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A MEPLAN MODEL OF TAMA URBAN MONORAIL

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Abstract: This paper assesses a wide range of alternative policies and scenarios for TAMA urban monorail by applying an urban simulation package. The package is MEPLAN model that is designed as a general mathematical framework for modeling the spatial economies of cities or regions. We used MEPLAN model for assessing comprehensive impacts of the route extensions of the monorail by making some adjustments to Tokyo region. First, we calculated the base case in which existing land-use, employment, and transportation network have been used to adjust model results to actual data, and second, compared it to the results of two scenarios: the extension to HAKONEGASAKI route and MACHIDA route. We evaluated how many passengers will be increased or decreased on which lines. Meaningful conclusions on its worth are drawn.

Key Words: Urban railway planning, Simulation model, Regional plan

1. INTRODUCTION

This paper aims at applying the MEPLAN model to Kanto region to evaluate how introduction of a new transportation system impact on surrounding areas, especially focusing on the flow of railway passengers. The monorail system has been in operation since 2000 in the western part of Tokyo. The MEPLAN mode is the integration land use and transportation model that was created in the Martin Center for Architectural and Urban Studies, University of Cambridge (Hunt, 1993). It is a Lowry derivative model that was constructed using economic base theory. The Model uses places of basic employment to calculate household locations and then calculates the service employment needed to serve these households. What differences this model from other Lowry derivatives is the way the land use module or, as its author puts it, the economic module, operates (US DOT, 2001). The economic module incorporates three economic concepts, i.e. input-output module, price function and random utility (Abraham, 1998).

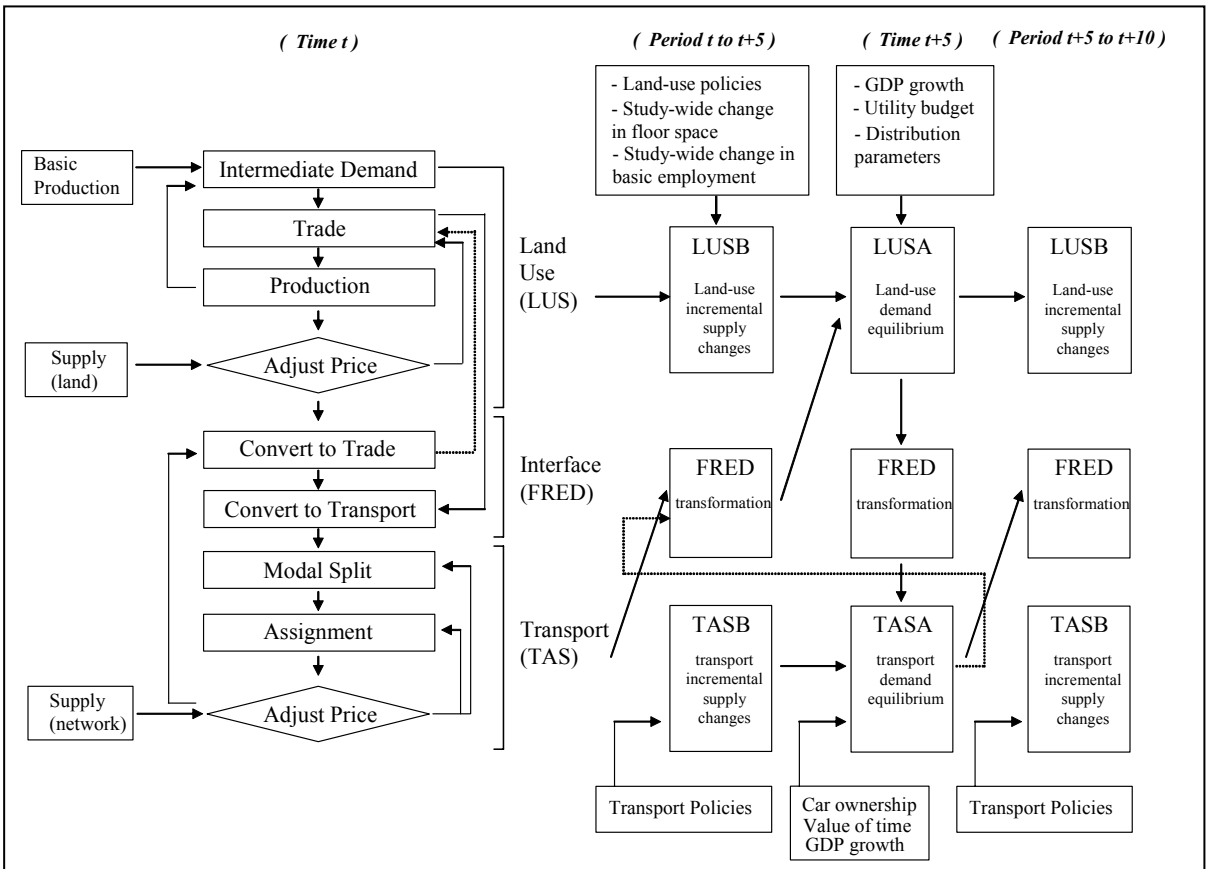
Our MEPLAN model is based on the MEMOTO, the MEPLAN model of Tokyo, developed in 1996 by Marcial Echenique and Partners Ltd of Cambridge, England, and Appraisal Co of Tokyo, Japan (ME&P, 1996). MEMOTO sets the region into some 62 zones based on the Kanto area 1988 origin-destination (O-D) travel survey. This zoning system has been adopted for two reasons: 1) transportation O-D data are available, 2) the zones are all of local government areas and land use data are

available from Census. Our MEPLAN sets the region into 169 zones to evaluate at local government area levels: Ward, Town, City.

2. STRUCTURE OF MEPLAN MODEL

MEPALN consists of three main modules: LUS, FRED, TAS (US DOT, 2001). Fig.1 shows the flow of interaction among three modules over the linkage through time. LUS is the regional/urban land use – economic module. LUSA is used to allocate a zone the households, firms catering for the local market, and travel factors. LUSB is to allocate the firms engaged in production for the non-local market in manufacturing, headquarter offices, and the service sector (US DOT, 2001). FRED is the interface module which converts flows from production and consumption zones into flows of goods and people. TAS is the freight/passenger transportation modules which allocate FRED outputs to modes and routes.

Several iterations of the systems are required to balance the land use and transportation modules with feedback in the form of costs (prices and congestion). In Fig.1, the flows from TASA of Time t to



* drawn based on (US DOT, 2001) and (Williams, 1994)

Figure1. The Linkages between Modules and Time in the MEPLAN Model

FRED of Period t to t+5 (years) and FRED of Period t to t+5 to LUSA of time t+5 mean that the evolution of the pattern of land use which results from changing transportation condition is a response to past price and congestion signals. On the other hand, the flow from TASA of time t+5 to FRED of Period t to t+5 means the averaging of the current travel costs with those of the previous time period.

Fig.2 shows the structure of our MEPLAN model based on MEMOTO. This diagram displays the

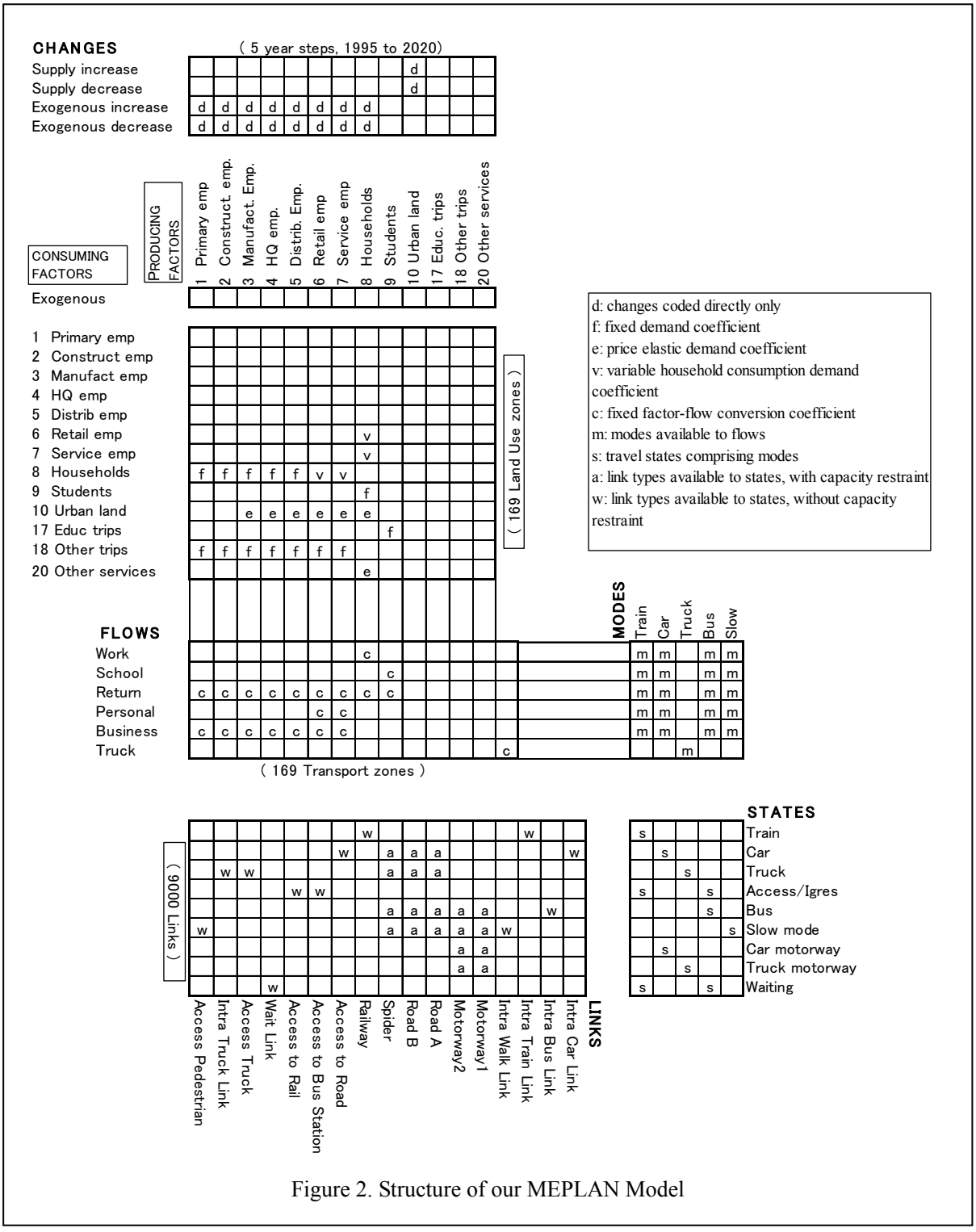


Figure 2. Structure of our MEPLAN Model

variety of aspects of the model structure. The large matrix in the middle indicates the pattern of consumption and production for each factor considered in the land-use model. For example, the households factor consumes output from primary, construction, manufacturing, high quality, distribution at fixed rates, and from retail and service at variable rates. The fixed rate means that households consume as employee productions from those sectors at fixed demand coefficient. The variable rate means that they consume at the rate that fluctuate with living costs, transportation costs and attraction factors which MEPLAN uses in the land use module. In the matrix, it is indicated that primary, construction, manufacturing, high quality, and distribution do not consume from their own. Since we assume in our model that those sectors are the least likely ones that consume other sectors, the row of those sectors are blank. In other words, it is hardly imagined that agglomeration of households lure those sectors to be located near them. The matrix at the top of the diagram concerns the structure of the incremental models. It indicates increases and decreases in the supply of space and the exogenous demands. The matrix just below the main matrix indicates the structure of the interface model. Each row in this matrix concerns one of the matrices of transport demand whose conversion rate is constant. The matrix to the right concerns the modes available to each flow. It indicates train, car, truck, bus and slow (walk). The matrix below this indicates the travel states making up each mode. Each column concerns a given mode and indicates the states that comprise that mode. The matrix to the left indicates how the travel states are treated on the links in the transportation network. It indicates the links that can be used when in that state and whether there is capacity restraint operating (a) or not (w). Our model carries 9000 links in the transportation network.

3. GLOBAL DATA FOR PROJECTIONS

MEPLAN needs several key projections as control factors for forecasting the future. These include:

1) Household

The total number of households of our study area, Kanto region, for 2000, 2005, 2010, 2015 and 2020 are calculated based on the growth rates used by the Tokyo Metropolitan governments. Since Tokyo Metropolis dominate our study area in terms of the number of population, which shares more than 40%, we used them as the growth rates of Kanto region to calculate the total number of households. Table 1 shows the growth rates we used.

Table 1 Household Growth Rates

	00→05	05→10	10→15	15→20
assumed growth rates	1.2	-1.3	-3.2	-4.6

(%)

2) Employment

The total numbers of employment are also calculated for the same period as the household. We again used the growth rates by the Tokyo Metropolitan governments as the same reason of the household projection, except the rate from 2015 to 2020. Since the official projection rate during this period does not exist, we employed the same rate as 2010 to 2015. Table 2 shows the growth rates.

Table 2 Employment Growth Rates

	00→05	05→10	10→15	15→20
Primary	-9.4	-10.2	-10.3	-10.3
Construction	-1.1	-2.3	-3.1	-3.1
Manufacturing	-6.6	-6.9	-7.0	-7.0
Distribution	-2.8	-3.7	-4.2	-4.2
Retail	-3.6	-4.3	-4.4	-4.4
Service	0.1	-1.3	-1.9	-1.9

(%)

3) Land

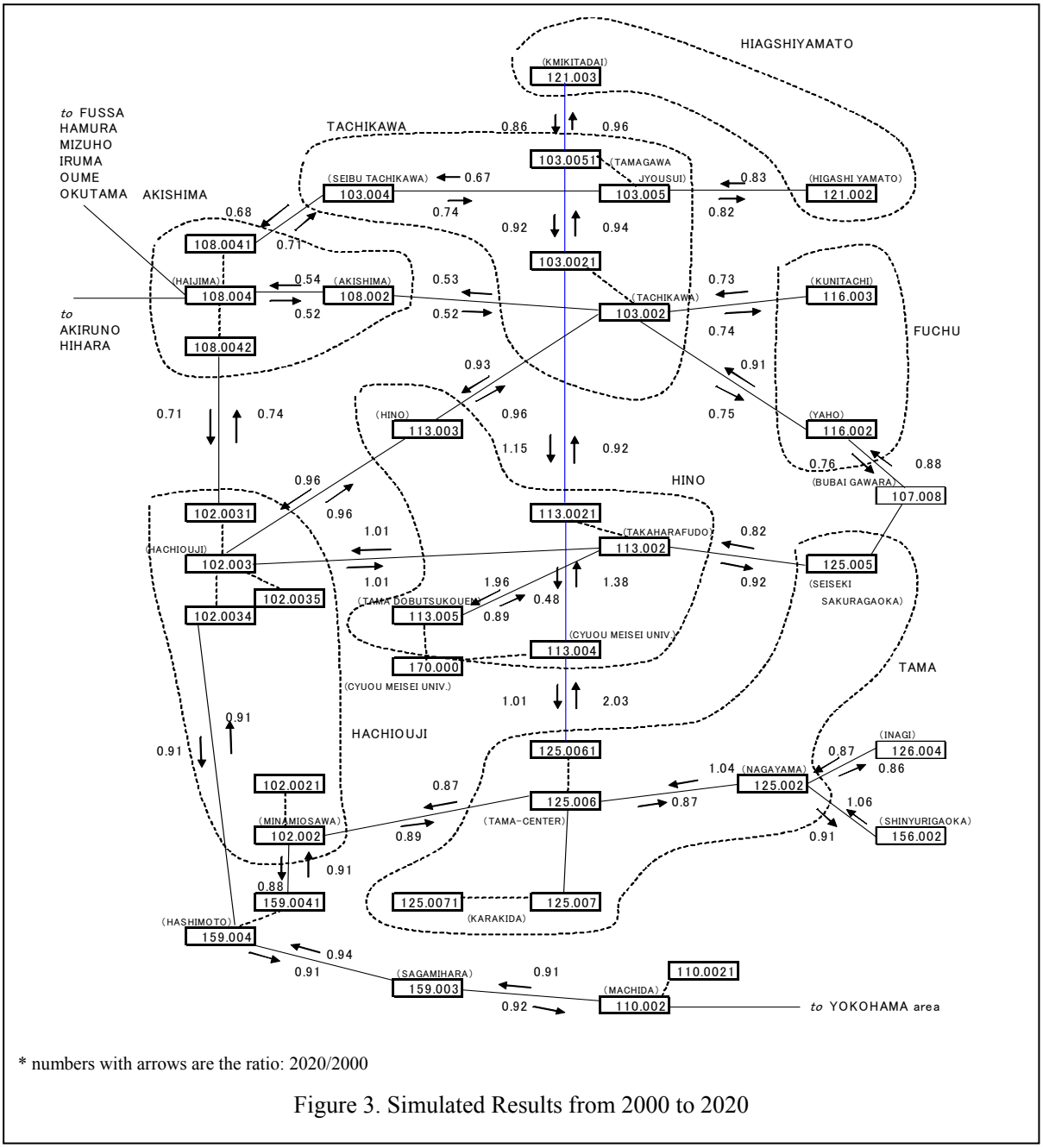
The aggregate supply of urban land is assumed to increase since MEPLAN model distribute household and non-basic sector based on utility, time and cost from centers to surrounding areas. As long term growth rate 5% per five year period has been assumed (i.e. for the increments between 2000 and 2005, 2005 and 2010, 2010 and 2015, 2015 and 2020).

4) Transportation assumptions

Transportation assumptions include public transport fares, toll highways, car and truck costs, parking costs and values of time. We assumed that car and truck costs are mainly deprived form gas prices. Values of time means the opportunity cost of time. We assumed the increases of all of these factors based on the growth rate of GDP, which we assumed 3% for five year period.

4. MODEL RESULTS

First, we compared simulation results of 1995 and 2000 with statistical data of the same years to examine the significance of MEPLAN. The statistical data we used to compare is the number of railway passengers published in TOSHIKOTSU NENPO, Urban Transportation Yearbook. In order to examine the significance, we divided the numbers of passenger of MEPLAN by the ones comparable in the statistical data. In the results of 1995, 35 links out of 45, which cover the Westside of Tama area, are between 0.8 and 1.2. The 77% of our focused links are within 20% of errors. The results of 2000 show 28 links out 55. Since MEPLAN model is designed to make macro projection, not to examine link by link, we found that our MEPLAN model is significant enough to see overall directions. However, we understand the biggest weakness of our MEPLAN model. It is that railway network is too loose to catch real behaviors of people's choice. For example, even thought there are several railway stations in a zone, our model abbreviated them



* numbers with arrows are the ratio: 2020/2000

Figure 3. Simulated Results from 2000 to 2020

into single or a couple of nodes for simulating purpose. Therefore, an extreme number of passengers may occur on a single link. There is another weakness we thought in our model. Since we do not distinguish between JR and Shitetsu, private railway, and do not take into account variation of railcar speeds on each link for simulating and data collecting purpose, some links shows more than 50% difference from the statistical data.

Fig.3 shows on which links the numbers of passengers are mostly decreased or increased from 2000 to 2020. simulating MEPLAN model of the monorail line connecting from KAMIKITADAI to TAMA CENTER. The ratios in the figure mean the numbers of 2020 divided by of 2000. There are four links that MEPLAN model projects the biggest decrease by 2020: TACHKAWA to AKISHIMA, AKISHIMA to TACHIKAWA, AKISHIMA to HAIJIMA and HAIJIMA to AKISHIMA. Their numbers would be almost in

Table 3 Numbers of Households in the Zones Located Further West

city	2000	2005	2010	2015	2020
IRUMA	49771	47387	48277	47043	45523
OUME	48840	46881	47209	46046	44377
AKISHIMA	42782	40044	40489	38938	37454
FUSSA	25922	23480	23263	22412	21361
HAMURA	21817	20794	20979	20531	19781
MIZUHO	11461	11345	11659	11599	11303
HIHARA	1112	1106	1135	1118	1092
OKUTAMA	2749	2671	2704	2660	2580
AKIRUNO	29886	28365	29059	28426	27663

half. Those links are located further west than TACHIKAWA city. One of the reasons we thought from the outputs of MEPLAN model is a decrease in the number of households in the zones. MEPLAN model distributes households from central cities based on level of utility that household members would experience in daily activities such as commuting and shopping. We thought that the zones would decrease their households because their utility levels decrease comparatively to those of other zones, and people would move out to the zones they might get higher utility level. Table 3 shows the numbers of households in the zones located further west. IRUMA, OUME, AKISHIMA, FUSSA and HAMURA would decrease. However, those decreases in the households are not large as in the passengers. As explained above, the deceases in the passengers would be almost in half. This is not reasonable and acceptable results. We thought that this is due to technical problems our MEPLAN model carries as we mentioned above, and needs further improvements in formulating model.

Thirdly, we simulated MEPLAN with the extension of the monorail line to HOKONEGASAKI, MACHIDA and both. Fig.4 shows on which links the numbers of passengers would mostly decrease or increase, and how many passengers would be generated on the extended routes by the year 2020. The links that would increase in large are the links around TAMAGAWA JOUSUI and TAMA CENTER. A unique implication can be found the links from CHUO DAIGAKU/MEISEI DAIGAKU to MACHIDA through TAMA CENTER. Since CHUO DAIGAKU/MEISEI DAIGAKU station is near two universities, CHOU and MEISEI, and the number of students together with both are about 30,000, most of who commute by the monorail, the route extension would provide more conveniences to whom commuting by transferring other railways to the monorail. Because of this reason, HASHIMOTO to MINAMIOOSAWA and HACHIOJI to HASHIMOTO are somewhat decreased.

The biggest reason we simulated the extension model is to see how many passengers would increase from the extended route. Since our MEPLAN model carries technical problems on formulating network as we explained, we project the numbers of the passengers on the extended routes by calculating average number of back and forth. MACHIDCA – TAMA CENTER would increase about 15,000 a day while HAKONEGASAKI – KAMIKITADAI would increase about 5000. The number of passengers increased from the extension would be about 20,000, which is almost 20% increase from 110,000 a day. We thought this is due to rising conveniences in commuting from YOKOHAMA area.

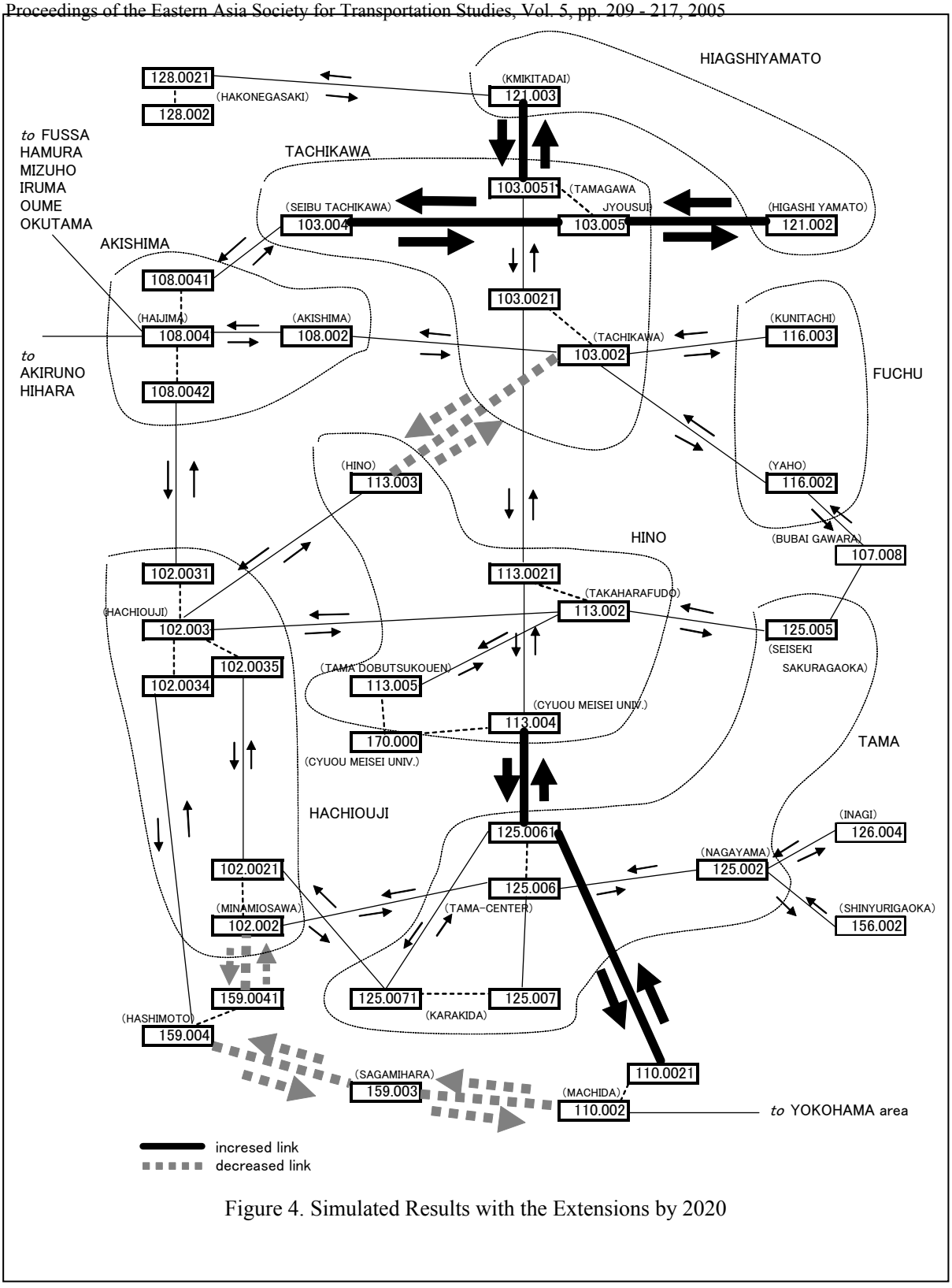


Figure 4. Simulated Results with the Extensions by 2020

5. CONCLUSION

MEPLAN model applied to Tama urban monorail indicated two implications. One is that the number of passengers on the lines connecting the areas further west than Tachikawa city would dramatically decrease. Even though there are some errors that might be derived from the weaknesses of our

transportation network and calibrations, we thought that this outcome would be meaningful to the regional planners in Tokyo region, who may face regional imbalance caused by the population decline. It is said that Japan, including Tokyo region, will face dramatic decline in population due to the decreasing number of newborn babies and the rapid transformation into aging society. We see our outcome as it indicates where would be the first one experiencing the decline, and which railway lines would be affected. To overcome the problems, insightful sets of social policies need to be introduced. The second outcome from our MEPLAN model is that the route extension of the monorail causes 20% increase in the passenger par day. Even thought there might be great difficulties to the route extension in reality, it would be interesting to consider the extension scenario with positive effects on environment. Introduction of public transportation may induce less car driving, which reduce CO2 emission ultimately. Therefore, the route extensions need to be evaluated in terms of not only the number of passengers increasing or monetary cost but environmental benefit.

Our model needs further improvements as we mentioned already. In addition to transportation network and calibration, the transportation data and various economic data we used are needed to be replaced with the latest ones. Therefore, we recognize our model applied this time as the first attempt to evaluate the total impacts of the monorail, and needs massive efforts to reach at ultimate goals.

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REFERENCES

Abraham, J.E. (1998) A review of the MEPLAN modeling framework from a perspective of urban economics, Department of Civil Engineering Research Report No.CE98-2, University of Calgary

Hunt, J. D., Simmonds, D.C. (1993) Theory and application of an integrated land-use and transport modeling framework, **Environmental and Planning B: Planning and Design, volume 20**, pp.221-244

Marchial Echenique and Partners LTD (1996) MEMOTO: MEPLAN model of Tokyo, Pilot calibration and testing, ME&P

U.S. Department of Transportation (2001) Literature review: Land Use Transportation Model Integration, The travel model improvement program, U.S. Department of Transportation, Washington D.C.

Williams, I. N. (1994) A model of London and the South East, **Environmental and Planning B: Planning and Design, volume 21**, pp.535-553