India

METROPOLITAN TRANSPORT CORPORATION (CHENNAI) LTD. (MTC)

Collaboration Program with the Private Sector for Disseminating Japanese Technology for Transportation Information System and Public Transport Planning in India

Final Report（Public Version）

February, 2018

Japan International Cooperation Agency (JICA)

Hitachi, Ltd.

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Map

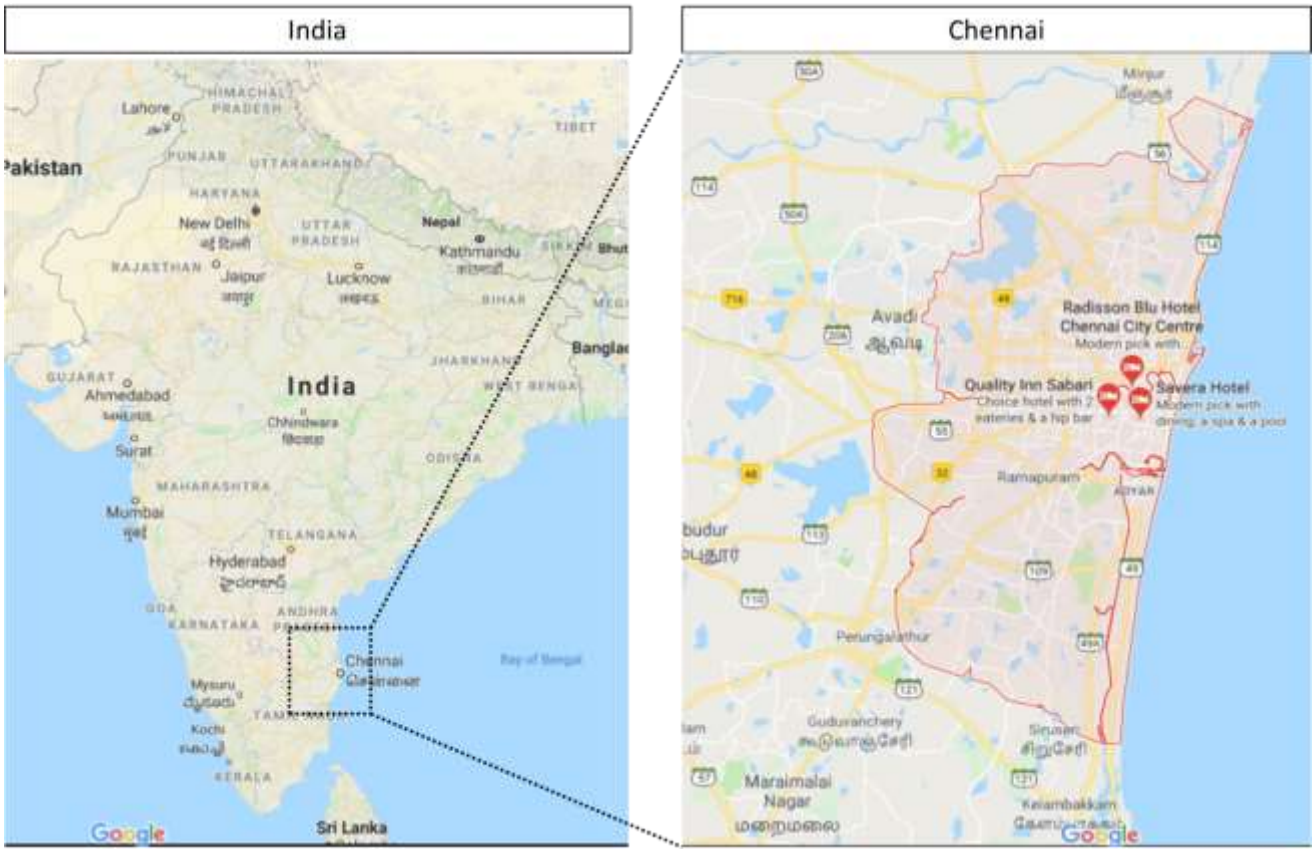
India
Chennai
Lahore
Pakistan
New Delhi
Nepal
Kathmandu
Jaipur
Lucknow
India
Ahmedabad
Surat
Mumbai
Hyderabad
Chennai
Mysuru
Kochi
Sri Lanka
Avadi
Radisson Blu Hotel
Chennai City Centre
Quality Inn Sabari
Savera Hotel
Ramapuram
Perungalathur
Maraimalai
Nagar
Google

Table of Abbreviations

Abbreviation	Official Name
GPS	Global Positioning System
ITS	Intelligent Transport Systems
NAAQS	National Ambient Air Quality Standards
MTC	METROPOLITAN TRANSPORT CORPORATION (CHENNAI) LTD.
MoU	Memorandum of Understanding
NO_2	Nitrogen dioxide
SCM	Smart City Mission
SO_2	Sulfur dioxide
TNIDB	Tamil Nadu Infrastructure Development Board
OD	Origin and Destination
PM_{10}	Particulate Matter
VMS	Variable Message Sign

Chapter 1. Abstract

1.1. Abstract

Population in India has been increasing year after year and according to the report[1] on the estimated world population announced by the United Nation, its population was 1.25 billion in 2013 which ranked second in the world but its population is estimated to reach 1.45 billion in 2028 and rank first in the world. The numbers of cars and motorcycles have also been increasing year after year and the auto sales in 2013 were about 3 million which ranked fifth in the world, whereas the auto sales in 2024 are estimated to increase to 13 million or more than four times higher than that of 2013 and will rank third in the world. [2] With these estimated increases, there are growing concerns that traffic congestions will further worsen in the future. With the worsening of traffic congestions, traffic pollutions such as air pollution, etc. have become worse and prompt responses are required. With regard to the use of public transportation facilities, although the information providing service for bus users exist, its information accuracy and functions are not sufficient and there are issues such as waiting time at bus stops significantly fluctuates due to the traffic congestion conditions, it is difficult to search routes with consideration for transferring of buses, Metro, etc. For bus companies, visualization of bus operation information has not been realized and it is in a situation that whether or not bus routes, frequency of bus services, etc. are appropriate cannot be judged because user demand and traffic congestion trends have not been comprehended.

With a view to relieving traffic congestions which have now become a development issue in India, the performance goals of this project are to clarify that the data to be accumulated in the social infrastructure (the traffic control system) of which the introduction will be considered in the future is also effective in the information providing service for bus users and operators and to present the data to the local government and bus company (MTC). Furthermore, with an eye on the future business deployment, the performance goals are also to begin collaborating with a local company at the end of this project and to exchange a partner agreement with the local government and MTC as proof of a relationship of mutual trust.

To achieve these goals, we first comprehended the local traffic conditions through the field survey and obtained MTC's shift data, timetable data, etc. We also heard local requests which were the realization of the operation guide to citizens by accurately comprehending bus operation and review of the operation plans by accurately comprehending bus operation. Based on these local field survey results, we built demo system based on the probe processing system and information providing system for bus users and operators which is the technology subject to dissemination in this project and conducted technology verification by dividing into three evaluation items. With regard to the first evaluation item, we collected GPS data from MTC's buses and calculated the travel speed in each road in Chennai by utilizing the probe processing system. To evaluate whether or not traffic information is correctly created by utilizing bus GPS data, we collected GPS data from taxi, used this data as the actual traffic information, and compared the average travel speed calculated from the bus data and the average travel speed calculated from the taxi data. As a result, errors were within the allowable range. With regard to the second evaluation item, we estimated the arrival times using the information providing system for bus users and operators

by utilizing the calculated bus travel speed and compared with actual bus arrival times. As a result, we could surpass 70% in accuracy which was the target. With regard to the third evaluation item, we also collected the GPS data from those who carried smartphones and demonstrated whether or not automatic modality classification could be done by utilizing the probe processing system. To evaluate whether or not these classification results were correct, we asked test subjects to record and declare the means of transportation used and when we compared the results and modality classification results that the system recognized, the degree of classification accuracy slightly surpassed the target and confirmed that we could apply modality classification technology in India as well.

We held a workshop for local companies in which we lectured about the system architecture, operation, etc. of the demo system that we created and participating members actually experienced the lecture content. When we evaluated their level of understanding in the questionnaire form, we could achieve over 90% in their level of understanding and the result was excellent. In addition, we could conclude an MoU and gain a consensus on starting collaboration. In exchanging a partner agreement with the local government and MTC as proof of the relationship of trust, we held a technology seminar to demonstrate the demo system that we created and to report the results of aforementioned technology evaluations to MTC with a view to promoting their understanding on the proposed technology and producing an effect to improve their willingness for introduction. We had discussions with participants and when we confirmed MTC's willingness for introduction, they said that they wanted to promptly introduce the system.

1.2. Project Schematic Diagram

The project schematic diagram is shown in the Figure 1.2-1.

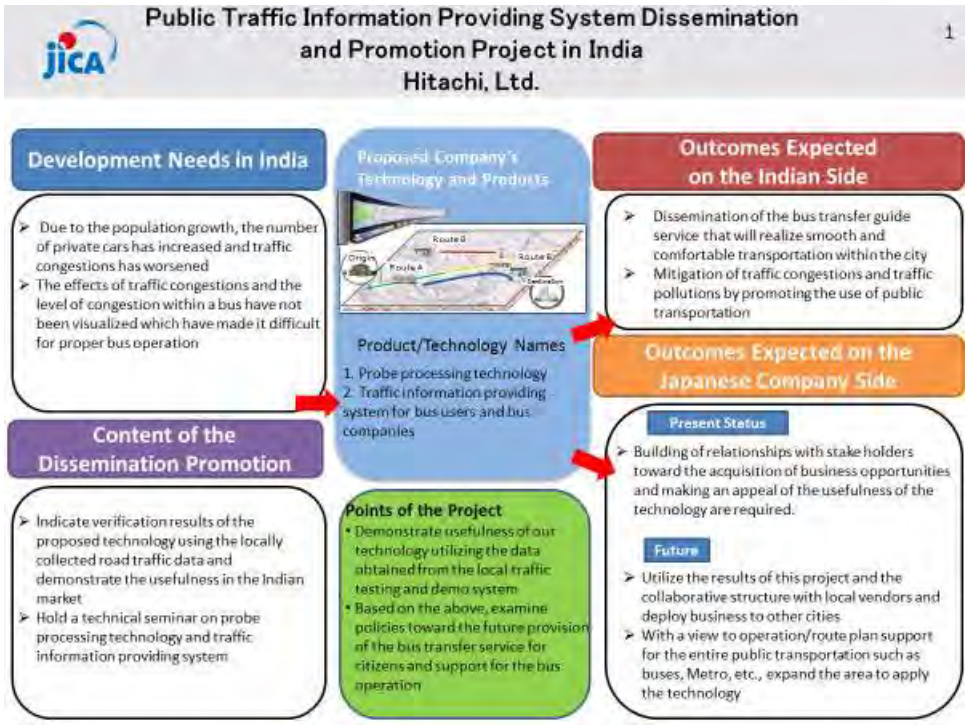

Figure 1.2-1 Project Schematic Diagram

Chapter 2. Background of this Project

2.1. Background of this Project

Population in India has been increasing year after year and according to the report[1] on the estimated world population announced by the United Nation, its population was 1.25 billion in 2013 which ranked second in the world, following China but its population is estimated to reach 1.45 billion in 2028 and rank first in the world, surpassing China. The numbers of cars and motorcycles have also been increasing year after year and the auto sales in 2013 were about 3 million which ranked fifth in the world but the number is estimated to increase to 13 million in 2024 or more than four times larger than that of 2013 and rank third in the world. [2] With these estimated increases, **there are growing concerns that traffic congestions will further worsen in the future**. With the worsening of traffic congestions, traffic pollutions such as air pollution, etc. have become worse and prompt responses are required.

With regard to the use of public transportation facilities, although the information providing service for bus users exist, its information accuracy and functions are not sufficient and there are issues such as **waiting time at bus stops significantly fluctuates due to the traffic congestion conditions**, **it is difficult to search routes with consideration for transferring of buses, Metro, etc**. For bus companies, visualization of bus operation information has not been realized and it is in a situation that **whether or not bus routes, frequency of bus services, etc. are appropriate cannot be judged** because user demand and traffic congestion trends have not been comprehended.

2.2. Technology Subject to Dissemination and Potential Contribution to the Development Issues

2.2.1. Potential Contribution to the Development Issues

Currently, introduction of the traffic control system with a view to relieving traffic congestions has been planned in India. A policy (Smart City Mission) with a view to constructing IT-intensive smart cities has also been upheld in India and Chennai has been chosen to be one of the target cities in the first period (20 cities among 100 cities).

By utilizing the data accumulated by introducing the social infrastructure (the traffic control system) and introducing the technology subject to dissemination in this project, development of appropriate bus operation plans (optimization of the operation intervals, increasing/abolishing bus routes, etc.) will become possible and realize sustainable improvement of the quality of bus services. By beginning at the services for bus users and operators and constructing effective public transportation facilities by demand analysis utilizing services for other public transportation (multiple-mobility transfer navigation, etc.) and accumulated data, realize the improvement of convenience of urban transportation as a whole for citizens. With the improvement of convenience of public transportation including buses, it is expected that private car users will decrease and public transportation users

will increase which will also contribute to relieving traffic congestions. As a result, travelling time that accounts for the considerable portion in daily life can be effectively used for business, amusement, etc. and diverse lifestyles will be formed which will significantly contribute to the realization of affluent and high-quality livelihood of the people.

Chapter 3. Outline of this Project

3.1. Objectives and Goals of this Project

3.1.1. Objectives of this Project

To make possible the local business deployment utilizing our technology, we conducted this project with the following three objectives:

(1) By verifying our technology in the field, encourage MTC which is a bus company to understand the technology and proceed with consideration toward the technology introduction.

(2) By building relationships of trust with the local government and MTC, establish the channel for proposal activities.

(3) By implementing education to local companies, secure and enhance the structure for the local business deployment.

3.1.2. Performance Goals of this Project (Contribution to the development issues in the target country, region, and city)

With a view to relieving traffic congestions which have now become a development issue in India, this project's performance goals are to clarify that the data to be accumulated in the social infrastructure (the traffic control system) of which the introduction will be considered in the future is also effective for bus users and operators and to present the data to the local government and MTC.

As just described, by indicating the effectiveness of our technology to the local government and bus company, we will lead to improve their willingness to introduce the traffic control system. We believe that, through the outcomes of this project, it will become possible to promptly introduce the actual system, continuously provide our technologies, and expand business.

3.1.3. Performance Goals of this Project (from the of business)

The performance goal shall be to begin collaborating with a local company at the end of this project. Collaboration with a local company is considered to be necessary to reduce the costs of negotiations with the local government and bus companies and system architecture/operation in deploying the local business utilizing our technology.

Therefore, in this project, we provided education necessary for the system architecture/operation in regard to the technology to be proposed at the time of future business deployment in the form of a workshop for local companies and had them understand our thoughts on our local business and exchange MoUs toward collaboration.

Exchanging a partner agreement with the local government and bus company as proof of a relationship of mutual trust shall be the performance goal. In this project, as efforts to build a relationship of mutual trust with a bus company, we conduct investigations to organize requirements with a view to extract potential needs that they are holding under the present circumstances and hold a technology seminar with a view to promote their understanding on our technology and improve their willingness for the introduction. To make the confirmation of their level of understanding as the performance goal, we prepare a questionnaire and ask them to fill out the questionnaire after the end of the event.

We assume that the content of the questionnaire results obtained in this event include potential needs of the government and bus companies at the end of this project and will be used as the basic information in examining business with them in the future.

3.2. Content of Implementation of this Project

3.2.1. Implementation Schedule

Implementation schedule of this project is shown in Figure 3.2-1. The contract begins on the contract day in October, 2017 and ends with the submission of this report to be conducted in February, 2018.

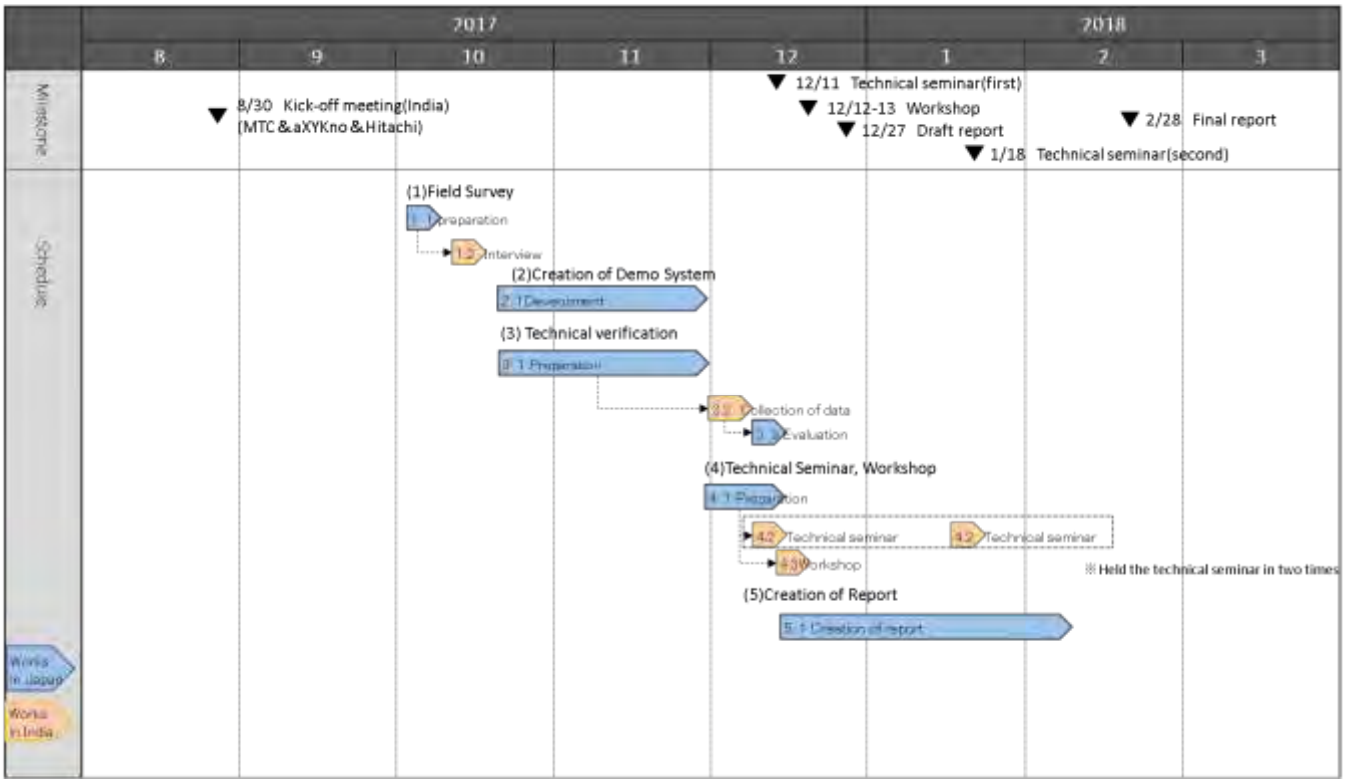

Figure 3.2-1. Implementation Schedule

3.2.2. Content of Implementation

(a) Objectives and Outline of the Activities in India

Activities in India are conducted with a view to verifying the technology subject to dissemination in the field and organizing the needs/requirements by conducting hearings to the government, bus company, and citizens in the field through the demonstration of business utilizing the technology. Specifically, field surveys, development of the demo system, organization of requirements, technology verification, and a technology seminar/workshop will be implemented.

i. Field Survey

Obtain data necessary in creating the demo system and extract requests, etc. on the scope of technology verification in the field from the local government by conducting hearings.

ii. Development of the Demo System

A demo system is developed to effectively implement the organization of requirements for business from the government toward the business deployment utilizing the technology subject to dissemination in the future. We give consideration to the needs of the government and bus company, give degrees of priority to the demo systems that we create, and for the systems with high priority, the demo environment is created in the server and laptop PC procured locally. For the systems with low priority, create demo movies.

iii. Technology Verification

Accuracy of processed traffic information in deploying business in the future is associated with the level of the service quality. To verify the accuracy of the results of processing through the demo system using the digital map of India and GPS data, we collect information using manpower in the filed along the scenario and conduct comparative verification. With this, we confirm that sufficient accuracy for the future service provision is ensured. Specifically, we assume the following three types of verifications by utilizing 50 smartphones in Chennai.

(1) Collect GPS data of the running buses using smartphones for 4 days, generate the travel speeds in the center of the city with the demo system, and confirm that the data which makes possible the recognition

of frequently congested locations and comprehension of traffic demand peak and off-peak hours will be generated.

(2) To verify the accuracy of estimated bus arrival times calculated by the demo system, collect GPS data of running busses using smart phones for 4 days, calculate the estimated arrival times, and compare with the actual conditions to verify the accuracy of the predicted arrival times.

(3) Collect the GPS data and acceleration sensor data for 4 days from the test subjects who carry smartphones and verify the accuracy by comparing the actual conditions of the test subjects' travel paths and means of transportation used and automatic classification results.

iv. Implementation of the Technical Seminar and Workshop

To be implemented for the purposes of building relationships with bus company such as MTC, TNIDB, etc. and the government agency, promoting their understanding on the business utilizing the technology to be disseminated, and fostering local companies. For the technology seminar, we invite bus companies such as MTC, TNIDB, etc. and the government agency and aim to promote their understanding on the proposed technology and have the effect to improve their willingness for the introduction. In the workshop, we promote their understanding on the superiority, usefulness, and expansibility of the technology subject to be disseminated through the classroom lecture and practice and try to improve technological and organizational capabilities.

Table 3.2-1. Content of Implementation of this Project (Outline) and Performance Goals

#	Task **Items that should be implemented within the project toward business deployment**	**Activity Plan** 10/2017 11/2017 12/2017 1/2018	**Content of Implementation**	**Goals (Status at the end of the project)**
1	Field Survey		(1) Prepare plan documents (2) Collect information on the status of maintenance of the means of transportation from the websites, literature, etc. (3) Research the status of maintenance of various data	-All information on survey viewpoints provided in the plan documents have been collected and researched.
2	Development of the Demo System		(1) Create demo scenarios (2) Crate demo system movies	-Basic information such as the target city's map data, etc. has been reflected on the demo system.
3	Technology Verification		(1) Prepare plan documents (2) Conduct verifications (3) Analyze verification results (4) Prepare a report	-Degrees of accuracy for traffic information, arrival time estimation, and modality recognition are 70% or higher.
4	Workshop		(1) Prepare plan documents (2) Hold a workshop (3) Prepare a report	-Confirm the level of understanding on the system architecture and operation conducted in the workshop through the questionnaire survey. The questionnaire results on the level of understanding are 90% or higher. -Exchange an MoU to begin collaborating with a local company.
5	Technical Seminar		(1) Prepare plan documents (2) Hold a technology seminar (3) Prepare a report	-Confirm the level of understanding on the element technology and future business deployment conducted in the technology seminar through the questionnaire survey. The questionnaire results on the level of understanding are 90% or higher. -Exchange a partner agreement with the government and bus operator.
6	Organization of Requirements		(1) Create an interview sheet (2) Implement interview (3) Organize requirement (4) Create a report	-The number of interview implementations must be at least 3 times for bus companies, government agencies, and citizens. -In addition to the functions demonstrated, we are in a state that we are receiving new functions as a request from bus companies and government agencies.

Table 3.3-2. List of Equipment

	Equipment Name	Model Number	Qty.	Use	Delivery Month and Year
1	Probe Processing Server	Server Lenovo TS150-70UAA007IH One Socket Tower Think Server	2	To be used for the demo system	October, 2017
2	Smartphone	Samsung Model no J7 Prime	50	To be used for the demo system	October, 2017
3	Laptop PC (Core i7)	Laptop Asus i7 R558UQ-DM701T	1	To be used for the demo system	October, 2017
4	Laptop PC (Core i3)	Laptop Asus i3 X541UA-GO1345D	4	To be used for the demo system	October, 2017
5	DB Software	Software Oracle Database 12C standard edition L103399	1	To be used for the demo system	October, 2017
6	OS	Software Microsoft Windows Professional 10 SNGLOLP License part no FQC-09478	7	To be used for the demo system	October, 2017
7	Digital Map	Map Data and Transit Data set for Chennai	1	To be used for the demo system	October, 2017

Chapter 4. Results of the Implementation of this Project

4.1. Field Survey

4.1.1. Overall Traffic Conditions

To comprehend the changes in traffic demand in Chennai, we confirmed the overall conditions of the recent traffic conditions in Chennai using "Chennai Comprehensive Transportation Study" [3] which is the master plan (the second edition) released by the Chennai Metropolitan Development Authority in August, 2010 toward 2026. With regard to part of the latest information, we also researched it on websites. In this section, we report the confirmation results of the activities.

(a) Changes in Traffic Demand

The number of cars in FY 2015 was over 4.93 million and you can see that the number rapidly increased by 2.4-fold as compared to FY 2004[4]. In addition, according to the results of the survey on the car model ratios of the private cars in Chennai conducted in 1992-95 and 2008[3], you can see that the private car ownership ratio in each household has noticeably increased.

From the above, you can see that vehicles including private cars have been rapidly increasing in Chennai.

According to changes in the number of buses owned by MTC from 2004 to 2009[3], the number of buses owned by MTC in 2009 was about 3,300 and the number of buses increased by 17.8% from 2004 to 2009. In addition, changes in population of Chennai from 1971 to 2008 and estimated population in 2026[3], the population increase rate from 2001 to 2008 increased by 17.3%. As of 2016, population was about 9.6 million (96 Lakhs) [5]and the population increase rate was 16.2% as compared to 2008.

From the above, it is believed that bus demand increased in response to the population increase and the number of buses increased.

(b) Traffic Congestions

The average vehicle travel speeds by road in Chennai[3], on the roads going to the central part, was in a situation where vehicles could only travel at 20 km/h or slower. As compared to the measurements in 1992, the average travel speed on all roads subject to the survey slowed down by 14% in 16 years.

By combining with the results in (a), it is believed that traffic congestions occur on the roads going to the central part due to the increase in the number of vehicles.

(c) Traffic Accidents

According to changes in the number of traffic accidents from 1995 to 2008[3], as for the number of traffic accidents, over 4,000 accidents have been continuously occurring for 13 years and the number of deaths was reported to be at an annual average of 625. In 2016, 7,486 traffic accidents occurred[6].

(d) Environmental Load

According to changes in the amounts of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM_{10}) contained in ambient air in Chennai[7], particulate matter which is one of the substances contained in gas emissions from cars surpassed the National Ambient Air Quality Standards (NAAQS).

4.1.2. Outline of the Bus Business and Operational Status

To comprehend the outline of the bus project, we conducted interview surveys to MTC and on-vehicle surveys on MTC's buses and organized results.

(a) Outline of MTC

MTC is a bus company which provides bus services in Chennai. As indicated in the Table 4.1-1, MTC operates 833 routes with 3,964 buses and the number of passengers per day is 4.8 million. You can see that MTC's bus is the means of transportation that supports the daily lives of citizens.

Table 4.1-1. Outline of MTC (As of the end of March, 2017)

No.	Item	Quantity
1	Number of bus depots *A bus depot is synonymous with a garage	33 locations
2	Number of bus	3,964 buses
3	Number of bus routes	833 routes
4	Number of employees	24,223 employees
5	Number of passengers per day	4,800,000 passengers

Source: MTC's website[8]

(b) MTC's Bus Services

●Bus Vehicles

MTC's bus vehicles are shown in Figure 4.1-1. The name of the bus route, destination, and transit bus stops are displayed in the upper part on the front side of the bus. Displaying methods are the lighting board type and paper type. On the routes with many bus users, two-car buses are operated. In overall, there are many aging vehicles and many vehicles of which the door does not open or even if the door opens, it remains open due to failure are operated. When we checked equipment in the buses, we could not find devices that support the operation of buses or recording devices such as on-board devices, cameras, etc.

Figure 4.1-1. MTC's Bus Vehicles

●Fare Collection Method

As is the case with other bus companies in India, MTC operates the mechanism in a way that an employee called bus conductor gets on a bus and collects fare from bus users. Figure 4.1-2 is the photo of a device that MTC's bus conductors are using. This kind of device has the function to calculate the fare according to the section by entering the bus stop where a bus user got on the bus and destination that the bus user told and the function to issue a receipt. The bus conductor collects fares in a way to hand over the receipt to the bus user in exchange for the fare.

Figure 4.1-2. Device that Bus Conductors are Using (Handy Terminal)

●Conditions of Bus Terminals and Bus Stops, and Bus Service Status

In MTC's bus routes, bus terminal stations are set in the places of departure and destinations. Figure 4.1-3 is the photo of a bus terminal. Several lanes with roof are available and a board on which the route name of the bus that will pull in is written is posted on the upper part of the lane.

As for the bus schedule, only the brief indications of the departure time of the first bus in the morning and final operation time are decided but the timetable in the day considering effect of the traffic congestions and weather is not created. Drivers and bus conductors' delay frequently occurs on a daily basis and it seemed to be often the case where the departure time of the first bus in the morning was not as scheduled. Therefore, bus arrival time and departure time cannot be predicted.

Figure 4.1-3. Bus Terminal (Terminal name: Thiruvanmiyur)

Figure 4.1-4 shows the scenes of bus stops. As indicated in the left photo, a roof and bench are often installed in the bus stops located along arterial roads and these bus stops can be recognized as bus stops. On the other hand as indicated in the right photo, there are places where there is no mark as a bus stop but are used as bus stops, and those who do not use the bus stop on a daily basis need to check the location of the bus stop on the map on the website, etc.

Figure 4.1-4. Bus Stops

As shown in Figure 4.1-5, the bus station where a roof and bench are installed has a bulletin board indicating the bus routes that stop. However, information has not been updated and routes not in service were still shown on some boards. The latest information needs to be confirmed on the website.

Figure 4.1-5. List of the Bus Routes that Stop Posted at the Bus Stop

(c) MTC's Operations

Key job types that support MTC's bus services are shown in Table 4.1-2. These job types implement the operations shown in Table 4.1-3 throughout the day. MTC's operations are conducted around the clock due to the influence of attendance management and fare calculation not systematized. Drivers and bus conductors' working hours are basically 16 consecutive hours, except when drivers and bus conductors are replaced in part of the buses during the day. Time keepers are in the three-shift system and their working hours are basically 8 hours.

There is an opportunity once a year to review the bus schedule. Under the present circumstances, review is conducted based on the numbers of passengers getting on and off the buses which are recorded by the ticket-vending machines or manually recorded by the bus conductors.

Table 4.1-2. Job Types in a Bus Depot

Type	Role
Driver	In charge of driving a bus
Bus Conductor	In charge of collecting fares on the bus
Time Keeper	In charge of driver and bus conductor attendance management in a bus depot
Person in Charge of Fare Calculation	In charge of fare calculation on a daily basis

Table 4.1-3. Daily Operations

Hours	Driver	Bus Conductor	Time Keeper	Person in Charge of Fare Calculation
4:00 - 8:00 a.m.	Come to the bus depot Depart the bus depot		Attendance confirmation and handing over of equipment	
8:00 a.m. - 9:00 p.m.	Travel back and forth between bus depots			
9:00 p.m. - 1:30 a.m. on the next day	Finish the last operation and arrive at the bus depot		Leaving confirmation and collection of the equipment and fares	
1:30 a.m. on the next day - 4:00 a.m. on the next day				Fare calculation

4.1.3. Connections of Public Transportation

To confirm the connectivity of public transportation, we obtained bus route information (563 routes), bus garage information (34 locations), bus stop information (4,430 locations), and railway route information. The bus-related information to be used in the experiments was obtained as the data with position information. In Figure 4.1-6 and Figure 4.1-7, bus stop information obtained is shown. According to railway and major bus route information obtained, you can see that railways and buses are connected in over 10 locations in the city. According to Figure 4.1-6 and Figure 4.1-7, you can also see that bus stops have been set up in many locations in the city. Based on these facts, as is the case with the sophisticated public transportation in Japan, you can understand the division of roles that long-distance transportation by railway and transportation within the city by bus has been taken into consideration.

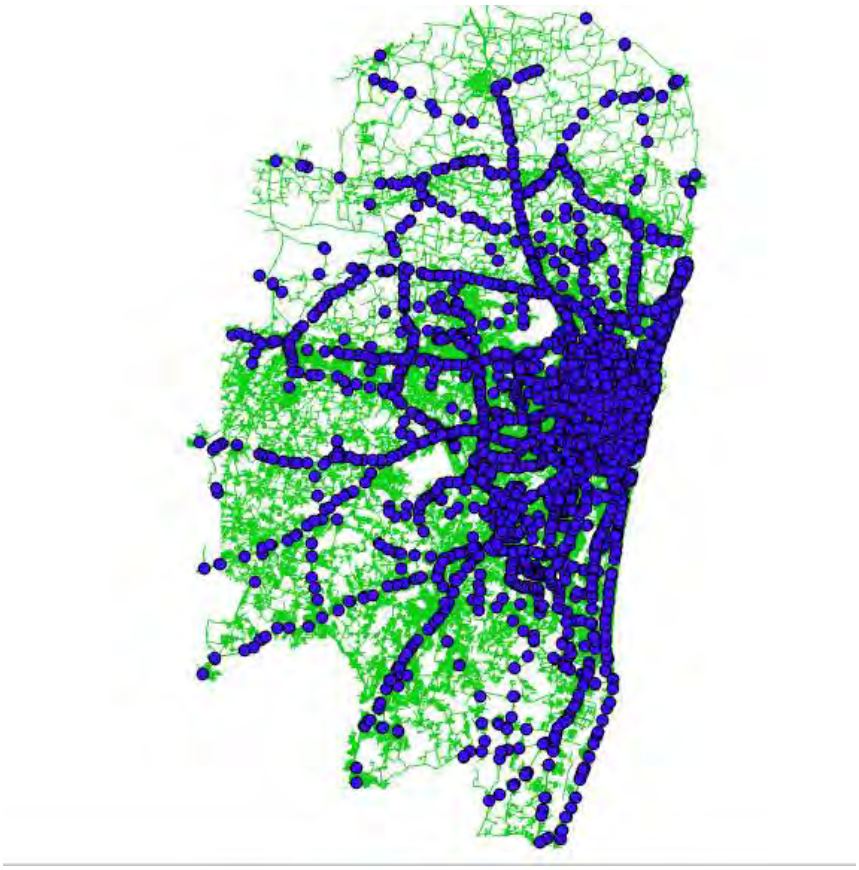

Figure 4.1-6. Bus Stop Information (All bus stops are displayed)

Figure 4.1-7. Bus Stop Information (Partly enlarged)

4.1.4. Status of the Management of Data on Public Transportation

In this survey, we surveyed the accessible data toward the construction of the information providing system for bus users and bus companies in the future. Survey targets were decided to be the data held by MTC and the data on public transportation sold by a major digital map vendor which creates and sells digital maps in the field.

(a) Data Held by MTC

Through the hearings from MTC, we could confirm that MTC holds the data in Table 4.1-4 and Table 4.1-5 for driver and bus conductor attendance management and fare collection and management. According to Table 4.1-4, you can see that only the start time and finish time were specified and the schedules while buses were in operation were not managed. On-board devices were not installed on the buses and results of bus operation were not comprehended in detail. Based on the data management status, it was considered to be difficult to improve bus operation and provide bus operational status to citizens under the present circumstances.

Table 4.1-4. Shift Data

#	Data Name	Content
1	Bus Depot Name	Name of the bus depot where drivers and bus conductors come to work
2	Bus Route Name	Name of the bus route that a driver and bus conductor are in charge
3	Bus Service Name	Alphabets given to recognize bus vehicles in the same bus route (The first bus in the morning is A and alphabets are given in a sequential order)
4	Driver	A driver's employee number and name
5	Bus Conductor	A bus conductor's employee number and name
6	Shift	Whether or not a driver and bus conductor will be replaced
7	Origin	The bus depot where a bus departs
8	Destination	The bus depot where a bus arrives
9	Start Time	The time when a bus departs a bus depot first
10	Finish Time	The time when a bus returns to a bus depot and a driver and bus conductor finish their operations

Table 4.1-5. Data Managed by a Handy Terminal

#	Data Name	Content
1	Bus Route Name	As per the data name
2	Bus Service Name	Alphabets given to recognize bus vehicles in the same bus route (The first bus in the morning is A and alphabets are given in a sequential order)
3	Bus Stop Name	As per the data name
4	Number of Persons on Board	Number of persons got on a bus at each bus stop
5	Total Fares	Fares collected at each bus stop

(b) Data on Public Transportation Circulating in India

A major digital map vendor which creates and sells digital map data in the field handles digital maps of each city in India but in this report, we report the data in Chennai. In Chennai, data on public transportation in Table 4.1-6 has been maintained.

Table 4.1-6. List of Accessible Public Transportation

No.	Public Transportation Name	Outline
1	MTC	A bus company providing the bus services in Chennai
2	Chennai Metro Rail Limited	A metro operator in Chennai
3	Indian Railway	A national railway company in India

The data in Table 4.1-7 has been maintained for each public transportation. The data is considered to be the important data in realizing the improvement of bus operation and provision of bus service status to the citizens. However, in fact, gaps caused by the conditions of traffic congestions, weather, etc. have been pointed out in regard to the times buses arrive at bus stops; therefore, timetables are used only as rough indications. When including bus in the routes including transfer, it is thought that improvement of the accuracy of arrival times with consideration for the real-time bus operational status will be necessary.

Table 4.1-7. Types of Accessible Data

#	Data Name	Content
1	List of Routes	List of IDs to recognize routes and route names
2	List of Stations/Bus Stops	List of station/bus stop locations
3	Route Shapes	Shapes of the paths that routes go through (In the case of MTC, shapes of the roads that buses go through)
4	Timetable	The time that a vehicle arrives at each station and bus stop (Data collected by the field surveys through human wave tactics)

4.1.5. Preliminary Organization of Requirements

(a) Organization Method

To organize requirements, we implemented the following two steps. In this chapter, we mainly report the results of preliminary hearings in (1).

(1) Preliminary hearings (Conducted at the time of the field survey)

To confirm the needs of the government and bus companies, hearings were conducted to the persons involved in MTC

(2) Organization of requirements

After building the demo system based on the above-mentioned preliminary survey, we introduced the system in the technical seminar and conducted hearings on requirement details

(b) Results of the Preliminary Organization of Requirements

As a result of preliminary hearings conducted this time, we formulated a hypothesis that the following two matters were the requirements to be preferentially realized for the state government and MTC in consideration of clear effects of the improvement of convenience for bus users and increase in the number of bus users and organized the requirements.

1. Realization of operation guide for citizens by accurately comprehending the bus operation
2. Review of the operation plans by accurately comprehending the bus operation

4.2. Outline of the Demo System

We created a demo system to be used in the technical seminar according to the requirements organized in 4.1.5. In this paragraph, we explain about the demo system configuration, outline of the technology used, and functions.

4.2.1. Demo System Configuration

The demo system configuration prepared in this project is shown in Figure 4.2-1. This demo system utilizes the GPS data and generates information that is usable for both bus users and operators. This GPS data is collected from traveling vehicles and people. In this project, GPS data was collected from MTC buses, taxis, and citizens of Chennai and the data items shown in Table 4.2-1 were recorded. Collected GPS data is processed by the probe processing system in the probe processing server and used for the information providing system for bus users and bus companies. Then, the information generated by the system can be confirmed through a laptop PC. In the latter part, we explain about the information providing system for bus users and bus companies that is processed by the probe processing system.

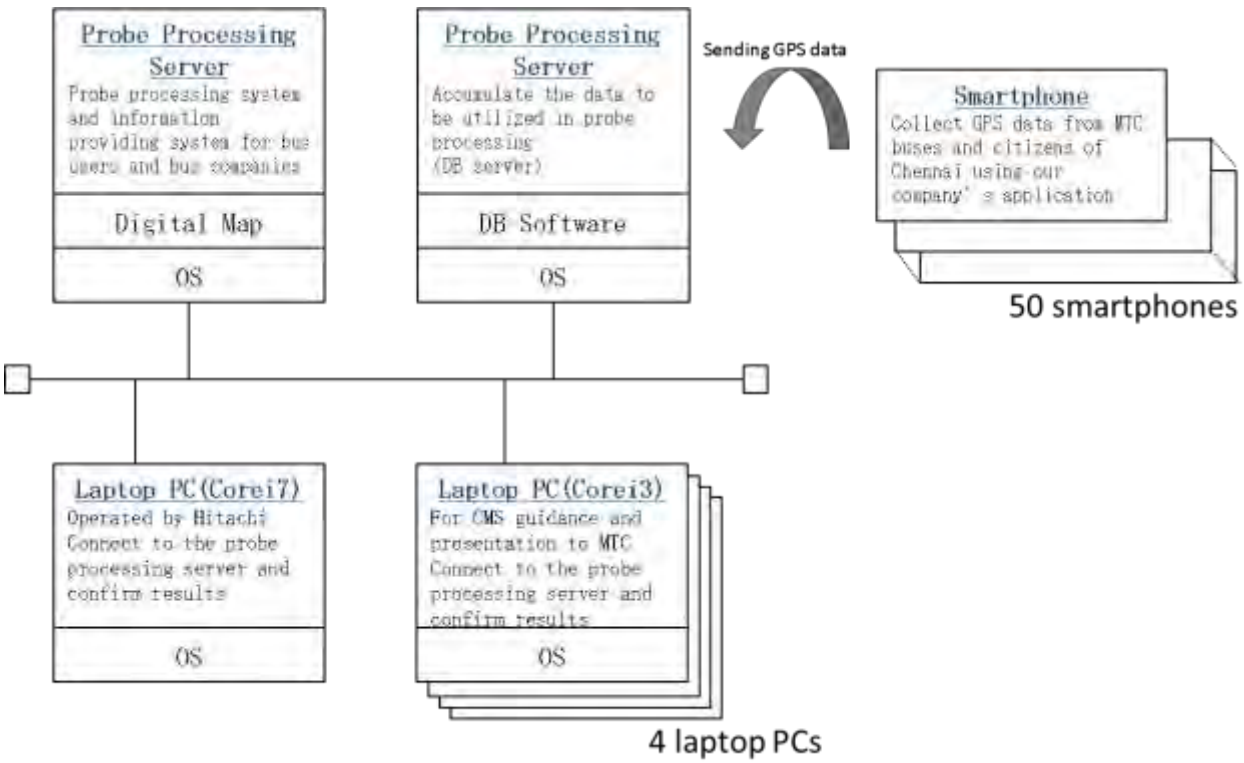

Figure 4.2-1. Demo System Configuration

Table 4.2-1. Items Recorded by the Demo System

#	Data Item Name	Content
1	Identification ID	IDs to identify MTC buses and citizens of Chennai
2	Date and Time of Data Recording	Date and time when data is recorded (Record up to the units of millisecond)
3	Position Information	Degrees of latitude and longitude
4	Acceleration	Data of the acceleration sensor in a smartphone
5	Means of Transportation	Results of manually entering the means of transportation that the citizens of Chennai actually used in traveling (Passenger cars, buses, motorcycles, auto rickshaws, and walk)

(a) Probe Processing System

This system is the system that generates traffic information based on GPS data. The schematic diagram of this system is shown in Figure 4.2-2. Traffic information generated by this system is called probe traffic information and is mainly composed of information such as travel speed and travel time in each road section.

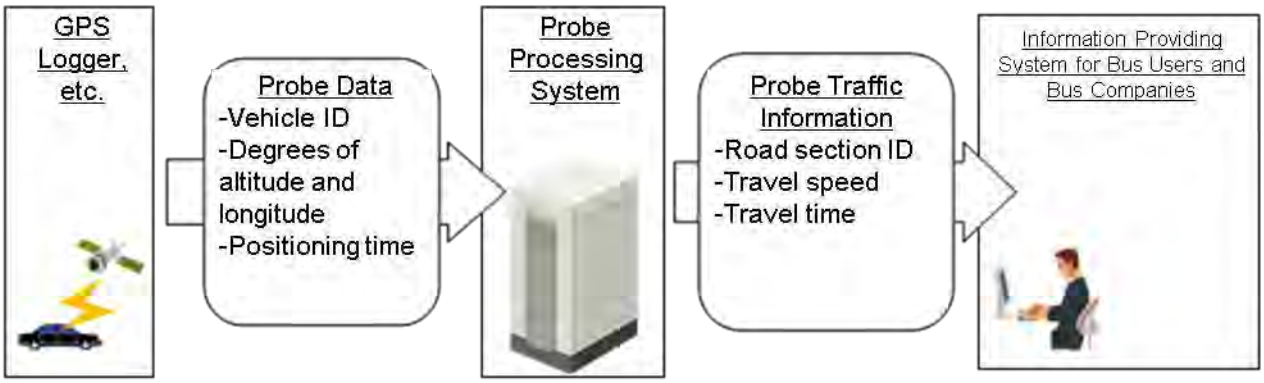

Figure 4.2-2. Schematic Diagram of the Probe Processing System

(b) Information Providing System for Bus Users and Bus Companies

This system is the system that provides bus departure times and arrival times to bus users and bus companies based on the probe traffic information generated from and the bus route information. If a user enters a departure place, destination, and desired departure time, he/she can check waiting time at a bus stop and estimated arrival time.

4.3. Technology Verification

To show that the probe processing system and technology associated with the system are effective for bus users and operators, we conducted technology verification in this project. In this paragraph, we report the outline of each verification, purpose of verification, verification content, and evaluation.

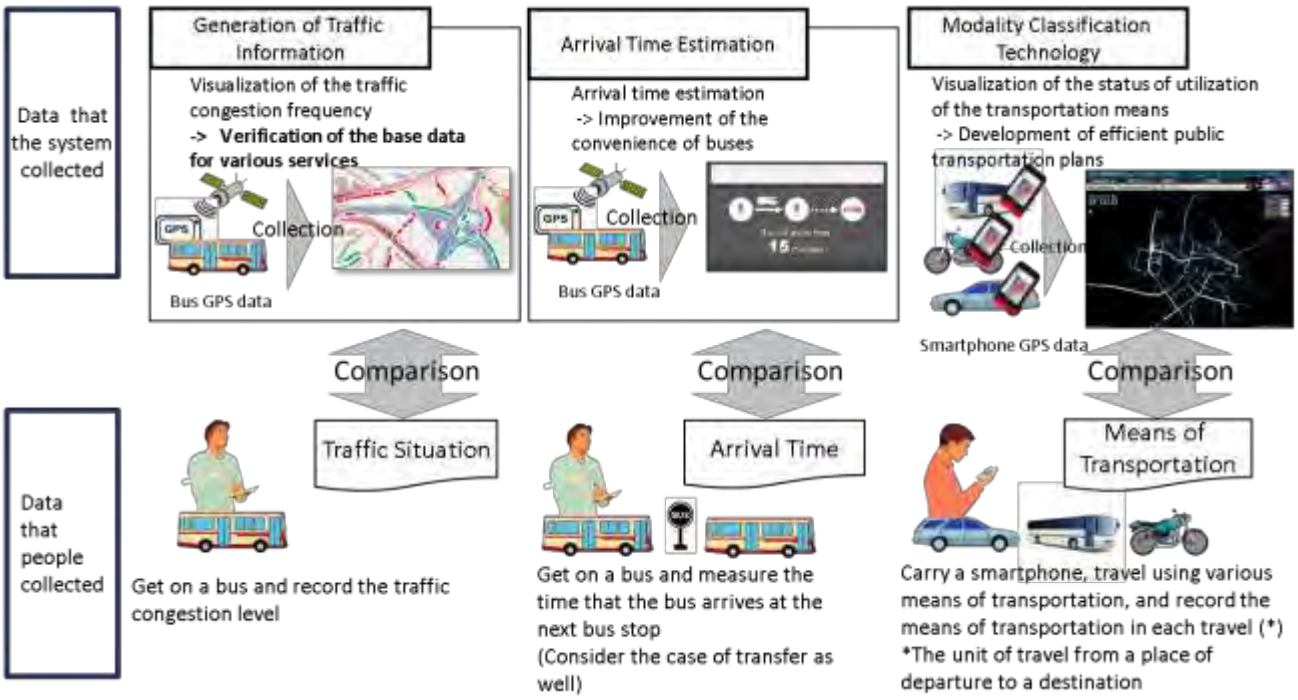

Figure 4.3-1. Outline of the Technology Verification

4.3.1. Evaluation of the Probe Processing System

In this section, we report the technology verification of the probe processing system. In this project, use and application of the probe traffic information generated from bus GPS data is proposed for the information providing system for bus users and bus companies. Therefore, in this technology verification, we evaluated whether or not the traffic information has the accuracy that contributes to the actual use.

(a) Purpose of Verification

In this verification, we aimed at evaluating that probe traffic information by the bus probe would meet the following two perspectives based on the actual data.

- Although the number of bus vehicles in each route is limited to around 20, being able to extensively comprehend the travel speeds on routes
- Being able to comprehend important trends such as traffic congestions, etc. in comprehending the bus service status

(b) Content of Verification

We set 25 bus routes selected by MTC as verification targets, selected two buses from each route, and collected GPS data from a total of 50 buses. We gave consideration to the trends of bus operation that were different from general traffic streams such as stopping at bus stations, basically no overtaking other vehicles, etc. and also collected GPS data from one taxi for comparison. After that, we generated GPS traffic information from the bus GPS data and taxi GPS data respectively and implemented evaluations based on the perspectives written in the preceding item. In the following items, we explain about the methods and conditions of GPS data collection and probe traffic information generation and then, state the evaluation results of the collected GPS data and probe traffic information.

(c) Collection of GPS Data

GPS data collection work was conducted under the conditions shown in Table 4.3-1.

Table 4.3-1. GPS Data Collection Work Conditions

Item	MTC Bus	Taxi
Period	Four days from November 30 (Thu.) to December 3 (Sun.), 2017	November 30 and December 1, 2017
Number of Vehicles	50 MTC buses (The number of routes was 25 and two buses were selected in each route)	One taxi
Scope of Collection	Bus routes that go on main streets in Chennai (See Figure 4.3-2)	Part of the bus route section (See Figure 4.3-3
Collection Means	Use the application for smartphones that our company developed. It detects travel of 5 m or more and records the device ID, degrees of altitude and longitude, and geodetic time.	Same as on the left
Collection Procedure	Go through the following procedure on each day 1. Visit bus depots in 15 locations in Chennai in between 3:00 and 8:00 a.m. (see Figure 4.3-2) and hand out a smartphone to a bus conductor under the presence of a time keeper. 2. Use the application for collecting GPS data throughout the day and accumulate the GPS data in the smartphone while buses are in operation. 3. Collect the smartphones at the bus depots in 15 locations from 11:00 p.m. to 1:00 a.m. on the following day. 4. Upload the GPS data to the server environment arranged for this project.	Actually get on a local taxi, use the application for collecting GPS data, and collect the GPS data. To be able to collect data during peak hours and off-peak hours of the traffic demand respectively, collect the data in the morning (7:00 – 9:00 a.m.), during the day (2:00 – 3:00 p.m.), and at night (5:00 – 7:00 p.m.).

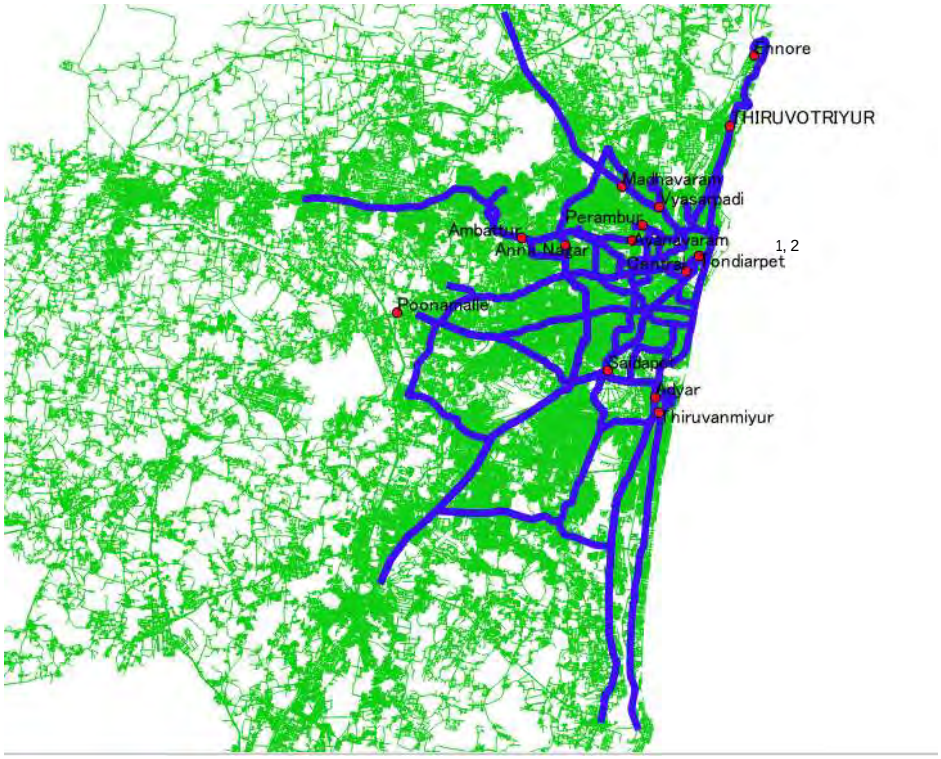

Figure 4.3-2. Overall View of the Bus Depots Subject to Smartphone Distribution/Collection and Routes Subject to Verification

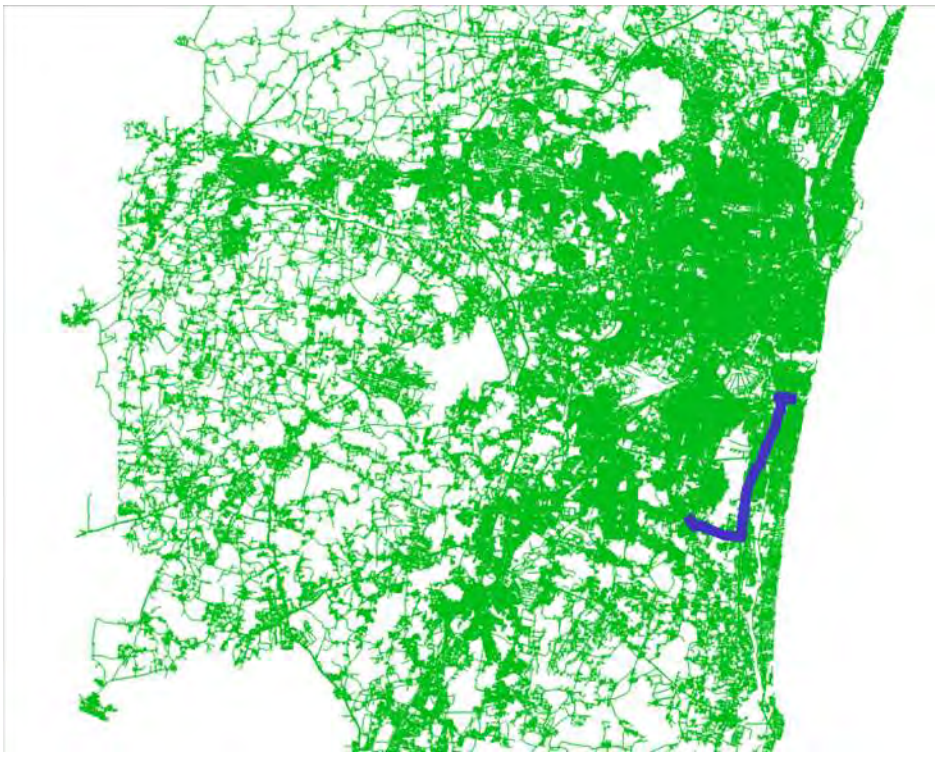

Figure 4.3-3. Taxi Traveling Section

(d) Analysis/Evaluation

●Analysis of the collected bus GPS data

The number of GPS data collected on each day is shown in Figure 4.3-4 and the number of buses that collected the GPS data is shown in Figure 4.3-5. The number of GPS data collected exceeded 1 million on all days. This is calculated (*3) that the GPS data was collected about every three seconds from each bus which can be said to be successful in collecting the GPS data with high frequency. However, the number of bus vehicles fell below the planned number of 50 on all days which resulted in not being able to generate probe traffic information in part of the routes. Reasons of not being able to collect data were that the bus driver or bus conductor to whom a smartphone would be distributed was absent and a bus conductor refused to receive a smartphone due to being concerned about the smartphone's failure because of bad weather.

*3: As a result of calculating the number of GPS data collected divided by the number of bus vehicles to see in how many seconds it took to collect one data

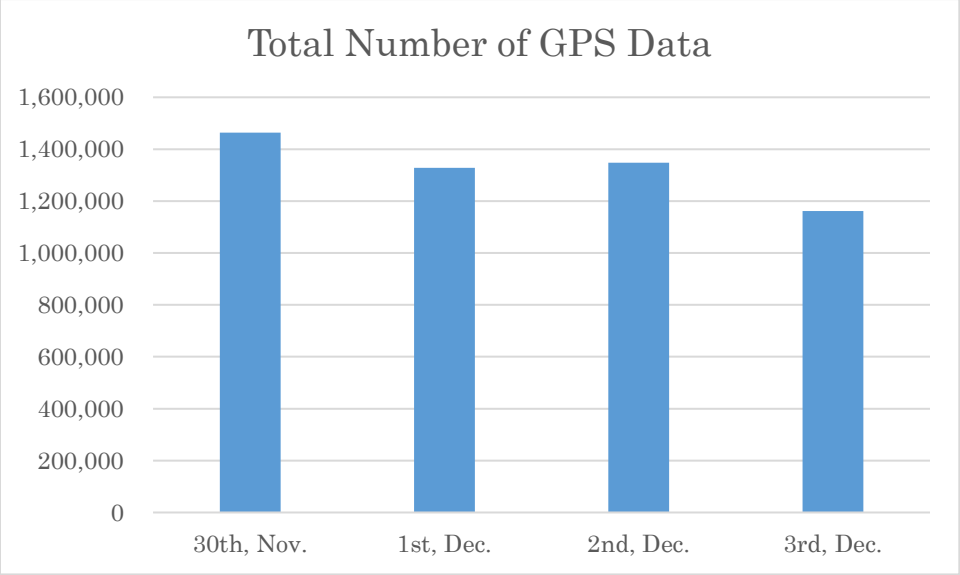

Figure 4.3-4. Number of GPS Data Collected on a Daily Basis

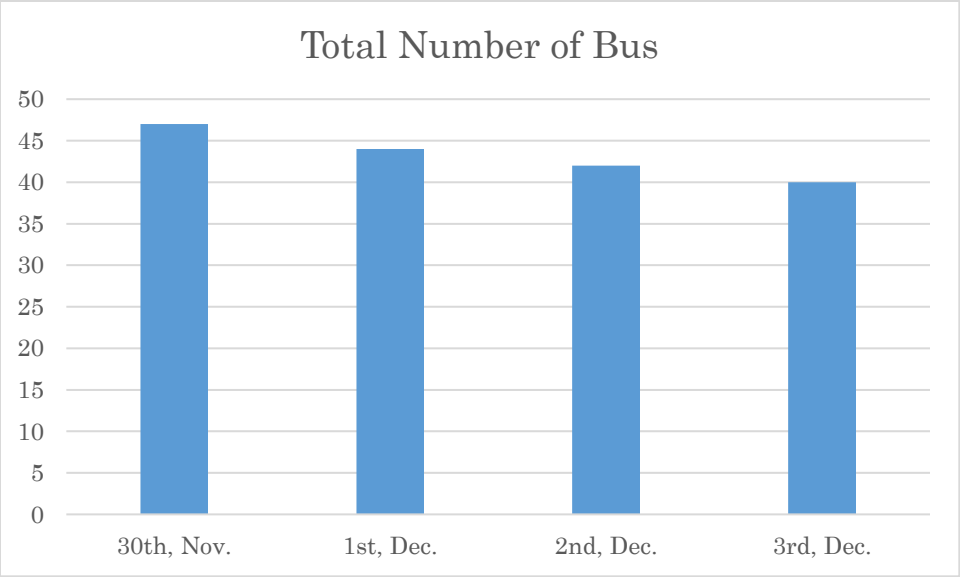

Figure 4.3-5. Number of Bus Vehicles that Collected the Data on a Daily Basis

The number of GPS data collected by time is shown in Figure 4.3-6 and the number of bus vehicles that collected the GPS data by time is shown in Figure 4.3-7. Because the number of GPS data has an influence on both the generation scope/accuracy of the probe traffic information, it is preferable that a larger number of data can be stably collected regardless of the passage of time. According to Figure 4.3-6 and Figure 4.3-7, it is thought that we could stably collect GPS data from 9 a.m. to 11 p.m. in each route on all days and it can be said that we could obtain preferable results.

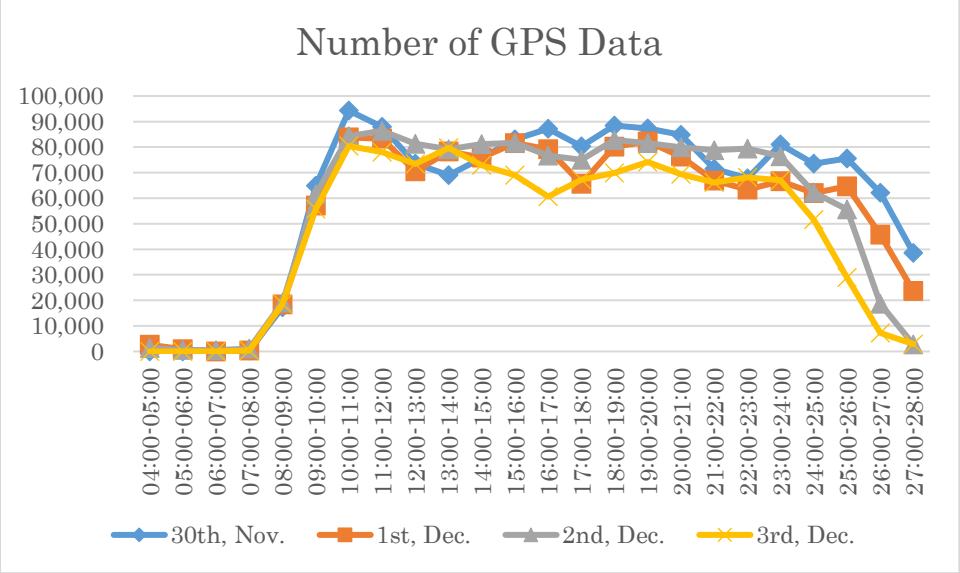

Figure 4.3-6. Number of GPS Data Collected by Time

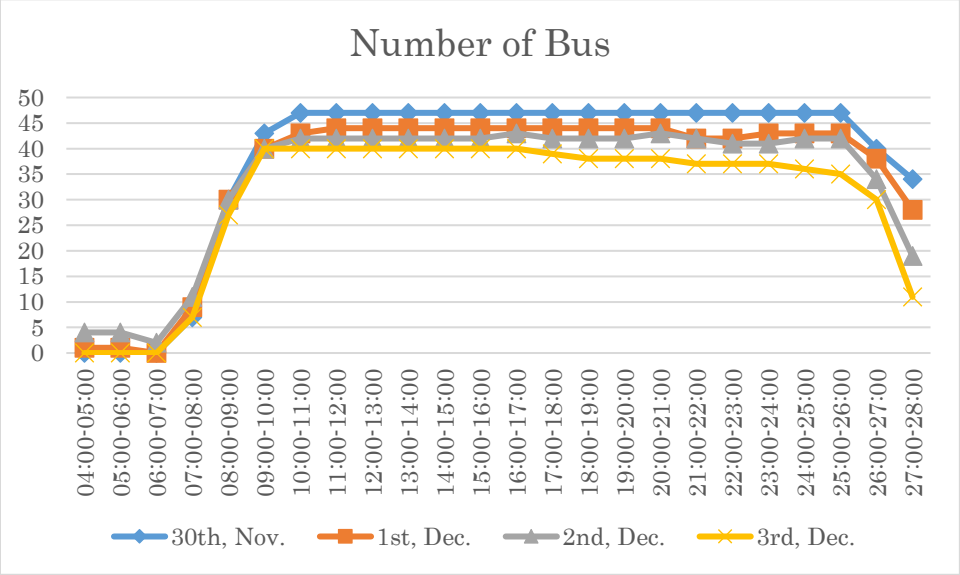

Figure 4.3-7. Number of Bus Vehicles that Collected the Data by Time

●Analysis of the collected taxi GPS data

With regard to the taxi GPS data, data was collected about every four seconds and we succeeded in collecting the data with high frequency.

●Evaluation of the probe traffic information

Results of evaluations conducted in accordance with the perspectives indicated in the preceding item are described here. Figure 4.3-8 is the bus probe traffic information during the off-peak (5-6 a.m.) hours. Because there was less number of buses that collected the GPS data, there were less roads for which data was generated but many of the road had the average travel speed of 25 km/h or more and you can see that there were less locations where traffic congestions occurred. Figure 4.3-9 is the bus probe traffic information during the peak (6-7 p.m.) hours. You can see that there were more roads for which data was generated as compared to Figure 4.3-8, main roads in the city were covered, and traffic congestions occurred mainly in the central part of the city. In comparison with the probe traffic information generated from the taxi probe, errors in the average travel speed in the same spot were within the allowable range and it is thought that it is possible to comprehend traffic situations from the bus GPS data. We selected only two buses from each route but because around 20 buses are actually running on the same route, it is thought that probe traffic information on the bus routes can be comprehensively generated.

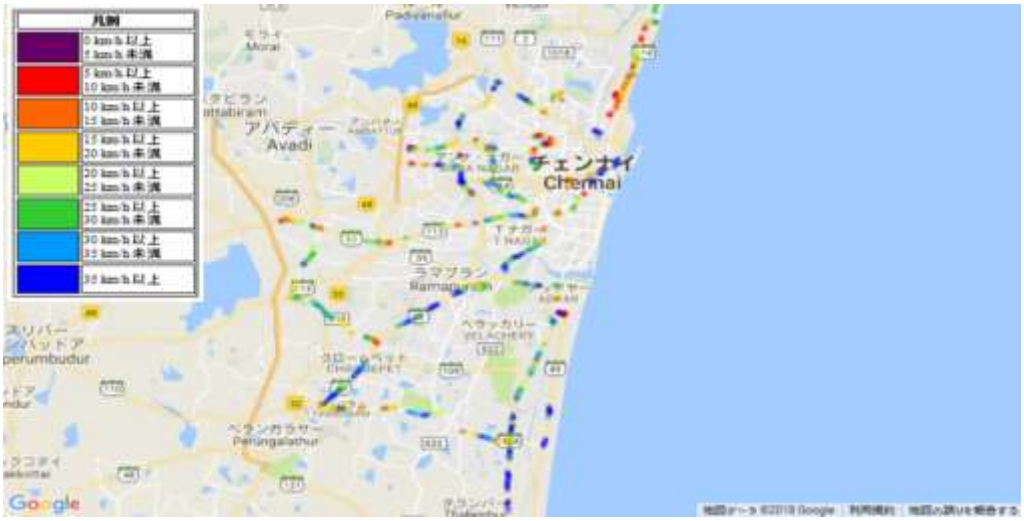

Figure 4.3-8. Visualized Screen of the Probe Traffic Information (Off-peak hours)

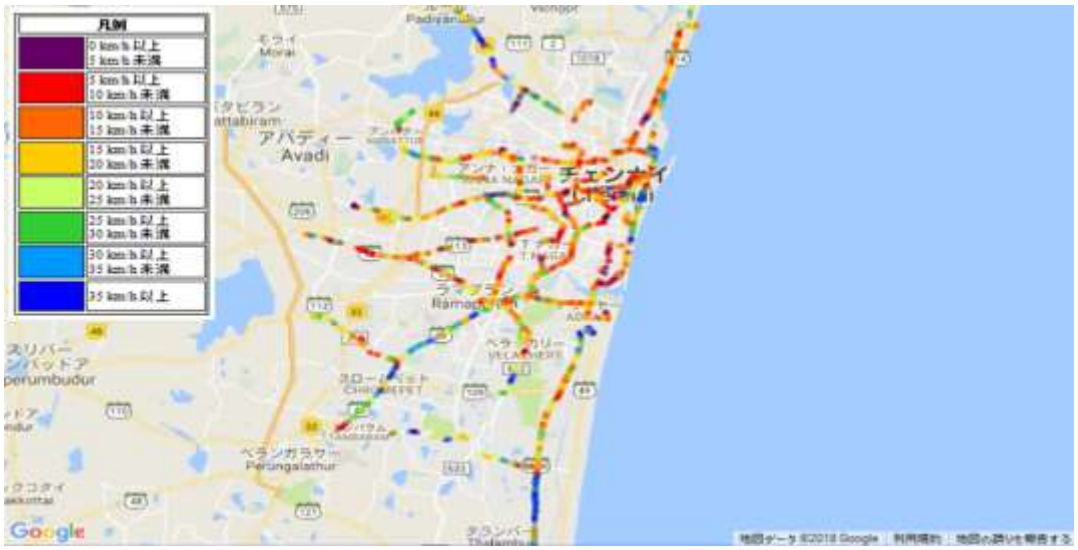

Figure 4.3-9. Visualized Screen of the Probe Traffic Information (Peak hours)

4.3.2. Evaluation of the Accuracy of Bus Arrival Time

This project assumes to provide the time to get on a bus, transfer time, and destination arrival time in the information providing system for bus users and bus companies. Therefore, it is necessary to accurately estimate

the time that a bus arrives at a bus stop. Therefore in this verification, we evaluated the accuracy of bus arrival times estimated from the probe traffic information.

(a) Purpose of Verification

In this verification, we aimed at evaluating whether or not bus arrival times that our company's demo system estimated from the probe traffic information have accuracy that can bear a practical use by analyzing to what extent there would be differences in comparison to the actual bus arrival times.

(b) Content of Verification

We verified how accurately we could estimate the bus transfer time and destination arrival time in the route decided upon consultation with MTC. Specific routes are shown in Figure 4.3-10. We assumed the actual travel by citizens and chose the route that includes bus transfer. Route 102 and Route 95 were the verification targets and the route was to start from Broadway on Route 102 which is the departure place of Route 102, transfer from Route 102 to Route 95 at SRP tools or Sholinganallur which were the bus stops shared by Route 102 and Route 95, and go to Junction of Perumbakkam on Route 95.

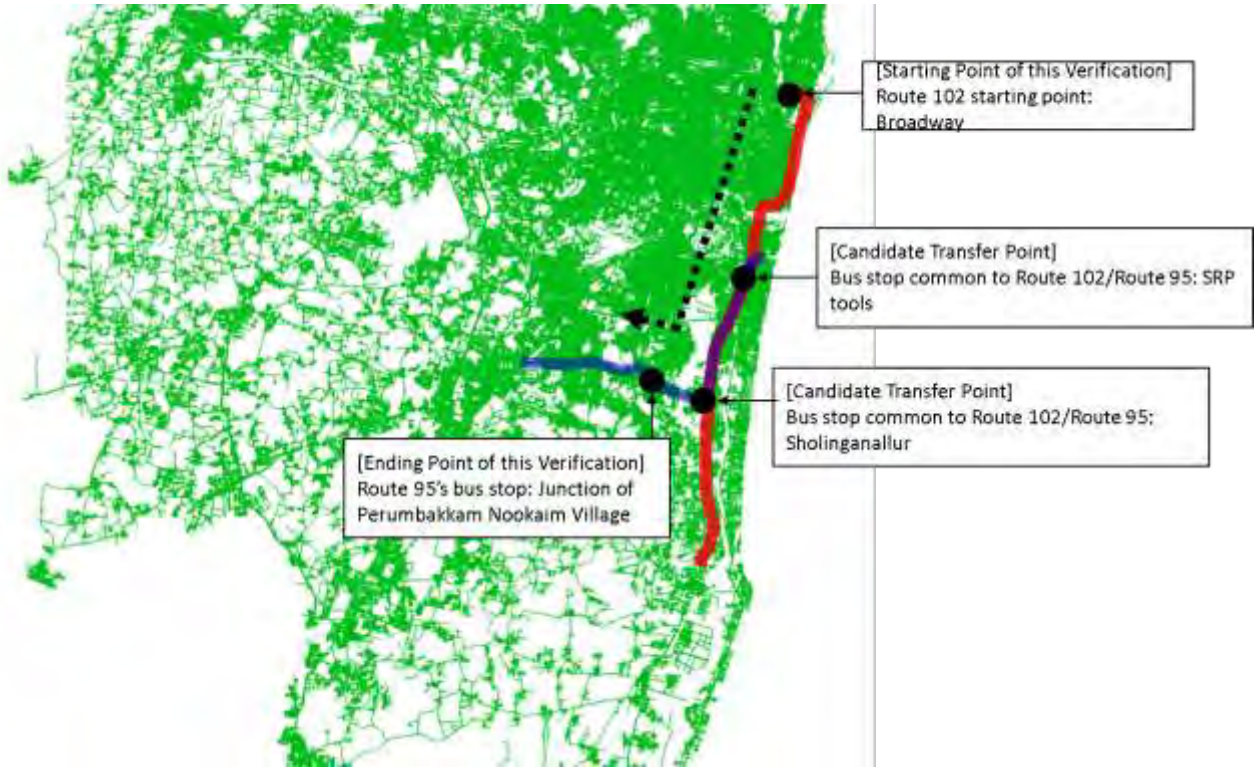

Figure 4.3-10. Route Subject to Verification

The method to estimate the bus transfer time and destination arrival time is shown in Figure 4.3-11. We selected three consecutive buses on Route 102 and Route 95, collected GPS data from each bus, and generated the probe traffic information. Each bus estimated the travel speed ahead from the probe traffic information of the preceding bus and estimated the amount of time required at the present location and subsequent locations.

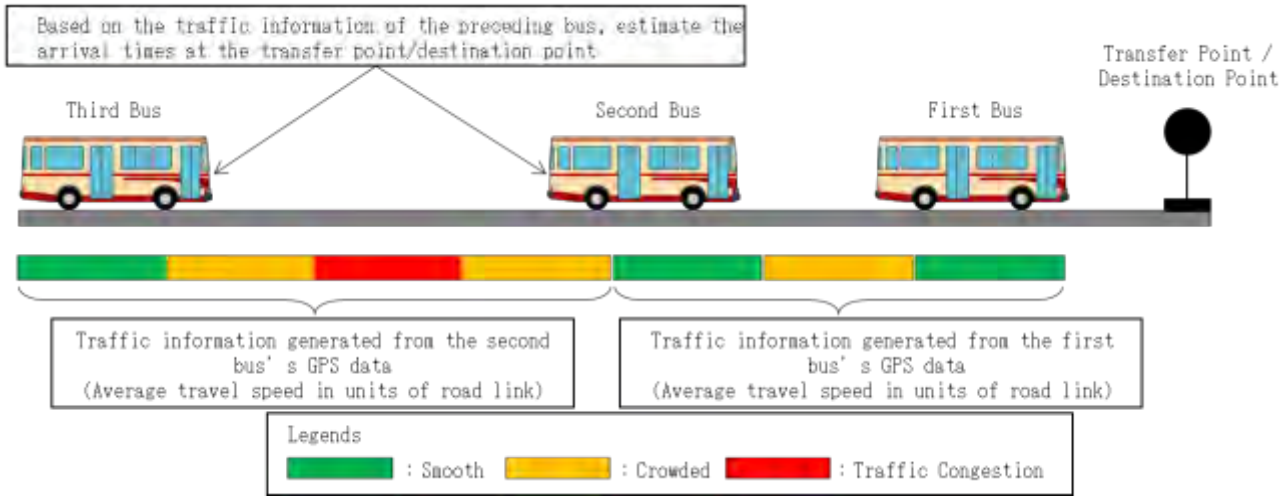

Figure 4.3-11. The Method to Estimate the Bus Transfer Time and Destination Arrival Time

(c) Collection of GPS data

We set the GPS data collection period for four days from December 7 to 10 and in order to collect the GPS data during peak hours and off-peak hours of traffic demand, we collected the GPS data three times a day. As this verification needed to collect the GPS data on Route 102 and Route 95 only, test subjects carrying a smartphone actually got on the buses and collected the GPS data.

(d) Analysis/Evaluation

When we checked the actual time and time estimated by the demo system at each point on the route, the size of errors was nearly within 10 minutes. As compared with the situations where you do not know in how many minutes the next bus will come and in how many minutes the bus will arrive at the destination under the present circumstances, it is thought that the times provided by this system are sufficiently useful.

The accuracy in the section where the error was the largest resulted in exceeding 70% which was the target value.

From the above, we evaluate that our company’s technology is useful for estimating bus arrival times. However as shown in Figure 4.3-11, this method adopted the travel speed of the preceding bus as an estimated value of the

travel speed when a following bus passes the road ahead; therefore, this works out only under the condition that the following bus operates in a way that is similar to the preceding bus. Thus, if a bus stops due to an accident, etc., this method cannot estimate the accurate arrival time. In the future, consideration of the method to respond to the situation where the preceding bus and following bus operate differently will be required.

With regard to the buses other than above, GPS data could not be collected in part of the routes and time estimation by the demo system could not be conducted.

4.3.3. Evaluation of the Modality Classification Technology

With the new establishment of Metro and increase in population in Chennai, review of the MTC bus routes will be continuously required. In this demonstration, with a view to supporting MTC's bus route plans in the future, we evaluated the modality classification technology which is the related technology.

(a) What is Modality Classification Technology?

Modality classification technology is the technology that automatically recognizes the means of transportation used by comparing the characteristics of the data in chronological order of the acceleration sensor recorded in the GPS data and the statistical data of the acceleration sensor in each means of transportation that our company owns. By combining with the ID of the device used and GPS data, it can recognize who, when, and where the means of transportation is used. This is graphically shown in Figure 4.3-12.

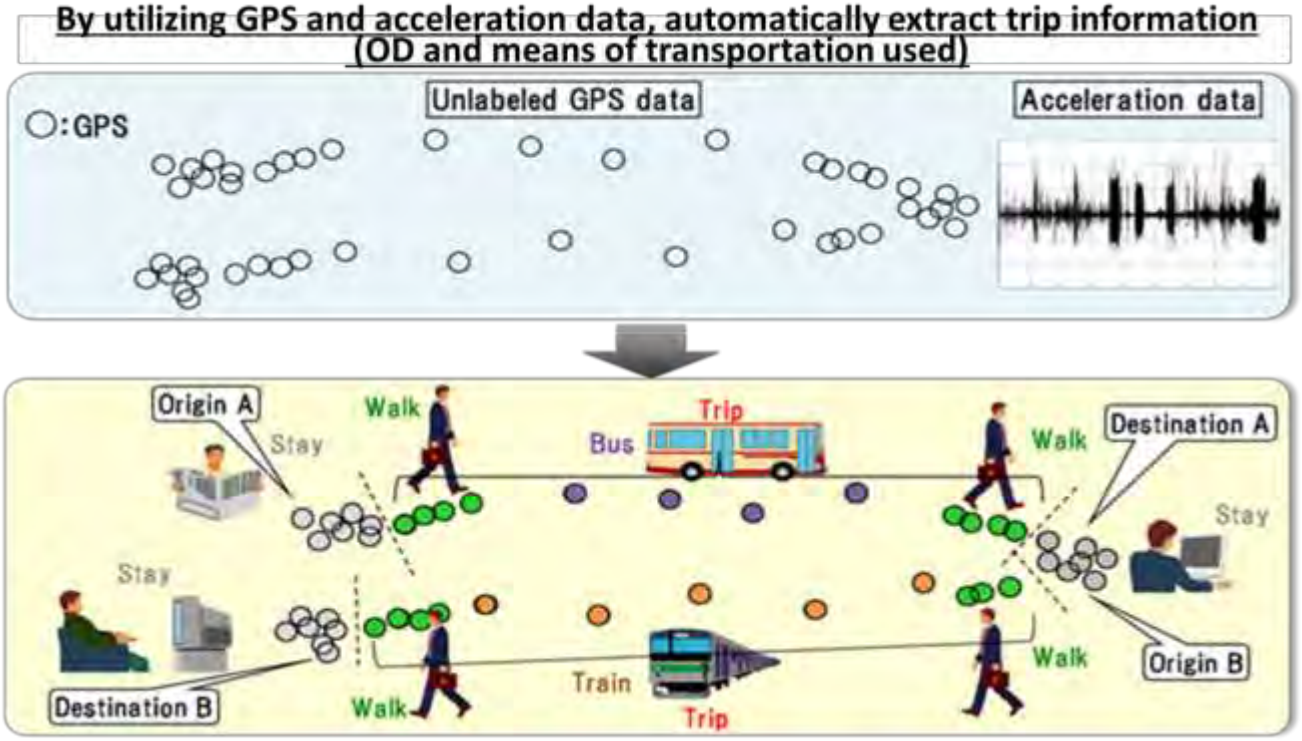

Figure 4.3-12. Outline of the Modality Classification Technology

(b) Purpose of Verification

This verification is aimed at verifying that modality classification technology can accurately recognize the means of transportation in India as well. As for the means of transportation to recognize, we set buses, cars, motorcycles, auto rickshaws, and walk which were the main means of transportation in India.

(c) Content of Verification

For collecting GPS data, we used the application for smartphones that our company developed. This application automatically records the GPS data and acceleration sensor which are the input information for the modality classification technology. It also has the function to record the means of transportation that a user is using. Test subjects participated in this verification used this function and recorded the means of transportation every time they changed the means of transportation. We evaluated the accuracy rate by comparing the means of transportation that the modality classification function automatically recognized and the means of transportation that users recorded.

(d) Collection of GPS data

The data for this verification was collected from test subjects who participated in the accuracy evaluation in 4.3.2. Specifically, we asked them to use the means of transportation (buses, cars, motorcycles, auto rickshaw, and walk) when returning to the start point after getting off a bus and when going back and forth their home and start point and collected the GPS data for modality classification.

(e) Analysis/Evaluation

We evaluated the accuracy by comparing the results that the application for smartphones that our company developed automatically recognized and the contents declared by the test subjects. As a result, it slightly exceeded the target value; therefore, it is considered that the modality classification technology can be applied to India. By increasing more sample data collected, it is thought that the improvement of accuracy can be highly possible.

4.4. Workshop

4.4.1. Purpose of Implementation

With a view to promoting understanding of the superiority, usefulness, expansibility of the technology subject to dissemination through the classroom lecture and practice for local companies and trying to improve technological and organizational capabilities, we held a workshop.

4.4.2. Implementation Outline

(a) Content of Implementation of the Workshop

●Equipment

Equipment used in the workshop is described in Figure 4.4-1.

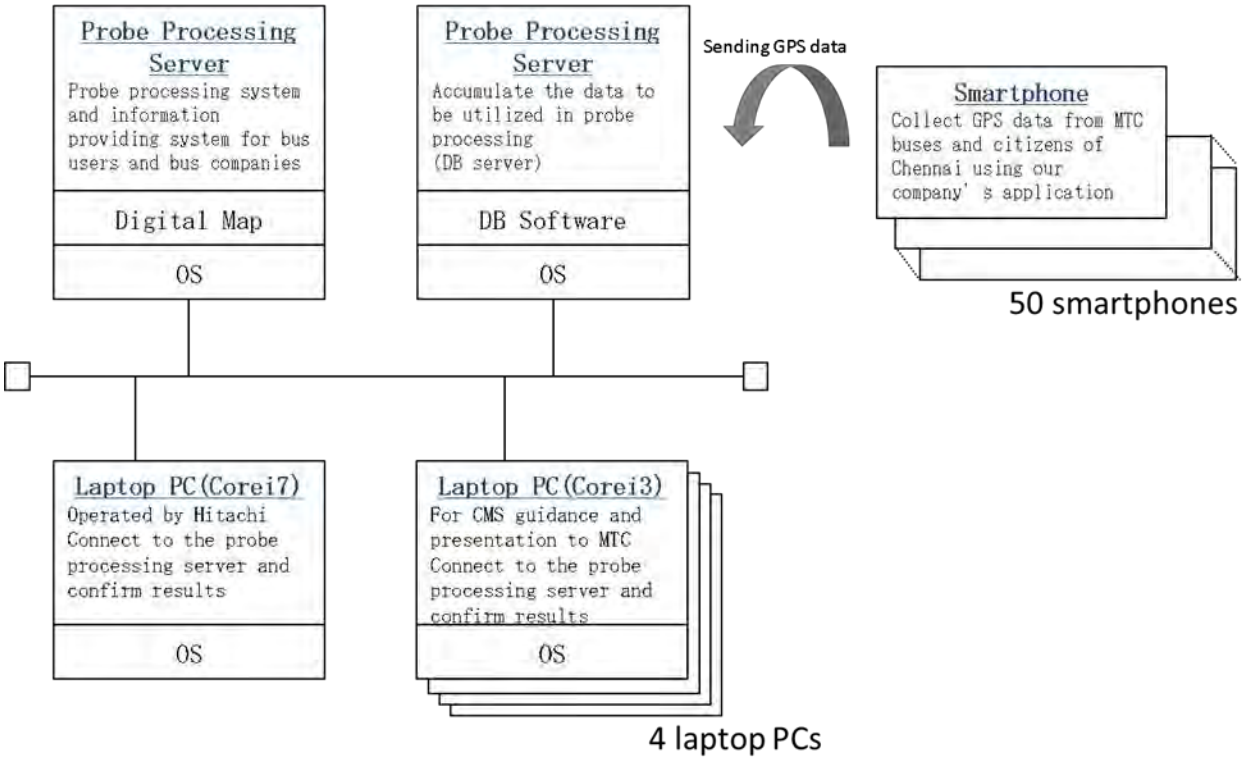

Figure 4.4-1. Composition of the Equipment Used in the Workshop

Table 4.4-1. A Set of Equipment

#	Name		Model Name	Qty.	Content
1	Hardware	Server	Lenovo TS150-70UAA007IH One Socket Tower Think Server	2	Application server and database server
2		Terminal 1	Laptop Asus i7 R558UQ-DM701T	1	The terminal operated by the supervisor at our company
3		Terminal 2	Laptop Asus i3 X541UA-GO1345D	4	Terminals operated by local companies
4		LAN Switch	-	1	Network equipment
5		LAN Cable	-	1	Network equipment
6	Software	Server OS	Cent OS 7	1	Application OS
7		Database	Oracle Database 12C standard edition L103399	1	Database management software
8		Traffic Information Generation Application	-	1	Our company's application to generate traffic information
9		Java Runtime	6.0	1	Assumption software
10		Tomcat	7.0	1	Assumption software
11		Traffic Information Generation Client	-	1	Our company's application to generate traffic information
12		Application for Demonstration	-	1	Simplified application which has a function to visualize and display traffic information
13		Terminal OS	Microsoft Windows Professional 10 SNGLOLP License	5	OS for terminals

●Documents

We prepared the following set of documents in the workshop.

Table 4.4-2. A Set of Documents

#	Target Equipment	Name	Content
1	Server	CentOS_7_Detailed Design Document (Japanese/English)	Design document for OS
2		CentOS_7_Installation Procedure Manual (Japanese/English)	OS installation procedure manual
3		Installation Checklist (Japanese/English)	Checklist to confirm that the server is correctly configured
4		Oracle Database 11G R2 Detailed Design Document (Japanese/English)	Database design document
5		Oracle Database 11G R2 Installation Document (Japanese/English)	Database installation procedure manual
6		List of Passwords	List of various passwords for servers
7	Terminal	Traffic Information Generation Application Terminal Installation Procedure Manual (Japanese/English)	Procedure manual to build the traffic information generation application and application for demonstration for terminals

●Participants' Level of Understanding

The survey on the participants' level of understanding was conducted based on the perspectives in Table 4.4-3.

Table 4.4-3. Items in the Survey on the Level of Understanding

#	Perspective		Confirmed Content
1	Material		Did you understand the necessary materials in construction?
2	Configuration		Did you understand the system configuration?
3	Construction Procedure	Server	Did you understand the OS construction procedure? Are there any unclear points in the procedure manual?
4			Did you understand the database construction procedure? Are there any unclear points in the procedure manual?
5		Terminal	Did you understand the terminal construction procedure? Are there any unclear points in the procedure manual?
6			Did you understand the functions and necessity of the terminal's assumption applications (Java and Tomcat)?
7	Function/Technology		Did you understand the traffic information generation technology?
8			Did you understand the benefits of the traffic information generation technology?
9			Did you understand the application interface?
10			Can you operate the application?

We asked the participants to answer to the respective questions on a six-point scale of "Completely understood (5 points)," "Well understood (4 points)," "Mostly understood (3 points)," "There are some unclear points (2 points)," "There are many unclear points (1 point)," and "Didn't understand at all (0 point)" based on the confirmation table above. The aggregated results are shown in Table 4.4-4. The five participants' average points for the answers are written in the result of answers. The total average calculated the aggregate average of the average points in item numbers 1-10.

Table 4.4-4. Result of the Answers to the Survey on the Level of Understanding

Item Number	Perspective		Confirmed Content	Result of Answer (A total of 5 persons)
1	Material		Did you understand the necessary materials in construction?	4.8 points
2	Configuration		Did you understand the system configuration?	4.8 points
3	Construction Procedure	Server	Did you understand the OS construction procedure? Are there any unclear points in the procedure manual?	4.4 points
4			Did you understand the database construction procedure? Are there any unclear points in the procedure manual?	4.0 points
5		Terminal	Did you understand the terminal construction procedure? Are there any unclear points in the procedure manual?	4.8 points
6			Did you understand the functions and necessity of the terminal's assumption applications (Java and Tomcat)?	5.0 points
7	Function/Technology		Did you understand the traffic information generation technology?	5.0 points
8			Did you understand the benefits of the traffic information generation technology?	5.0 points
9			Did you understand the application interface?	4.4 points
10			Can you operate the application?	4.4 points
			Total Average	4.66 points

With regard to each item, in particular, the level of understanding in the Item Numbers 7 and 8 which were about the technology content and benefits of the traffic information generation technology reached 100% and results were satisfactory. On the other hand, although the server's OS and database construction had slightly lower scores, we can evaluate that in general, these indicated the good level of understanding.

4.5. Technical Seminar

4.5.1. Purpose of Implementation

With a view to inviting MTC, promoting their understanding on the proposed technology, and improving their willingness to introduce the technology, we implemented the seminar by dividing into two.

4.5.2. Content of the Technical Seminar

(a) Outline

We held the technical seminar on December 11, 2017 and January 18, 2018 at MTC's headquarters (address: No. 2 Pallavan House Ground Floor, Pallavan Salai, Mount Road, Chennai - 600002, Opposite Gymkhana Club). We conducted a demonstration of the demo system that our company constructed, made a presentation of the results of visualizing the probe information obtained in the technology verification and the bus travel speeds analyzed from the probe information on the map, and discussed the requirements for the actual system. As just described, we publicized that the probe processing system and information providing system for bus users and bus companies proposed in this project could be applied to India through the seminar and improved their willingness to introduce the system.

(b) Implementation of the Demonstration

The demonstration was conducted with the assumption that we search the route started from Broadway to Tambaram East.

(c) Technology Verification Result Presentation

With regard to the results of technology verification, we made a presentation of the content in 4.3 in this report.

(d) Discussions on Their Willingness to Introduce the System

We confirmed the seminar participants' willingness to introduce the system in the discussion style.

For both the bus companies and users, the problems that buses do not depart or arrive on time and bus arrival times are unknown are the primary issues and because this demo system could estimate bus arrival times by reflecting the road traffic conditions on a real-time basis and the differences between the operation schedule and actual departure and arrival times could be utilized for improving the operation plans, the opinion that they would like to introduce the system early was the most common. However, because the difference between the actually

measured bus arrival times and bus arrival times estimated by the system was around 10 minutes, there was an opinion that the accuracy should be improved. Regarding this, by expanding the number of bus vehicles to collect prove data at the time of introducing the actual system and increasing prove data to be collected from the same road section, we can expect the improvement.

As the bus company detects buses which go out of the predetermined routes, there was an opinion that it would be better if there was a function to display buses' current locations on the map screen on a real-time basis.

Chapter 5. Summary of this Project (Evaluation of the results of implementation)

5.1. Outcomes of this Project (Contribution to the target country, region, and city)

In this project, we aimed at developing appropriate bus operation plans, sustainably improving the quality of bus services, and improving the convenience of the citizens in the entire urban transportation by utilizing the data accumulated by social infrastructure (traffic control system) and implemented technical verification in Chennai, India to see whether or not the demo system we created could be technologically applicable. As a result of verification, we found out that the demo system could correctly provide traffic congestion conditions and bus arrival times to bus users and operator and modality classification was correctly conducted. Therefore, we could demonstrate the usefulness of the technology provided in this project in Chennai, India. We also presented the results to MTC at the technical seminar and could extract functions toward the introduction of the actual system during the discussions based on the results.

Outcomes for this project are shown in Table 5.1-1.

Table 5.1-1. Outcomes for this Project

#	Task Items that should be implemented within the project toward the business deployment	Action Plan and Results 10/2017 (Local site) / 11/2017 (Japan) / 12/2017 (Local site) / 1/2018 (Local site)	Status of Achievement and Evaluation
1	Field Survey		-We could collect/survey all information against the survey perspectives proposed in the plan document and obtain information necessary for creating the demo system.
2	Demo System Creation		-We considered functions based on the requirements preliminarily researched and created the demo system. We also reflected basic information such as the map data of the target city, etc. in the demo system.
3	Technical Verification		-Regarding traffic information, when we compared the probe traffic information generated from the taxi prove and the probe traffic information generated from the bus probe, the difference was within the allowable range. The accuracy of the arrival time estimation exceeded the target value of 70%. Regarding the accuracy of the modality classification, results of recognizing the means of transportation based on the GPS data and the means of transportation declared by the test subjects slightly exceeded the target value.
4	Workshop		-We had a workshop on system architecture, operation, etc. and surveyed their level of understanding by questionnaire. The level of overall understanding was 93.2%. -We concluded an MoU to begin collaboration with a local company.
5	Technical Seminar		-We discussed the element technology conducted in the technical seminar and future business deployment with participants and gained their understanding.

5.1.1. Outcomes of this Project (The aspect of business)

(a) Field Survey

We researched traffic conditions in Chennai from literature. With regard to the data necessary for creating the demo system, we obtained data necessary for drivers and bus conductors' attendance management and fare collection management from MTC and the list of the routes of the means of transportation, list of stations and bus stops, route shapes, and timetables from a major digital map vendor in India.

When we also conducted hearings to MTC and extracted their requests for the scope of technical verification in the field, we found out that realization of the operation guide to the citizens by accurately comprehending bus operation and review of the operation plans by accurately comprehending bus operation were the requirements to be realized.

(b) Development of the Demo System

To realize the above-mentioned requirements, we created a demo system consisting of the probe processing system and information providing system for bus users and bus companies. The data obtained in the filed survey and map data were reflected on the demo system.

(c) Technical Verification

●Traffic Information

We generated probe traffic information using the probe processing system. We could collect GPS data from each bus every three seconds and succeeded in collecting the data with high frequency. To evaluate whether or not traffic information was correctly created by utilizing bus probe, we collected taxi probe every four seconds and used this as the actual traffic information, and compared the average travel speed calculated from bus probe and the average travel speed calculated from taxi probe. As a result, the errors were within the allowable range.

●Arrival Time Estimation

The accuracy in the section which had the largest error resulted in exceeding 70% which was the target value. In comparison to the situations where you do not know in how many minutes the next bus will come or you do not know in how many minutes you will arrive at the destination, it is considered that the times provided by this demo system are sufficiently useful.

●Modality Classification

We conducted modality classification by using the probe information processing system. To evaluate whether or not the recognition results were correct, we asked the test subjects to record and declare the means of transportation used and when we compared the results and modality classification results that the system used, it slightly exceeded the target value and we could confirm that the modality classification technology can be applied to India as well.

(d) Workshop

We had a lecture on system architecture, operation, etc. in the workshop and participating members actually implemented what we lectured. When we divided the content of implementation into 10 items and surveyed their level of understanding in questionnaire on a scale of one to five, the overall score was 4.66 points out of 5 points and their level of understanding was 93.2%. In particular, the level of understanding on the traffic information

generation technology was high, whereas the server's OS and database architecture had slightly low scores. But we can evaluate that in general, these indicated the good level of understanding.

We could also conclude an MoU with a local company to begin collaboration and it has become possible for us to collaborate with the company as a good partner when introducing the actual system to MTC and introducing the system to other bus companies.

(e) Technical Seminar

We conducted a demonstration of the demo system that our company constructed, made a presentation of the results of visualizing the probe information obtained in the technical verification and the bus travel speeds analyzed from the probe information on the map, and discussed the requirements for the actual system. As just described, we gained their understanding that the probe processing system and information providing system for bus users and bus companies proposed in this project could be applied to India through the seminar and improved their willingness to introduce the system.

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