METHOD FOR PRODUCING TRAFFIC INFORMATION UTILIZING BIS AND MOBILE ACCESS POINT

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ABSTRACT

Bus Management System (BMS) is designed to trace the public buses in operation using GPS so as to control the headway of public buses for efficient management of the road. This system may be used as Bus Information System (BIS) which provides passenger service information such as displaying the arrival time and so on. As BMS functions to manage the location of the buses on a real-time basis, travel time and running speed of each specific route could be easily identified. Likewise, intelligent transportation system (ITS) for general vehicles is aimed at efficient operation of roads and traffic information provision through detectors installed on the roads.

The objective of this study is to research methods to utilize traffic information collected through BIS into ITS. Using BIS would possibly reduce the number of ITS detectors as well as have the benefit of providing space information instead of point information. Test results confirmed that the section speed produced through the study method is very similar to the section speed provided by existing ITS.

1. BACKGROUND AND OBJECTIVES

Bus management system (BMS) for public transportation is designed to promote efficient operation of public transportation by regulating the headway of public buses on the roads through tracking using global positional system (GPS), and utilized as bus information systems (BIS) to inform bus passengers of bus arrival time.

Likewise, intelligent transportation system (ITS) for general vehicles is aimed at efficient operation of roads and traffic information provision through detectors installed on the roads. The two systems utilize the traffic information collected in different ways for different purposes, but have one thig in common in that they collect traffic information like travel time on the roads, which suggests that there may be a method to achieve two purposes of the two systems simultaneously through the convergence of BIS and ITS or introduction of a complementary system.

The objective of this study is to research methods to utilize traffic information collected through BIS into ITS. And it is expected that the method (through BIS into ITS) will help reduce the number of ITS detectors to be installed and obtain sectional information of buses instead of detector information centering on a single location.

Toward this end, this study is carried out in the following order. Through case studies on BIS, research systematic properties and characteristics of traffic information collected through BIS. Investigate the method to supplement the characteristics of BIS traffic information in terms of complementary systems and algorithms considering travel

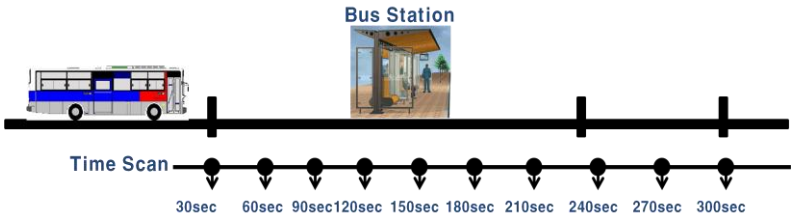
characteristics. Verify possibility for BIS information to be utilized as ITS information in comparison with traffic information collected through ITS.

2. RELATED THEORY AND RESEARCH TRENDS

2.1. Method to Collect Bus Information

Strictly speaking, to collect traffic information in BIS is to collect bus location information of individual buses. However, to collect bus location information of individual buses in real time is to collect traffic information about the travel speed of specific sections. In case of BIS, there is no need to be provided with location information of buses constantly due to characteristics of public transportation operating on the defined bus route, but bus center needs to control delays due to road congestion or incident events. The bus OBU transmits location information of buses according to a regular cycle, using two techniques of time and space illustrated in Table 1. In terms of time, there is a time scan to set time interval and transmit location information within fixed time. In terms of space, there is an event scan to set event points (through the intersection, bus arriving, bus starting) in advance and transmit location information at the point of time when the bus passes through the points. Event information is used to create link information of buses, and time information is used to estimate the location of buses at processing time. Initially, event scan and time scan were used altogether, but it caused many problems such as wireless traffic overload, rising communication charges and overlapping problem of event and time. At present, Korea uses time scan after event (for example, 30 seconds after event) to transmit location information every defined time cycle after certain event in order to minimize inefficiency of time scan. Jeju region which is to obtain data used in this study uses time scan after event.

Table 1 Method to Collect BIS Bus Information

Segment	Description	Concept Diagram
Event Scan	·Method to collect information only in case of occurrence of defined event	
Time Scan	·Method to collect information every defined acquisition cycle	

2.2. Research Trends of Related Fields

2.2.1 *BIS Research Trends*

BIS appeared in the late 90s, when IT technologies were actively developed. At that time, research was mainly conducted on the promotion of public transit bus services rather than research on the systems or utilization of bus information using BIS.

In line with this, research related to plans for optimal bus service as also carried out to improve publicity of bus services.

Ceder (1984, 2007) considered passenger demand and presented four methods to determine frequency and headway. Methods 1 and 2 were maximum load (point check) methods, while methods 3 and 4 were load profile (ride check) methods. Of these, method 1 determined frequency and headway based on the heaviest daily load point of the line, whereas method 2 made the determination based on the bus stop with maximum load in each time period. Method 3 considered the lower-bound level in terms of frequency and the upper bound in terms of headway, while method 4 considered level of service by restricting the total portion of the line length to attain larger loads than desired occupancy. In addition, research on public service standards as also carried out, considering bus as public service provided by a state.

Grosfeld-Nir et al. (1995) applied a service standard that determined headway by considering a crowding-over-distance (COD) factor based on passenger discomfort and a probability-of-failure (POF) factor based on the concept of additional waiting time of passengers who failed to board because of lack of bus space.

Wongil Kim (2009) developed a real-time interval control model for change of plans for bus service in real time, using Seoul BIS data as a case study related to direct utilization of BIS data. Case studies on utilization of BIS data for ITS information were researched and tested by each local government of Korea, but they are not used substantially due to difference in traffic characteristics of bus and general vehicles and different purposes of system construction of the two systems.

2.2.2 *Research Trends of Data Fusion*

Gijoo Choi (1999) verified the applicability of data fusion algorithm for estimation of link travel time, using virtual materials through fuzzy linear regression model. It was expected that the suggested algorithm would be widely used if the reliability were proven through data verification between predicted data and measured data, presuming the environment for collection of traffic information would be promoted in the future.

Youngchan Kim (2001) developed a traffic information fusion model of point-traffic information system and section-traffic information system, using the measured travel time through survey on the license plates of vehicles, and presented an accuracy improvement model of link travel estimated time.

Youngin Lee (2005) suggested data fusion techniques to estimate more accurate travel time by links by figuring out travel characteristics by links through KHCM-type estimation using data from video image detectors and reflecting the characteristic ratio applied as correction coefficient into route travel time information collected in AVI.

2.3. Implications

Looking at the research trends of data fusion presented earlier, various models to combine point traffic system and section traffic system have been presented and the results have been verified. There are limitations on the number of samples of sectional traffic system due to limitations of data fusion.

In addition, the relationship between traveling characteristics of buses and those of general vehicles is to be figured out to utilize BIS information as travel speed information.

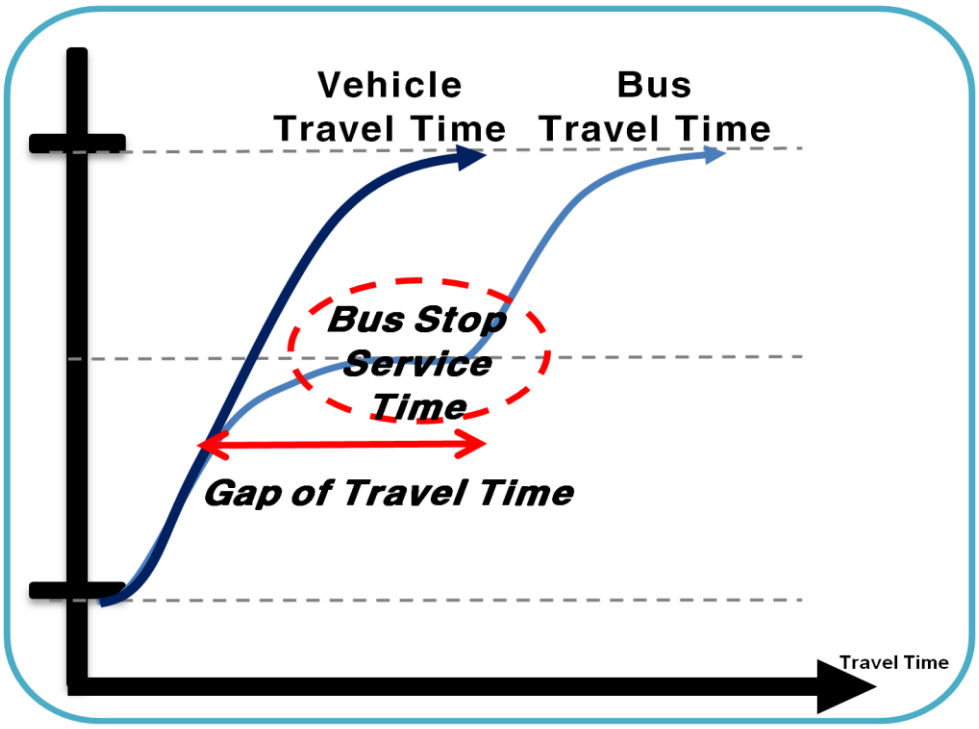


Figure 1 Characteristic of BIS Traffic Information Gathering

The picture (Figure 1) shows the characteristics of buses and general vehicles, showing speed on a vertical axis and distance on a horizontal axis, which illustrates the speed being changed in the neighboring areas of intersection and bus stop when general vehicles and buses are operating in the same section. As shown in Fig. 1, the speed of buses is similar to that of general vehicles in passing through the intersection, but the speed is hugely affected by stoppage time in passing through the bus stop.

Unlike general vehicles, bus requires additional stoppage time for passengers to get on and off the bus at the bus stop, which means that the section travel time of buses is different from that of general vehicles even while operating the same sections. To sum up, the more crowded the area and the longer the section, the larger the difference.

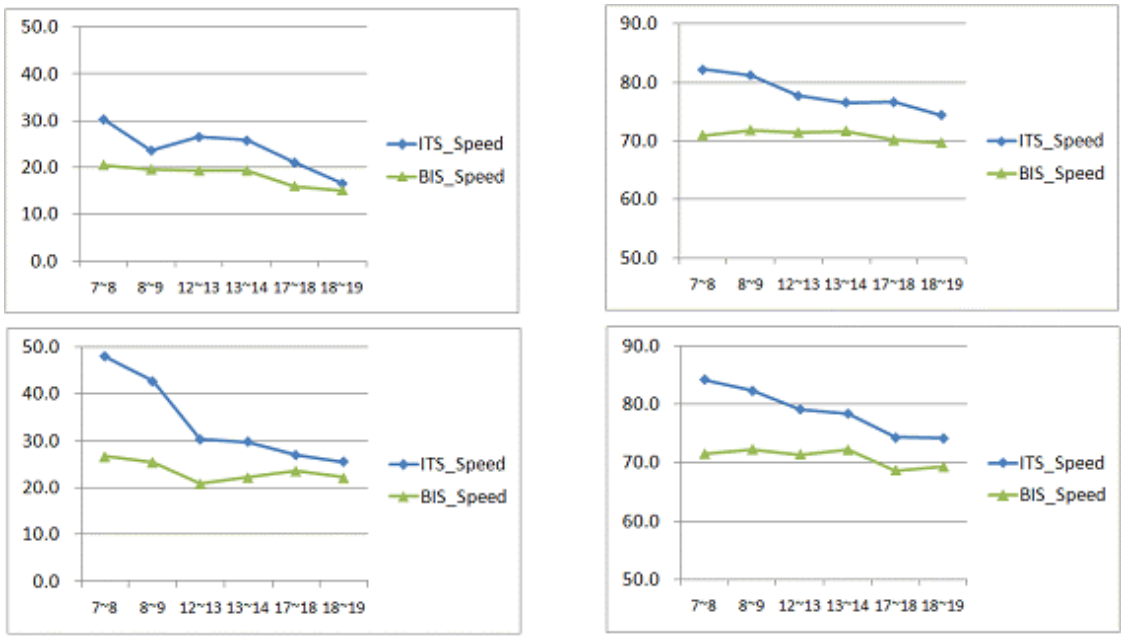


Figure 2 Characteristics of BIS Traffic Information Gathering

Fig. 2 shows graphs to compare the average value of travel speed per hour between BIS section and ITS section, using detector in the area (Jeju city, Jeju special self-governing province) within the country, where BIS and ITS were developed at the same time. The left side of the figure shows the area within the city limits and the right side of the figure shows outside the city limits. There are times of day in which the difference of speed is a maximum of 20~30km/h, others with minimum of 5km/h. In addition, it is confirmed that the relative change in speed for BIS and ITS has similar pattern as shown in the graph. In other words, there are small differences in the absolute values of the speed, but the y increases or decreases together, which signifies that there is possibility of providing general vehicles with reliable section travel time and section speed information service, utilizing bus location information collected in BIS. Since it is caused by waiting time for passengers to get on and off the bus, the deviation can be calculated according to constant patterns. Therefore the travel time of specific sections can be estimated, utilizing BIS in cases where the relationship between traffic characteristics of buses and general vehicles are figured out. However, there is a key issue on how to revise the difference in speed of maximum 20km/h, and minimum 5km/h accurately in order to utilize BIS for ITS information substantially. In this study, the method to provide general vehicles with traffic information centering on BIS data is to be explained by revising the difference of ITS data based on BIS bus location information of Jeju region, using T-Map data of SK Telecoms.

3. METHODOLOGY

3.1. Traffic Information Research of T-Map System

As a wireless carrier (mobile phone) operator, SK Telecoms to collect T-Map information has radio base stations in all parts of Korea so nationwide expansion is possible except for some mountainous areas. Fig. 3 shows the flow to create mobile hand-off based link traffic information for drivers with mobile phone without additional infrastructure construction or vehicle mounted terminal. At present, Korea collects information on major roads where mobile phone usage is frequently made and operates service provision, centering on wireless carriers.

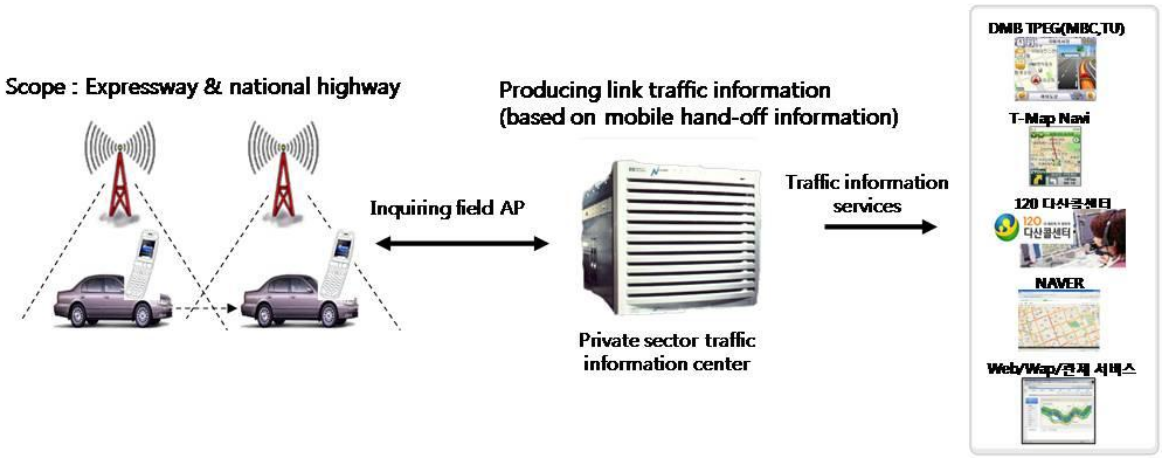


Figure 3 T-Map traffic Information Gathering Flow

T-Map data collects traffic information based on the probe concept, utilizing radio base stations. The comparison between the number of BIS data collection and that of T-Map data collection is shown in Table 2.

Table 2 The Number of Data Collection of Specific Section BIS in Jeju Region and T-Map Data Collection

Time Zone	Jejujungang girls high school~City hall (the town) section		Samsaseok-ro (the suburb) section	
	BIS Data collection (number)	T-Map Data collection (number)	BIS Data collection (number)	T-Map Data collection (number)
13:00 ~ 13:05	15	25	5	0
~ 13:10	16	18	5	4
~ 13:15	17	32	4	3
~ 13:20	15	15	3	4
:	:	:	:	:
~ 13:45	15	7	6	1
~ 13:50	16	20	4	8
~ 13:55	16	23	4	2
~ 14:00	15	35	5	0
5minutes Avg./Std. (13:00~14:00)	15.2/1.2	28.4/10.7	5.2/1.7	2.4/5.2
1 hour Avg./Std. (05:00~20:00)	178.3/1.8	310.2/12.8	60.8/1.9	39.2/11.2

As shown in the table, it is confirmed that due to characteristics of T-Map, a lot of data is created in the areas within the city limits with many floating populations, but in case of the areas outside the city limits with fewer floating populations, there are many cases where there is no data gathered for 5 minutes, and the average value for 1 hour is 39.2. In conclusion, it seems to be difficult to collect exact traffic information by using T-Map data alone.

In addition, T-Map data which has a large standard deviation of the number of amount collection is not appropriate for the creation of reasonable amount of information in areas where mobile phone usage is rarely made. On the other hand, in case of BIS data, the standard deviation of the amount of data collection is relatively low, and data can be collected at all times due to characteristics of public transportation. In case of T-Map data, since it is probe data, it is considered to be superior to bus data without bus stop service time, considering accuracy of section travel time.

3.2. Method to Create Section Communicate Information Using BIS and T-Map Data

In this study, information obtained from detectors was excluded and bus location information of BIS was utilized to provide general vehicles with section travel time. But in this case, there exists bus stop service time unlike other vehicles, and information for the sections in which bus routes are not operating cannot be created. On this, actual travel speed and section travel time of general vehicles was created by giving different weight values depending on situations to T-Map data of probe concept using mobile phone base stations.

The flow in the left side of Fig. 4 illustrates the process of combining the sectional speed information created through BIS data and that created by T-Map for the purpose of utilization into ITS information, and arithmetic expression used in creating the final fusion speed to be weighted is shown in the right side.

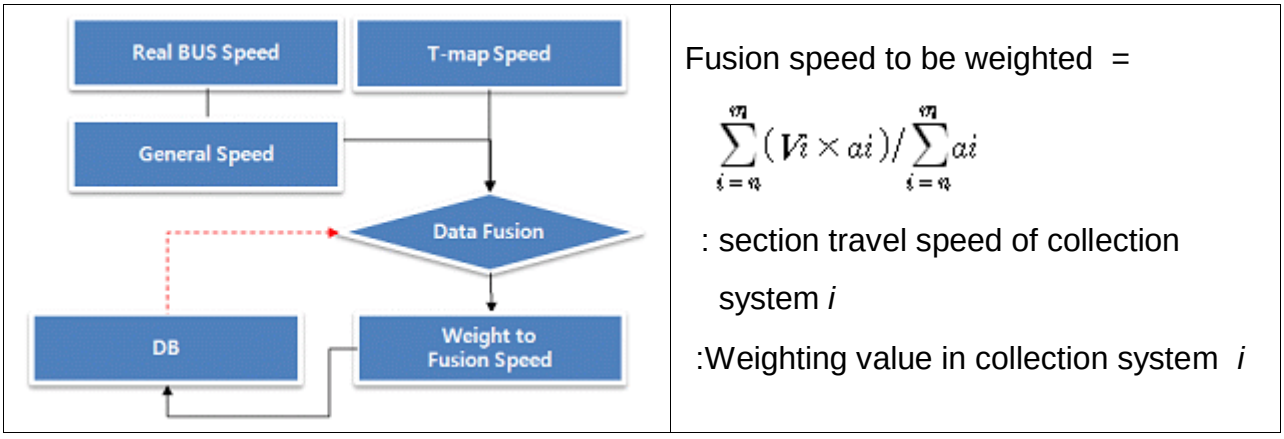


Figure 4 Fusion Traffic Information Creating Flow and Fusion Speed Creating Formula

The weight value for creating final fusion speed was used based on the ratio of the number of BIS and T-Map data collection. The details are shown in Table 3. Since due to characteristic of public transportation, buses operate in the predefined sections on the roads, centering on the sections providing current information, if the sections are the same

as those in which the buses operate, more weight value is given to bus information and if not, to T-Map information.

Table 3 Definition of Weight Value by Situations

Segment		Given weight	
		BIS	T-Map
In case bus operation link and current information providing section are the same	The town	70%	30%
	The outskirts	50%	50%
In case bus operation line and current information providing section are not the same	The town	40%	60%
	The outskirts	30%	70%
In case of incident events		10%	90%

In case incident events occur, the final fusion speed information is to be created by giving more weight value to T-Map information whose real-time value is superior, rather than non-incident traffic patterns.

4. TEST RESULTS

The finally created fusion speed is provided in the applicable sections in real time by 5 minutes to the minimum. The graph of Fig.5 shows the comparison of the sectional speed information by time zones in the specific sections of Jeju region, which was created by the existing system and the final fusion speed information created using the method suggested in this study.

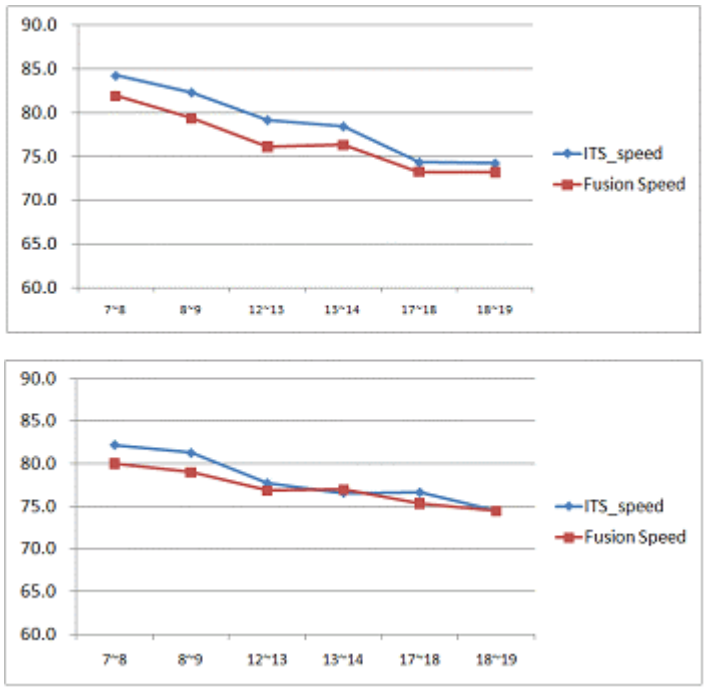


Figure 5 Comparison between Fusion and ITS Speed by Time Zones

The graph in the upper part shows the comparison of section speed in the section from Jeju Jungang Girls High School to city hall and the graph in the lower part shows the comparison of section speed in Samsaseok-ro section. As shown in the graph, it was confirmed that the section speed produced through the method suggested in this study is very similar to the section speed information of ITS which is currently providing.
The below mentioned MAPE (Mean Average Percent Error) of 5 minutes and 1 hour in the 2 section is shown in Table 4. It was verified that the fusional section speed of the outskirts is more similar to ITS section speed than that of the town.

Table 4 MAPE by Sections

Sections	5 minute MAPE	1 hour MAPE
Jeju Jungang girls high school ~ City hall	8.9%	5.2%
Samsaseok-ro	4.2%	2.4%

5. CONCLUSION

In this study, sectional traffic information was created, utilizing bus location information of BIS rather than the detecting systems of ITS. Since bus location information of BIS has a shortcoming in that unlike other vehicles, buses require bus stop service time and the creation of information for sections where bus route is not set up is impossible, T-Map probe data using mobile phone base stations was used to complement this disadvantage. In addition, actual travel speed and sectional traffic time of general vehicles was created by giving different weight values depending on situations, and it was confirmed that the created information is similar to the information provided by ITS. This suggests that the traffic information of major sections can be provided for general vehicles without construction of separate ITS in the areas where BIS was constructed. At present, ITS construction costs of the capital region are estimated to be approximately 100,000 dollars per 1 km. The finding of this study can be used to reduce the costs through created data verification. Of course, the traffic characteristics of Jeju island, a target region in this study are very different from those of the capital region in that the traffic volume 1) and the number of bus passengers 2) is low, compared with the capital region. For this reason, congestion hours are not that long, and bus stop service time is always short and constant in Jeju region, but in the populated capital region, there are a large number of bus routes and the number of T-Map data collection is estimated to be much larger than that of Jeju region. On this, further research and test is required to make the system combined BIS and T-Map be realized in the capital region, considering the difference between the two regions.
Uncertainly regarding on the accuracy of spot detecting information was the catalyst for introduction of probe concept such as DSRC and RFID systems. In this study, the possibility of combining BIS and T-Map for system construction to meet the demand for section detecting information was confirmed. This has the same significance with current ITS technologies in terms of low costs and high efficiency.

1) Internal sources of Jeju special self-governing island, Main points AADT 12,000~10,000 units

2) Internal sources of Jeju special self-governing island, The number of bus passengers by bus stops: 78 persons a day on average

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