A STUDY OF MEASURES TO IMPROVE THE AVERAGE SPEED AND CAPACITY OF LOCAL BUS SERVICES IN JAPAN

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Abstract:
Some cities in Japan introduced certain measures to ensure sufficient capacity and to improve the average speed of local bus services. Since most of the past studies focused on only few cases without comparison among the cases, this research focused on several cities which tried some measures to improve the capacity and the average speed. Through investigation at fifteen sites in eleven cites, the study found that provision of rapid services can improve average speed of buses about 5 km/h and that installing an exclusive/priority bus lane with strict regulation by police officers is also effective._

Keywords: Local Bus Services, Capacity, Average Speed, Priority/Exclusive Lane, Fare Control System

1. INTRODUCTION

The number of passengers of local bus systems in Japan has been decreasing. Although the population in Japan is stable, the number of bus passengers has been decreasing more rapidly (Figure 1). As a background to this rapid decrease, there are progressing motorization and worsening the service levels of the local bus services such as deterioration of punctuality and decrease of the average speed, both of which have close relationship especially on congested roads. In addition to this unfavorable market condition to local bus services, some bus companies have tried to cover the decrease of the revenue by the increase of the fares and decrease of the bus services frequency. Thus, the current condition of the local bus services in Japan is in the middle of vicious circle.

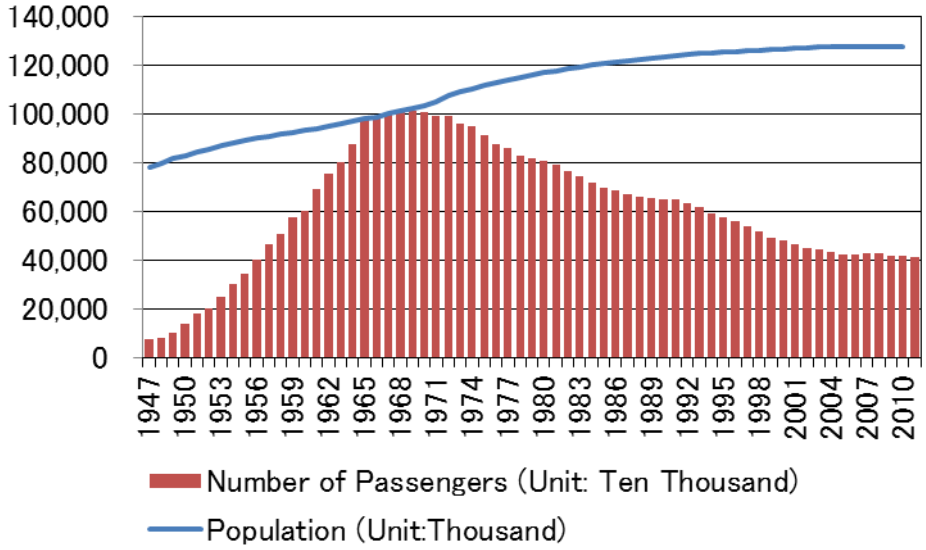

Figure 1. Trend of the local bus passengers and population in Japan
Source: Japan Bus Association (2014) and Ministry of Internal Affairs and Communications (2013)

On the other hand, some of the Japanese bus companies have made their efforts to make the current conditions better. They tried to improve the passengers' demand by several measures:

1) improving the average speed and punctuarity;
2) modifying the operating routes and timetable for passengers' convenience;
3) introducing various discount fares;
4) others(e.g.: introducing step-free bus, make roof at bus stops and real time location system, etc.)

Especially, improvement of the average speed and punctuality contributes to satisfying the passengers and results in the increase of the demand. Thus, various measures have been implemented to improve the average speed and punctuality of the local bus services in Japan.

Based on the above background, by reviewing the past studies, this paper firstly surveys the measures which have been implemented in Japan for improving the average speed and punctuality and how those measures have worked. Then, through the practical surveys to several local bus services in Japan, the present study investigates the current traffic conditions such as transport volume and capacity. Then, the study finds out what kind of measures should be introduced for improving the capacity and average speed of the local bus services in the future.

2. REVIEW OF THE PAST STUDIES

Various studies have been implemented so far about the punctuality, average speed of the local bus services and the capacity of passenger transport. Among them this section reviews the practical studies which have studied some cases that introduced certain measures to improve the local bus services and also reviews their effects.

2.1 Introducing Exclusive/Priority Bus Lanes

The most common measures to improve punctuality and the speed of bus services are to introduce the exclusive/priority lanes for bus services in certain hours. These measures were

already introduced into a number of cities in Japan, and some studies have been implemented focusing these measures.

Honda *et al.* (1985) investigated the exclusive bus lanes introduced in Fukui city at that time, and the study indicated some issues which hinder the performances of the exclusive bus lanes:

1) imperfect separation between the local buses and other vehicles;
2) some disturbances at crossings;
3) lack of the exclusive bus lane length;
4) short length of the route;
5) lack of continuity of the exclusive bus lane.

On the other hand, Kojo *et al.* (2005) points out the effectiveness of the exclusive bus lane in Shizuoka city. In this case, the city introduced the exclusive lane for 3 kilometers length with a Public Transportation Priority System (PTPS) and highlighted by color pavement since October 2004. The measures could attain shortening the traveling time by one or two minutes. The study also surveyed the consciousness of the residences along the route and found:

1) the consciousness and behavior were changed by the introduction of the exclusive lanes;
2) participation to the social experiment prior to the practical introduction largely affected their evaluation to the practical measures.

In addition to the above-mentioned cases in the two cities, there are some other cases which have introduced exclusive/priority lanes.

Hamamatsu city introduced an exclusive bus lane in 5.2 km and a priority lane in 9.7 km with a PTPS, and the running time was shortened by two or three minutes on an average (Hamamatsu city, 2007).

Kawanishi city in Hyogo Prefecture made a bus priority lane in 6.6 km along with a PTPS and a bus operation control system. The city also provided a transport information system for the public, and police officers and traffic guards worked along the route for smoothing the bus transport. These measures have attained the following results:

1) shortening the bus operation time by approximately 2 minutes (6.3% of the original);
2) decreasing the number of private vehicle by approximately 2%;
3) increasing the local bus passengers by more than 10%
(on an average 5 passengers per bus).

In the above measures, the exclusive/priority bus lanes were provided beside shoulder of the road. Although nearly all the examples in Japan utilize this type for providing the exclusive/priority bus lanes, this type has disadvantages in that the bus services are easy to be affected by:

1) the other vehicles which turn left;
2) the vehicles which stand beside the shoulder;
3) bicycle running beside the shoulder.

Different from the examples mentioned above, in the city center of Nagoya city, the priority bus lanes were provided in the central lanes of the road for the trunk route of bus services. Suzuki and Ikeda (1985) studied the effectiveness of this case quantitatively. In summary, performance of the bus operation was improved as Table 1 shows.

Table 1. Change of bus operation performances in Nagoya city

	Before introducing the priority bus lanes	**After introducing the priority bus lanes**
Standard required time in the peak hours in the morning	50 -53 minutes	33 -35 minutes
Average speed	11.7 - 12.4 km/h	17.7 - 18.7 km/h
Approximate number of passengers	2.6 thousand/day	3.2 thousand/day

Source: Suzuki and Ikeda (1985)

As the above comparison shows, the measures taken by Nagoya city could improve the average speed of the bus services by 5-7 kilometers/hour, and the number of passengers has increased accordingly.

The survey by Nagoya city found that the bus passengers and residents had the following opinions (Hosoda, 1987):

1) passengers expressed their positive opinions for the improved speed and frequency of the services, and more than 80 percentages of the passengers took positive views for the services;
2) 40 percentages of the residents thought that traffic jam had become worse;
3) 30 percentages of the residents thought that private vehicle started to go into other roads;
4) 25 percentages of the drivers had negative opinions for introducing the new bus lanes because of the worsened traffic jam.

As noted above, there are some cases which the exclusive/priority lanes have worked effectively. However, according to social experimental tests, which Kanazawa city implemented before introducing exclusive bus lanes, sufficient effects cannot be expected only by a drivers' voluntary will (Sawayama *et al.*, 2003). Thus, the following sections investigate some measures to promote the effectiveness of the exclusive/priority bus lanes.

2.2 Effects of Coloring on the Priority Lanes

This section reviews the effects of coloring on the priority lanes.

In September 2007, Amagasaki city in Hyogo Prefecture colored the priority lanes in red-brown. Firstly the pavement was colored by the length of 600 m, and the colored section was extended into 1,500 m afterwards.

The results of the coloring works were:

1) Drivers who recognize the priority lanes increased about 20 percentages (The rate was 43 % before coloring, and it was increased to 65 % after coloring.);
2) The number of private vehicles on priority lanes decreased by 9% during traffic restriction time;
3) The running time by the buses decreased by 7%.

As the above results show, the coloring on the priority lanes works for improving the effectiveness of the lanes.

2.3 Standing Time at Bus Stations

Standing time at bus stations largely affects the average speed and punctuality of the bus

operation. Especially in Japan, it is common that a driver checks the ticket or payment when a passenger gets on/off the buses. Therefore, the buses tend to stand at bus stops longer time. There are some past studies about necessary time at bus stops, and the following section reviews some studies which were based on site investigations.

Yabe *et al.* (2005) studied length of the time which is required to get on/off the buses for fare control. The study focused on overseas three cities, Curitiba, Jakarta and Seoul, as the buses in these cities have different fare control systems. According to the study, it was found the necessary time to get on/off the buses is largely different:

1) It takes 0.8 - 0.9 seconds/person when fare control is implemented outside of the buses and the door size is wide;
2) It takes 1.8 seconds/person when fare control is implemented by IC card system.

The study also found:

1) When some passengers get on and get off the buses utilizing the same door, the place around the door is congested and it takes more time (1-3 seconds/stop);
2) When the bus is congested, especially when there are passengers around the door, it takes more time.

Yabe and Namamura (2008) studied the effectiveness of the IC card system, PASMO, which has been introduced widely around Tokyo metropolitan area. The study investigated 251 bus stops around Tokyo, Yokohama and Kawasaki metropolitan areas and clarified:

1) The time to get on/off the bus can be shortened by introducing IC card systems;
2) Improvement of the card usage rate is effective to shorten the time for bus standing.

2.4 Summary of Literature Review

The findings in the past researches can be summarized as following.

1) In order to improve the average speed, punctuality and capacity of the bus services, it is effective to prohibit private vehicles from running on the bus lanes.
2) In order to attain the above, close cooperation with road and traffic administrators is required.
3) Shortening the standing time at bus stops is essential to improve the average speed, punctuality and, thus, capacity of the transport.
4) In Japan, since a driver usually implements fare control in the bus, it is also essential to implement fare control in shorter time by, for example, introducing IC card system.

As the above researches were implemented some years ago, they do not cover the current status over Japan sufficiently. Thus, this study aims to investigate into:

1) the current status in Japan through the site studies in several cities;
2) the measures to improve average speed and punctuality; and
3) the effectiveness of the above measures.

3. METHODOLOGY OF THIS STUDY

3.1 Site Studies about the Transport Capacity and Average Speed

This study implemented site investigations as Table 2 shows.

As Table 2 shows, the authors made 15 sites investigations in total, which covered 11

cities. The studied sites do not include snow falling areas, and they were fixed so that they have various types of site conditions. The major points to decide investigation sites are shown below.

1) Number of road lanes (1 to 3 lane(s))
2) Number of buses in a peak hour (9 to 121 buses per hour)
3) Whether priory/exclusive lanes are existing or not
   (Including police officers are located or not)
4) Number of vehicles (Based on “Road Census”
   (The survey carried by Ministry of Land, Infrastructure, Transport and Tourism))

To compare how the different situations affect bus service, the investigation sites were chosen not to be biased by in any other factors.

Table 2. Outline of site investigations

Site investigated	Category of the site	Investigation section's length (km)	Day Studied #6	Time zone investigated	Number of buses in a peak hour	Time of payment	Payment by IC card	Priory/exclusive lanes	Bus Bay	Rapid services	Number of road lanes (one way)	Number of Vehicles (per 10 mins)
A	Suburb of Tokyo MA	1.1	7th May	6:00 - 9:00 AM	47	Get on	Able	No	Partly	No	1	45-75
B	The center of local city	0.6	8th May	6:30 - 9:30 AM	121	Get off	Unable	Yes	No	No	3	60-100
C	The center of Tokyo MA	2.6	10th May	7:10 - 10:10 AM	63	Get on	Able	Yes	No	No	3	250-400
D1	Suburb of Kansai area	0.9	30th May	6:30 - 9:30 AM	45	Get off	Able	#1	Partly	No	1	0
E1	The center of local city	1.2	8th July	6:20 - 10:10 AM	41	Both	Unable	#2	Partly	No	1	25-65
E2				2:00 - 3:00 PM	40	Both	Unable	No	Partly	#5	1	50-80
E3				4:30 - 8:00 AM	42	Both	Unable	#2	Partly	#5	1	60-90
E4	The center of local city	1.2	9th July	7:00 - 8:00 AM	43	Both	Unable	No	Partly	#5	1	45-90
F	Suburb of local city	10.7	3rd Sep	6:50 - 10:10 AM	9	Get off	Able	No	No	No	1 & 2	20-120
G	Suburb of local city / The center of local city	6.3	4th Sep	6:30 - 9:40 AM	6	Get off	Unable	No	No	No	1	60-140
H	The center of local city	3.2	17th Sep	7:00 - 10:00 AM	32	Get off	Able	Yes	No	No	2	40-110
I	Suburb of local city / The center of local city	8.7	18th Sep	6:40 - 9:50 AM	47	Get off	Able	Yes	Partly	Yes	2,3 & 4	400-700
D2	Suburb of Kansai area	3.2	8th Oct	6:30 - 9:30 AM	27	Get off	Able	No / #1	Partly	No	2	50-140
J	Suburb of Chukyo area	10.9	9th Oct	6:00 - 9:10 AM	30	Both	Able	No / #3	No / #4	No	3	50-140
K	Suburb of local city / The center of local city	10.9	10th Oct	6:40 - 9:50 AM	22	Get off	Able	No / Yes	No / No	Partly	1	100-170

#1: In some hours, private vehicles were regulated by police officers.
#2: In some hours, private vehicles were regulated by sign boards.
#3: A central bus lane system was installed. (In peak hours, the lanes were exclusive to the local buses. In other hours, the lanes were prioritized to the buses.)
#4: Bus stops with shelter were installed in the middle of roads, and two buses could stop there at the same time.
#5: Although rapid services were not provided, bus stops for urban services and those for suburban services were separated.
#6: All the studies were implemented in year 2013.

Then, the site investigations were planned and implemented as the following conditions.

1) Investigations were made in three hours in the morning peak hours.
2) Two staffs were allocated at both ends of the investigation section.
3) The up side buses, which go to city center, were investigated.

In the site investigations, by allocating each member at both ends of the section, they investigated the fundamental data such as the time each bus passed in front of them, the type of buses (small-/ medium-/ large-/ highway type) and congestion of the road by private vehicles.

The results of the investigation are analyzed in terms of the capacity and average speed and summarized in Figure 2. The capacity is calculated by multiplying the number of passing buses and the standard capacity of the four types of buses mentioned above. As this result shows, the two factors, the transportation capacity and average speed of the bus services, have correlation. As a background of this, many buses are operated on the lanes which are appropriate for bus driving with higher speed. Even if the road conditions are not appropriate for bus driving with higher speed necessarily, some efforts, such as installing exclusive bus lane or allocating police officers, can make the bus operation faster with more number of buses. That is, increasing the average speed of the services not only improves service levels but also enables to increase transportation capacity in many cases.

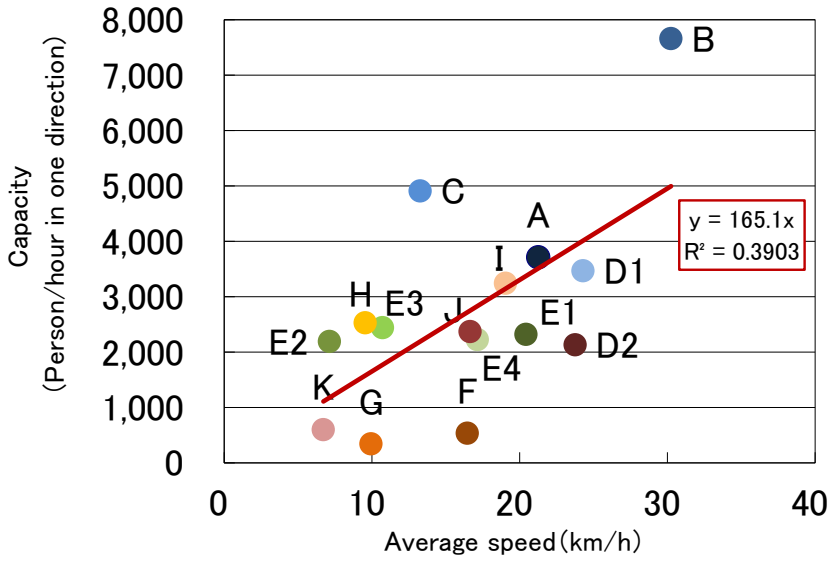

Figure 2. Transport capacity and average speed in the invested cases

Through the site investigations, even though the number of road lanes is the same, it was found that the average speed of the bus services can be improved by 5 km/h by way of one of the following three measures:

1) Introducing exclusive bus lane (See Section 3.2);
2) Introducing rapid services (See Section 3.3);
3) Modifying central traffic lanes to the exclusive bus lanes (See Section 3.4).

As for the transportation capacity of bus services, this study compared the results gained from this study with Nakamura (1995). Nakamura (1995) showed that in terms of transport capacity, 4,800 passengers/h can be attained only by introducing bus priority lanes (See Table 3). Nevertheless, this current study found that there are a number of cities which have not reached this transportation capacity. Through the comparison between the two studies, it appears that the transport capacity of Japanese local bus services can be improved by some measures such as installing bus priority lanes.

Table 3. Transportation capacity by bus services:
comparison between this study and Nakamura (1995)

The results of Nakamura (1995)		**The results of this study**	
Transport capacity	Measures taken	Site investigated	Transport capacity (Exclusive/priority lanes)
Over 6,700 passengers/h	In addition to the measures below, bus stops were designed so that passing can be made.	B	7,700 passengers/h (Exclusive lanes)
Over 5,800 passengers/h	1 minute headway on exclusive lanes without signaling		
Over 4,800 passengers/h	Bus operation on exclusive lanes	C	4,900 passengers/h (Exclusive lanes)
Over 2,800 passengers/h	2 minutes headway on the normal conditions	A D1 I	3,700 passengers/h 3,500 passengers/h (Priority lanes) 3,200 passengers/h (Exclusive lanes)
-		H E3 J E1 E2 E4 D2 K F G	2,500 passengers/h (Exclusive lanes) 2,400 passengers/h (Priority lanes which are not effective) 2,400 passengers/h (Center lanes) 2,300 passengers/h (Priority lanes which are not effective) 2,200 passengers/h 2,200 passengers/h 2,100 passengers/h (Priority lanes) 600 passengers/h (Exclusive lanes) 500 passengers/h 300 passengers/h

Source: Nakamura (1995) and the results of this study

3.2 Findings Through Exclusive Bus Road In Peak Hours

City D is located in a suburb of Kansai area. In this city, exclusive bus road is settled on weekday morning. The designated section is just only 0.9km and designated time is just one hour, but there are no detour routes for private vehicles. The interesting point of this exclusive road is that police officers stand at the starting point of the exclusive lane during designated time every morning and prevent private vehicles' driving into the lane.

The site inspections were made to investigate the effect of this exclusive road twice at the site. Through the investigations, it was found that speed of the buses improved 4.7 to 5.9km/h compared to unregulated time on an average (See Figure 3 and Table 4). Besides, the differences between fastest and slowest buses within the designated time are smaller than those in the non-designated time.

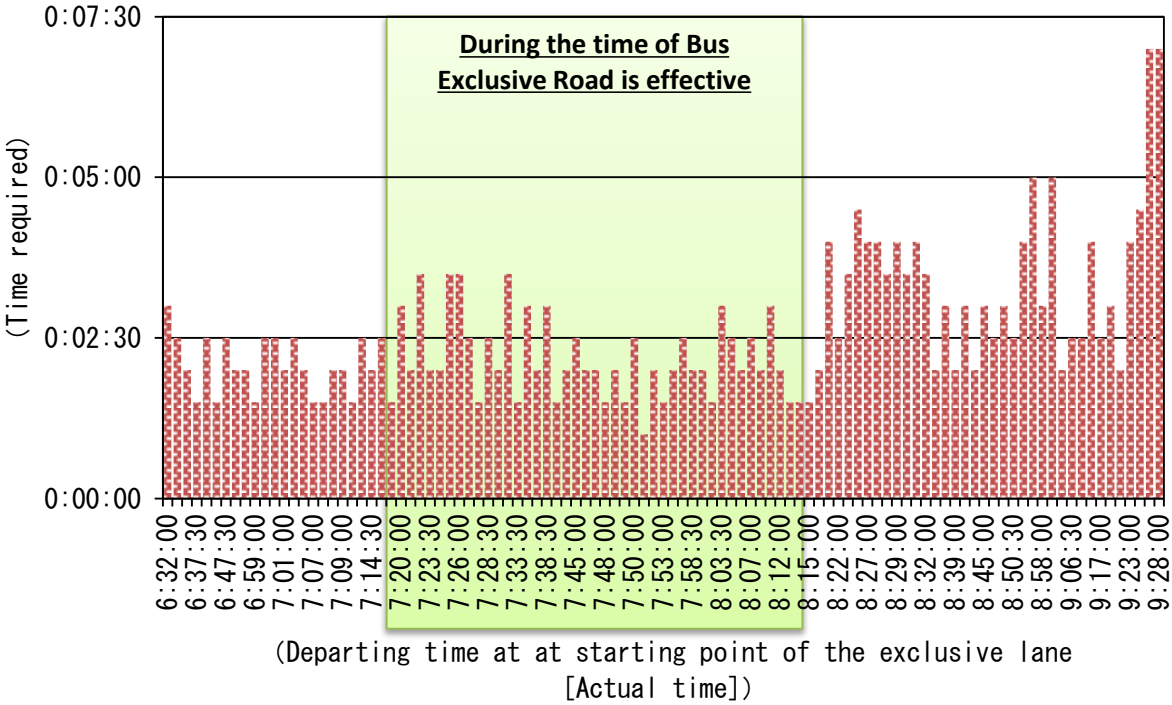

Figure 3. The required time at exclusive bus road by each bus at city D

Table 4. The effect on bus operation on exclusive bus road at city D

		During regulation(A)	Out of regulation (B)	(A-B)
Time		7:15 am〜8:15 am	6:30am - 7:15am and 8:15 am - 9:30 am	—
May	Average	24.5km/h	18.6km/h	+5.9km/h
	Slowest(A)	15.4km/h	7.7km/h	+7.7km/h
	Fastest(B)	36.0km/h	36.0km/h	±0.0km/h
	(B/A)	2.34	4.68	—
Oct.	Average	19.3km/h	14.6km/h	+4.7km/h
	Slowest(A)	13.5km/h	7.2km/h	+6.3km/h
	Fastest(B)	36.0km/h	36.0km/h	±0.0km/h
	(B/A)	2.67	5.00	—

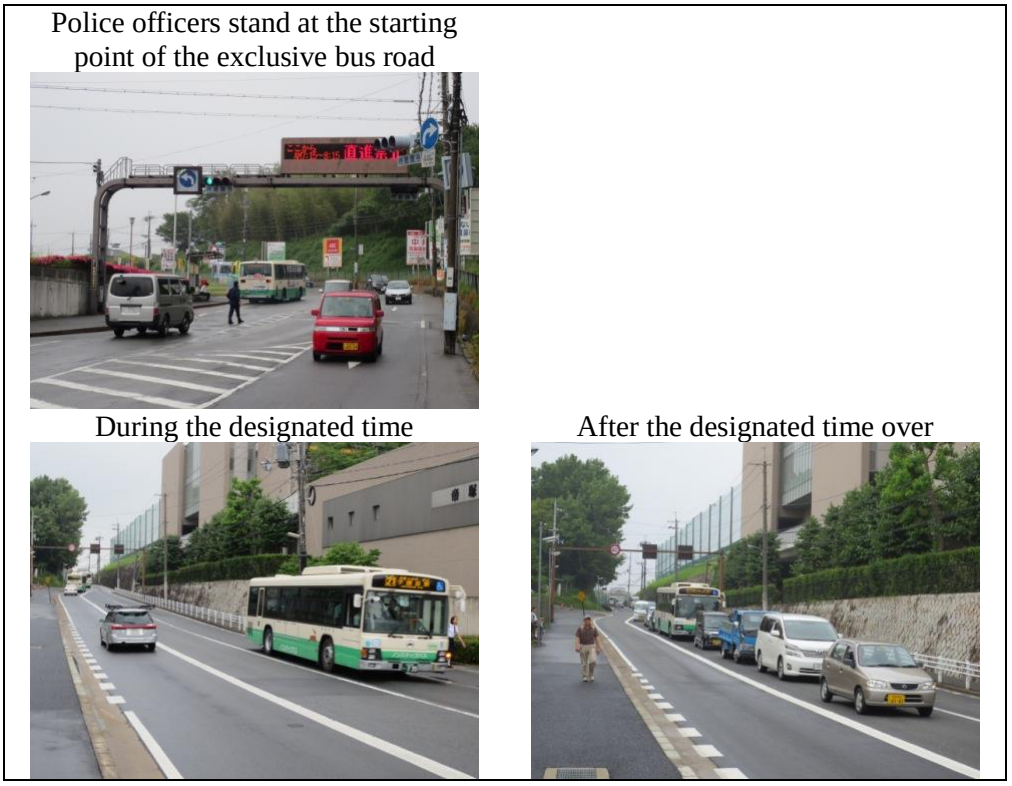

Figure 4. Situation of exclusive bus road at city D in the morning

Source: Results of this study

On the other hand, investigations in city E show different results (See Figure 5). In city E, exclusive bus road is installed on weekday morning and evening. However, as no police officer restricts the road, more than hundreds of private vehicles run the road even in the designated time. As a result, the average speed of the buses largely depends on the number of cars regardless of the regulation.

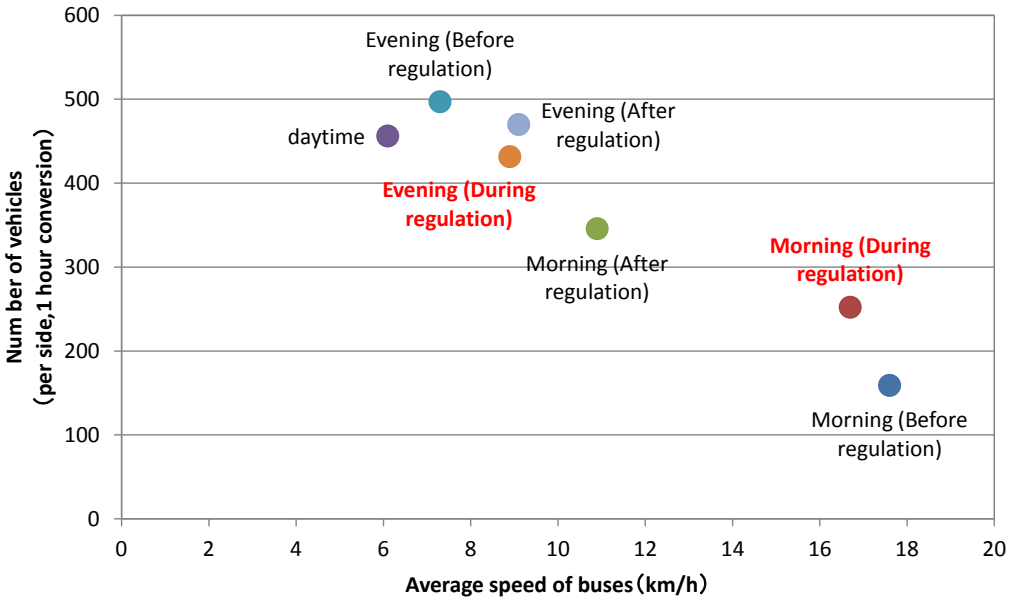

Figure 5. Number of vehicles and average speed of bus at city E

Through the study on the case of city E and other some cases, the number of vehicles largely affects the condition of the roads and operation of the buses, and it was found that road congestion occurs as follows.

1) When the number of vehicles going to one direction exceeds 50 per 10 minutes, depending on the other conditions of the roads, road congestion occurs and bus operation is also affected.
2) When the number of vehicles going to one direction exceeds 70 per 10 minutes, road congestion usually occurs and bus operation is also largely affected.

Additionally, the study also found that road congestion occurs only by buses when the number of buses going to one direction exceeds 10 per 10 minutes.

3.3 Findings Through Rapid Services In Peak Hours

In some cities where investigations were carried out, rapid (skipping some bus stops) services are provided. The share of rapid services is different. The largest is City I, and 20% buses are operated as rapid services. As for average speed, it was found that the speed was improved about 6 km/h by changing local services to rapid services (See Figure 6 and Table 5).

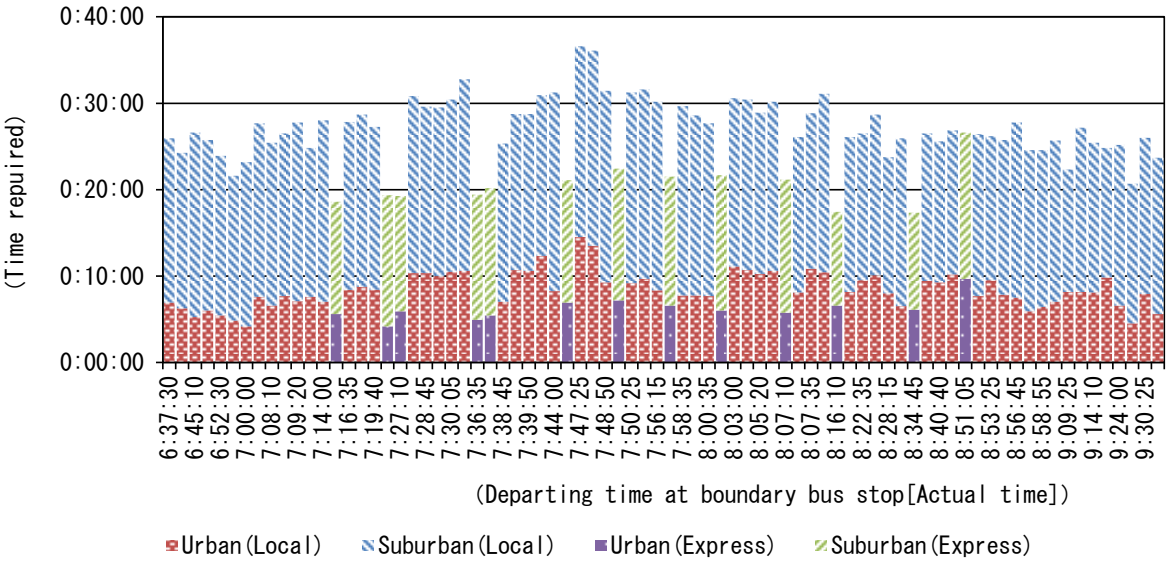

Figure 6. The required time by each bus at city I

Table 5. The effect of rapid service at city I

Section	Suburban			Urban		
Remarks	(Except some sections for local buses, an exclusive bus lane is allocated)			(An exclusive bus lane is allocated)		
Type	Rapid(C1)	Local(D1)	(C1-D1)	Express(C2)	Local(D2)	(C2-D2)
Distance	6.1 km		—	2.6 km		—
Average	25.8 km/h	19.2 km/h	+6.6km/h	25.2 km/h	18.4 km/h	+6.8km/h
Slowest(A)	21.7 km/h	15.9 km/h	+5.8km/h	16.1 km/h	10.8 km/h	+5.3km/h
Fastest(B)	33.9 km/h	25.8 km/h	+8.1km/h	37.1 km/h	37.1 km/h	±0.0km/h
(B/A)	1.56	1.62	—	2.3	3.44	—

Another finding worth noting at the case of city I is that the differences between fastest and slowest buses. In the section of suburban area, the differences between fastest and slowest buses are similar and do not depend on service types such as rapid or local. However, in the urban area, the differences between fastest and slowest buses on rapid service are smaller than those on local service. Several reasons are considered for this result.

Firstly, rapid service could avoid congestion at bus stops. The mechanism of congestion at bus stops can be explained by the following steps:

1) When some buses for different routes stop at the same bus stop, there are some cases that more than two or more buses try to stop at the same time;
2) In the above cases, the number of standing buses exceeds the capacity of the bus bay, and a bus sometimes stands outside of the bus bay;
3) These cases lead to a delay of bus services;

As a result, buses' standing often disturbs smooth traffic flow even in the case which there is more than two lanes per direction and bus exclusive/priority lanes are allocated.

Secondly, it is expected that the type of fare collecting system affected for this result. Our investigation was carried out in the morning. Thus, many passengers headed toward the same direction and disembarked in the urban area. In Japan, bus fares are usually collected one by one in the bus. Even worse, in city I, bus fares are settled by varied fares depending on the distance and are collected when passengers get off the bus. In those circumstances, the rapid service buses which pass some stops can be operated more smoothly.

As investigated above, the standing time at bus stations is largely affected by the fare control system, MLIT (2006) shows that fare control system and time for payment as Table 6. MLIT(2006) also explains that introduction of the IC card system has largely contributed to minimizing the time for payment (Table 6). However, when there are some troubles such as lack of remained fare or errors in reading the electric data, the time for fare control is extended largely.

Besides, in one of the cases in this study, fare control is implemented out of the buses in a single case. The site investigation in this case found that receiving a fare out of the buses can improve the punctuality and capacity of the bus services. Although it is not common in Japan, this kind of measures might be effective when the number of passengers is large.

Table 6. Fare control system and time for payment

Method of payment	**Necessary time for payment per passenger**	
	(Payment in advance by a single fare)	(Payment at getting off by varied fares)
Cash	4.9 seconds	5.8 seconds
Cash (A bill is accepted, and change is given)	18.9 seconds	30.8 seconds
Electric card	6.9 seconds	8.9 seconds
IC card	5.7 seconds	7.2 seconds

Source: MLIT (2006)

3.4 Findings Through Modifying Central Traffic Lanes to the Exclusive Bus Lanes

In city J, there is a section where an exclusive bus lane in the morning. There is no barrier or staff at the entrance of bus lane, but sign and colored pavement and arrangement of lanes works well for other drivers so as not to come into the exclusive lane. The section is used as bus priority lane at all other time. The bus lanes are ensured at central traffic lane. At this site, it cannot be compared between present and previous situations. Thus, the present study carried out the comparison between urban section where an exclusive bus lane is installed and suburban section where an exclusive/priority bus lane is not installed.

The survey at the city J also identified that the average speed of the buses on exclusive lane is faster than that on an ordinary road. Besides, the differences between the fastest and slowest buses on exclusive lane are less than those on non-regulated sections (See Table 7).

Table 7. The effect of exclusive bus lane on the center of the road at city J

	Suburban(A)	Urban(B)	(B-A)
Type	Ordinary road	Exclusive bus lanes located on center of the road	—
Distance	2.2km	8.7km	—
Average	13.6 km/h	17.4 km/h	+3.8 km/h
Slowest(A)	10.2 km/h	14.7 km/h	+4.5 km/h
Fastest(B)	19.7 km/h	21.8 km/h	+2.1 km/h
(B/A)	1.94	1.48	—

Figure 7. Situation of central exclusive bus lane at city J in the morning

3.5 Effects of Fare Control System on the Standing Time

The studies in the past made it clear that standing time at bus stations affects the average speed, punctuality and capacity of the transport. Thus, as one of the site studies, an investigation into Kaihin-Makuhari Bus Station, where connected buses are operated for rapid services, was carried.

As a result of the study, despite a single platform, the bus services are provided about 2 minutes headway and passengers are carried over 3,000 passengers/hour (Figure 8). The site inspection found that the buses are operated in peak hours at Kaihin-Makuhari Bus Station as listed below in order to attain this high standard performance (Figure 9):

1) Fares are collected outside of the buses;
2) Passengers make queues and get on a bus from all the doors;
3) Ticket gates are installed at the station by routes and by type of services;
4) The performance of the connected buses is maximized by introducing them to the routes which have the same fare for all the passengers.

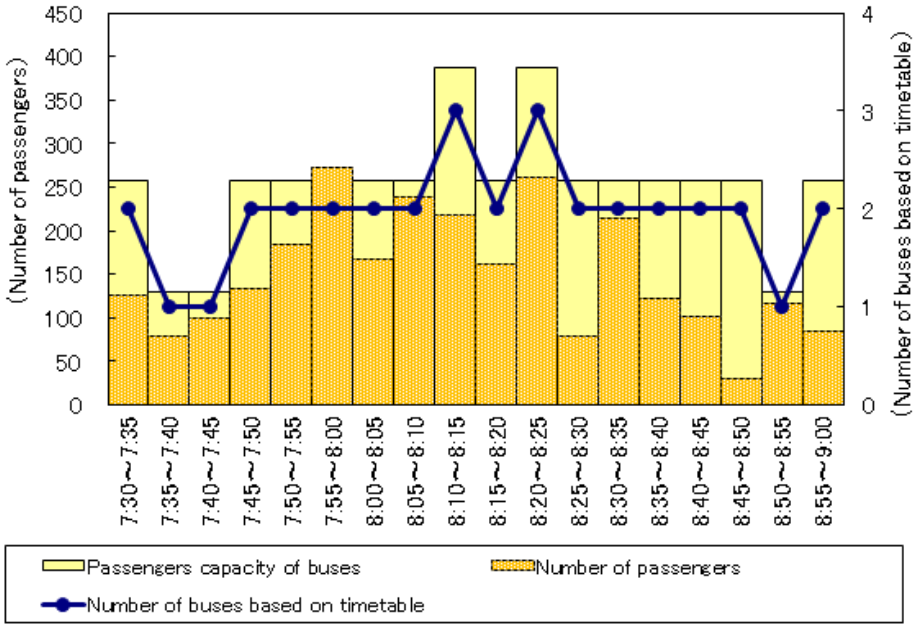

Figure 8. Passengers for connected Buses in Kaihin-Makuhari bus station

A ticket gate outside of the buses

Passengers' queue after paying a fare

A connected bus for rapid services

Information in the morning

Figure 9. Situation of Kaihin-Makuhari bus station in the morning

4. CONCLUSION

Although this study found a case with the capacity of 7,700 passengers/hour, in many cases the capacity was about 4,000 passengers/hour. As compared with the study by Nakamura (1995), this level is much less than the overseas bus transports systems with high standard capacity. This study also found that the introduction of exclusive/priority lanes in Japan can improve passenger capacity along with some measures.

This study also found that average speed of buses can be improved by approximately 5 km/h through making an exclusive/priority bus lane or provision of rapid services. Especially, the study verified that a central bus lane system and strict regulation by police officers are effective since these measures prevent private vehicles from intervening into exclusive/priority bus lanes.

The study found private vehicles' intervention and parking on an exclusive lane largely hinder the smooth bus operation. Thus, in order to improve the average speed, punctuality and capacity of the local bus services, it is expected that putting some barriers between an exclusive bus lane and other lanes is very effective. However, putting some barriers takes long negotiation with road and traffic administrators, and it is not easy to attain in many cases. Practically, it is effective to keep close and continuous cooperation with road and traffic administrators to prohibit private vehicle's entering into the exclusive lane. The study also found that coloring on a pavement is effective as well.

For introducing such measures, it is essential to gain understandings by residents as well. The study found that, in some cases, the cities could succeed in gaining understandings about introducing exclusive/priority lanes by holding some meetings to explain about the plan.

Not only the hardware measures but also such software measures are also important to improve the average speed and capacity of local bus services.
In particular, one of the most important points that enable the improvement of the local bus systems' performance is fare control system. In Japan, usually a driver checks the passengers' fare, and this takes certain time. In Europe, in some cases, passengers themselves validate their ticket when they get on the buses. This study found a case that fare control is managed at the bus station before their getting on the bus. These measures can shorten the standing time at the bus station and improve the performance of bus services both in passenger capacity and in average speed.

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