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Intelligent Transport System and its application in Ho Chi Minh city.

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Abstract

Besides rapid development both on economic and population, the transport system in Ho Chi Minh city faced many challenges from different factors. Hence, ITS would be determined as the most suitable solution for these problems. The research was conducted in order to give an overview of constraints in the transport system in Ho Chi Minh city. Moreover, the achievements in ITS application in Japan was studied to pick up the most essential and fundamental applications that could be applied in Ho Chi Minh city.

The objectives of the research were (a) to provide essential knowledge and useful remarks related to ITS and (b) to analyze how it would improve traffic status in Ho Chi Minh city.

The qualitative and systematic literature review was chosen in the research. Firstly, a literature review which covered the related topics to ITS and its application. The theory on ITS focused on history of ITS, concept of ITS, application of ITS, how ITS works and equipment requirement. Data was collected from various sources such as competent authorities, existing statistical data, etc.

Consequence, the research findings covered the figures regarding on CO2 emission reduction, a decrease in number of deaths caused by accidents, money benefits. In addition, the research not only mentioned challenges would restrict the ITS application but also made improvement proposals to deal with these difficulties.

Keywords/tags (subjects)

Intelligent Transport System, Ho Chi Minh city, VICS, ETC, traffic congestion, CO2 emission

Miscellaneous

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ABBREAVIATIONS

BOT – Build – Operate – Transfer

DSRC – Dedicated Short Range Communications

ETC – Electronic Toll Collection

FM – Frequency modulated

GPS – Graphic Positioning System

ITS – Intelligent Transport System

ISO – International Organization for Standardization

ITU – International Telecommunication Union

MLIT - Ministry of Land, Infrastructure, Transport

VICS – Vehicle Information and Communication System

1 INTRODUCTION

1.1 Background context

It is said that:" Individuals in every generation, at least since the birth of the Industrial Revolution, have thought they were watching the most rapid changes ever seen in history. They have all been correct." (Bruegmann 1996, 336). These days, along with the explosion of science as well as information technology, the growth of urbanization is rapidly scaling up and an increasing in demand of traveling and movement. Ho Chi Minh city is not an exception. An article on thedailystar.net stated that according Oxford Economics carried out a survey about the fastest growing economies in 30 Asian cities by 2021 that led a result Ho Chi Minh city ranked 2nd, just right below New Delhi. However, the transportation infrastructure is not compatible with that level of development. The infrastructure of transportation system in Ho Chi Minh city is overload and cannot meet the demand of citizens due to outdated technology, old framework and high population density. As stated in a report of Ministry of Natural Resources and Environment in July 2017, congestion occurs frequently and continuously across most of the streets while the environment is changing negatively. Traumatic accidents are happened every day without any effective solution. Hence, a smart system called ITS-Intelligent Transport System was introduced to come up with a solution for the urgent issues mentioned above. Basically, ITS is a modern electronic information technology and telecommunication to operate and manage the transportation system. In addition, in field of freight forwarding, a series of technology has been introduced to improve movement of goods and means smoother and support commercial transactions as a supply chain department.

The concept of ITS is not unfamiliar and widely applied in the developed countries such as America, Japan, Korea, European counties, etc. ITS is the key element in traffic management system (Sussman 2005, 5). To be more specific, those combination of high technology in information and communication, sensors, and prior mathematical methods to infrastructure and vehicles (mainly in cars), optimization of management and administration to minimize traffic jams as well as accidents and enhance-

ment of passenger transport capacity (ibid., 3). All benefits of ITS contribute to significant improvement of traffic system throughout 3 obvious results: reducing traffic congestion, accidents and emissions. As a result, ITS creates a better transport system, more secure and more efficiency. The movement of goods and people are smoothly and altogether contributed to the development of Vietnam's economy. Nevertheless, ITS is not a key to unlock all problems related to transportation. There should be a proper transport policy and well preparation of competent authorities with corresponding infrastructure.

1.2 Ho Chi Minh city transport system overview

Besides the fact that Ho Chi Minh city has superior social and economic advantages compared to local region and the whole country. Ho Chi Minh city has been and will continue facing many serious problems and risks that might become obstacles in the development of the city. The obvious problem is the capacity and quality of urban transport system.

City's urban transport features are mainly road, and this is also the main way of addressing urban transport needs. Ho Chi Minh city with a total area of 2095 km2 is the largest city in Vietnam. It is a major center of economic, culture, technology, focal point for trading with other nations and has the important political position of the country. By the end of 2014, there were around 7.95 million people. In the past, Ho Chi Minh city has made a great effort in improving infrastructure system. Specially, by the end of 2014, 231.38km road was renovated, 65 new bridges were constructed, road density was increased to approximately 1.9 km/km2, the rate of traffic land reached 7,91%. However, the growth rate of transport land was low in comparison with population growth rate and personal vehicle which made a great impact on urban traffic. (HCM City Information and Communication Department 2007)

As mentioned on an article (Ngoc An & Mau Truong 2014), the Department of Transport of Ho Chi Minh City claimed that there are 7 toll gates now around the city and this number will raise up to 20 toll gates in 2025. Therefore, the amount of toll gates will approximately 3 times higher than today. The main reason for this plan is to return budget of traffic projects, assist in control and regulation of vehicles into

city center and at the same time to create resources for investment in road traffic infrastructure of Ho Chi Minh city. The conditions for considering the location of the toll gates were based on investment projects complying to BOT plan on roads which meets requirement 2000 PCU/day and night. Priority shall be given to investment projects on traffic construction that had payback period of less than 30 years.

According to Circular No. 90/2004-TT-BTC of the Ministry of Finance of Vietnam, the distance between 2 toll gates on the same routes which were invested by state budget had to have a minimum length of 70km. This Circular applied only to roads which were invested by the government budget. Therefore, the increase in number of toll gates up to 20 toll gates by government fund in near future seems to be unreasonable because it will not ensure the minimum length according to the Circular.

The number of accidents and traffic congestions has increased worst in Ho Chi Minh city recently. According to report of Department of Transport, in the first 6 months of 2017, there were 1500 accidents which 268 deaths and 1201 injuries. Compared to 2016, accidents increased 30 units (2,04%), deaths decreased 55 units (17,03%) and injuries increased 3 units (0,25%). Furthermore, the gateway to the East, the South, the North; roads which leads to industrial parks and export processing zone in Ho Chi Minh city and close provinces are under huge traffic pressure while infrastructure is narrow and degraded. This difficulty could not be solved without a comprehensive and basic solution. The investment in transport infrastructure in Ho Chi Minh city in recent years could not catch up the growing speed of personal vehicles. As reported in statistic data from Department of Transport of Ho Chi Minh city, the growth of amount vehicle is shown in Figure 1. Government is struggling with solution which many traffic experts determined these solutions were situational solution but not sustainable solutions. This problem came from urban space structure and constrains of urban space development. Therefore, there were many issues needed to be looked back to solve this trouble.

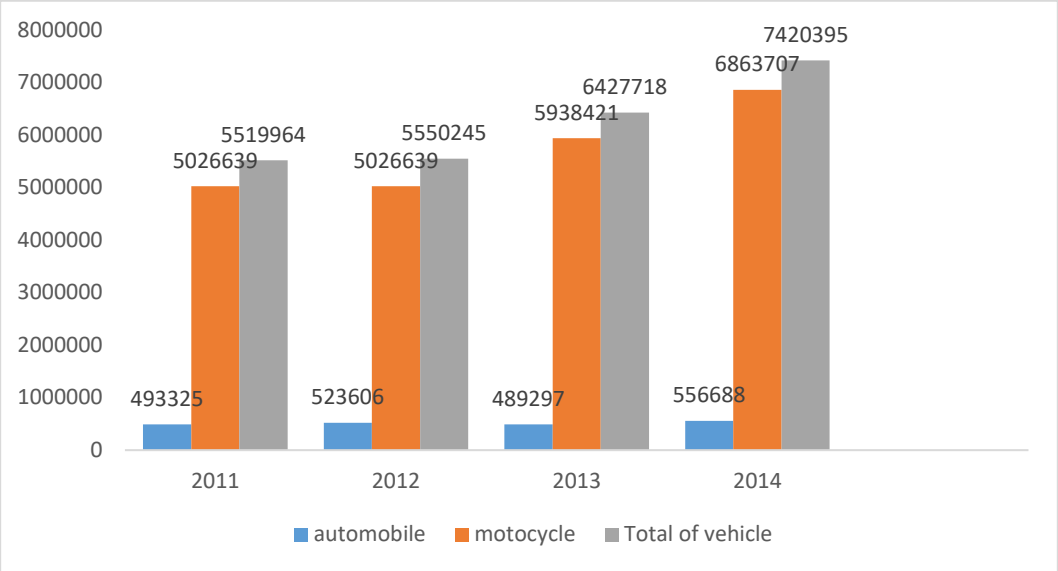

Figure 1. The growth of vehicles from 2011-2015

People's Committee of Ho Chi Minh city reported that traffic congestion reduction program has been focused on 37 congestion points in 2017. By far, 16 of those has turned into positive, 14 points had little change and the rest were on complicated situation. To acquire mentioned results, government implemented many solution including building traffic directional distribution, adjusting routes to reduce traffic jams with total investment capital of more than 11.300 billion Vietnam dong. In particular, the city built a series of congestion reduction project such as an overpass at intersection of Go Vap district, another Y letter overpass on Truong Son street. However, at the meeting of the People's Council of Ho Chi Minh city in 2017, the chairman assessed the program to reduce traffic jams – one of seven breakthrough programs of the city still not be effective as expected (Anh Duc 2017). This shows that traffic congestion in the city continues to be complicated especially in peak hours. The reason is that it was affected by heavy rain, the works of transportation infrastructure improvement, etc. However, the main reason is crowded population density along with huge amount of vehicles concentrated in peak hour. Besides that, the area of road surface was narrow, so the vehicles were stuck and caused slow moving which led to traffic jams.

The Ministry of Transport of Vietnam has come up with some proposal short term and long term solutions to deal with avoid congestion and reduce accidents. Short

term solution includes: encouraging citizens to use public transportation by reducing ticket price in peak hours, making a priority lane for public transport, changing frame time in and exit city center for trucks and containers while long term solutions includes: moving stations, vocational schools, colleges and universities to sub urban areas, expansion of roads and sidewalks and lowing population density. Thus, besides continuing investing on transport infrastructure in accordance plan, government should focus on effectively exploiting the existing infrastructure by applying of advanced technology. According to currently report of department of transport of Ho Chi Minh, there are 841 traffic lights in the city, more than 300 traffic cameras and 41 electronic traffic information boards have not been worked efficiently in urban traffic control due to the following reasons:

- The systems worked independently, served for individual needs of each fields and did not have a synchronous management that led to difficulties in coordinating activities to related levels and fields.
- The application of information technology was still disjointed, lacked synchronism and did not support each other in solving traffic problems.
- Due to lacking synchronous connection between the relevant agencies such as Department of Transport, Police, Department of Information and Communication that resulted difficulties in exploiting the existing transport infrastructure. (Ministry of Transport of Vietnam 2016)

1.3 Objectives

The primary objective of this thesis is initiative to identify how ITS brings positive improvement to transportation in Japan. To be more specific, the achievements of ITS will be conducted through the successful applications in Japan. Next, this thesis will figure some most highlight aspect related to ITS in order to consider its useful remarks in transportation system in developed countries and then apply it in Ho Chi Minh city. The first reason why Vehicle Information and Communication System (VICS) and Electronic Toll Collection (ETC) are considered to be conducted in order to apply in Ho Chi Minh city because it brought a significant improvement for traffic in Japan. Moreover, VICS is a new approach that has the advantages of technology including tracking, providing information, etc. It not only serves the drivers but also

helps the government to improve traffic management. Turning to ETC aspect, on the contrary, it is more familiar than VICS. ETC has been applied at 1 or 2 lanes of the toll gates at some points alongside Vietnam while the rest of lanes still use the traditional collecting cash method. Therefore, a research of fully ETC application in Ho Chi Minh City would improve traffic jam situation. This thesis will not go through all the components inside ITS but just only pick up the essential and fundamental applications that would be applied to Ho Chi Minh city. Because ITS is a giant topic and it is impossible to cover all aspects within this research. Moreover, this thesis will concentrate on ITS application and achievement in Japan which cannot go through all topics of other countries due to time and resources limits.

The reason why this thesis will only focus on ITS in Japan and its application in particular is that because firstly Japan is an Asia country, so it has some similarities in culture in comparison to Vietnam. Next, Japan and Vietnam have a really tight relationship proved by supporting Vietnam to build many infrastructures and other support types. Japan also the biggest ODA sponsor for Vietnam (Investment Promotion Center South Viet Nam 2017). This thesis is conducted in order to clarify two vital research questions. Those questions are:

- What is definition and history of Intelligent Transport System?
- How could Intelligent Transport System improve efficiency and effectiveness of transportation system in Ho Chi Minh city?

1.4 Research Methodology

The most known research methods are quantitative and qualitative. In this thesis, qualitative research will be the primary approach. Basically, qualitative research is implemented in an exploratory that results a theory or hypothesis in the end (Creswell 2009, 1-2). It primally concentrates on collecting of non-quantifiable data such as words through question interviews, evidence, etc. while quantitative research focuses with numerical and statistical data (Pickard 2007, 30). Quantitative method is meant to clarify narrow question by analyzing quantifiable data using statistics in unbiased, objective manner (Johnson & Christensen 2008, 34). Moreover, qualitative

research is used to provide a detailed an insight look of phenomenon or events that cannot be clearly explained by mathematical skills (Glenn 2010, 96).

Besides that, according to Grant (2009, 91) "the expansion in evidence-based practice has led to an increasing variety of review types". Basically, a systematic literature review defines, chooses and critically evaluates research to clarify a clearly constructed question (Baumeister, 2013). Before review is conducted, the systematic should follow a clearly defined plan with already stated criteria. It is a comprehensive and transparency research that is studied through multiple databases and resources. In addition, these researches then could be replicated by other researchers. The review, which includes research term, research strategy and limits, defines what kind of information needed and reports within known timeframes. Consequently, a systematic review is considered the most suitable method for this thesis because the three mentioned above questions will be analyzed, summarized and reviewed by using systematic and explicit methods to determine, choose and appraise relevant research from the studies that are included in the review (ibid.).

The structure aspects, theoretical data of ITS and its applications were researched through academic documents and several sources related meanwhile the theories about benefit and achievements are gained through the published studies and online articles. Moreover, the method includes reviewing published literature from several sources without tolerances. Next step is to get the overview picture about ITS then this research could bring more accurate and reliable for research findings. After getting knowledges about ITS, the two successful applications of ITS in Japan will be considered to be applied in Ho Chi Minh City. In addition, it needs seeking information related to Ho Chi Minh city due to the different conditions in both countries. However, this is not enough to answer the second question because it requires to gather and calculate data in order to evaluate the effectiveness of the findings. The data was collected from Ministry of Transport of Vietnam and other previous publication or studies related to the topics. These data are then calculated and analyzed to come up with a result which illustrates the improvement and effectiveness when applying ITS.

Research Limitation

This thesis only focused on road transportation modes which ITS had the most applications. Moreover, by reason of data collected of Ho Chi Minh city and research designs are used for only in this city. Any findings and recommendations are only suitable to this matter. In addition, due to limited research time so the scope of this study only valid to traffic in Ho Chi Minh city and not any other cities. Hence, any consideration of application in national level are required more appropriate researches.

2 Intelligent Transport System (ITS) in Japan

2.1 History and development of Intelligent Transport System

The term of ITS was generated from Japan since 1994 and proceeded as a national project in Japan. The annual World Congress on Intelligent Transportation system is held every year since it was first held in Paris in 1994 with the participation of transportation experts represented for many nations and famous brands from distinct industries such as carmaker, communication equipment, train and other types of transportation. “The First World Congress on Advanced Transport Telematics and Intelligent Vehicle-Highway Systems” was named as the first World Congress and the chosen topic was “Towards an Intelligent Highway Transport System”. (European Commission 1995). As a result, in 1996 the “Grand Plan to Promote Intelligent Transport Systems (ITS)” was authorized by 5 concerned ministries and then it was boosted forward. Figure 2 below illustrates the following timeline. (Japan’ ITS: ITS annual report 2014)

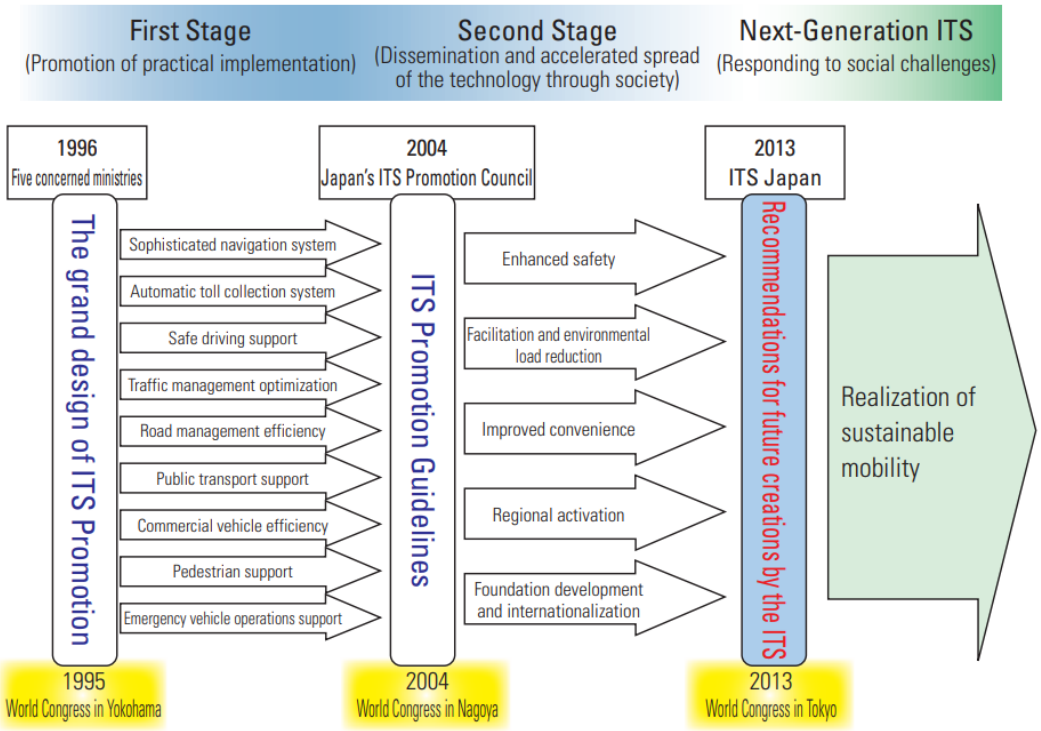

Figure 2. The development of ITS 'Japan (Hasegawa 2014)

The first stage of ITS was carried out from 1996 to mid-2004. In this period, 21 services and 9 fields have been launched such as Vehicle Information and Commination System (VICS) and Electronic Toll System (ETC) among different services. In 2004, Japan's ITS Promotion Council introduced "ITS Promotion Guidelines" including safety, security, efficiency and convenience as the pillars for ITS. The first step of the promotion was practical application of technology while the second step was the publication of technology through society. Since 2010, the realization of sustainable mobility has been promoted as the next generation of ITS due to replying to social issues and it has been recommendation for future creations. (ibid.)

Turning back to World Congress, the main topics was discussed consisting of traffic safety, emission control, reducing traffic jams, producing intelligent vehicles, traffic safety equipment, etc. It could be clearly seen that ITS has exploited the advanced technology available in many areas in order to improve traffic at different levels. (ibid.)

ITS studies were diverse, and its effectiveness based on other countries at distinct grade. Depending on characteristics of each country, the following key area were focused: Road infrastructure improvement; emergency accidents handling; modernization of toll collection; electronic weighting station; road traffic management; information system for people who involved in traffic; exploiting the advanced public transport system (buses, urban railway, metro); improvement of institutional issues and common rules at intersections; research about launching intelligent vehicles; application of information technology; testing and driving management.(ibid.)

In recent years, in some European, America, Asia, ASEAN countries and especially Bangkok – Thailand, the development of ITS has come up with achievements that contributed to solve traffic congestion and improve transport capacity. The authorities were established at there for instance: in United State, there is a Office of the Assistant Secretary for Research and Technology under the Federal Highway Administration. This office provided budget for database development to analyze as well as synthesize data and then provided the best applications and technologies consisting of road data collection; traffic conditions; information of vehicles participating in traffic; analysis of database; establishing effective and safe solution for people and objects joining traffic. (U.S Department of Transportation 2017).

In Vietnam, ITS has been approaching and applying step by step in fields of: Toll collection; heavy truck load control; test driving. A series of scientific research projects have been carried out and obtained positive results. Typically, a system of toll collection was installed and tested on An Suong – An Lac highway. In addition, automated driving test has been successfully run in Phu Tho, Bac Ninh, Da Nang and many other provinces among the country. (Ngoc An & Mau Truong 2014)

In the near future, the application of periodic traffic light according to the topic “Green wave” in order to optimize traffic signal in capital Hanoi and Ho Chi Minh city will contribute to raise traffic effective. Besides that, it helped decrease traffic jams. Hence, the outcome was over expectation. ITS plays an vital role in the development of transportation of each nation and mostly in the current traffic of Vietnam. (ibid.)

2.2 The concept of Intelligent Transport System

Basically, ITS (Intelligent Transport System) is a term related to the use of modern electronic information technology and telecommunication to operate and manage the transportation system (Bob McQueen & Judy McQueen 1999, 3). Thus, ITS could be defined as an application of sophisticated calculation system, complicated information and communication in vehicle management network that related to mobility of goods and people in real time. The relation inside ITS is showed in figure 3. However, ITS term might be different in each country due to the situation and other condition.

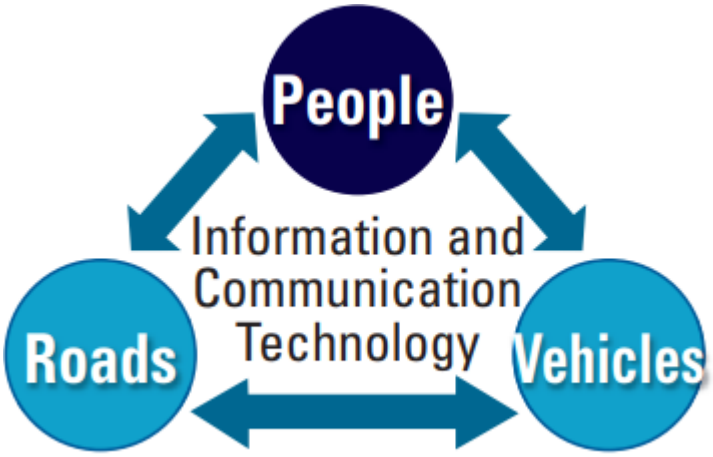

Figure 3. Interface relation about ITS (Hasegawa 2014)

ITS is considered to be a massive system but closely connected each other in which people, vehicles, traffic networks are principle components of the system. ITS is designed to reduce traffic congestion, ensure safety, mitigate negative impacts on the environment and optimize passenger transport capacity. Moreover, it is possible for new industries and markets created caused by variety in technologies and potentially generates a driving power in changing the social system. ITS is not only appeared in air, rail and sea; however, road transportation application is still the most diverse and effective (ibid.).

ITS is the perfect system that applied advanced technology and computer software to manage and authorize the transport system more effectively. In addition, ITS uses communication equipment to transfer data for processing and analyzing purpose in order to improve the capability of transport. This simple definition has been making things changing positively in operation and management of the transport system in general and urban in specific. These achievements and knowledge are worthy for study and applied in Vietnam especially in Ho Chi Minh city accordance conditions (ibid.).

2.3 Vehicle Information and Communication System – VICS

2.3.1 VICS overview

Generally, it is an complex system including dynamic information and communication that handles road traffic information for instance congestion, traffic restrictions, weather condition, etc. at VICS center. Specifically, VICS (Vehicle Information and Communication System) is a digital communication system which quickly updates and provides the latest necessary traffic information to drivers via on-board unit equipment. One of advantage function of VICS is that drivers can receive real-time information such as traffic jams ahead, new regulations, etc. Furthermore, the cost for that kind of services is included in the cost for the equipment so users will not have to pay any extra fee. In order to control VICS system, a brain which is known as VICS center has mission to contribute the establishment of safe and convenient traffic environment and to develop social economy. To be more specific, VICS performs following services to obtain mission mentioned above:

- Collecting, processing traffic information, and then providing via communication and broadcasting media
- Inspection and research on traffic information system
- Management of intellectual property right related to road traffic information system
- Consignment of business activities to reach the goal of the mentioned mission above

- Collecting traffic information of both inside and outside of the country, and having contacts with authorities or corporations concerned
- And all other task in order to fulfill the purpose of VICS center

The purpose of VICS was improving driving experience by these benefits. Firstly, it helps reduce costs by cutting down the time travel. Secondly, it helps ensure safety by providing precise information related to situational driving. Last but not least, it helps reduce environmental pollution by streamlining traffic. Hence, VICS creates a higher standard of living and contribute to the sustainable development of society. (Vehicle Information and Communication System Center)

2.3.2 Briefly History of VICS

Starting from 1990, “VICS Consultative Liaison Council” was first established by the National Police Agency, the Ministry of Ports and Telecommunications (present is Ministry of Public Management, Home Affairs and Telecommunications) and the Ministry of Construction (present is Ministry of Land, Infrastructure and Transport). One year later, 203 corporations and organization established “VICS Promotion Council”. After that, VICS did demonstrations and public experiments from 1993 to 1995 and first VICS center was established in July 1995. The first VICS services started in Tokyo area in April 1996. Since then, road traffic information has been provided and services have been improved until today. In March 1998, VICS service began expanding to all national highway and other ordinary roads in other cities till the end of 2001. Therefore, VICS could be used in 32 prefectures and a map of all prefectures covered by service of VICS could be found in Appendices 1. The figure 4 illustrates fast expanding of VICS service through accumulative number of VICS units have been shipped (ibid.)

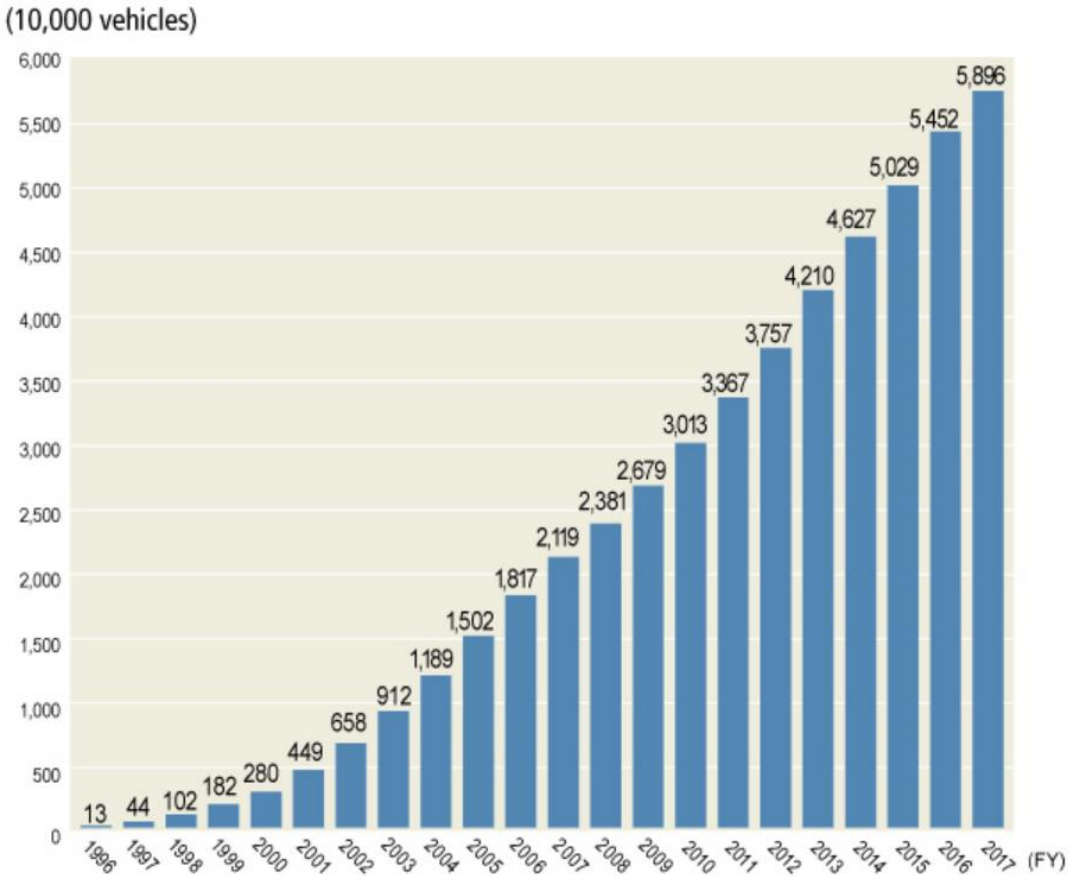

Figure 4. Accumulative number of VICS units shipping (The Ministry of Land, Infrastructure, Transport and Tourism)

The number of death people caused by accident witnessed a decrease from 1990 to 2015 (IATSS Research 2016). Below figure will show it in more specific:

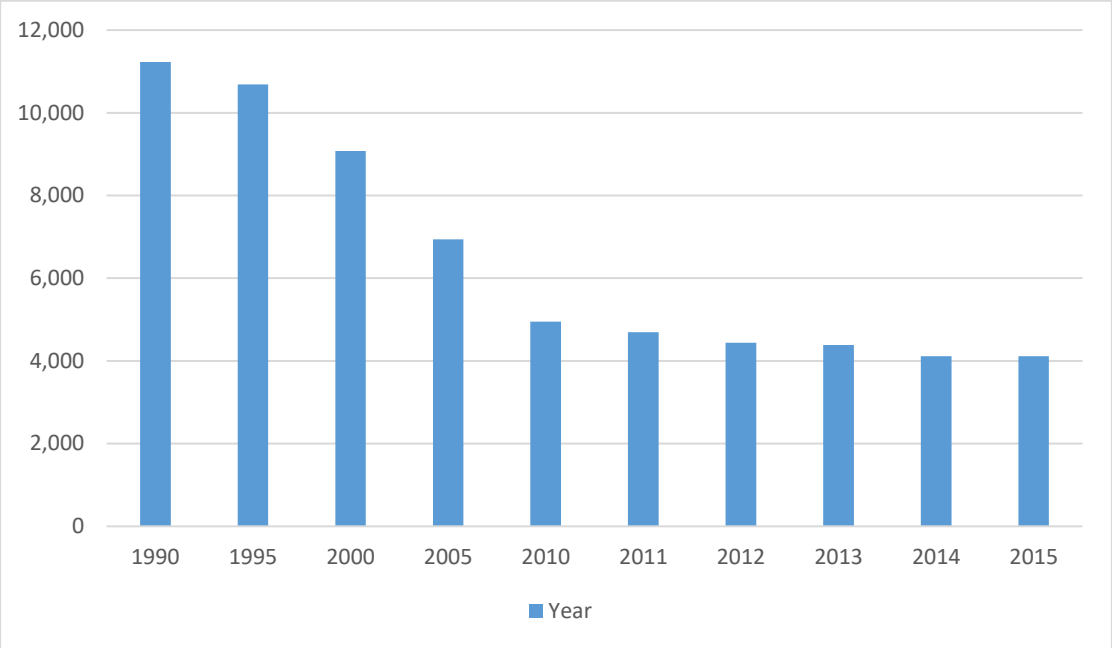

Figure 5. Number of death people by road traffic accidents

2.3.3 Purpose of VICS

VICS center is the brain to handle all collected information. This information initially was collected by highway administrators and prefectural police and then forwarded them to the Japan Road Traffic Information Center before being sent to VICS center. VICS center systematically connected all mentioned information and sent them from beacons set up alongside roads which used infrared rays and radio waves. The task of Radio beacons on highway and optical beacons on major main roads was providing road traffic information for drivers while the FM multiplex broadcasting via FM radio was providing traffic conditions information. Thus, vehicle drivers could use available information directly from VICS units in vehicles. The process of handling information described could be divided in four main functions: Collecting information; processing and editing information; providing information and utilizing information. (Vehicle Information and Communication System Center).

2.3.4 Equipements Requirement

The equipment contains radio beacons alongside roads and on-board unit devices in vehicles. This figure 6 displays how radio beacons look like:

Figure 6. Radio beacons (Antenna) (Hollborn 2002)

Basically, there are devices for communication with ITS spots alongside roads which are FM antenna, beacon receiver and on-board unit. These needed information is then sent from and to VICS center through VICS unit (car navigation). The figure 7 will present which components and how they are equipped to receive VICS information (ibid).

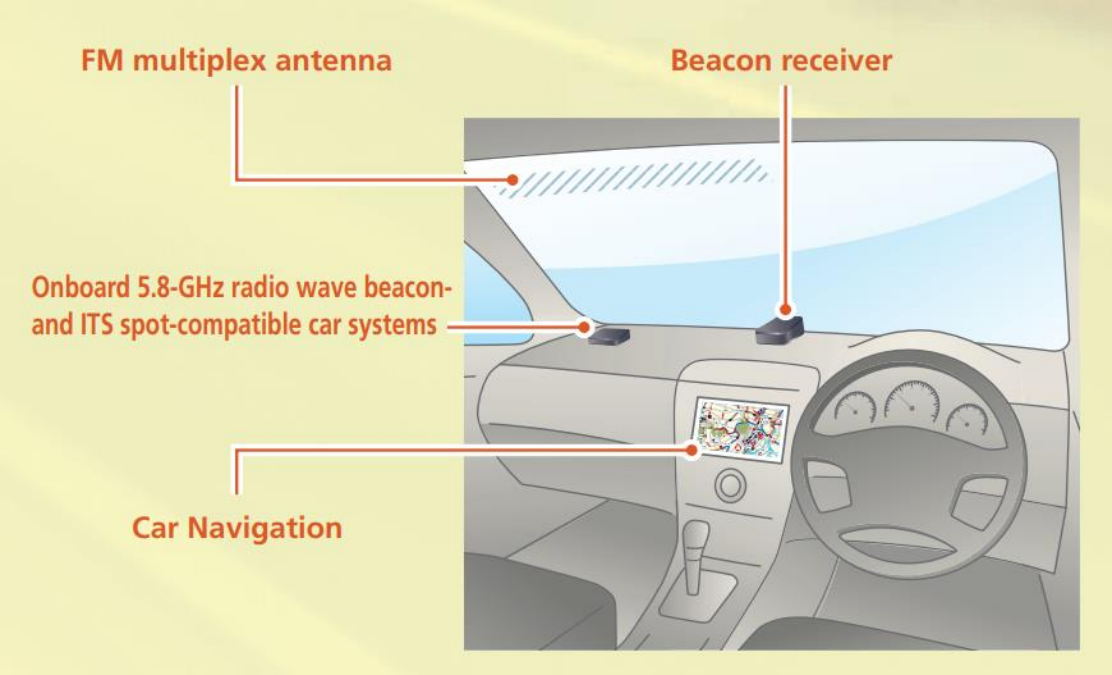

Figure 7. Equipment on vehicle (Vehicle Information and Communication System Center)

This information is then showed in three forms on navigation system and other on-board devices through radio wave, infrared bacons and FM multiplex broadcasting. The purpose of this information is providing a visual look with the announcement about situational area via text or imagine display. It could work whenever driver need it without interrupting:

- **Text display (level 1):** Only text and simple numbers, letters are display on monitor screen.
- **Simple graphic display (level 2):** This type is more complicated than the first one. It shows information in simple graphic form with patterns and signals so that drivers can easily read.
- **Map display (level 3):** This type is the most complicated one which gives more detail information about traffic jams, constructions, accidents, etc. Drivers can actively avoid problems by simply detecting their location and other problem areas that showed on the map (ibid.)

The figures 8, 9 and 10 will demonstrate more detail:

Figure 8. Text display in level 1 (Vehicle Information and Communication System Center)

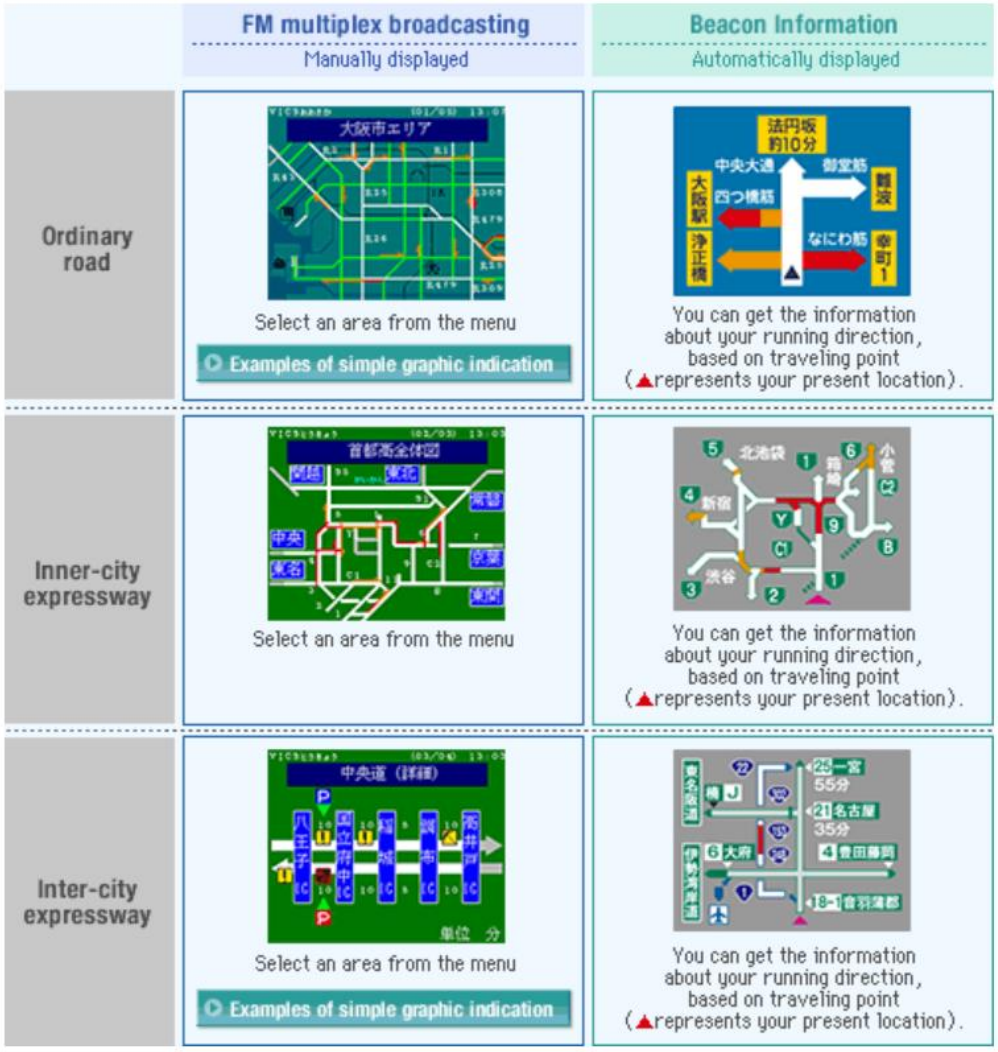

Figure 9. Map display in level 2 (Vehicle Information and Communication System Center)

Figure 10. Map display in level 3 (Vehicle Information and Communication System Center)

Three following transmission are participating in:

- **Radio beacons:** Spots are primally located alongside highway that provides information of traffic within 1000 km and 200 km based on type of band (5.4 GHz and 2.4 GHz band respectively). The information includes travel time, real time congestion, junctions as well as traffic restriction (road closures, speed limitation, etc.) due to road construction, natural disasters and other conditions.
- **Infrared bacons:** Spots are primally located along ordinary roads to provide traffic information within 30 km ahead and 1 km behind the vehicles. The information showed is the same to radio beacons but added extra information about parking locations and its availability. Moreover, the navigation system could provide the optimum route for drivers based on traffic circumstances by activating the automatic congestion avoidance function in equipped receivers.

- **FM multiplex broadcasting:** The traffic information is provided by regional NHK (Japan's national public broadcasting) and FM broadcasters. The information is the same as radio beacons and availability of parking locations. (Society of Automotive Engineers of Japan)

This chart below shows the connection between these factors in VICS (Vehicle Information and Communication System Center):

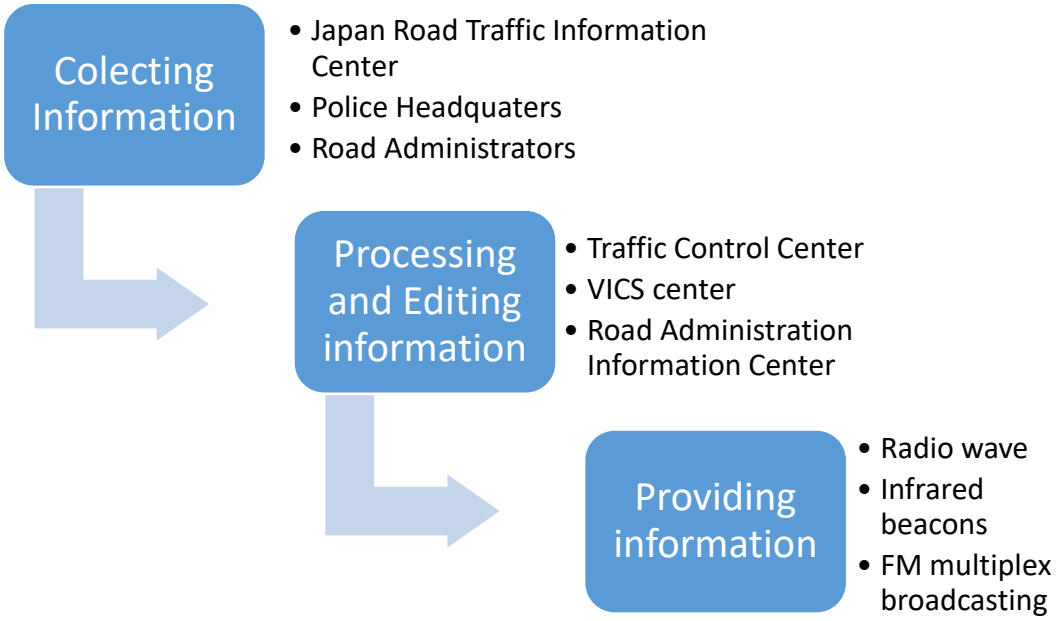

Figure 11. Connection in VICS

A vehicle navigation system which is a primary device that acts as a brain of the vehicle as well as it will link all related vehicle information and its operation. It is obviously seen that the number of vehicles equipped navigation system in Japan had rapidly increase year over year and the amount of units which is compatible with real-time VICS traffic information has exceeded roughly 59 million units at the end of 2017 (Fig. 4).

2.4 Electronic Toll Collection – ETC

2.4.1 ETC overview

One of major impact that makes traffic jams is tradition toll collecting stations. That is the reason why electronic toll collection was developed to replace the old system in order to save time as well as congestion. Toll gates is one of the main factors that accounted for 30% of congestion. This led Japanese government had to seriously focus to build ETC system that can be used in highway. There are 3 consideration factors when ETC started at Japan: reduction in congestion near toll stations, more convenient for users by removing cash handling and reduction in cost management. A standard ETC system must handle complicated charging system at different charging amount according to different type of vehicles and distance travelled. (ITS-TEA)

2.4.2 Briefly history of ETC in Japan

A group included The Ministry of Construction and four expressway public corporations studied to introduce ETC technology in 1995. After that, 63 tollgates with ETC service available for standard users in several areas including Chiba were initially launched on March 30th, 2001. A research was conducted to adjust ETC to four main requirements:

- ETC had to be available for all national users and compatible for all transactions through all toll roads in Japan.
- 5.8 GHz-band active system must be accepted as a DSRC (Dedicated Short Range Communications) system to make sure correct interactive communication between vehicles and ITS spots
- Launching IC card which was used on-board equipment could allow using multi functions and developing future functions.
- An IC card that can make mutual verification with other equipment and encoding of recorded data for security purpose (ibid.).

Since then, the number of ETC users has been rapidly grown with the popular of on-board ETC units. At the end of 2017, there were approximately 85 million vehicles equipped with ETC with nearly 90% ETC in use which is shown in Figure 12

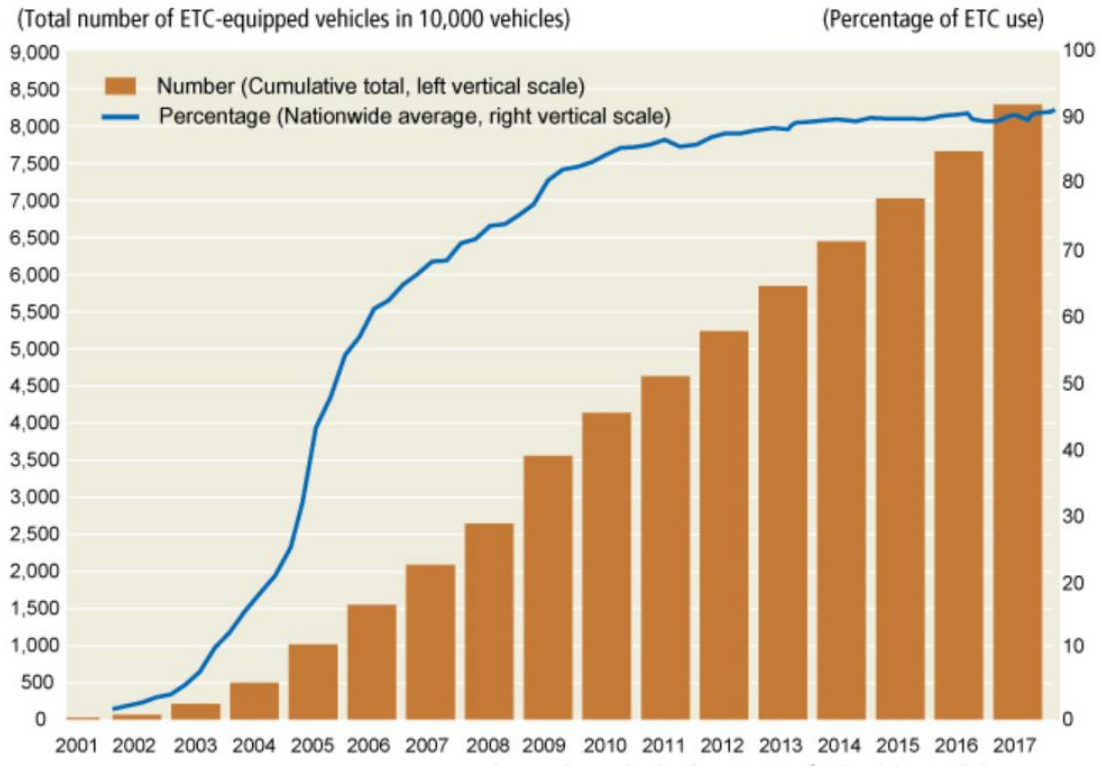

Figure 12. Number of vehicles equipped ETC on-board units and percentage of ETC in use (The Ministry of Land, Infrastructure, Transport and Tourism)

2.4.3 How ETC works

There is an antenna installed at toll gates and an on-board equipment installed on vehicles. These 2 components create a communication system between toll gates and vehicles. An IC card inserted in on-board equipment will store and provide needed information such as e-ticket, driver information, etc. so that when a vehicle passes through tollgate, a signal is sent to the antenna and then the toll fee will be paid automatically. Vehicle can easily move through toll gate without stop and congestion at toll gates has been eliminated. The main advantages of ETC are: the processing capabilities of toll gates will improve, ETC can be used by private operators for instance: parking, ferry boarding and other similar uses (ibid.). This picture 13 below shows how ETC systems works:

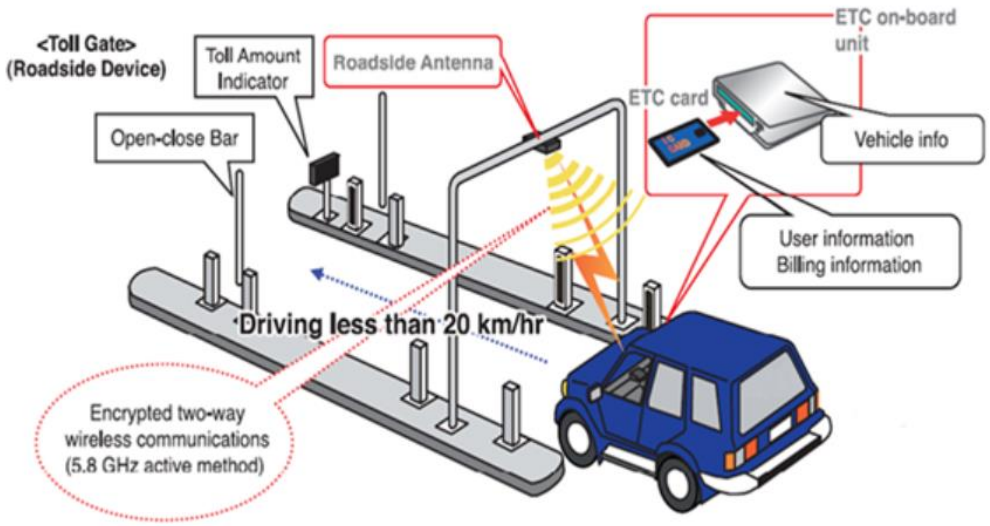

Figure 13. The ETC system (ITS Technology Enhancement Association)

Consequence, limited resource of roads can be used more efficiently and smartly for a long period of time. In addition, ETC helps cutting down waste time, reducing management and construction costs, eliminating traffic jams and contributing to reduce CO2 emission up to 25.4% in fiscal 2013 compared to fiscal 2005 (Japan Automobile Manufacturers Association, Inc. 2016) In this table below illustrate specifically about benefits of ETC to related factors.

Table 1. Benefits of ETC

Factors	**Benefits**
Government	- Build up national traffic data
Drivers	- Save time - Save energy - Increase vehicles life
BOT (Build-Operate-Transfer) investors	- Avoid losses - Save construction cost - Save labor cost compared to traditional toll gates - Save cost for printing tickets
Social	- Reduce congestion

	- Reduce environment pollution - Reduce accidents - Reduce cash payments

2.4.4 Equipments Requirement

There are 3 integral parts are needed in order to run ETC system which are the ETC card, the car transmitter and the ETC antenna at toll gates. Each device is described in following:

ETC card: These cards are issued by ETC system administrators or an organization contracted by the road administrator (Ministry of Land, Infrastructure, Transport and Tourism). There are 2 types of ETC card: ETC exclusive card that can be used only for paying toll road while all-in-one ETC card could combine with credit card and this type of card can be used on toll road as well as shopping facilities.

Car transmitter: Installed on ETC on-board unit of vehicle to communicate with the antenna. These transmitters can be easily bought at most dealers and car part shops.

ETC antenna: It immediately collects travel information from transmitter and then calculates required payment to charge ETC card for toll road. Due to automatic payment, this could reduce queuing time comparing to traditional cash collection toll.

As reported by Mitsubishi heavy industries, LTD. 2014, the reliability of ETC systems used in Japan reached 99.99% reliability in late 2014 with ETC network of 9000km and approximate 5000 lanes throughout Japan (ITS technology Enhancement Association).

2.4.5 ETC 2.0

In 2011, Ministry of Land, Infrastructure, Transport and Tourism launched the world's first Vehicle-to-Infrastructure (V2I) communication service which widely known as ETC 2.0 or 2nd generation of ETC. Mentioned by MLIT, the main difference is that ETC 2.0 has GPS, so it could measure the position. Furthermore, various type of services

including Congestion Avoiding System, Safe Driving Support System and Disaster Information System. These systems are called ITS spots which are installed along freeway across Japan. This system uses 5.8 GHz DSRC, an international standard approved by ISO and ITO which allows high speed, high volume, two way communication in ETC 2.0. DSRC offers diverse services available by communicating to ITS spots and compatible in-vehicle car navigation systems. As a result, there were about 1600 ITS spots positioned on highway throughout Japan in 2011. Moreover, there was an ITS spot located about every 10 to 15km consisting of 90 slots in front of intersections while on urban highway that was every 4km.

Since 2014, new services for ETC 2.0 has been introduced. It provided advanced driver assistance on highway including following extra assistance services in addition to existing automatic toll payment:

- Detouring assist: presents precise information about traffic jams on real-time basis with actual pictures of the road ahead.
- Assistance in the event of disaster: announces safety precautions for example obstacles on roads, weather condition of road ahead or useful information related to current disaster, etc.
- Safe driving assist: provides danger warning due to collisions or slippery road, information related to road closures (ibid.)

3 Application of Intelligent Transport System in Ho Chi Minh city

The project of setting up VICS should be completed in 2 stages. The first stage is establishing VICS center and set up antenna alongside main roads in suburban areas which connect directly to city center. VICS service would be implemented first for the government staffs. If it was successful, then this project would be expanded for everyone who own a car in stage 2.

3.1 Vehicle Information and Communication System in Ho Chi Minh city

3.1.1 Benefits

In Japan, scooters are not popular than in Ho Chi Minh city. Japanese use car as their main transport vehicle. However, Ho Chi Minh city had faster growth rate of car than Japan from 2011 to 2014 which were 1.36 times (in section 1.2) compared to that of Japan which was 1.03 times. On contrary, the number of cars in Japan in 2014 was approximately 60 million vehicles that equaled 8.8 times higher than Ho Chi Minh city (Automobile Inspection & Registration Information Association 2016). In addition, the average road width of Ho Chi Minh city and Japan were almost the same around 3.5m (Ministry of Construction 2007). Assuming that other factors would not affect too much to the context. By using VICS service, vehicle drivers only could actively handle the upcoming situations with related data provided via on board unit (OBU) but also strictly obey traffic rules because all performance information of the vehicle would be recorded and sent to VICS data. Next there would be the expectation achievement after applying VICS. In Japan, after 1 year launching VICS in Japan, the death ration has reduced up to 15%. Hence, the ratio of death in Ho Chi Minh City is expected to decrease 8.8 times which following to the different in number of cars between Japan and Ho Chi Minh city. According to a report of police, in 2018, there were 705 deaths caused by accidents in Ho Chi Minh city. This number would be expected to reduce 1.7% in the first year which means 693 deaths in 2019 since Therefore, the figure which reduce 1.7% is expected to be successful.

According to Mr. Le Van Khoa, vice chairman of the people's committee, from mid-2016, the average speed of traffic in the central area of the city was 20.3 km/h due to high ratio of traffic congestion (M.Q 2017). Moreover, the low level of awareness of traffic leads to non-compliance with traffic regulations. However, by applying VICS, this situation could be improved. On the words of Mr. Y.C Chang, the General Director of FETC, LTD. which stated that 4-5 % increase in speed in freeway would decrease 2-3 minutes in travelling time and reduce in energy consumption up to 7-8 % which means saving 8.76 million euros per year (Ngoc Anh 2017). In Japan, the average speed has increased 30 % since 2005 with 18.8 km/h to 25 km/h in 2015 (MLIT

2013). Therefore, the average speed in Ho Chi Minh city would be expected to increase one-eighth the achievement in Japan which is approximately 4 % and this means ~ 21.8 km/h in 2028 when VICS is widely used. In addition, due to the increase in average speed, the travel time would decrease 2 minutes in average. As a result, the actual fuel consumption would decline to 8.15 million euros per year.

Table 2. Benefits of VICS

Factors	**Improvement**
Travelling time	Shortening up to 2 minutes in average
Average speed	Increasing up to 21.8 km/h in average
Fuel consumption	Decreasing up to 8.15 million euros per year

Those above figures were just the expected result based on the theory and achievements from Japan. It would be different on the practical situation due to various factors.

3.1.2 Challenges

In order launch VICS project, it would be needed a massive investment both on infrastructure and labor. Firstly, a new VICS center must be established in order to processing and editing information. However, according to Department of Finance, it is really difficult to find a suitable location in city center due to high rent. On the other hand, VICS could be located in suburban area which costs less than in city center. However, it is more convenience for staffs to travel since citizen prefer living in city center than suburban. In addition, there is no more room for buildings due to high demand from the citizen. Therefore, the government should consider a plan to redesign the public land fund. Moreover, information could not be transmitted without antenna set up alongside roads or freeway and the investment on these antennas would cost a lot. As a result, the government would need some kind of international loans such as ODA (Official Development Assistant) from developed countries or ask for sponsor ship from domestic enterprises.

After building up infrastructure for the VICS system, human resources would be the vital key to run the system smoothly. Because Vietnam has no experience before in managing and developing intelligent transportation systems so Japanese experts are needed in helping to set up the system and train employees. Additionally, the trained staffs are required to have some experiences related to transportation field or road administration field. This would be a good chance to create more jobs and income for citizen which directly contributes to promoting and developing society.

Turning to user side, in order to use these remarkable services, they would equip themselves an OBU (on board unit). In Japan, 1 OBU would cost 60 dollars. Therefore, when it comes to Vietnam, the actual price including 10 % VAT and 0 % import tax (General Department of Vietnam Customs 2018), so the price without profit would be approximately 66 dollars. That would be an obstacle for the majority of users.

Motorbike would be a giant obstacle for the development of VICS because the majority of population in Ho Chi Minh city use motorbike as their primary transport vehicle due to narrow road condition. However, OBU can only work on cars and it cannot be established or equipped on motorbike. Hence, this would cause inconvenience when operating VICS system.

3.2 Application of Electronic Toll Collection System in Ho Chi Minh city

3.2.1 Benefits

As it was mentioned in the introduction, Ho Chi Minh city has seven toll gates located around city in total. Most of toll gates still use manual method by collecting cash. However, according to People's Committee of Ho Chi Minh, there are only three out of seven toll gates are planned to use Electronic Toll System (ETC). To be more specific, there will be a total investment of more than 35 billion Vietnamese dongs (approximately 1.33 million euros), 1.34 million euros and 3.35 million euros in Phu My bridge's toll gate, Ha Noi highway's toll gate and An Suong – An Lac' toll gate in respectively (Luu Duc – Hoang Tuyen 2017).

It was estimated that each time the vehicles stop to pay the toll charge would slow the journey approximately 2-3 minutes. As it was mentioned on an article by Quang Toan in 2017, VETC. Ltd. had a total of 28 ETC projects located on central and northern of Vietnam would save a total cost up to over 112.78 million euros. To be more specific, each ETC project belongs to VET. Ltd. would save approximately 94 thousand euros in printing cost, 312.8 thousand euros in fuel cost, 3.76 million euros in reducing the time involved in traffic and 483.5 thousand euros in cost of traffic management. Turning to Ho Chi Minh City, there are 7 toll gates at the moment, so if all of these toll gates utilize ETC, it would help saving paper ticket cost roughly 658 thousand euros; saving fuel cost around 2.2 million euros; reducing the time involved in traffic approximately 26.32 million euros and save the cost of traffic management 3.38 million euros per year. Therefore, Ho Chi Minh city would save up to 32.56 million euros. This huge amount of saving money could be use in maintaining road and other public infrastructures. In addition, the vehicle would save up 2 to 3 minutes in travel time which means shorting travel time by 4 to 5 % and saving energy up to 8 %. The table below will illustrate more about these benefits:

Table 3. Money benefit

Factors	Saving money (in million euros per year)
Printing ticket cost	0.658
Fuel cost	2.2
Time involved in traffic	26.32
Traffic management cost	3.38
Total	**32.56**

Besides that, the application of this technology also leads to indirect benefits such as minimizing environmental pollution; decrease the number of stop and start engine, thus increasing engine life. In addition, it helps to control the overloaded vehicle load thereby saving the repair cost; shorten the time of goods circulation on the road and contribute to implementing the Government's policy of reducing payment in cash.

Turning to another aspect, in section ETC in Japan, the CO2 emission reduced up to 25% over 8 years from 2005 to 2013. A statistical data of WHO showed that the median fine part particulate matter in air of Vietnam double to Japan which was 26 and 13 micrograms per cubic meter, respectively (Foley 2016). Thus, the environmental pollution in Vietnam was evaluated worse 2 times than Japan in comparison. Hence, assuming that other factors would not affect too much to the air pollution, it could be expected that the CO2 emission in Ho Chi Minh city could reduce up to 12.5% which is equal one-half of Japan's achievement after widely launching ETC. According to statistical data from Japan International Cooperation Agency, the emission of Ho Chi Minh city in 2013 was 38.5 million t-CO2 which accounts for 16% of the national GHG (Green House Gases) while the population is only 9% of population of Vietnam in total. Thus, the expected result could be 33.7 million t-CO2 in 2021 which is shown in this figure below.

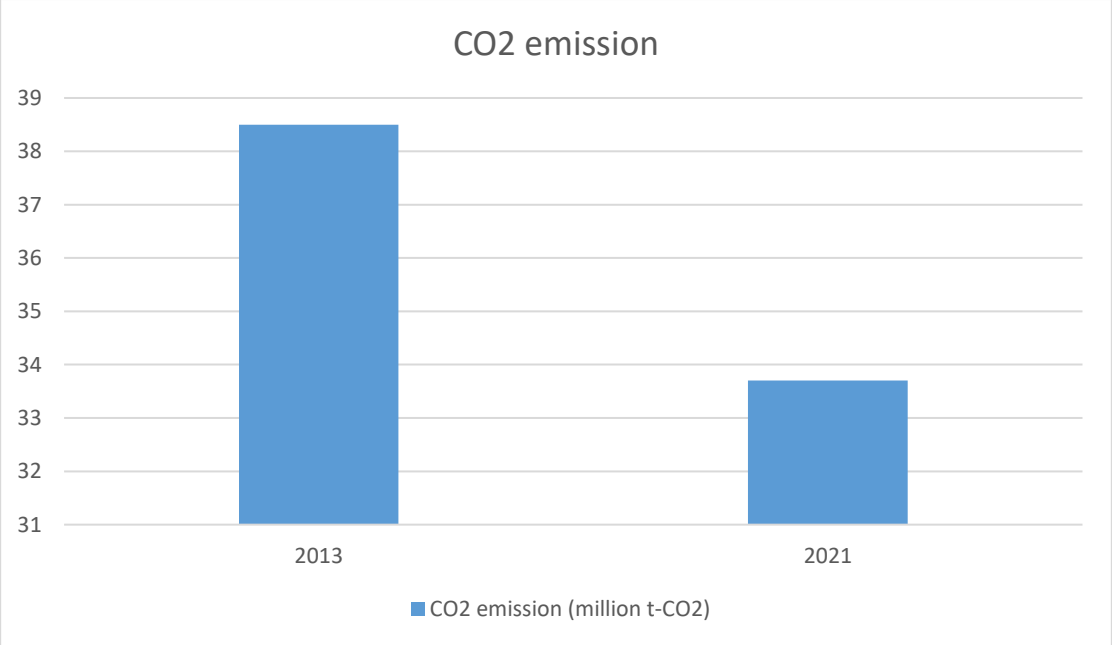

Figure 14. Expected CO2 emission reduction

To be expanded more, ETC could also be used in intelligent parking. This system has the main function: Automatically reading plates when the vehicles enter the gate; automatically printing number plates on vehicle tickets; accompanying by other information required by the management; equipping camera with night vision; allowing

manual typing, etc. All of that process takes only 1-3 seconds. Consequently, the traffic congestion near parking area or shopping center would decrease significantly.

3.2.2 Challenges

On the contrary, ETC in Ho Chi Minh city would face several challenges. There are several reasons that leads the number of enterprises involved in using ETC is extremely low. The reasons for this because the fee in use of ETC could not be shown on the bill, therefore it could not be added for additional fees, especially for foreigners. Turning to transportation enterprises in general, all costs incurred need to have appropriate documents and seals to express to the Ministry of Finance. Hence, a connection network should be established between 3 parties: transport companies – banks – BOT in order to not only solves the procedures on documents but also helps businesses reduce stress in the cost.

On the side of individuals, the fee seems too high to cover. More specifically, as stated by Ministry of Transport, the toll fee for expressways covered by the project's financial plan varies from VND1000 / 1km / PCU to VND2000 / 1km / PCU – Passenger Car Unit / km depending on the plan. main project. So, one round trip for 70 km would cost VND 140000 ~ 5.26 euros and VND 280000 ~ 10.52 euros per day for 70km depending on plan respectively (because the distance between 2 toll gates has to be at least 70 km). It would vary from 157.8 euros to 315.6 euros per month for everyday travel and 105.2 euros to 210.4 euros for 20 day working days each month while the per capital income of Vietnam in 2017 was approximately 2300 euros per year which was 192 euros per month (The World Bank 2017). That was unacceptable for citizen to cover a huge amount of traveling cost. As a result, this cause restriction for citizen to widely use ETC.

Another constraint is that the construction and installation of the ETC system requires massive capital. According to Ministry of Finance, Currently, BOT road projects are being implemented by domestic investors and commercial loans from domestic banks at relatively high interest rates (The national credit institutions mainly provide short-term and medium-term credits) and the credit contract period usually is only under 20 years, but there are some special projects that could be 22 years. Therefore, the return on projects is still a complicated issue. Moreover, there are many

ambiguous in the terms of BOT contract between the investor and the competent state agency such as maintenance, operation, etc. The financial analysis has been implemented, but there are discrepancies, the forecast data flow using many unofficial sources causing difficulties in the evaluation.

4 Discusion

The Chapter 2 which included all theory and practical achievements in Japan has successfully fulfilled the first research question and given a clearly picture about ITS. Among many applications of ITS, this research picked VICS and ETC up to apply in Ho Chi Minh city because the information related to these applications are available from many sources. Moreover, these systems successfully launched in Japan and gained some benefits. According to Investment Promotion Center South Vietnam, Japan remains the largest sponsor of ODA to Vietnam. This illustrates the tight relationship between Vietnam and Japan. Thus, these applications are considered to be suitable for Ho Chi Minh City. Turning to second research question, the calculation on the sections above would help to improve the current situation of transportation system in Ho Chi Minh city. As it was calculated in section 3.1.1, VICS is expected to help to reduce travelling time up to 2 minutes and cut down fuel consumption up to 8.15 million euros per year while the number of death people would reduce 1.7 %. At the same time, in section 3.2.1, ETC is expected to save annual cost including printing tickets, fuel cost, time involved in traffic and management cost approximately 32.56 million euros.

As it is clearly shown in previous chapters that in the next few decades Vietnam's transport network will meet the common standards of the regions and the world by applying ITS. The speed of urbanization is getting faster as well as the means of transportation will increase rapidly, especially in Ho Chi Minh City. If the situation is not change by using old technology and traditional manual work. This leads to a serious congestion and environment pollution which directly affects to social and economic. Therefore, the research and application of ITS in Vietnam is indispensable to overcome frequently traffic jams and meet the needs of management and coordination of traffic activities under the planned network.

In order to set up the ITS system, it is necessary to computerize all agencies and departments related to transportation. After completing the computerization of all the traffic management agencies, the next step is to install traffic monitoring systems such as automatic traffic light control system and electronic board for traffic announcement. The most important step is combining applications into a closed solution. However, in order to monitor and coordinate traffic in real time, the system needs to be self-contained, automatically analysis and decision making. This is the most important and costly step because consisting of both technical resources and capital investment. Hence, the government could use this comprehensive solution for all these agencies and traffic data is managed and stored to assist the experts in analyzing traffic issues. This is really important to VICS because as much as information gathered will provide more precise and detail to VICS users. As mentioned on challenges section of VICS, scooters would be a big obstacle in the development of VICS. Hence, the Department of Transport has proposed to the People's Committee of Ho Chi Minh a long term plan related to banning motorcycle in 2030 and beginning from 2018 (soha.vn 2018). On the other hand, one solution for reducing cost of OBU is that, the car manufacturers would add OBU before they sell final product to customer, the cost of OBU will be calculated to every year maintenance fee for the first 3 years (for example). This would not only help to reduce extra fee for customer but also a value added service to their product for the customer. Besides that, there should be some regulations that restrict motorbike in rush hour and encourage people to use public transport station.

Turning to ETC aspect, ETC should be applied as soon as possible to reduce vehicle downtime and travel time as well as traffic congestion. Nonetheless, the mentioned plans above is only successful if the consciousness of people in traffic is well raised. The government should also have some policy to share the fare fee with people and promote people to participates in the ETC system. The next step is to overcome the following difficulties that happened in the transportation of Ho Chi Minh city:

- The rate of traffic land only accounted for 7,91% which is quite low and cannot meet the demand for the explosion rate of personal vehicle growth.
- There are various types of vehicle and many of them do not obey the traffic rules

- Due to lack of transport infrastructure which leads to the difficulty of public transportation. The cross section of the road was generally narrow. The ability to expand urban roads was very difficult due to the clearance work.
- Citizens still prefer personal vehicle than public transportation. Bad service is considered the most important reason for this. Hence, the development and upgrading of the public transport system should be prioritized.
- Lacking high quality human resources. Besides that, the experience in implementing ITS projects was limited. The problem solved during the implementation of the project was quite slow. The efficiency of existing system was still actual small.

In conclusion, ITS development is an important direction in the process of establishing and developing transportation system. However, the government should pay attention to develop and improve the current transport infrastructure before implementing ITS projects. Due to the opportunities and advantages, Ho Chi Minh city has the favorable opportunities to build a successful ITS system to improve traffic capacity, minimize traffic congestion and improve the environment

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Appendices

Appendice 1. All prefectures covered by service of VICS in Japan