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

Diah Ayu Retnani Wulandari
Information System Department
University of Jember
Jember, Indonesia
diah.retnaniw@gmail.com

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 increased 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 jogia 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 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.

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 the model waterfall as shown in Figure 2. The model 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 1. Illustration of the Trans Jogja Service Indicators

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 library 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.
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

<table>
<thead>
<tr>
<th>SIZE</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10 minutes</td>
<td>Time between:</td>
</tr>
<tr>
<td>10-20 minutes</td>
<td>• Average - Average</td>
</tr>
<tr>
<td>5-10 mins</td>
<td>passenger waiting time</td>
</tr>
<tr>
<td>300-500 m</td>
<td>Walking distance to the shelter</td>
</tr>
<tr>
<td>500-1000 m</td>
<td>• Solid Territory</td>
</tr>
<tr>
<td>0-1 times</td>
<td>Number of replacement modes:</td>
</tr>
<tr>
<td>2 times</td>
<td>• average - average</td>
</tr>
<tr>
<td>60-90 minutes</td>
<td>bus travel time:</td>
</tr>
<tr>
<td>120 minutes</td>
<td>• average - average</td>
</tr>
<tr>
<td>of 10-12 km / h</td>
<td>Free bus ride</td>
</tr>
<tr>
<td>15-18 km / h</td>
<td>• dense areas</td>
</tr>
<tr>
<td>25 km / h</td>
<td>• Regional bus lines</td>
</tr>
<tr>
<td>(Source: Directorate General of Land Transportation; Ministry of Transportation, 1996)</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Standard</th>
<th>Parameter</th>
<th>indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>463-555 person / bus / day</td>
<td>Number of passengers transported per bus per day (person / bus / day)</td>
<td>Number of passengers</td>
</tr>
<tr>
<td>230-260 km / day</td>
<td>Average distance traveled; (km / day)</td>
<td>Utilization of transportation</td>
</tr>
<tr>
<td>0.3 to 0.4</td>
<td>number of administrative staff / bus number of employees garage / bus number of employees total / bus</td>
<td></td>
</tr>
<tr>
<td>0.5 to 1.5</td>
<td>Productivity of employees</td>
<td></td>
</tr>
<tr>
<td>3-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80-90%</td>
<td>ratio of the number of buses that operate with the bus number overall (%)</td>
<td>Availability</td>
</tr>
<tr>
<td>15-25 liters / 100km</td>
<td>fuel consumption per bus per 100 km (liters)</td>
<td>fuel consumption</td>
</tr>
<tr>
<td>7-12</td>
<td>ratio cost of part with operating costs of transportations</td>
<td>Requirement Part sper year</td>
</tr>
<tr>
<td>10 years,</td>
<td>average lifespan of</td>
<td>Age transportation</td>
</tr>
</tbody>
</table>


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(fleetsize), pas sanger 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
detect problem formulation
● obstacles Function purpose: 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 kilometer
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:

\[ \sum_{j=1}^{n} c_j x_j \] ........................... 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 3B = x_6)

So the objective function formula obtained as
follows:

\[ Z_{\text{minimum}} = c_1 x_1 + c_2 x_2 + c_3 x_3 + c_4 x_4 + c_5 x_5 + c_6 x_6 \]

\[ \sum_{j=1}^{n} c_j x_j \] ........................... equation 2

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 objective and constraints
constraint equations into mathematical
equations linear programming. 1A is likened x_1,
1B is x_2, 2A is x_3, 2B is x_4, 3A is, 3B are x_6, to
facilitate the reading of the equations to a variable
parameter and constraint can be seen in Figure
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 objective
function is analyzed by using one of the library in
excel is jensen lib as in Figure 6. At first determine
lib jensen objective (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, 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.

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 route 1A and 1B, it is suitable for route 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.

V. REFERENCES

- Taha, Hamdy, 1996, Riset Operasi Jilid 1, Binarupa Aksara, Jakarta
- Forum SKPD, Paparan Kepala Dinas DISHUBKOMINFO DIY, Unit 8 Kepatihan Yogyakarta, 2014
- Wiryanta dan Dian Sestining Ayu. Evaluasi Terhadap Usulan Jalur Baru ANgkutan Bus Perkotaan DI Yogyakarta,Media Teknik No.3 Tahun XXVI Edisi Agustus 2004 No. ISSN 0216-3012
15 May 2017

No : 002/caipt-aptikom/III/2017
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 : Dahay Retnani Wulandari
Title of article : Implementation of Integer Programming in decision support system for operational optimise 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,
General Co-Chairs CAIPT 2017,

[Signature]

Dr. Eva Handriyantini, S. Kom, M. MT