reading of the equations to a variable parameter and constraint can be seen in Figure 4 linear programming analysis tables. Konstrains used is the availability of the fleet operating constraints, frequency konstrains demand, and konstrains passenger demand. Konstrains passenger demand to adjust the route followed by any stretch of trans jogja. Numbers 1,2,3 in Figure 5 describes the bus route is divided into three regions and points a and b indicate the opposite direction (the direction opposite to the direction a b).

Figure 5. Illustration of slices of pedestrian routes for Trans Jogja bus lines 1,2,3

next step after determining the mathematical equations and konstrains objektive function is analyzed by using one of the library in excel is jensen lib as in Figure 6. At first determine lib jensen objectivenya function (in this case minimized), objective measure (in this case the cost to determine the operational costs incurred trans jogja), the number of variables and konstrainsnya. In the form of an integer number of variables in this study is the large number of trans jogja lines studied.

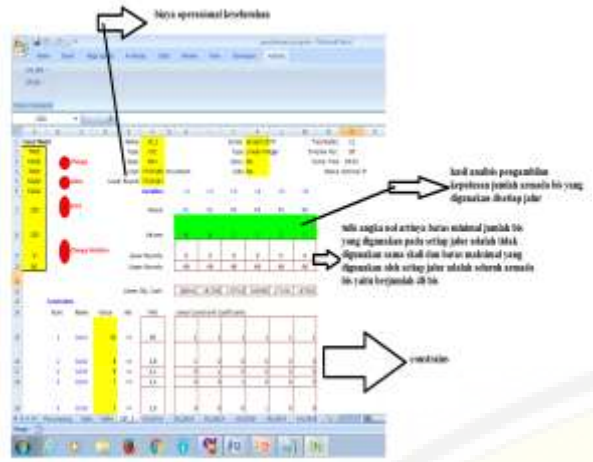

Figure 6. Results of analysis using linear methods jensen lib with programming

user interface on the display lib jensen less understandable and nature can not be used for onward because it is used for decision making on the spot, so as to ease the user to make decisions periodically need a system that can used regularly and need an easy to use interface as in Figure 7. in the results obtained by the system requirements analysis features that are needed in making decisions operational optimization of transport trans jogja.

Figure 7. Transjogja operating system

This system is a small-scale system which is intended to assist in decision making on optimization of the amount of buses and to know operational costs only. In Figure 7 it can be seen that this system has several features that are indicators that affect the optimization of the number of modes of transport buses and to mnegetahui operational costs such as, among others, the number of the fleet, the capacity of the bus, load factor, the bus interval, bus speed averaged, reserve buses, the number of passengers per day. The scale of this indicator can be changed according to the conditions in the field to change the decision-making needs. There are several indicators that have been set by the standard Department of Land Transportation and standards of the World Bank can not be changed and there are some that can be changed in accordance with the conditions in the field, such as when there was a surge of passengers of the user decision-makers can alter the approximate number of passengers, or when there are increasing number of bis of the user decision-makers can alter the number of buses. On the results of the analysis using linear programming methods result is that the current state of each path is given the same bus number. In figure 8 the results of the optimization system of the number of buses running 74 bus to the provisions of load factor according to provisions the World Bank is 70%, a capacity of 41 passengers, and assuming each track has three buses backup interval 15 min bus, and bus speeds average 20 then obtained optimization of the number of the largest bus on route 1A and 1B, it is suitable for track 1A and 1B are tourist central. total cost of the entire route Transjogja operations amounted to 7,747,436 with the assumption that 5189 rupiah / km. The advantages of this system, the system can generate several alternative options, thus simplifying the result on the user decision-makers in choosing the right solution as in Figure 8.

1	41	60%	15	54	6	20	17476	8	8	8	8	8	8	48	
2	41	60%	15	54	6	20	17476	8	8	7	7	7	7	44	
3	41	60%	15	54	6	20	34952	8	8	7	7	7	7	44	
4	41	60%	15	54	6	20	52428	Infeasible							
5	41	60%	15	74	6	20	52428	9	10	8	9	9	8	53	
6	41	60%	15	54	6	40	17476	4	4	4	4	4	4	24	
7	41	60%	20	54	6	20	17476	6	6	5	5	5	5	32	

Figure 8. Figure table alternative recommendations that can be selected by the user

In Figure 8 can explain that the comparison between number 1 and number 2 appears now fairly optimal conditions. If one assumes an increase in passengers of up to 3-fold, the addition of 20 bis be realistic. Adding the average bus speed of up to 40km / h can reduce the number of buses needed. Reducing the frequency of arrival of buses to 20 minutes can reduce the number of buses needed.

IV. CONCLUSIONS

- Based on the results of an analysis using linear programming method, the results of the optimization system is 74 amount of buses operated to the provisions of load factor according to provisions the World Bank Policy Study is 70%, a capacity of 41 passengers, and assuming each track has three bus up, interval bus 15 minutes, and the average bus speed of 20 of the obtained optimization of fleet highest amount on rute 1A and 1B, it is suitable for rute 1A and 1B are widely through tourist central.
  The total operational costs amounted to 7,747,436 with the assumption that 5189 rupiah / km.
- Optimization of decision support system the amount of buses in each route is only reviewed from passengers or users so that the indicators used are not all indicators set in the Ministry of Transportation and the World Bank but only load factor, bus capacity, bus speed, bus interval number of passengers, head way , Lane

length and amount of buses in one route.

- This system functions to provide assistance in decision making resetting the fleet size according to the needs of passengers so can be increase the operational efficiency of the fleet Transjogja.

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15 May 2017

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Subject : Article Acceptance

Dear

On behalf of the Organizing Committee of the **4th International Conference on Computer Applications and Information Processing Technology (CAIPT, 2017)**, held from 8 to 10 August 2017, at the Anvaya Resort Hotel, Bali, Indonesia, we are very pleased to inform you of the acceptance of your full paper the title of which appears below.

Name of Author	:	Diah Ayu Retnani Wulandari
Title of article	:	Implementation of Integer Programming in decision support system for operational optimize procurement of public bus transport distribution (case study: Trans Jogja)
Presentation Type	:	Parallel presentation

In this connection, we would like to invite you to attend the above said Conference. Please confirm your attendance by editing your status on the conference website and transferring the conference fee no later than 25 June 2017. Should you fail to confirm by that date, the Organizing Committee has the right to cancel your presentation. For more information, please see the crucial points related to the Conference attached herewith.

We would like to take this opportunity to express our appreciation for your interest in participating in the Conference.

We look forward to your participation.

All the best wishes,
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