A Person-Trip-Survey in Sapporo Metropolitan Area

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(Received August 20, 1969)

Abstract

Transportation improves with competition and cooperation of various items, consisting of such individual means such as cars, street cars and pedestrians which cannot function well individually without external aid provisting. Thus, recent traffic surveys with an emphasis on individual means can not fully grasp the entire traffic scheme, and hence all-out plans for systematic transportations could not be obtained.

From the fact that all transportation means at work carries a man or men, the total pursiut of man's movement shows the movement of transportation means. This pursuit is referred to as a person-trip-survey. It is an excellent method especially when personal interviews on streets are impossible due to heavy traffic or a large number of pedestrians.

In this paper complicated traffic problems are clarified by the person-trip-survey in the metropolitan area of Sapporo. Adopted analytical methods are as follows; (1) Origin and Destination analysis (2) Trip length analysis (3) Trip end analysis (4) Time belt analysis (5) Stratified change analysis.

I. Introduction

The urban problems in the contemporary world urge the interests not only of a few specialists, but also people in various fields. Such urban problems are generally itemized into the following[1],

(1) population problems
(2) social problems
(3) transportation problems

of which (1) is primary and the latter two are derived from (1). For example, poor housing, which is one of the major social problems, in the result of over-concentration of men in urban areas; and the transportation problems are population problems viewed from a kinetic angle.

Thus, for the solution of urban problems, a view with full consideration to

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life and livnig are required.

In the past, however, the industries and economic activities were often over-weighted, while city life of man was neglected. Influenced by such tendencies, the transportation planning often payed little interest to man, and as a result, extraordinary traffic jams at commuting time and school attendance have become an everyday experience, and the frequent traffic accidents pose a threat to urban life.

Traffic surveys and plannings heretofore were done according to transportation means or facilities. That is to say, road placement plan were made based on traffic survey of cars, railway settlement plans were based on a survey of railway transportation, harbor improvements were based on harbor traffic surveys, and airport placement were based on the air lift surveys etc., and there were no interrelations between any two plannings or surveys.

Needless to say no transportation facilities or individual means can be managed independently. But, with cooperation and competition, between individual means systematic functions may be produced which work effectively provided that man is given primary consideration[2].

There exists no car without a driver, no ship without a helmsman. Therefore, systematic transportation plannings should be made based on research data on the traffic behavior of man. The person-trip-survey meets the above requirement with satisfactory results. This method was first adopted in the *Imizu* region of the Toyama prefecture by the City Bureau of the Ministry of Construction in 1965[3]; later it was adopted in the *Kita Kyushu* metropolitan area of the Fukuoka prefecture[4], Hyogo prefecture[5], the Hiroshima region[6], and Tokyo megalopolis[7].

Followed by a preparatory survey in Feb. 1967, the person-trip-survey was accomplished in the Sapporo metropolis on Friday June 30, and Sunday July 2.

This is a report of the survey and its analysis.

1-1. Sapporo Megalopolitan area and its zonings

The Sapporo megalopolitan area here includes the cities of Sapporo and Ebetsu, the towns of Ishikari and Hiroshima. The area and the population of each city or town are shown in table 1.

Referring to the the Origin and Destination Survey[9], and for convenience in totaling, the Megalo-area was divided into the following 66 zones, and are shown in Figure 1.

1-2 Person-Trip-Surveying Method

In order to follow up on the traffic movements of man in their respective zones, the home-interview method was adopted.

The questionnaire sheets were simplified and made easy for the individual.

TABLE 1. Area and Population of Sapporo Megalopolis[8)]

city	city planning area		Densely Inhabited Districts		administrative division		expansion of roads in city planning
	area (ha)	population	area	population	area	population	
Sapporo	52,952	821,048	6,970	688,777	111,798	821,217	519.6
Ebetsu	18,884	44,510	260	14,964	18,884	44,510	43.9
Ishikari	9,365	7,605			12,877	8,522	
Hiroshima	8,402	7,546			12,180	8,022	
	89,603	880,709			155,739	882,271	

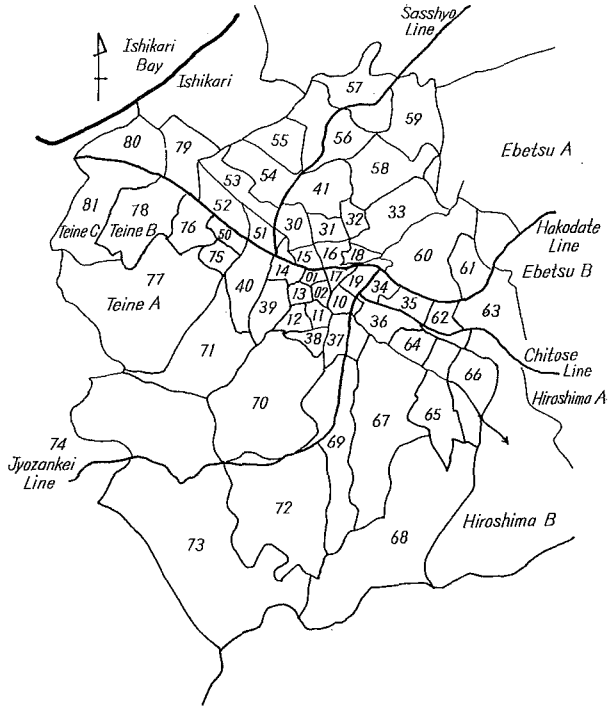

Fig. 1. Zoning in Sapporo Metropolitan Area

downtown area	01.02
first urban area	01–19
second urban area	30–41
suburban area	50–81

They were distributed and collected by second year pupils of junior high schools in the area. They were distributed in the zones in the same proportions as classified by age and by occupations.

The Questionnaire for City and Transportation Planning

City and Transportation Planning
Department, Faculty of Enginnering,
Hokkaido University
City Planning Section of Hokkaido
Prefectural Government

Please fill the blanks with your trip information of 30th (Fri.). of June.

No: (age: Mr. or Miss. Mrs.) Home Address:

Occupation: Place of Business. or School:

Business Address:

Object of trip	Departure Time and Place	Arrival Time and Place	means of communication a) walking b) bicycle c) streetcar d) private railway line e) national railway line g) passenger car h) hire car or taxi i) truck j) light-van k) motorcycle l) other means
			○ means ( ) ○ means ( ) ○ means ( ) ○ min. min. min. *min *min. the time required in min. the time required in min. the time required in min.
			○ means ( ) ○ means ( ) ○ means ( ) ○ min. min. min. *min. *min. *min. *min. the time required in min. the time required in min. the time required in min.
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			○ means ( ) ○ means ( ) ○ means ( ) ○ min. min. min. *min. *min. *min. *min. the time required in min. the time required in min. the time required in min.
Objects of trip			1) going to work 2) going to school 3) returning home 4) business 5) shopping 6) amusement 7) visiting 8) hospital 9) welcoming and sending off of guests 10) other objects

2. Origin and Destination Analysis

2-1. O. D. Table

The results of the survey were as a first step divided into origins and destinations, then these were classified according to occupations, purposes, and for weekdays and holidays, these were placed in the Origin-Destination table. Then

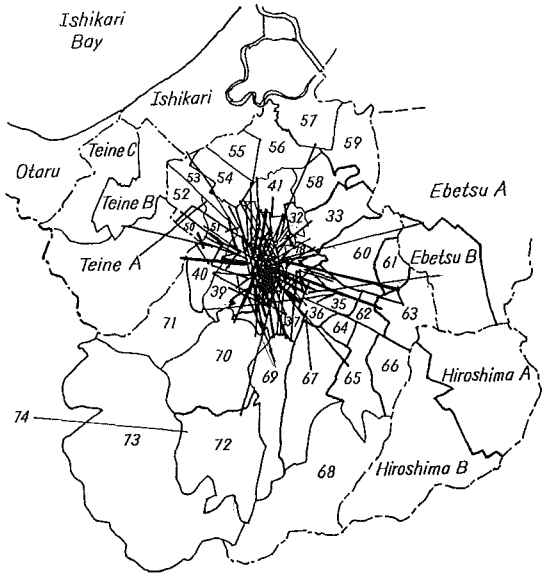

Fig. 2. Desire Line Map
(commuters : weekday)

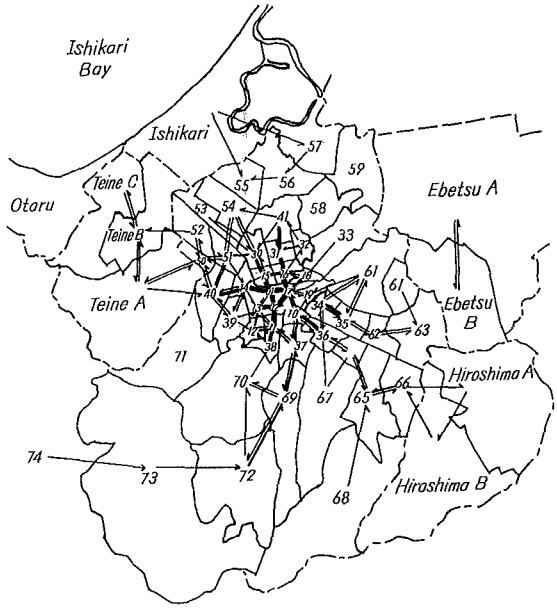

Fig. 3. Pass-Through Zones in Commuting

the pass-through zones which O. D. table cannot express by reason of its nature, were examined. Figure 2 shows the desire line map made from the O. D. table of commuters, and Figure 3 is its pass-through Zones.

2-2. O. D. Analysis

O. D. analysis was done by occupation, weekdays and holidays. In volume, the total trips of a weekday reach as high as 1,780,000 trips; among which office workers (men and women), students (pupils included) and self-supporting workers come to 79.3%, while housewives, and children under the age of six and others amount to 20.7%.

Office workers and students start their trips at certain times in the morning and evening, and as a consequence, rush hours occur, during which the traffic in zones 01 and 02 shows the highest values. The fact that all transportation means join in zones 01 and 02 accelerate the centralizations; all street car lines running through the first urban area cause the trip developing area to join here, and the bus networks which cover the trip developing area of the second urban area are controled here at the bus center.

Speaking of holidays, the total trips amount 1,240,000 trips, which is 30% decrease of weekday trips. This may suggest that many people stay at home on holidays. There are, however, noticeable movements into the downtown, area, especially into zone 02. This is because of the fact that many shopping and recreation facilities are located in in zone 02. This is in distinct contrast with the fact that zone 01 receives heavier traffic than 02 on a weekday. Also on a weekday, trips are concentrated mostly in the mornings and evenings, while on a holiday, they concentrate around noon.

Viewing the present traffic conditions, we suspect that the cities will be confronted by critical situations with the increase of the populations and as a consequence of the concentration of commuters and school attendants at the center. These are summed up in two items and urgent countermeasures are required.

1. traffic jams during the rush hours
2. traffic jams in the downtown area

For the first step, the transportation network plan···on the foresight of city functions and utilities···is required. Re-examination of the city functions, plannings of effective and efficient use of land, proper placement and distribution of the population, control over the traffic of city dwellers, the limitations of the urban activities arising from transportation···these items are essential for synthetic transportation planning.

3. Trip Length Analysis

3-1. Trip Length

TABLE 2. The average trip length according to purpose, and weekdays and holidays

upper : weekday
lower : holiday

	commuting	school attendance	returning home	business trip	shopping	recreation	visiting	hospital	welcoming & sending off guests	others
office workers (man)	6.5 6.6		6.7 7.5	12.7 11.9	4.3 5.6	3.9 10.0	5.8 11.2	5.7 7.5	7.8 11.2	4.7 6.0
office workers (woman)	5.2 5.1		5.0 5.5	4.4 8.9	1.0 3.7	2.8 8.7	4.6 8.0	1.8 4.8	 7.5	5.2 4.0
house wives			2.2 4.0	3.8 4.2	1.5 2.2	4.4 7.7	5.4 5.9	3.5 3.5	4.4 4.6	4.0 4.8
self-supporing workers	6.1 5.2		 6.6	8.9 6.5	5.1 5.8	5.5 10.3	5.7 10.5	5.8 	 8.1	6.3 6.7
students	6.8	7.1	6.9 5.7		2.0 4.6	3.5 7.1	2.0 5.3	2.2 	6.6 3.1	3.3 4.8
pupils		1.6	1.6 3.9		1.1 3.9	2.6 6.8	1.5 5.1	1.4 1.9	 	1.2 4.3
child under the age of six		1.1	1.0 3.5		0.8 2.0	0.8	1.9	2.3	 	0.9 2.2
others			2.4 6.3	2.8	3.7	1.6	4.0	2.0	 2.0	1.6

TABLE 3. The average trip length of commuters and students divided by mode of transportation

	a	b	c	d	e	f	g	h	i	j	k
commuters	0.8	4.4	6.3	7.9	17.9	21.5	(25.0)	9.3	3.8		8.5
students	1.0	5.8	6.5	8.6	18.6	22.3	(11.5)	8.5	4.1	(18.0)	8.8

a) on foot
b) by street-car
c) by bus
d) by street-car and bus
e) by railway
f) by railway and bus
g) by railway, bus, and street-car
h) by car
i) by bicycle
j) by bicycle, railway and bus
k) by other means
( ): lack of data

A trip length is defiued as the length of one trip. The examination of trip-lengths of man indicates the sphere of every day trips.

Trip lengths differ in purpose, productivity of man, time of travel, transportation means, etc. Thus, the following are taken into consideration in the analysis. (1) purpose (2) occupation (3) weekdays or holidays (4) transportation means.

The results are shown in Table 2 and Table 3.

3-2. Trip Length Analysis

The average trip length of man differs in purpose, and whether it is a holiday or weekday.

Now selecting morning commuting, school attendance, business trips in the day time, shopping and returning home, the mean daily trip length will be examined.

The average trip length for a commuter is approximately 5 to 6 km, mostly by bus or by city street-cars which will be shown in the following Time-Belt Analysis.

With regard to school attendance, there is a great difference between students and pupils: the average trip length for a student is 7.1 km, while for a pupil, 1.6 km, the former is 4.8 times longer than the latter, because of the fact that the former makes use of buses or city street-cars in a manner much the same as commuters when the latter walks. The required time for both cases are 40 minutes. In Sapporo, the average required time for going to school are 40 minutes; thus these form the 40-minute-commuting zone at present.

When holidays and weekdays; are compared there is no difference in the trip length with regard to such production activities as commuting, but on a holiday, the consumption activities such as shopping, recreation, etc. are three times as long as that of weekdays.

This is because many shopping and recreation facilities are located in zone 01 and 02 and with a few in the suburban areas, thus a large number of people are attracted to such areas.

Now considering the present and the future development of the city, it is anticipated that the trip length in such production activities as commuting and business trips will grow longer, for there is a strong inclination at present to build houses in low population density areas, for example, in zone 51, 52, 53, 54, 55, 56 to the north, 61, 62, 63, 64 to the east, 67, and 69 to the south, with an ever growing distance from the downtown area.

But the trip-length for consumption activities especially for shopping will remain with little changed: shopping is done mostly on foot, and the sphere of activity on foot can hardly change. Thus, the fact that more than 70% of a average trip for shopping is within 1.5 km or 1.0 km this may be utilized in the future placement of shopping centers in residential areas.

4. Trip End Analysis

In the preceding sections of Origin-Destination Analysis and Trip Length Analysis, the spheres of means movement, in other words, the direction and length of the trip were examined.

In this chapter, the evolution and absorption of a trip, namely the trip end (in the following descriptions, the word trip in a strict sense means the trip end) will be examined by occupation and purpose.

4-1. Rate of trip-evolution according to occupation

Occupations are classified into (1) office workers (men), (2) office workers (women), (3) housewives, (4) self-supporting workers, (5) students, (6) pupils, (7) children under the age of six, and (8) others, and their trip evolution rates were calculated.

Table 4 shows the respective rates for a weekday.

(1) Office workers (men)

The rate of generation in commuting for male office workers is 0.915 on a weekday and 0.255 on a holiday. This indicates that a large percentage go to work even on holidays. Thus, business trip for the day time is 0.304.

A study on consumption activities shows that recreation on a weekday is 0.1, while on holidays it increases up to 0.223, and shopping up to 0.142: The questionnaire were not adequate in tracing weekday recreation.

Based on the above mentioned fact from the previous O. D. analysis, it was noted that male office workers show a pattern of downtown concentration both on weekdays and holidays the former for the sake of production activities, and

TABLE 4. The rate of trip-generations on a weekday

	number	attendance office	attendance school	business	shop-ping	amuse-ment	visiting	hospital	welcoming and sending off a guest	others	returning home	trip per head
office workers (man)	1,056	967 0.915	4 0.004	323 0.304	47 0.044	105 0.099	35 0.033	20 0.019	13 0.012	42 0.038	1.077 1.015	1.468 (2.483)
office workers (women)	619	375 0.895		38 0.061	69 0.165	15 0.036	21 0.050	15 0.036		26 0.062	444 1.060	1.305 (2.365)
house wives	730			10 0.014	567 0.777	23 0.032	99 0.136	72 0.097	13 0.018	12 0.017	859 1.176	1.071 (2.267)
self-supporting workers	191	14 0.073		127 0.665	24 0.126	3 0.016	10 0.052	8 0.041		9 0.047	186 0.874	1.020 (1.894)
students	567	7 0.012	573 1.011		38 0.067	21 0.037	10 0.017	5 0.009	2 0.003	37 0.065	581 1.025	1.221 (2.246)
pupils	933	4 0.004	896 0.960		61 0.065	9 0.010	19 0.021	29 0.031		89 0.095	1.088 1.161	1.186 (2.347)
children under the age of six	69		17 0.246		24 0.348	4 0.058	6 0.087	10 0.145		13 0.188	65 0.342	1.072 (2.014)
others	138				38 0.271	8 0.060	30 0.226	20 0.150	1 0.008	20 0.195	100 0.752	0.918 (1.670)

upper generating trips
lower *rate of generating trips*
( ): average of generating trips including returning home

the latter for consumption activities.

(2) Office workers (women)

The rate for a weekday is 0.895 for commting which is a little lower than that of men, because many women are part time workers. The business trip rate for female workers is extremely small. The Shopping rate is 0.165, which is extremely low when compared with housewives, and the shopping trip length is similar to that of housewives.

On a holiday for women, the commuting rate increases to 0.272, which is higher than male office workers, because women are frequently employed in such places as department stores which are open on Sundays. Also, shopping goes up to 0.411 which is higher than on a weekday, but still lower compared with housewives. This may mean that such female office workers are not good customers for stores and supermarkets which handle consumer goods.

(3) Housewives

Shopping trips on a weekday are 0.777 which is a considerably high rate, and other trips are nominal, among which visiting hospitals is outstanding. Shopping on holidays shows 0.560.

Recreation for house wives is 0.144. The trip evolution rate and the trip length analysis show a rather small sphere of activity for housewives.

(4) Self-supporting workers

Because of the nature of their occupation, the trip generations are small in general···only 0.545 for business trips which is a remarkable rate. This may be because many of the self-supporting workers are farmers.

(5) Students

School attendance is, of course, their major trip. The trip rate 1.011 which slightly larger than 1.000 means they return to school again for club activities or other work. On a holiday, trips become frequent with 0.247 for shopping and 0.232 for recreation. Adding all trips excluding school attendance, four students out of five were found to depart from their homes for certain purposes on a holiday.

(6) Pupils

The same picture as seen in students for school attendance is seen. However more pupils depart from their homes than students on a holiday.

(7) Children under the age of six

The kindergarten attendance rate is one out of four, namely 0.246. In the future, however, with the increase of infantile education, special heed for such

infants in the transportation planning will be required.

(8) Others

No remarkable trips patterns can be traced for older generations.

4-2. Trip-generation according to zones

Generally speaking, the more populous an area becomes, the higher the traffic rate becomes with an heigtening of economic and social activities. Thus, the interrelations between the population and the trip evolutions in commuting, school attendance, and household shopping were investigated, and the following results were obtained.

(1) Population (P) and commuting (Tao)

$$Tao = 0.334P - 132$$

correlation coefficient: $r = 0.95$

(2) Population (P) and school attendance (Tas)

$$Tas = 0.333P + 461$$

correlation coefficient: $r = 0.97$

(3) Population (P) and shopping of housewives (Ts)

$$Ts = 0.132P + 180$$

correlation cofficient: $r = 0.92$

Correlation coefficient in all cases shows values exceeding 0.9. Thus, the evolution number of Tao, Tas and Ts may be obtained if the population in a zone is given.

4-3. Trip-absorption according to zones

In the following section, the relations between the economic index of every zone and trip absorption of commuting, school attendance, and business trips were examined.

(1) Commuting absorption

Commuting absorption in a zone is closely related to the number of employees there. The model formula below expresses the relation between the number of employees in a zone (Pw) and commuting absorption trips (T'ao):

$$T'ao = 0.725Pw - 863$$

correlation coefficient: $r = 0.95$

Also, explanations by means of gross floor extention of commercial and industrial facilities were attempted but the work was unsuccessful. In producing such a model formula as given above for a person trip survey, it is appropriate to choose some explanatory variables related to the population.

(2) School attendance absorption

All school attendance trips are, needless to say, absorbed in schools. Thus, further explanations are not required, however, this study is useful in examining the accuracy of a Person Trip Survey.

Table 5 shows the number of students and the number of the attendance

TABLE 5. The number of students and the attendance absorption trips according to zones

zone	number of students	attendance absorption trips	zone	number of students	attendance absorption trips
02	386	200	40	3,679	6,600
10	9,450	8,600	51	922	800
11	7,669	12,000	52	1,118	200
12	1,002	4,200	62	1,370	600
13	3,770	5,000	64	2,261	1,200
14	6,785	6,000	67	1,069	600
15	12,134	11,000	69	563	1,600
16	5,530	7,200	70	1,927	2,400
19	1,659	3,000	72	778	400
30	3,584	4,000	Ebetsu	4,564	5,000
32	1,507	4,200	Hiroshima	1,014	400
36	3,406	6,200	Ishikari	542	400
37	2,598	1,000	Teine	570	0
38	2,569	3,400			
33	1,235	2,800		83,661	99,200

absorption trips, and the model formula is

$$T'as = 1.01\ Ps + 513$$

correlation coefficient: $r = 0.89$

here T'as means the absorption trip, and Ps, the number of students.

The data used here are, The table of schools in Hokkaido for the year 1968 issued by the Bureau of Education of Hokkaido ··· for hige school students, and for university students and training school students. The above is the result of research by the Transportation Planning Seminar of the Hokkaido University. The number of training schools or, vocational school students are of schools of large size.

(3) Business trip absorption

The second largest trips for commuters followed by commuting are business trips. They evolve 55,800 in total and absorb 50,600 on a weekday. The discrepancy may well indicate the absorption by areas outside of Sapporo. In zone

01 and 02 which are called the central business district, 21,000 trips evolve, and 17,400 trips are absorbed, the former, 38% and the latter 34% of the whole. The high percentages suggests the importance of this district.

5. Time Belt Analysis

5-1. Rush hours

Traffic congestion at the time of commuting and school attendance is so intense that without countermeasures, smooth and rapid commuting will become impossible.

For the purpose of grasping the present state of the rush hours and in search of countermeasures, the following assumed rush hours in the morning and evening were selected···7 : 00 to 9 : 30 a.m. and 4 : 00 to 8 : 30 p.m., and are analyzed according to 1) occupation, 2) means of transportation, and 3) zones.

5-2. Time belt analysis

(1) Analysis by occupations

The percentage of the morning trips by occupation are

commuters (men and women)	38.9%
school attendance	54.1%
others	7.0%

As seen on figure 4, those who start trips from 7 : 00 to 9 : 30 a.m. are commuters and students (93% in both), and others are nominal. Students, between 7 : 00 to 8 : 45, at its peak 8 : 00, go to school. The Commuter rush comes around 7 : 30 to 8 : 45, with its peak at 8 : 00, and after 9 : 00, the trips decrease drastically. Others, which occupy 7% of the morning rush hours, increase steadily when the rush hours are over.

Looking at the evening rush hours, commuters occupy 40.4%, students 40.2%, and others 19.4%, which is different from the mornings the increase of others to 19.4% may mean housewives returning from their shoppings during the time when commuters and students arrive home. The commeters draw a peak at 6 : 00 p.m., while students and others at 4 : 00 p.m.

(2) Analysis by transportation means

The three major transportation means in the morning are walking 40%, 33% by bus, and 11% by city street car, and other means are cars (4.7%) the National Railways (4.6%), bicycles (3.5%), and private railways (1.0%), among which cars are noticeable with the rapid increase of owner drivers at present.

In the evening, the transportation means are walking 40%, bus 26%, and city street cars 10% ; there are many people who arrive home latter than 8 : 30 p.m., avoiding the evening rush hours.

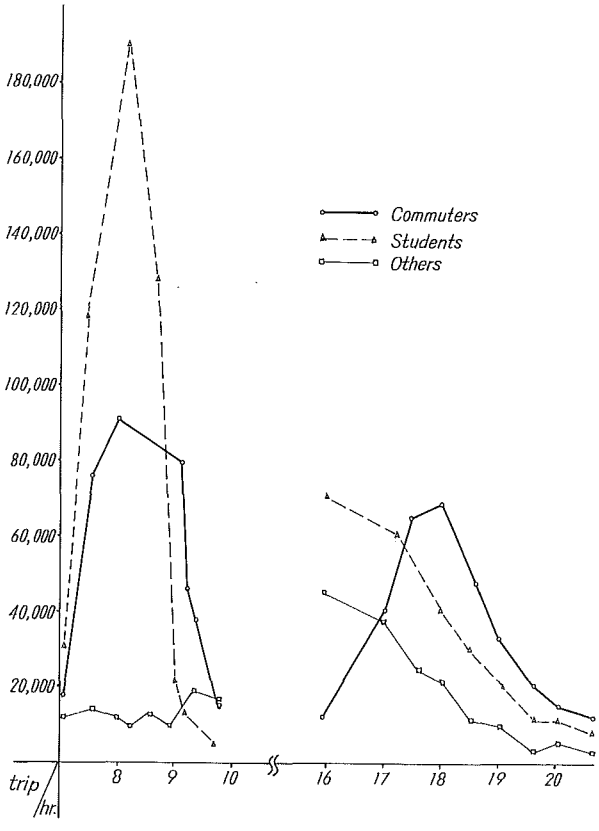

Fig. 4. Trip Time Belt by Occupation

(3) Analysis by bus

As mentioned in (2), bus transportation is an important means in Sapporo. With the peak at 8:00 between 7:30 to 8:30, the students concentration is highest, commuters concentration falls between 7:30 to 8:45, with the peak at 8:15 a.m.

In the evening, the peak for students is at 4:00, and at 6:00 for commuters.

(4) Analysis by city street cars

Another important means in the city of Sapporo is the city street cars. The time belt and the peak in the morning are the same with bus, however, more trips appear a little later than the bus users, because of transferring from bus to street car occurs.

In the evenig, unlike the case of bus transportation, the peak of students takes place at 5:30.

(5) Time belt by the Japan National Railways

This differs from both bus and street car transportation the morning peak appears earlier; for example, the student rush forms a peak from 7 : 30 to 8 : 15, and the commuters form peaks from 8 : 00 to 8 : 30.

In addition, the fact that commuters, and others concentrate in wave assault fashion is because of the railroad time table.

6. Constitution of the Sapporo Area in View of Travelling Time

Among various trip purposes, the most susceptible to time are commutation and school attendance, which are performed on predictable schedule. Here, the commuting was selected as a target and the Sapporo area was divided by its travelling time.

6–1. Commuting time circle

The required time for commuting by mass transportation means from every zone into the downtown area are shown on figure 5. They draw concentric

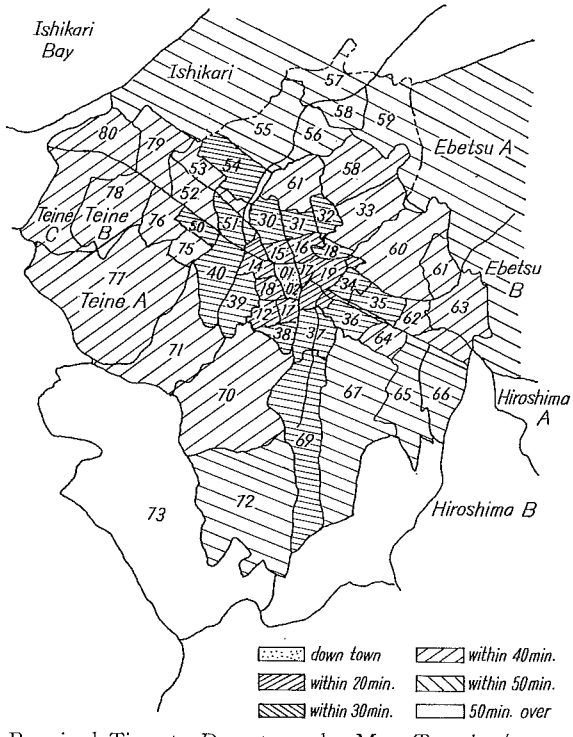

Fig. 5. Required Time to Downtown by Mass-Trausits (street car, bus)

circles, in accordance with the distance from the center; zone 18 may be in a 20-minute circle on a physical map, but with the lack of directly connected bus lines and street car lines to the center, it is placed in the 30-minute circle. And zone 50, 54, and 69 are placed in the 30-minute circle, because of the conveniences of the national railways in zone 50, of street car lines in 54, and directly connected bus routes to the center in 69, which are all assumed to be in the 40-minute circle on a physical map. Accordingly, the divisions of the megalo-area by commuting time become possible.

6-2. Commuting into the downtown and in zone areas

(1) into the downtown area

The relations between required time to the downtown and the commuting evolution to the downtown divided by the entire commuting evolution are shown in table 6.

TABLE 6. Commutation time circle

commuting time circle	average required time to downtown	A number of commuters	B number of commuters to downtown	C in-zone commuter	B/A	C/A
20 min. cycle	20 min.	73,200	29,400	10,200	40%	14%
30 min. cycle	29 min.	133,200	52,600	15,800	39%	12%
40 min. cycle	38 min.	36,000	11,000	5,400	31%	15%
50 min. cycle	47 min.	18,600	2,200	10,400	12%	56%
50 min. over	65 min.	6,400	400	4,400	6%	69%
		267,400	95,600	46,200	36%	17%

The entire commuter population in the Sapporo area is 346700, of which 95600, 28% are concentrated in the downtown area; and the numbers of residents by required time in commuting circles are

within	20-minute circle	27%
	30-minute circle	50%
	40-minute circle	13.5%
	50-minute circle	7%
more than 50-minutes		2.5%

90.5% of the entire commuters live within the 40-minute circle, and they are 97.5% of downtown day population.

(2) in-zone commuting

The relations between the required time in commuting and in-zone commuters are different from (1);

within	20-minute circle	14%
	30-minute cricle	12%
	40-minute circle	15%
	50-minute circle	56%
more than	50-minutes	6.9%

With the increase in time required for commuting, the higher the rate of in-zone commuting becomes; the fact that the 20-minute circle has a higher percentage than the 30-minute circle means that the latter does not make a man feel farther than the former time distance when the former absorbs more commuters than the latter, that is, the employees in 30-minute zone are 84,400, and 160,400 in the 20-minute zone.

The entire in-zone commuters are 46,200 which is 17% of the entire commuter population in the Sapporo area. There is a discrepancy between the 40-minute and the 50-minute circles in in-zone commutating.

Considering the fact that there is a big gap between the 40-minute and the 50-minute circles in commuting time, along with the above statement, it is evident that the 40-minute commuting circle exists in the Sapporo region, which should be kept in mind in the case of transportation plannings.

7. Stratified Change of the Transportation Means

Person-trip-length varies in accordance with transportation means; for example, 800 to 1,000 meters of distance is within easy walking distance, but a large number of people use street car or buses to reach distant places.

The change of transportation means is not done abruptly, but it proceeds

TABLE 7. Trip from the street car-and-bus available areas to downtown on a weekday

distance (km) / means	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000
pedestrian	272	30	6	1	0	0	0	0	0	0	0	0	0	0	0	0
street-car	3	0	0	13	10	10	11	10	4	3	1	3	1	0	0	0
bus	1	2	4	8	9	16	7	6	5	9	1	5	2	0	1	1

distance (km) / means(%)	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000
pedestrian	98.6	73.2	37.5	4.5	0	0	0	0	0	0	0	0	0	0	0	0
street-car	1.1	21.9	37.5	50.1	52.6	38.5	61.1	62.5	44.5	25.0	50.0	37.5	33.3	0	0	0
bus	0.4	4.9	23.0	36.4	47.4	61.5	38.9	37.5	55.5	75.0	50.0	62.5	66.7	0	100	100

rather gradually from short distance means to long distance means; in the morning rush hours, a trip length within 1 km is covered by 54% of pedestrians, 30% by street car, 14% by bus, while in distances of 2 km, 2% by pedestrian, 56% by street car, 42% by bus.

Taking the trip length along the X-axis and utility rate along the Y-axis, the changes of the means are drawn by stratification therefore, this is called the stratified change of the transportation means.

Here, in the Person-Trip-Survey, the stratified change of the transportation means are examined with classifications by street car and bus available areas, and bus available areas, and trip purposes. The following explanations are giver for

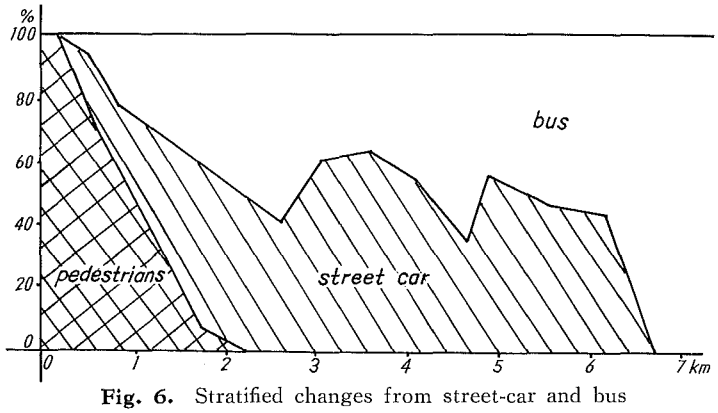

Fig. 6. Stratified changes from street-car and bus available areas to downtown

TABLE 8. The utilization rates in the bus, street-car available areas (commuters, in rush hours of June 30, 1967)

	number of users		utilization rate	
	bus	street-car	bus	street-car
10	9	4	0.56	0.44
11	7	8	0.47	0.53
12	8	9	0.47	0.53
13	2	8	0.20	0.80
14	3	2	0.60	0.40
15	3	4	0.43	0.57
17	3	13	0.19	0.81
30	5	19	0.21	0.79
38	3	5	0.38	0.62
39	18	6	0.75	0.25
41	14	5	0.74	0.26
54	2	1	0.67	0.33
	77	84	0.476	0.522

Table 7 is the weekday commuting trip volume from street car and bus available areas to downtown, and the stratified changes are presented in figure 6. commuting in street car and bus available areas.

The pedestrian volume decreases linearly with the increase of distance, and the limitation is about 2,000 m. Also, the utilization rate of street-cars in the bus-street car available areas is as high as 52.2%, as shown in Table 8.

Acknowledgment

The author wishes to express his hearty appreciation to professor Hirozo Ogawa, Faculty of Engineering, Hokkaido University, for his advice and critical reading of the manuscript.

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