Estimation and Evaluation of the Effect of LRT Under the Limited Information at Chinese Middle City

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Abstract: In this research, we develop a computer simulation system which aims to estimate and evaluate the effect as LRT is introduced, and is set in Qingdao, a medium-scale city of China. Concretely at first, we investigated a current traffic situation for Qingdao by surveying its traffic flow and collecting statistical information, etc. Secondly, we made an estimation on the traffic situation and the public transportation business management assuming LRT was constructed here. Then we evaluated the effect of the introduction, based on our investigation and assumption. Finally, we concluded our series of procedure and estimate method into an examination methodology, concerning about LRT introduction and settlement. This system is designed as a decision making support system for planners in real planning process, corresponding to planner's trial and error process.

Keywords: Light rail transit, Traffic volume estmation, Computer simulation, Decision support system, Chinese medium-scale city

1. BACKGROUND AND PURPOSE

The explosive increase of cars has aggravated the traffic jam in most cities of China. Despite many roads are constructed so fast that attempt to improve the traffic situation, traffic flow will not be able to be covered at all. In order to solve this problem, the construction of the urban traffic system that centers on public transportation will be in demand. So the building of its examination foundation definitely has much social meaning. Especially the examination of orbit systems should be given priority because of its excellent features, such as highly transport capacity and excel energy efficiency. And light rail transit (LRT) can be considered to be the representative.

According to our understanding and awareness of above issue, we develop a computer simulation system which aims to estimate and evaluate the effect as LRT is introduced. Our researh is set in Qingdao, a medium-scale city of China.

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and estimate method into an examination methodology, concerning about LRT introduction and settlement. This system is designed as a decision making support system for planners in real planning process, corresponding to planner's trial and error process.

2. APPROACH

As regards the effect evaluation of introducing LRT, existing viewpointis are various. There's no single, universally accepted way. An overall evaluation approach is therefore requested. The approach we used in our research is different from general ones and aims to improving the applicability in the real planning procedure. To be concrete, it is as follows.

a) Ranging from the survey of existing circumstance to the calculation of evaluation information

With the exploring progress, the transportation research has been subdivided and develops towards more advance and precise level. However, it offers less practical convenience. In this study, we are aiming to gain a practical output dealing with all phases from the investigation and information collection, to the information for final decision making,

b) Estimation from minimum information and investigation scale

There are many restriction and limitation for period and items to investigate an overseas city. Therefore, we try to construct a methodology that yields estimate and evaluation to some accuracy degree on the minimum requirement. Through such approach, another effect can be expected. For example, it will be possible to confirm the indispensable information and necessary items, also, to search the information items that influence the estimate accuracy.

c) Not overfocus on the details of accuracy and theory

Apply estimate techniques the planners can understand. A method of estimate value in an easy understanding way is supposed to be more 'practical' than that of an advanced technique like 'Black Box'.

d) An interactive system supporting the decision making is constructed

Mounting the estimation procedures into a program, designing the I/O screens with panel display with steps, we construct the system as a planning tool. In this system, there are not only automatic calculating parts, but also a few panels for inputting a set value by operators. Meanwhile, functions for space information processing, which is difficult for artificial calculation, have been enhanced to estimate integrated impact of train station and the road network.

3. PROCEDURE OF ESTIMATION AND ASSESSMENT OF TRAFFIC IMPACT AFTER LRT IS CONSTRUCTED

The flow chart of the estimation and the assessment is shown in Figure 1. Thus, we fixed two indices of "Income" and "Expense", which are usually applied during the assessment of the valid treatment of the possibility of introducing LRT. Here, we want to clarify that we try not to evaluate the effect of the introduction only by the balance of revenue and expenditure. It is necessary to keep examining closely the validity of obligation fees and we regard them as the representative indices for proceeding the estimation.

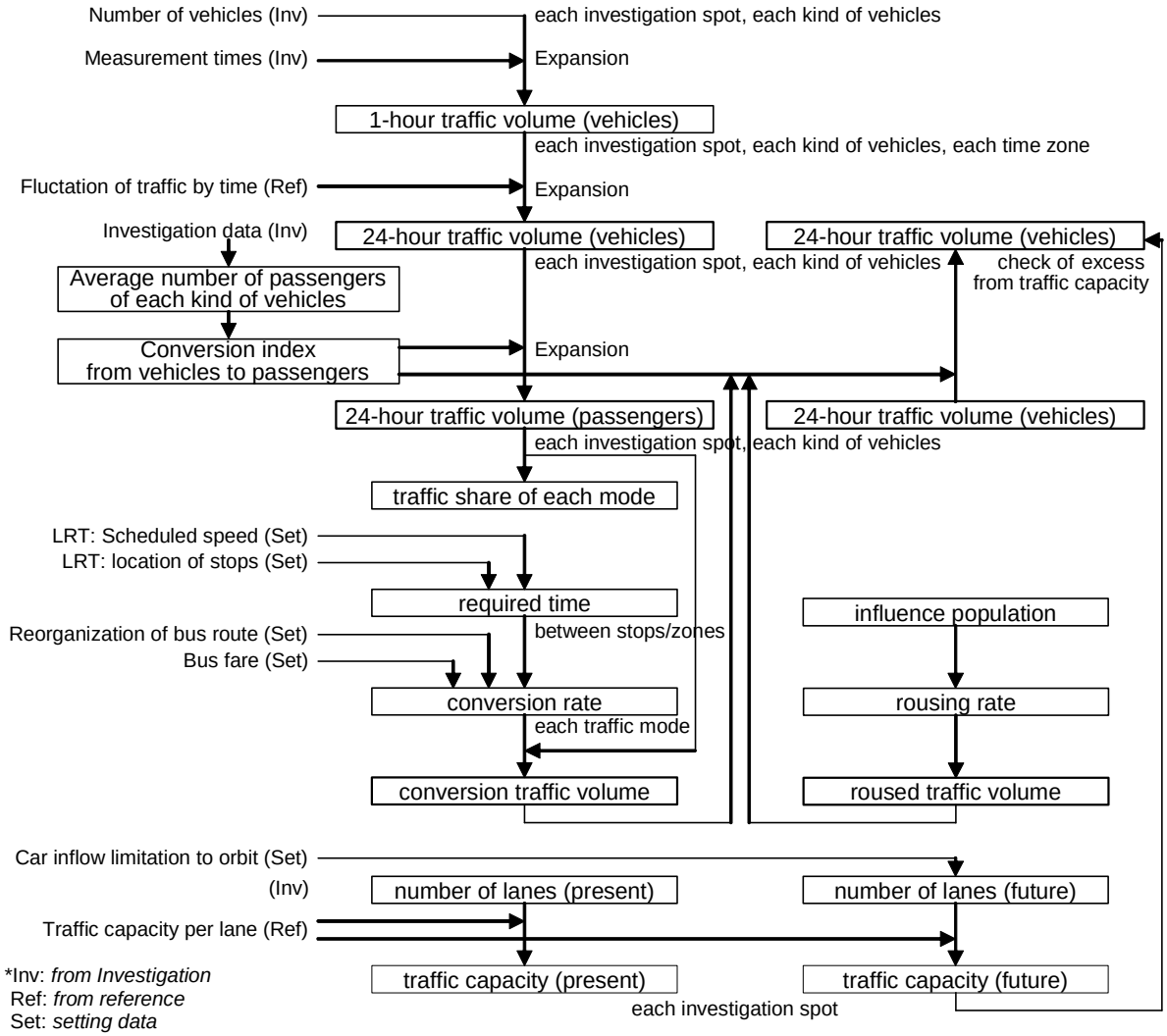

Figure 1 Flow charts of estimation and assessment

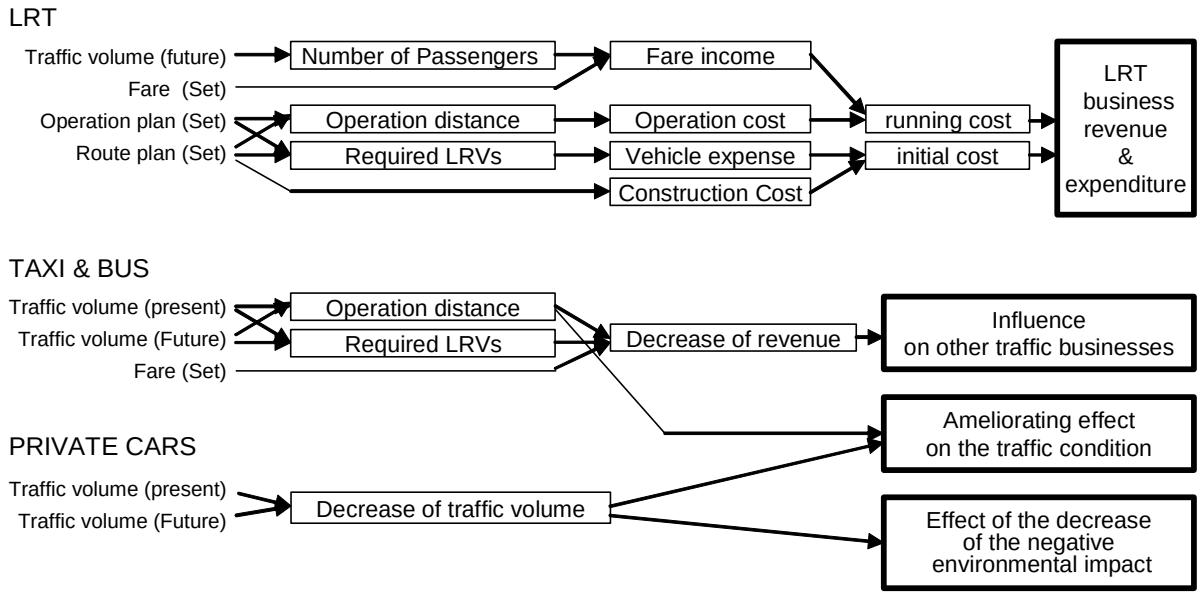

Figure 1 (Continued)

4. ASSUMPTION OF SETTING LRT ROUTE AND SITE INVESTIGATION

4.1 Assumption of Setting LRT route

Qingdao city can be comparatively clearly divided into three areas with different characters (business center, tourist site, and commercial area). The connection of those three areas became the major traffic backbone of the city. Therefore, the trunk roads with enough width for railway tracks constructiong are limited. We set the candidate route where LRT is introduced as shown in Figure 2 around these trunk roads.

4.2 Outline of site investigation

(1) Investigation spots

Based on a LRT route set above, the investigation of existing circumstance of the road situation and traffic were executed on weekdays from August 21st to September 13th of 2007. At last we chose ten investigation spots shown in Figure 3, taking account of the large traffic volume and significant change in addition.

Figure 2 LRT route

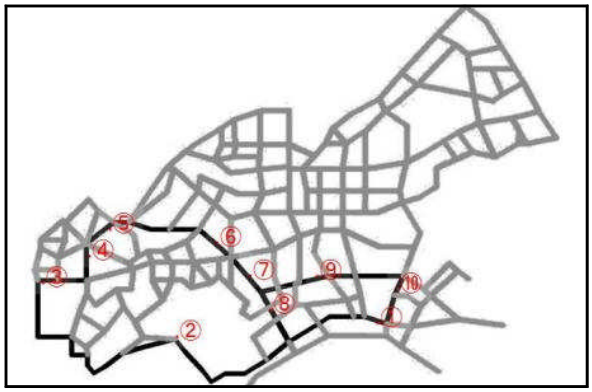

Figure 3 Investigation spots

(2) Measurement of the automobile flow

We counted 5-minute traffic volume (number of vehicles) of both direction at each investigation spot, classfied into bus, taxi, private car, track and van, tourist coach, motorcycle and bicycle.

(3) Measurement of average number of passengers according to model

The number of passengers per vehicle become the key parameter in the traffic volume conversion from car-base to passenger-base. Then, the number of passengers was visually counted in the characteristic investigation spots. And the mean values of the private cars, taxi, and buses were calculated. Additionally, the number of lanes were confirmed.

5. ESTIMATION OF CURRENT STATE TRAFFIC

5.1 Calculation of 1-hour traffic volume (number of vehicles) during each measurement

In the site investigation, approximate 5-minute traffic volume (number of vehicles) was measured under the policy to acquire data in a minimum labor. Because signal cycle had been considered, measurement periods were less than 5 minutes in accuracy. Accrodingly, one hour traffic volume of each kind of vehicles were calculated by multiplying each measurement value by the ratio of the measurement time (second) of one hour (=3600 seconds).

5.2 Calculation of 24-hour traffic volume (number of vehicles) of each investigation spot

One hour traffic volumes mentioned above can be calculated only by discrete period of time. So, we converted 1-hour traffic volume into 24-hour one by "Expansion" using the fluctuation graph of traffic by time during a day. By our method, upgrade of the technique and the reliability of the calculation result can be improved one by one by replacing the calculation routine only in this step as soon as information with higher reliability can be acquired

5.3 Calculation of 24-hour traffic volume (number of passengers) of each investigation spot

Then we converted the vehicle-base traffic volume into the passenger-base. Such conversion is necessary, because in the estimate procedure the conversed traffic volume to LRT is required to be calculated by each user. Based on these values, necessary number of trains and the diagram will be examined. For this, we adopted the average number of passengers of each kind of vehicles calculated from the site investigation data.

5.4 Calculation of traffic share of each modes at each investigation spot

Here the traffic share of each modes at each investigation point was able to be calculated, and it came to be able to help understand a traffic situation quantitatively.

5.5 Estimation of road traffic capacities

As the road capacity for each lane was set, the road capacity at the current state could be calculated based on the survey data of the number of lanes. It becomes basic information for road capacity calculation after LRT is constructed (Two lanes decrease is normal).

5.6 Traffic calculation function of current state

According to the procedure of this chapter, we constructs the program in the form of "Traffic calculation function of the current state" as a part of the system that supports planners to make decision. The interface screen is shown in Figure 4.

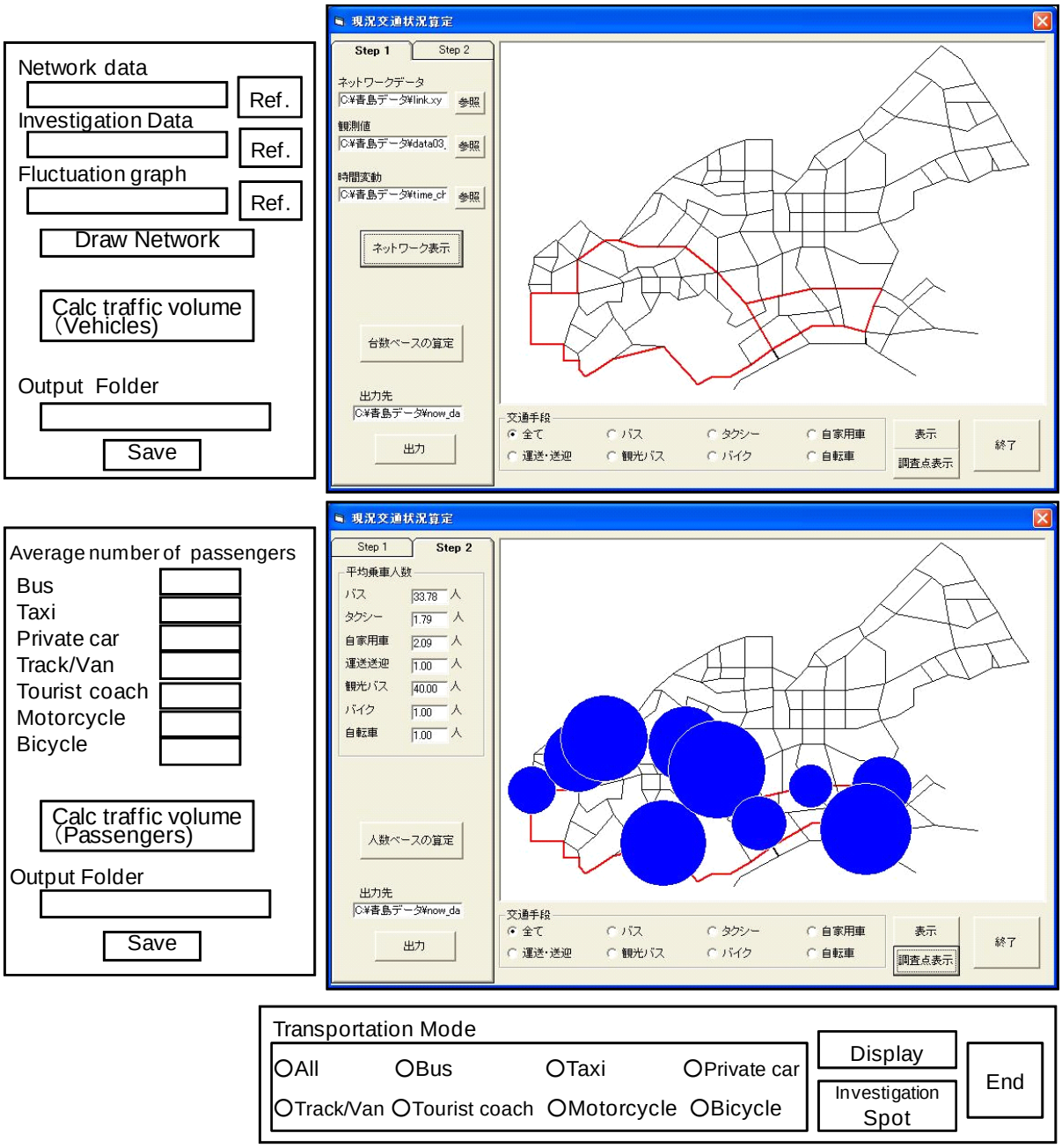

Figure 4　Traffic calculation function of the current state

6. SETTING OF ROUTE PLAN AND OPERATION PARAMETER

Some numerical values should be fixed beforehand when estimate the future traffic volume after LRT is constructed. Because the ratio of the passenger conversion to LRT will change according to different conditions. A free value setting is possible in our system and we set assumed values as follows.

6.1 Reorganization policy of the bus route after LRT is constructed

Buses in the construction section are completely abolished, and are reorganized into the shortened routes which bear the feeder line. Some terminals are set as transfer points between buses and LRT.

6.2 Fare setting

The fare for the LRT is assumed to be the flat system for buses, and no disadvantage for passengers who newly need transferring.

6.3 Times required between stops of LRT

By providing the schedule speed, times required between stops can be calculated after dividing the section length by this speed （Figure 5）.

Figure 5 Times required between stops of LRT ('分'=minutes)

6.4 Car Inflow limitation to orbit and car lanes decrease

It was set, "Uniformly using two lanes for orbit and car inflow to orbit is assumed to be improper".

7. ESTIMATION OF TRAFFIC IN THE FUTURE

In this chapter, the traffic situation after LRT is constructed will be forecasted. Concretely, the number of LRT passengers are estimated as total values of two parts, one is conversed from other traffic modes and the other is an increase due to the traffic convenience. Decreases of passengers of each other modes by the conversion is also estimated. Estimated value of a total vehicle decrease of all traffic modes can be effectively used as an index to evaluate an improvement in the traffic situation and a decrease of the negative environmental impact .

7.1 Estimation of conversion traffic to LRT

About the conversion ratio, we judged now that it was difficult to adopt a numeric method because various of factor affect each other. Then, as shown in Figure 6, we took a man-machine approach of presenting information that had been obtained up to now on the screen by the panel form, inputting the numerical value of the conversion ratio while referring to them, calculation and displaying the result (traffic situation) on the assumption condition instantaneously after inputting it, and supporting the trial and error process. Concrete estimate procedure employed is as follows.

Step1: Calculation of 24-hour traffic (number of passengers) after LRT construction by using the input conversion ratio of each mode.

Step2: Calculation of the LRT traffic (number of passengers) in the future by counting up the traffic volumes converted from each mode to LRT.

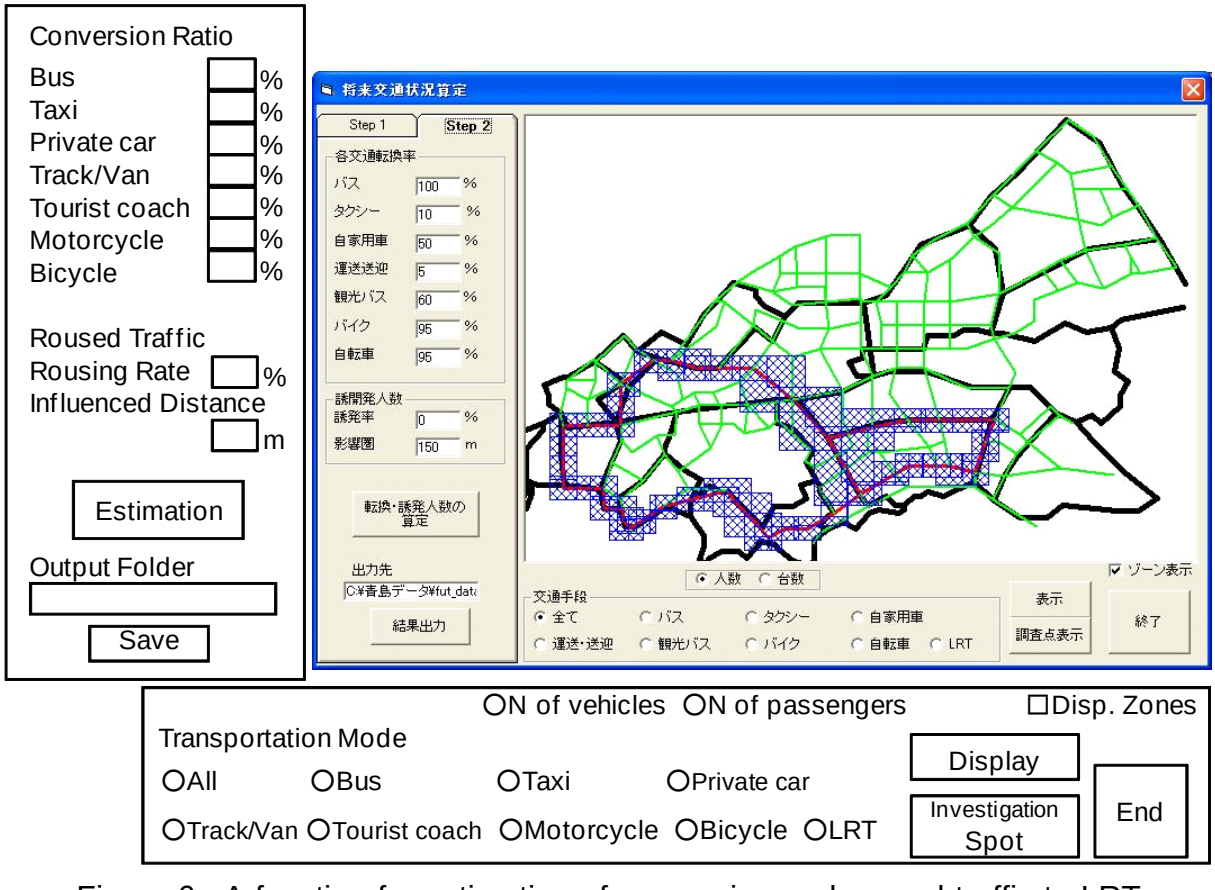

Figure 6 A function for estimation of conversion and roused traffic to LRT

Step3: According to auto transportations, conversion into the vehicle-base values by dividing the average number of passengers of each kind of vehicles.

7.2 Estimation of roused traffic

The traffic demand is expected to be roused newly by the rise of the traffic convenience after LRT is maintained. Considering the handy calculation method aimed in this study, we decided to deal with only the place along railway-tracks region where the main rousing demand was assumed though, to be strict, these were caused in the entire city region.

The approach similar to 7.1 is also taken here. That is, presenting the radius of influenced population as information for the decision making. And let the planner input expected increase percentage of "Rousing rate", in it as a number of passengers each day (Figure 6). However, the area proportion distribution from the LRT route to a zonal region of both sides with 150m is calculated automatically by using the obtained regional population, The roused traffic (the number of people base) will be calculated by multiplying it to "Rousing rate" already inputted.

7.3 Estimation of future traffic volume

The future traffic volume of LRT of each investigation section was able to be calculated with the number of people-base by adding the above conversion and rousing traffic. It will be an important information to predict the traffic situation, for example, traffic share of each mode. Figure 7 is an example of displaying the estimate result of the future traffic volume.

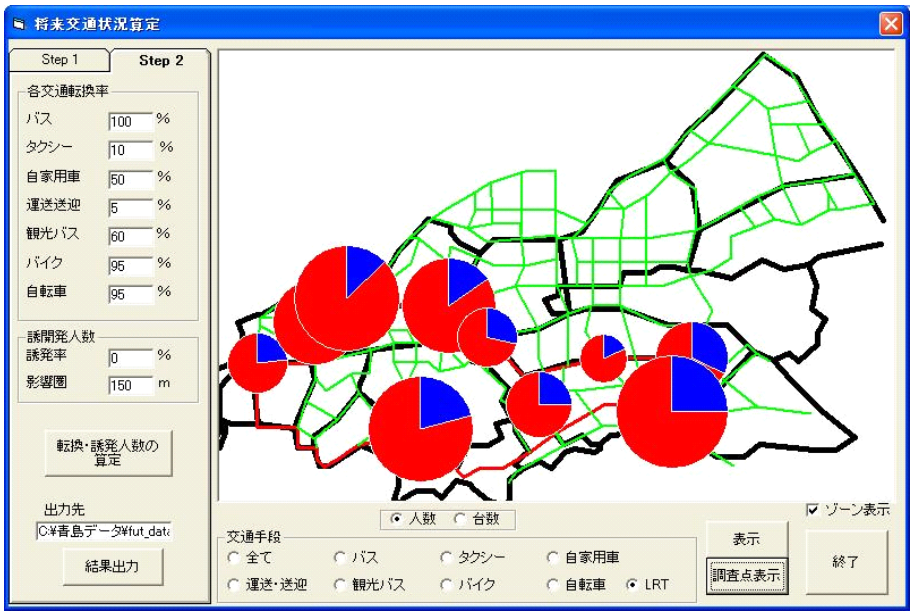

Figure 7 A display of future traffic volume

8. SETTING OF LRT OPERATION CONDITION AND CALCULATION OF BUSINESS REVENUE AND EXPENDITURE

The number of passengers of LRT expected in the future was able to be obtained in the form of 24-hour traffic by chapter 7. Here, the revenue and expenditure of the LRT business can be forecasted finally by providing the condition such as the operation diagram to transport these passengers, and calculating a necessary number of trains and carriages.

8.1 Setting of LRT operation condition

Operation form: Simply this time, It was set as "Circular drive in both directions".
Fare: Because a current bus fare was one yuan or two yuan (with air-conditioning), the fare of LRT was set, "Flat rate of two yuan".
LRV organization: It was provided, "Connect 4 carriages of 50 maximum passengers capacity as one organization". The capacity of each train will be 200 passengers.

8.2 Setting of operation diagram

Pattern of diagram: It was set, "Operate from 6 o'clock to 24 o'clock, and the same frequency in the whole operating period".
Provided traffic capacity: It is necessary to calculate the traffic of every time periods, which will be provided, to set the diagram. Then, 24-hour traffic was distributed to each time period by using the fluctuation graph of traffic shown in Figure 8. Because the values are different according to the investigation spot, after finding each estimate value of the points where traffic volume is minimum and maximum in every time periods, we chose the maximum values of each period.
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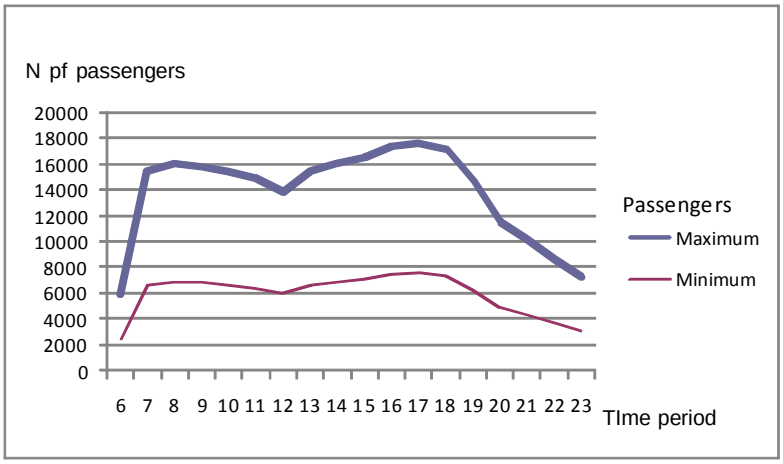


Figure 8 Maximum and minimum passengers of LRT

8.3 Function for setting up operation conditions and calculation of necessary number of trains

Figure 9 is a set panel of the operation condition mentioned above. Passengers capacity for each carriage, carriages per organization, and the fare can be inputed to upper section. The lower section is for setting the operation diagram.

After an operator set the number of operation organizations of each time period, the amount that can be transported is calculated automatically, and the difference between the capacity and LRT passengers estimated above is displayed.

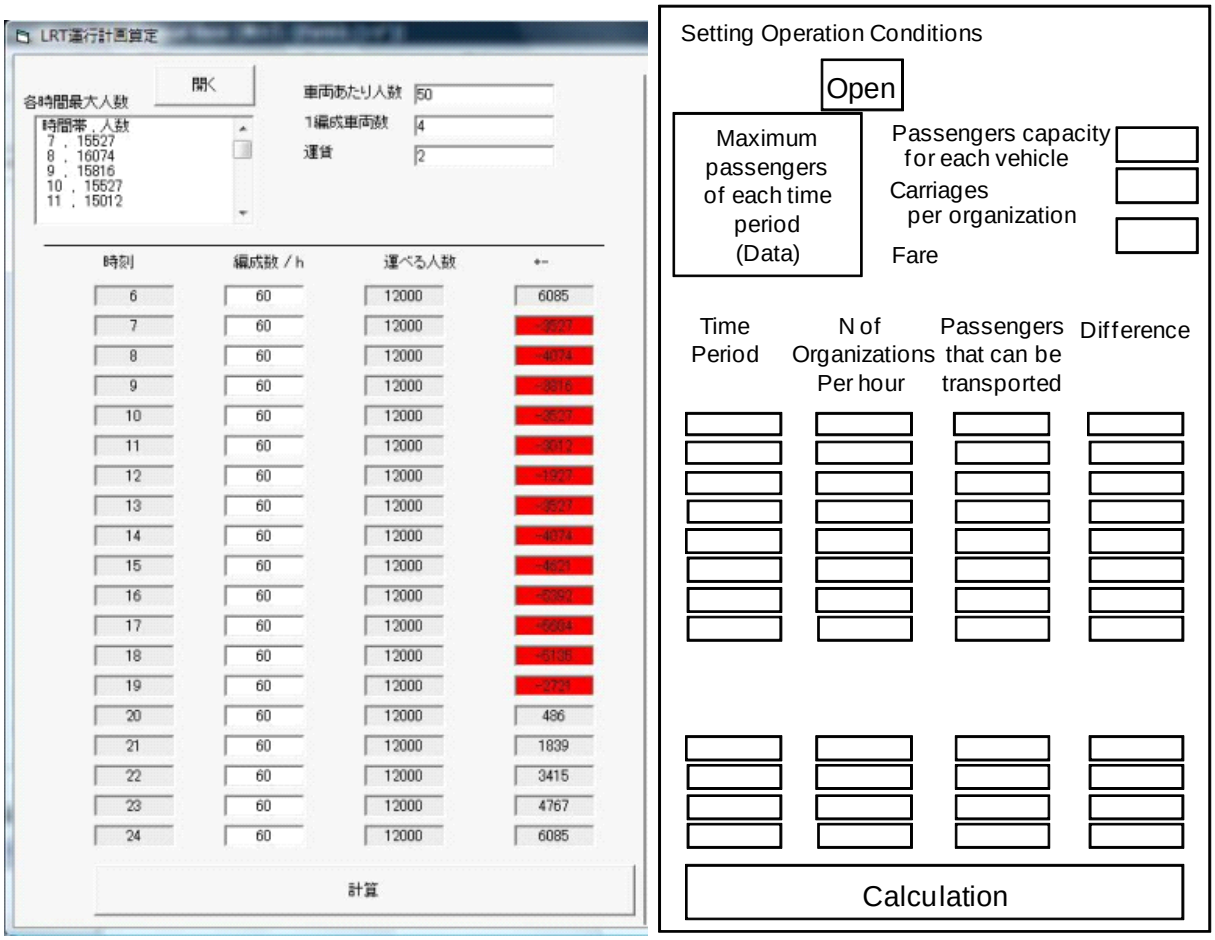


Figure 9　A fuction for setting operation conditions

8.4 Calculation of business revenue and expenditure

First, the business income can be calculated by multiplying the number of passengers to the fare provided by 8.1. The concept of "Average trip distance" was introduced here, and the number of passengers was estimated roughly by the numerical expression below.

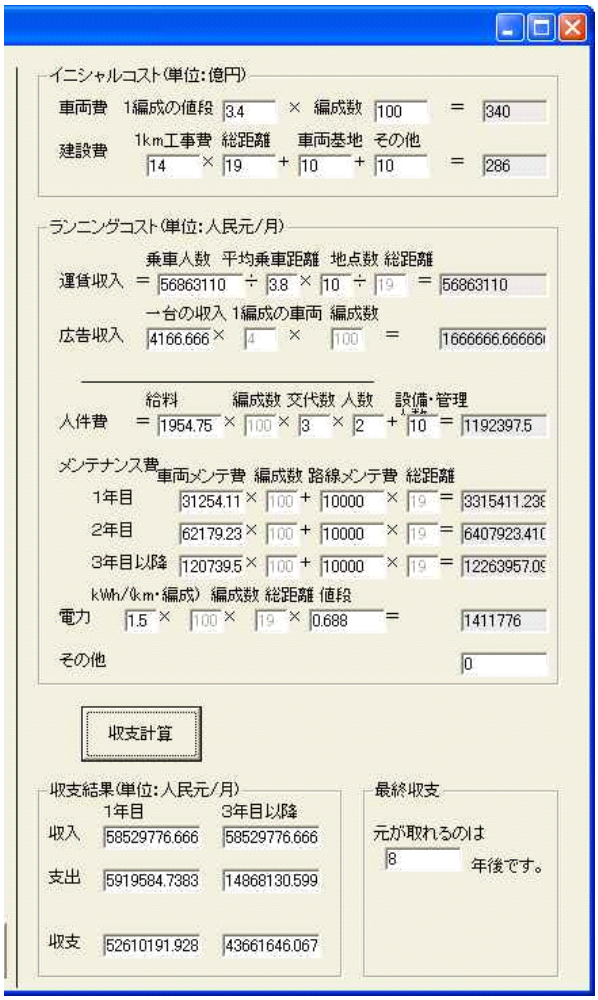
$$P = \Sigma\ (Ti / R)$$

where

$$R = (AD / L) * N$$

P: Number of passengers
Ti: Traffic volume at point i
R: Ratio of duplication
AD: Average trip distance
L: Length of orbit
N: Number of investigation points

Also, the cost of construction and the train expense as an initial cost, labor cost, maintenance expense and electric power expense as an running cost, are assumed.



Initial Cost (Hundred million Yuan)

Vehicle expense
Construction cost

Running Cost (Yuan/Month)

Fare income
Advertising revenue

Labor cost
Maintenance expense
1st year
2nd year
3rd year and more
Electric power expense
Others

[Calculation]

Revenue and expenditure (Yuan/Month)

Profitable Year

Revenue
Expenditure

Balance

Figure 10 A function for calculating business revenue and expenditure

9. ASSESSMENT INIDICIES OF ALTERNATIVES

In this study, the following four assessment indices are applied.

(1) Profitability

Profitability can be treated as one of evaluation indices figures. As a result of our simulations of the business revenue and expenditure, it is shown that the profit of LRT business will change to the surplus in eight years under this condition.

(2) Influences on other traffic businesses

By the LRT construction, passengers of other traffic is supposed to decrease. The degree of such influences of the taxi and buses is estimated as amount of a decrease of fare income.

(3) Ameliorating effect of the traffic situation

Because the main purpose to introduce LRT might be an improvement of the traffic situation, this becomes the most important evaluation index. On the other hand, under the same traffic volume of the car, congestion becomes intense as the number of car lanes decrease by the LRT introduction.
It is an important verification problem whether car traffic decrease by the conversion to LRT have a counterbalance of a decrease of car lanes.

(4) Effect of the decrease of the negative environmental impact

The amount of the reduction of CO is calculated. As the polluter of CO is regarded to the exhaust of cars.

To calculate and display these assessment indices, some functions and display panel shown in Figure 11 are constructed, and it is possible to have a look at the calculation result of the above-mentioned indices.

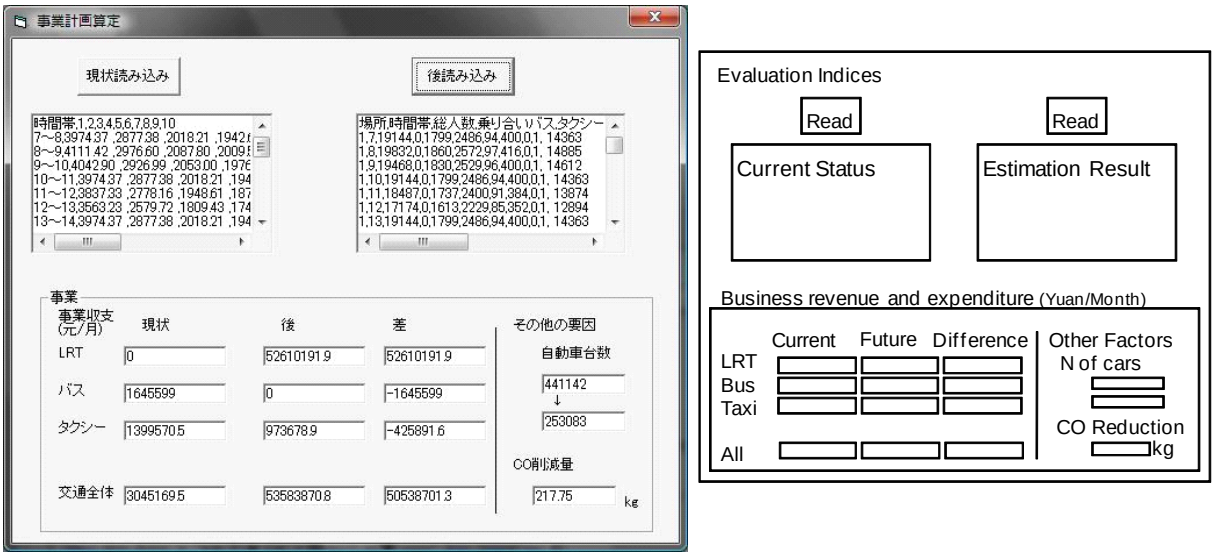


Figure 11 A display of assessment indices

10. CONCLUSION

Although a further introduction will be expected as for LRT in the future, evaluation approach of the effect has not been established, and there is a possibility that this becomes the problem of introduction promotion.

Especially, as we deal with the cities in China where an explosive increase of the traffic demand was expected, we aim to be able to get the planning information on the minimum requirement even if it estimates roughly in the situation in which information is limited, and conclude it as a series of methodology. It is great if it becomes an indicator when planning.

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BIOGRAPHY

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ZHAI Yaohui is a doctor course student of Osaka Sangyo University. After graduated from Tianjin Foreign Studies University and had worked in Quindao, she entered Osaka Sangyo University to learn more about transportation planning and now making a study with Professor Yoshikawa. She hopes to make use of her fruits of research during her stay in Japan for her hometown Quindao.