

**Understanding the Differences in the Development and Use of Advanced
Traveler Information Systems for Vehicles (ATIS/V) in the U.S.,
Germany, and Japan**

by

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Submitted to the Engineering Systems Division
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Master of Science in Technology and Policy
at the
Massachusetts Institute of Technology

June 2007

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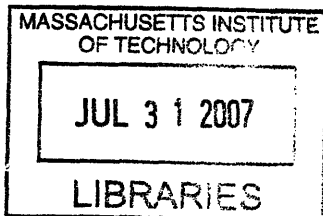
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ABSTRACT

Traffic congestion is becoming a serious problem. As a solution, advanced traveler information systems (ATIS) mitigate traffic congestion by providing real-time traffic information to travelers. ATIS includes various applications such as radio traffic reporting services and websites. Among those, this thesis focuses on more advanced real-time traffic information systems, which provide sophisticated traffic information to drivers via in-vehicle devices such as car navigation systems: we call them ATIS/V (advanced traveler information systems for vehicles).

ATIS/V has a high potential to mitigate traffic congestion and improve travel for individual drivers. However, in some countries, ATIS/V has not been accepted well by drivers. To improve this situation, three questions motivate this study: (1) why does ATIS/V in some parts of the world have more penetration than in others, (2) what can be done to increase the penetration of ATIS/V, and (3) what kinds of strategic alliances among stakeholders can help to make better ATIS/Vs.

This thesis compares three countries, the U.S., Germany, and Japan, by a qualitative analysis of the system dynamics methodology to clarify reasons which have been causing differences in the penetration. Additionally, a new supply chain model based on McQueen's model is used. Furthermore, stakeholder analysis and case studies regarding stakeholder alliances in current ATIS/Vs and highway service operators' strategies for alliances are conducted.

In conclusion, from a macro-perspective analysis, many prominent factors in the dynamics of ATIS/V penetration are found, such as public investment in a public-driven ATIS/V, the in-vehicle device market, and two-way communication technology development. Furthermore, from analysis for alliances among stakeholders, no absolute best alliances but many possibilities to create alliances for ATIS/V are clarified, and the use of ATIS/V as a differentiation tool is suggested as one option worth considering.

Thesis Supervisor: Joseph Sussman

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Acknowledgements

First and foremost, I would like to express my sincere appreciation to my thesis supervisor, Professor Joseph Sussman. Provided opportunities to work with him as well as his sincere support, skillful guidance, and insightful suggestions, I was able to complete this thesis and learn much throughout my research study.

I am also grateful to the faculty, the staff, and my friends in the Technology and Policy Program and beyond. Because of all of them, these two years at the Massachusetts Institute of Technology, full of wonderful experiences of study and more, became a special period in my life.

My graduate study at MIT could not be accomplished without the support of Denso Corporation, and I would like to thank Denso Corporation for giving me this great opportunity and my colleagues in Denso for supporting and encouraging me.

I would also like to thank my parents, sister and brother in Japan for their encouragement and steady support since my childhood. Moreover, I am deeply grateful to my parents-in-law for supporting my family from Japan.

Finally, I would like to give special thanks to my wife, Akiko, for all her love and steadfast support that enabled me to have this great time in Boston with our family, and to my sons, Kosei and Yusei, for energizing me and giving invaluable enjoyment.

Yoshihiko Sugawara
May 2007

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Chapter 1 Introduction

Transportation is essential for a nation's social and economic health. Especially surface transportation systems are directly connected to communities and facilitate commerce and residents' daily life such as work, school, shopping, etc. However, transportation faces variety of challenges such as congestion, traffic incidents, and emissions. For example, although the U.S. has one of the best roadway systems in the world, congestion is increasing and safety remains a serious problem. The 2005 Urban Mobility Report (Schrank & Lomax, 2005) shows that "congestion caused 3.7 billion hours of travel delay and 2.3 billion gallons of wasted fuel, an increase of 79 million hours and 69 million gallons from 2002 to a total cost of more than \$63 billion." Congestion decreases the productivity of the nation, wastes fuel, increases emissions, and caused deterioration in the quality of daily life. Therefore, the efficiency, safety, and effectiveness of surface transportation have huge impacts for countries' economy and environment.

There are several options to reduce traffic congestion such as building new roads, encouraging people to use car pools, imposing tolls to manage traffic flow, or improving public transportation to reduce vehicle use. Unlike conventional solutions, Intelligent Transportation Systems (ITS) in the development of information technology including computers and telecommunications has been considered as a powerful solution to the problem: the United States Department of Transportation (USDOT) defines ITS to include a broad range of wireless and wire line communications-based information and electronics technologies and relieve congestion, improve safety and enhance American productivity when those are integrated into the transportation system's infrastructure, and in vehicles themselves (US DOT). Among ITS, one promising option is advanced traveler information systems (ATIS), which enable travelers to make better choices about transportation and have less frustrating driving experiences by providing valuable real-time traffic information with use of information and communication technologies.

At this moment, as ATIS services, various types of services providing real-time traffic information allow drivers to avoid traffic congestion on the road: a company provides

real-time traffic information on its website; some organizations in the public sector also provide traffic information including the images captured by cameras on the highway. Recently more advanced real-time traffic information services, which are provided by in-vehicle devices such as car navigation systems, have been becoming popular; those services are relatively expensive, but their utility is high for drivers. Those kinds of services are expected to reduce environmental damage and inefficiency caused by traffic congestion and to increase comfort in the vehicles. This thesis focuses on such ATIS used in vehicles, which is called ATIS for vehicles (ATIS/V) in this thesis.

1.1. Motivation

Because ATIS/V services can efficiently reduce traffic congestion, if these services penetrate well in a country or area, they can make a huge beneficial impact on traffic congestion. However, in some countries, ATIS/V services have not been developed well. Now those services are more popular in Japan than in the U.S. or Europe. Furthermore, in Japan, there are traffic information systems which seem more advanced than those in the U.S. or Europe. So far, as one aspect of studies about ATIS, models or simulations about market penetration equilibrium, the saturation level of penetration, have been conducted. In those studies, market penetration is assumed to be determined by some factors including the information benefit from ATIS (Yang, 1998/4/1) with some different assumptions such as the time line of the growth of market penetration (Yang & Meng, 2001/12), or driver's compliance rate of ATIS (Yin & Yang, 2003/2). Although those studies give general understanding and prediction about the penetration, the actual penetration process must vary among regions due to a lot of differences such as road network, current penetration level, ATIS types, or prices.

This thesis aims to answer why ATIS/V in some parts of the world has more penetration than that in others and also what can be done to increase the penetration of those services. Moreover, under the assumption that the business model can be an influential element to develop ATIS/V, this thesis tries to find what kind of the alliances can be helpful for ATIS/V.

1.2. Research Objectives and Methodology

1.2.1. Research Objectives

This thesis has two objectives. Because there can be many reasons causing the difference of penetration in the world such as the relationship between public sector and private sector, or other stakeholders, data communication environments, or the difference of market share of automotive companies, the first objective of the thesis is to analyze dominant factors in each area that cause the difference and to clarify why there is the difference in the penetration or what make the difference in the penetration. The second objective is to make recommendations in order to increase the penetration which include the possibility of strategic alliances among various stakeholders to make better ATIS/Vs.

1.2.2. Methodology

First, to understand the difference in the penetration of ATIS/V, the most developed three automobile markets, North America, Europe, and Japan, are compared. The U.S., Germany, and Japan are selected as a representation of each area. Although United Kingdom is one of the advanced countries about ITS in Europe, Germany is selected to be analyzed since like the U.S. and Japan, Germany is a leading country in terms of automobile industry with a large domestic market and major automobile manufacturers.

In order to analyze the difference of the penetration, the system dynamics methodology (Sterman, 2000) is used. The methodology is beneficial for the explanation of the complex relationship regarding the penetration of ATIS/V. The system dynamics methodology helps to illustrate which factors work dominantly in each country. This methodology can be used not only qualitatively but also quantitatively by conducting numerical simulation. In this thesis, only qualitative analysis is conducted since it is difficult and beyond the scope of this thesis to produce sufficiently convincing results by conducting a quantitative analysis based on a very complicated system dynamics model with a lot of assumptions including huge amount of uncertainty. On the other hand, the qualitative analysis can provide a holistic understanding of the dynamics of the penetration and sources of the difference in the

penetration of ATIS/V.

A way of analyzing ATIS/V, a new supply chain model developed based on a model presented by McQueen et al. (McQueen, Schuman, & Chen, 2002) is used in this thesis. The supply chain divides ATIS/V into seven layers such as collecting data or delivering information and is helpful to understand the difference in ways of implementing a supply chain among the public and private sectors.

Lastly, a stakeholder analysis and some case studies are used to explore better alliances among stakeholders to make better ATIS/Vs and to increase the penetration of ATIS/V.

1.3. Thesis Structure

Chapter 1 describes general background about this study, as well as the motivations, objectives, methodology, and the structure of the thesis.

Chapter 2 provides general information about ATIS/V. The chapter starts with describing ITS and ATIS in general and then focuses on ATIS/V including the definition, technology aspects, current ATIS/V, the structure of business market of ATIS/V, and penetration.

In Chapter 3, the structure of ATIS/V in the U.S., Germany, and Japan is analyzed by using a new supply chain model for ATIS/V. The difference in the allocation of responsibility between the public and private sectors in the supply chain is clarified.

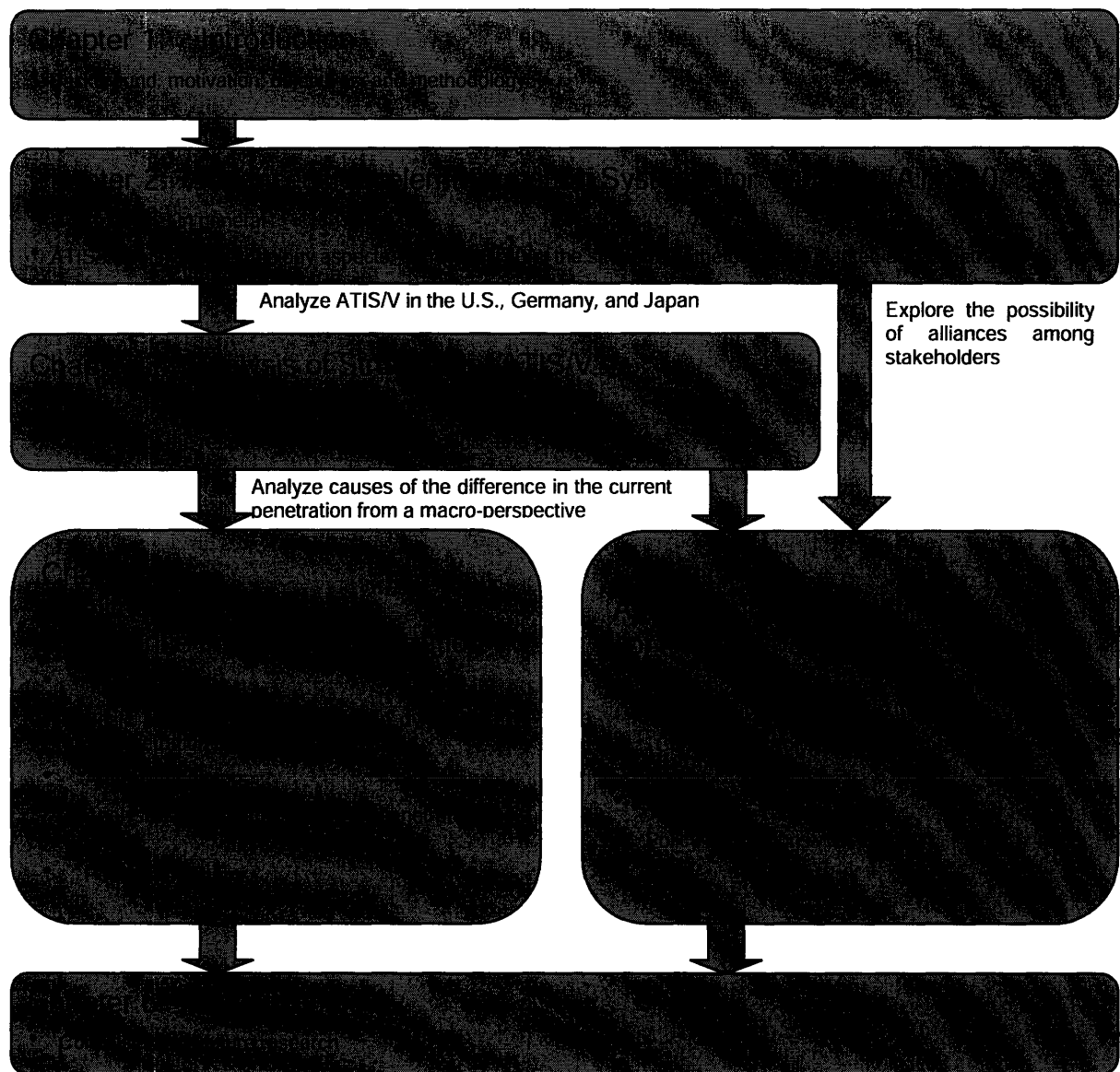
Chapter 4 analyzes the differences in the penetration of ATIS/V by using system dynamics methodology. After explaining a basic dynamics model of the penetration, a detailed model is provided. Then by examining major factors working in the dynamics model and comparing the three countries, the causes of the difference in the penetration are analyzed.

In Chapter 5, the possibility of alliances among stakeholders is analyzed. First, a stakeholder analysis is conducted. In the analysis, stakeholders are identified, and value exchange among them and each stakeholder's roles in the supply chain are clarified. Next, current ATIS/Vs

are classified by types of benefits to ATIS/V providers. Then, case studies of stakeholders' alliances and stakeholder strategies are conducted to explore better alliances among stakeholders.

Finally, Chapter 6 gives conclusions about thesis objectives and proposes policy implications for further development of ATIS/V. Figure 1-1 graphically shows this thesis structure.

Figure 1-1: Thesis Structure



Source: Author

Chapter 2 Advanced Traveler Information Systems for Vehicles (ATIS/V)

ITS is a new transportation system which utilizes sophisticated communication and electronics technologies, reduces congestion, improves transportation safety, and enhances productivity. A variety of applications or programs are being developed. For example, the U.S. has ITS programs such as the Intelligent Vehicle Initiative (IVI) and the Vehicle Infrastructure Integration (VII) initiative. Among ITS applications, ATIS is one promising application.

This chapter describes characteristics of ATIS. Although ATIS has a wide range of applications, this thesis focuses on ATIS for vehicles (ATIS/V). First, the chapter describes ATIS/V's position in ITS and then defines ATIS/V. Then, technology aspects, current ATIS/Vs in the U.S., Germany, and Japan, and the structure of the business market of ATIS/V are described. Lastly, the difference in the penetration of ATIS/V in the three countries is shown.

2.1. Intelligent Transportation Systems

ITS is expected to be a solution to problems caused by transportation such as congestion, accidents, or environmental emissions and to be a strong incentive to encourage economic growth. The history of ITS development is relatively new. Although the development of ITS started from an early research program in the U.S. called Electronic Route Guidance System (ERGS) in the 1960s, major projects developed in the world in the 1990s. However, ITS is developing rapidly now. In addition, a world congress has been held annually since 1994. The U.S., Europe, and Japan are all working positively to develop ITS.

2.2. Advanced Traveler Information Systems (ATIS)

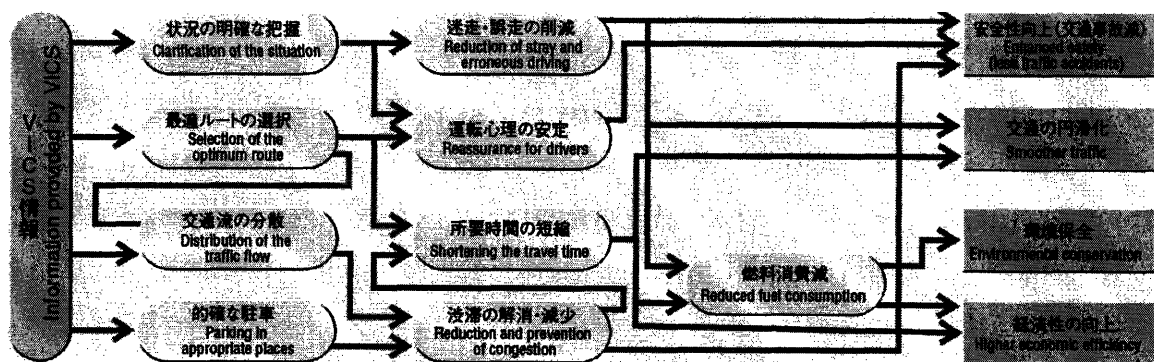
In the definition of ITS America (Intelligent Transportation Society of America), ATIS is defined as systems which "deliver data directly to travelers, empowering them to make better choices about alternate routes or modes of transportation. When archived, this historical data

provides transportation planners with accurate travel pattern information, optimizing the transportation planning process” (Intelligent Transportation Society of America). ATIS provides travelers with traffic and transit conditions, presenting multimodal options at the right time to improve the quality and convenience of their trip and the overall performance of the transportation system.

As the survey of customers of the Washington State DOT (Department of Transportation) traffic web site, one popular type of ATIS, showed, most users probably have five reasons to use ATIS in order of importance (Lappin, 2000): “to assess traffic congestion on their route; to judge the effects of incidents on their trip; to decide among alternate routes; to estimate their trip duration; to time their trip departure.” And they received four primary benefits, saved time, avoided congestion, reduced stress, and avoided unsafe conditions.

The Benefits of ATIS

A lot of benefits are expected from ATIS. One major aspect is to reduce the societal problems such as lost time, productivity losses, wasted energy, or environmental impact. The other aspect is to increase the comfort and convenience of driving. For example, Figure 2-1 shows the suggested benefits provided by VICS, an ATIS/V in Japan (Japanese Ministry of Land, Infrastructure and Transport, 2003).



Source: Japanese Ministry of Land, Infrastructure and Transport, 2003

Figure 2-1: Benefits from VICS System

So far, some studies have been conducted to evaluate the benefit of ATIS. Various types of

models or simulations with different assumptions such as the level of market penetration of ATIS, congestion level, or congestion type, have been developed in order to evaluate the benefit of ATIS. Various estimates show that ATIS equipped vehicles can save travel time from 7 percent to 40 percent and that the overall system travel saving can be from 1 percent to 55 percent (Levinson, 2003/2). In Japan, 20 percent and 30 percent of vehicles with VICS system were expected to reduce traffic congestion by 10 percent in the Tokyo metropolitan area and 6 percent in Japan, respectively (Japanese Ministry of Land, Infrastructure and Transport, 2003).

2.3. ATIS for Vehicles (ATIS/V)

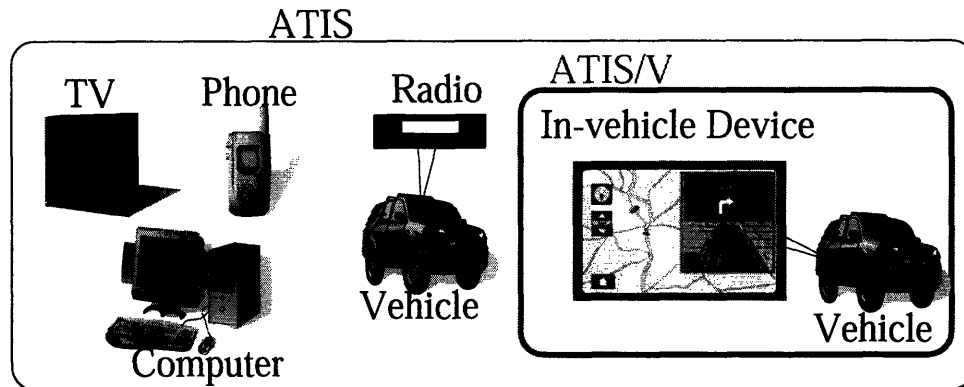
ATIS is not limited to automobiles but includes other transportation methods such as trains or buses since ATIS provides valuable information for any travelers. However, in this thesis, we focus on ATIS which is used in vehicles and define it as ATIS for vehicles (ATIS/V) in the next section.

2.3.1. The Definition of ATIS/V

- ATIS/V is the mechanism used in vehicles to realize efficient vehicle traffic by providing sophisticated traffic information (for example, current traffic status, construction events, and forecast of traffic status) to drivers in their vehicles via electric devices including car navigation systems or personal navigation devices.
- In detail, ATIS/V in this thesis includes services which provide a driver the vehicle location on an intelligent map calculated by Global Positioning Systems (GPS) or dynamic route guidance reflecting real-time traffic information. Real-time traffic information without route guidance for individual drivers, which is provided via TV, the Internet, or radio, is not included in ATIS/V.

Figure 2-2 shows the concept of ATIS/V. The figure does not include all ATIS applications; however, it might be useful for understanding of ATIS/V, which is included in ATIS. For example, changeable or dynamic message signs located along roads, radio traffic reporting services, dial-in telephone services like 511, e-mail alerts, or specific web sites providing

traffic information are included in ATIS. In addition, to compare ATIS/V with other ATIS without confusion, other ATIS is called “conventional ATIS” in contrast to ATIS/V, which requires devices in the vehicle to receive information.



Source: Author; DENSO EUROPE B.V.

Figure 2-2: Concept of ATIS/V

In contrast to conventional ATIS services which provide a huge number of people with the same traffic information, ATIS/V services can provide different traffic information to different people according to a driver’s preference or characteristics such as trip destinations. In such conventional ATIS services, users may have to pay more attention to get traffic information and to retrieve useful information from general traffic information. Therefore, ATIS/V’s ability to provide personalized traffic information can efficiently increase drivers’ awareness of traffic conditions and drivers’ ability to avoid traffic congestion, and reduce drivers’ stress during their drives. This kind of ATIS which can provide personalized travel assistance is called second generation systems by Adler and Blue in comparison to the first generation systems which are designed to improve flow at localized points in a network or to make travelers aware of non-recurring congestion (Adler & Blue, 1998/6).

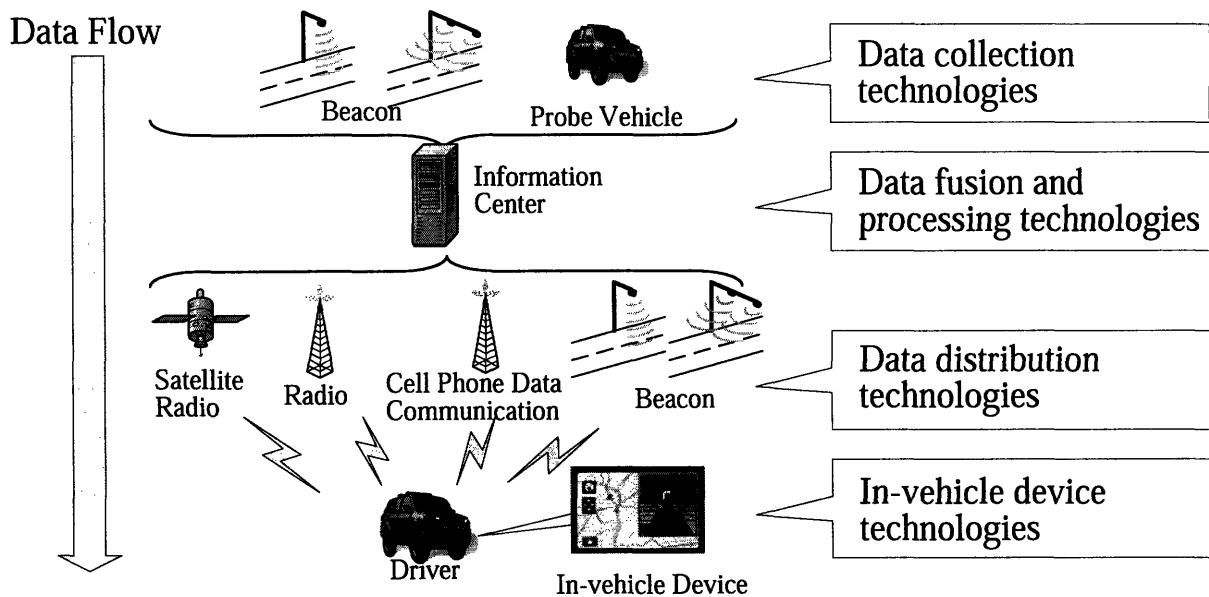
The benefits of ATIS are roughly divided into two types, pre-trip and enroute benefits. Because ATIS/V in the thesis is supposed to be used in vehicles, it does not contribute much to pre-trip benefits such as choices of whether a traveler makes a trip, which transportation mode a traveler takes, or when a traveler departs. On the other hand, it has huge benefits for

unexpected non-recurring congestion caused by accidents or special events or recurring congestion on a road which a driver does not know well, and reduces anxiety and frustration during driving and uncertainty.

2.3.2. Technology Aspects

As shown in Figure 2-3, there are four groups of technologies that are necessary to establish ATIS/V:

- Data collection technologies;
- Data fusion and processing technologies;
- Data distribution technologies;
- In-vehicle device technologies.



Source: Author; DENSO EUROPE B.V.

Figure 2-3: Technologies in ATIS/V

Data Collection Technologies

When new technologies to collect data had not been developed, the collection of real-time traffic data had to rely on traditional methods such as human reporters, cameras, helicopters and airplanes. Due to technology development, traffic sensors, which can be installed on the road, have become a main technology to collect traffic data. Because such traffic sensors can

collect numerical, relatively reliable data specialized to measure traffic, sensors have been installed on the road as the main infrastructure of ITS to realize many ITS applications including ATIS/V.

Traffic sensor technologies can be divided into two types, point sensors or area sensors. Point sensors collect traffic data at single point or small limited areas on the road network. Popular technologies are inductive loops, video image detectors, or radar. In contrast, area sensors can monitor a wide area of the road network. License-plate readers, smart cards and other ITS such as data collectors, or probe vehicle techniques are considered as area sensors (McQueen et al., 2002).

A probe vehicle system is expected as a next generation data collection technology with a huge potential. In the probe vehicle system, each vehicle would be a sensor to collect various types of information such as weather conditions, location, vehicle speed, or road surface conditions. Detailed information, which cannot be collected by installed traffic sensors, collected from vehicles can be gathered and communicated to data fusion centers.

Data Fusion and Processing Technologies

These technologies are used to process collected traffic data and produce useful traveler information. Data storage, database management, and data processing technologies are included in this category.

Data Distribution Technologies

Real-time traffic information is distributed to drivers in the vehicles by data distribution technologies. In the realm of ATIS/V, technologies, which distribute traffic data to the devices in the vehicles, are infrared communication, FM radio broadcast, satellite radio broadcasting, or cell phone data communication; cell phone voice communication is not to be considered to be a data distribution technology for ATIS/V.

In-vehicle Device Technologies

The devices which can provide a driver the vehicle location on an intelligent map and

dynamic route guidance reflecting real-time traffic information are included in in-vehicle devices in this thesis. Table 2-1 shows major features of such in-vehicle devices. As shown in Figure 2-4, one type of these devices is an embedded car navigation system which is installed in the dashboard of the vehicle. Recently, some of these navigation devices are becoming integrated human-machine interfaces between drivers and vehicles, which integrate not only ATIS/V but also other functions such as audio or vehicle status display function. Another type of in-vehicle device is a portable car navigation device with relatively simple functions and a small display such as personal navigation device (PND) or personal digital assistant (PDA). PND is rapidly becoming very popular in the U.S. and Europe: it is said that the market of PND in 2006 would be more than three times as that in 2005 (Gilroy, 2006c). Other devices are GPS-equipped cell phones offering wireless navigation. This solution is not popular at this moment. However, this might compete with the former two types of devices (Gilroy, 2005).

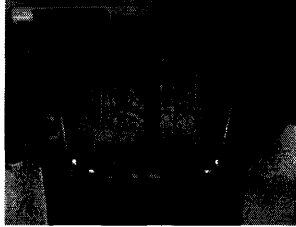
Table 2-1: Features of In-vehicle Devices

Features	Descriptions
GPS Navigation	GPS antenna is integrated and GPS technology is used for navigation.
Pre-installed Map Database	Map of each region (ex. all of the U.S. and Canada map for the U.S. market products) is pre-installed in the devices.
Turn-by-turn Voice and Visual Guidance	Turn-by-turn guidance is provided by voice and visual instruction on the display.
Intelligent Graphical Maps	Map is displayed in various modes such as 2D map, 3D map, twin map, or guide map.
Auto Re-route	When a driver makes a mistake to follow a route and get off the route, a new route is calculated automatically.
Points of Interest (POI)	Database of POI such as gas stations or restaurants is installed, and POIs are displayed on the map.
Real-time Traffic	Devices can receive real-time traffic information and provide alerts or new ideal routes for drivers.

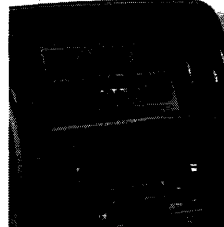
Source: Garmin Ltd.; Magellan Navigation; Pioneer Electronics (USA) Inc.; TomTom

Embedded Car Navigation System

Equipment of Automotive



Toyota:
Lexus LS 07



General Motors:
Cadillac 2007 STS

Aftermarket Product



Pioneer: AVIC-Z2

Portable Car Navigation Device

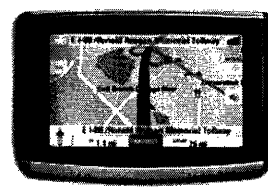
Personal Navigation Device



GARMIN:
nüvi 200



TomTom:
TomTom GO 910



MAGELLAN:
Magellan Maestro 4000

Source: Garmin Ltd.; General Motors Corporation; Lexus, a Division of Toyota Motor Sales, U.S.A., Inc.; Magellan Navigation; Pioneer Electronics (USA) Inc.; TomTom

Figure 2-4: Examples of In-vehicle Devices

2.3.3. Current ATIS/Vs

In this section, some current ATIS/Vs in the three countries are shown to lay the groundwork for the analysis in the following chapters.

U.S.

XM NavTraffic

XM Satellite Radio started XM NavTraffic service in October 2004. At the beginning, the service was provided to limited vehicles, the 2005 Acura RL and the 2005 Cadillac CTS.

However, the service is available not only at time of purchase of vehicles but also in the aftermarket products. Traffic information is sent via satellite broadcasting to navigation systems. As of February 2007, XM NavTraffic covered 44 metropolitan areas. To subscribe to the service, users need to pay monthly fees: \$16.94 or \$9.95 is a monthly fee for XM NavTraffic and XM audio combined or for XM NavTraffic only, respectively (XM Satellite Radio, 2007).

Clear Channel Radio

Clear Channel launched Radio Data System - Traffic Message Channel (RDS-TMC) based ATIS/V in January 2005 (TMC Forum, 2005). In the TMC Forum (TMC Forum), RDS-TMC is explained as "a specific application of the FM Radio Data System used for broadcasting real-time traffic and weather information." In RDS-TMC, data is received silently and decoded by devices with TMC compatibility and real-time information is provided in various ways to users. This service is also available in devices which are provided by an automobile manufacturer, BMW, and other aftermarket device manufacturers. As of February 2007, the service covers 49 metropolitan areas. Although in most cases, a trial subscription is bundled with the purchase of the device, typically \$60 is required as the annual subscription fee after the trial period (Total Traffic Network).

Germany

RDS-TMC

Germany has had a public-sector driven free RDS-TMC service since 1997. Traffic data is broadcasted by both public and private radio stations and the whole country is covered by the service. It is said that the service is used by some 3 million receivers especially via navigation systems (TMC Forum).

TMCpro

TMCpro is a national commercial TMC service operated by T-Systems Traffic. The service was started in March 2004 and covers more than 90% of the landmass and motorways of Germany. Not only all public sources but traffic flow data generated over an extensive network of stationary sensors mounted on German motorways and additional data collected

by a probe vehicle system are used to provide high quality traffic information (TMC Forum).

Japan

VICS

Vehicle Information and Communication System (VICS) is a free ATIS/V supported by the public sector. Traffic data is provided via three media: radio wave beacons, infrared beacons, and FM multiplex broadcasting. This service started in 1996 in the Tokyo area and covered the nation in 2003. This service can be received by anyone who has VICS compatible on-board devices: these devices are manufactured by electronics device manufacturers and sold by them or via automotive manufacturers (Vehicle Information and Communication System Center). However, when users purchase VICS compatible devices, they need to pay a royalty for the service which is included in the price of the device (Noguchi & Sakamoto, 1995).

Internavi Premium Club

Internavi Premium Club is a telematics service provided by Honda Motor Co., Ltd. In the service, Honda has provided its own probe car system by using car navigation systems installed in Honda cars since 2003. In the system, in-vehicle devices work not only as traffic information receivers for users but also as traffic sensors for Honda. Although some traffic data collectors apply the probe vehicle technology as one of many traffic data collection methods, most of those data collectors do not use users' devices as probes. However, Internavi Premium Club utilizes users' devices as probes, provides high quality traffic information, and covers roads which are not covered by VICS (Honda Motor Co., Ltd, 2003). Furthermore, Honda also provides on-demand VICS service and traffic congestion forecasts. In VICS, car navigation systems can get limited traffic information up to 10-30 km ahead from FM broadcast or beacons. However, on-demand VICS can provide all VICS information which is collected from all over Japan by telecommunicating to Honda's traffic information centers which gather VICS information from VICS center (Honda Motor Co., Ltd.). Although users need to pay communication fees, Honda does not charge any service fees to users.

G-BOOK ALPHA

Renovated from previous telematics services named G-BOOK in 2005, G-BOOK ALPHA is another telematics service operated by Toyota Motor Corporation (The Japan Corporate News Network, 2005). G-BOOK ALPHA includes not only ATIS/V but also safety and security functions. Although G-BOOK ALPHA does not support a probe car system, on-demand VICS and traffic congestion forecasts are provided. When the telematics service started, service fees were charged to users. However, some functions including on-demand VICS and traffic congestion forecasts have been provided without fees since April 2006 (Toyota Motor Corporation, 2006).

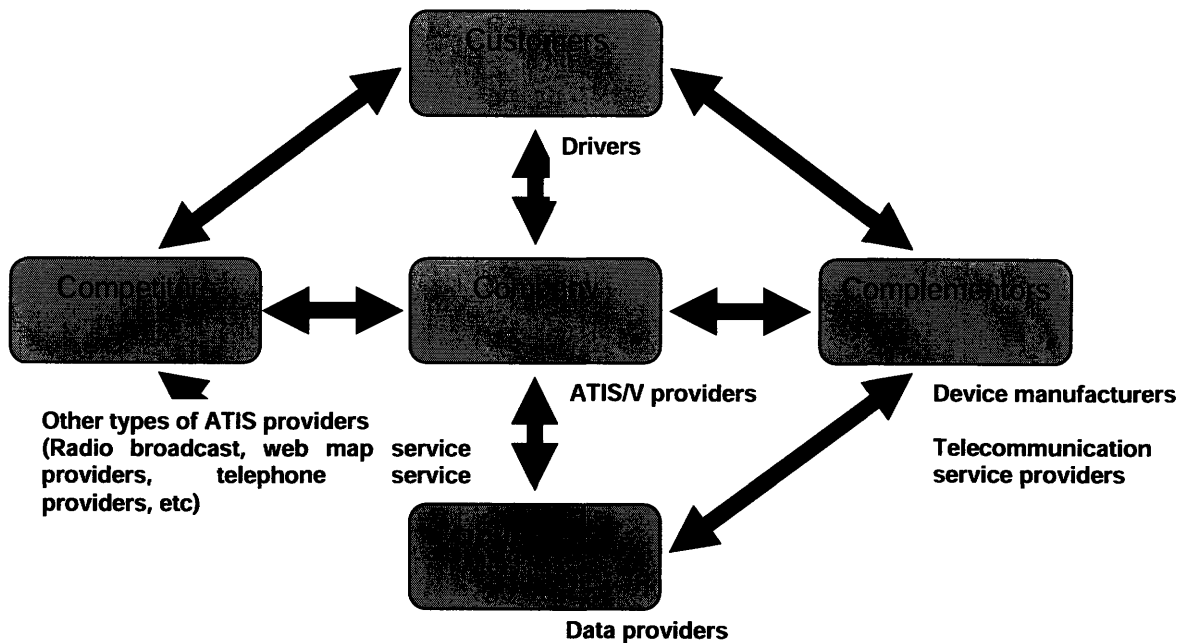
For private-driven ATIS/Vs such as Internavi Premium Club and G-BOOK ALPHA, VICS can be considered to be a complement since VICS's information is essential data for private-driven ATIS/Vs' high quality service. At the same time, VICS can be a competitor in some senses because VICS is also an ATIS/V and some people may be satisfied with VICS and may not want to have private ATIS/V services.

2.3.4. The Structure of the Business Market of ATIS/V

The basic structure of the business market of ATIS/V is clarified below by the value net (Brandenburger & Nalebuff, 1996). Figure 2-5 provides the value net of ATIS/V providers. Although various types of alliances among stakeholders exist in the real world, this figure shows the basic relationships among stakeholders in the industry of ATIS/V.

First, ATIS/V providers gather traffic information from suppliers. Suppliers include various types of data providers from both the public and private sectors. ATIS/V providers combine provided traffic data, add value to them, and provide real-time traffic information or more sophisticated information such as prediction of traffic congestion to customers. Other ATIS services which are not using devices dedicated to ATIS/V service are considered to be competitors. At this moment, there are many competitors such as Highway Advisory Radio or websites operated by state DOTs. Moreover, the relatively new web map services add competitors, such as the map service in Microsoft's Live Search. Lastly, device

manufacturers and telecommunication service providers can be described as complementors since these are necessary for customers to get ATIS/V services.

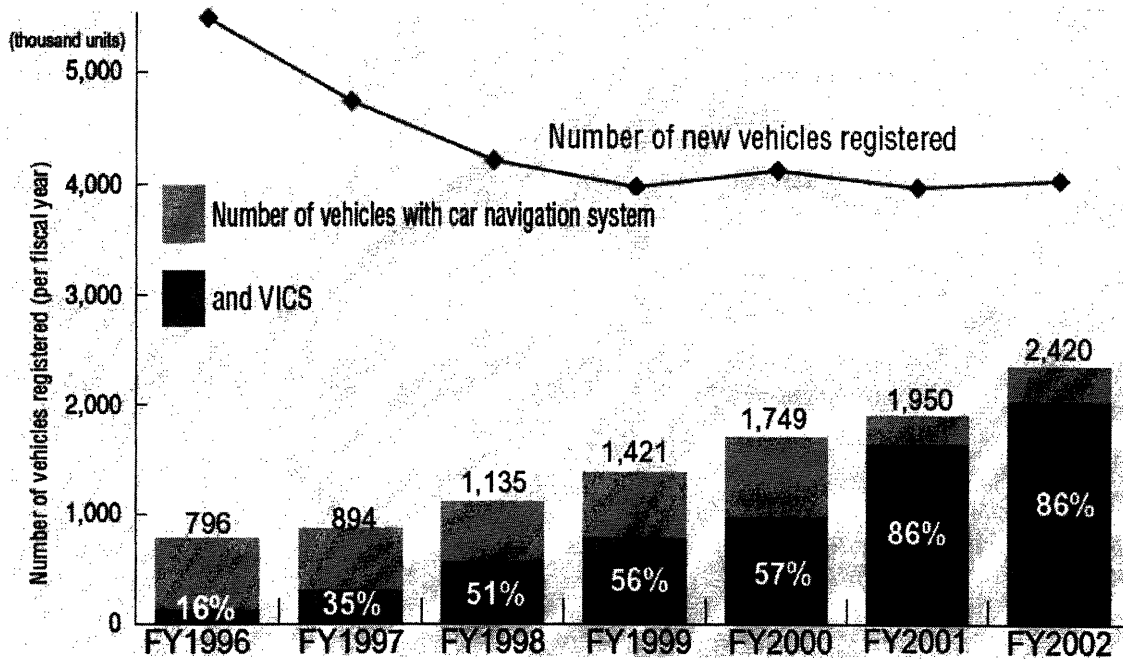


Source: Brandenburger & Nalebuff, 1996, adapted by author

Figure 2-5: Value Net of ATIS/V

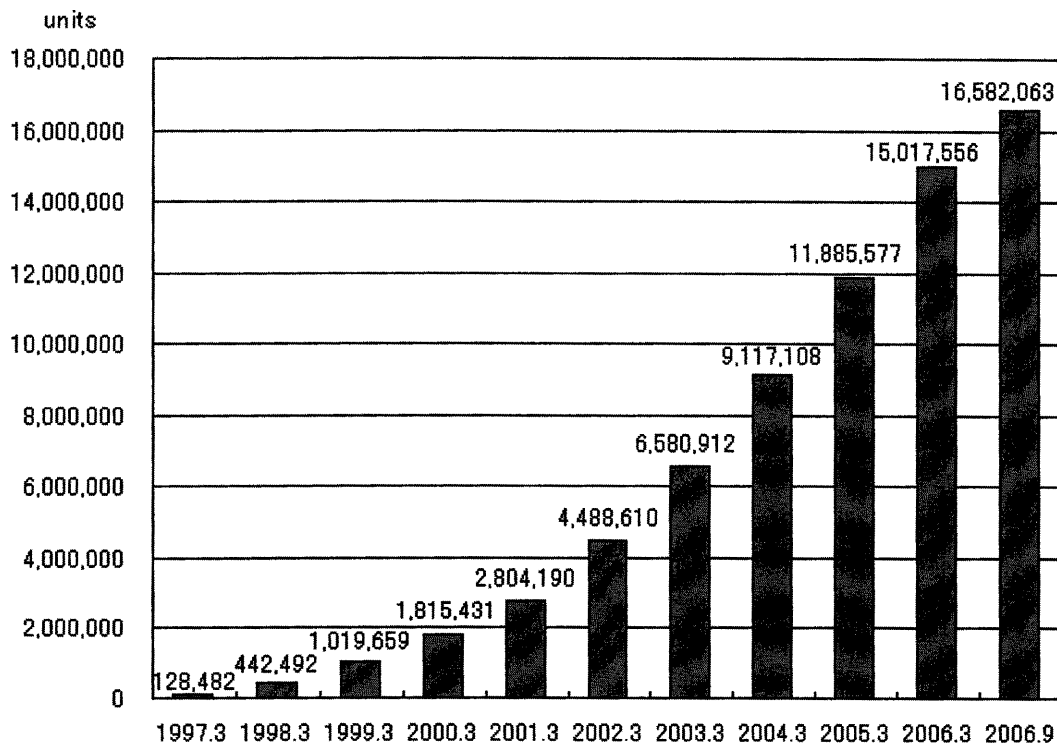
2.3.5. Penetration of ATIS/V

ATIS/V has become popular in all three countries. For example, in Japan, as shown in Figure 2-6, showing the number of VICS units newly sold each year and Figure 2-7, showing the cumulative number of VICS units, VICS has become popular: as of 2002, over 86% of 2.42 million of car navigation systems which were newly installed in vehicles have equipped VICS units; as of September 2006, the cumulative number of VICS units reached more than 16 million. Because of the lack of data about Germany, in this section, the penetration of ATIS/V in three areas, the U.S., Europe, and Japan, is calculated instead of in the three countries, the U.S., Germany, and Japan. Considering that Germany is a leading country in Europe regarding ATIS/V, Germany's penetration should be assumed a little bit larger than that of Europe.



Source: Japanese Ministry of Land, Infrastructure and Transport, 2004b

Figure 2-6: Growth in Installation of Car Navigation Systems and VICS



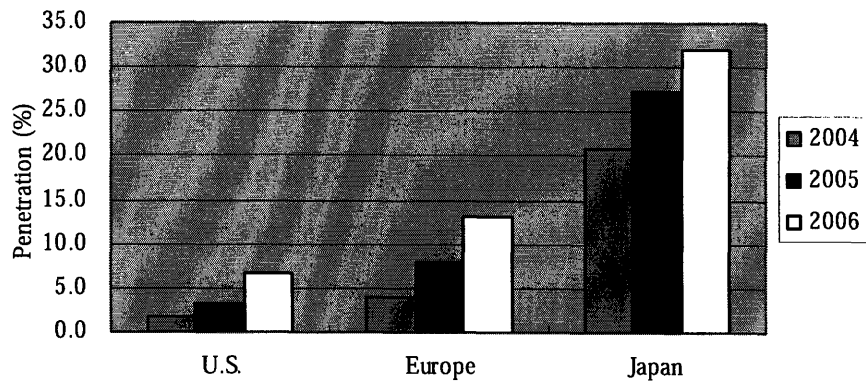
Source: Japanese Ministry of Land, Infrastructure and Transport, Road Bureau, 2007

Figure 2-7: The Number of VICS Units in Market

Penetration Rate

As explained at the beginning of this section, the penetration of ATIS/V in the three areas, not countries, is calculated below. Using some assumptions, the penetration of ATIS/V in the three areas is calculated as shown in Figure 2-8. In the calculation, the penetration rate was calculated by the number of total units divided by the number of total passenger vehicles. Because trucks are not included in passenger vehicles, the calculated penetration may be larger than the actual figure. The number of total units is the cumulative total of devices. For the U.S., the number of total units is the sum of the number of car navigation systems and personal navigation devices (PNDs); the number of Onstar devices is not included since Onstar is not considered as ATIS/V in this thesis due to the lack of map display. As for the U.S., for Europe, the sum of the number of car navigation systems and PNDs is used. For Japan, the number is the sum of VICS and telematics services provided Toyota, Honda, or Nissan. Especially in the U.S. and Europe, some of the car navigation systems and PNDs users do not subscribe or have real-time traffic functions. Furthermore, when estimated or predicted data which is used in the calculation have some ranges, the maximum data is used in the calculation. Therefore, calculated penetration must be larger than actual penetration rate.

Due to the assumptions in the calculation, the penetration can be much larger than actual penetration in those areas especially in the U.S. and Europe. However, some facts can be taken from the calculation. First, in all areas, the penetration is growing. Second is the difference in the penetration of ATIS/V in the three areas. Among the three areas, Japan has much higher penetration than the other two and the U.S. has the lowest penetration in the three areas.



Year	U.S. (%)	Europe (%)	Japan (%)
2004	1.7	4.1	20.9
2005	3.2	7.9	27.4
2006	6.6	13.3	32.0

Source: Ashahi Shimbun, 2006; Gilroy, 2005; Gilroy, 2006a; Gilroy, 2006c; Ogawa, 2006

Figure 2-8: Penetration Rate of ATIS/V in the U.S., Europe, and Japan

2.3.6. Summary

In this chapter, ATIS/V, which is analyzed in this thesis, is identified. ATIS/V is an advanced application of ATIS and different from conventional ATIS such as radio audio traffic information broadcasts. After the definition, technology aspects and current ATIS/Vs in the U.S., Germany, and Japan are described. Then the structure of the business market of ATIS/V is also explained by the value net. Finally, the difference in the penetration of ATIS/V in the three areas is shown. Japan has much higher penetration than the other two, and the penetration in the U.S. is lower than that in Europe.

In the following chapters, this thesis addresses reasons why this difference in the penetration of ATIS/V happened in the three countries. First, in Chapter 3, the structure of ATIS/V in the three countries is analyzed by using a supply chain model of ATIS/V. Through the analysis, the allocation of responsibility between the public and private sectors is clarified as one important element which has caused the difference.

Chapter 3 Analysis of Structure of ATIS/V

Generally the development of ATIS/V is affected by the structure of a system of ATIS/V. Similar to many of the other ITS projects, the development of a wide range of components such as data collection and data distribution is necessary for ATIS/V to work properly as a system. In order to build a system containing various technologies such as sensor infrastructure, telecommunication networks, and in-vehicle devices, various stakeholders including the public and private sectors have to work together.

Due to the need for such alliances and the difference in the context of each country, the three countries differ in the allocation of responsibility between the public sector and private sectors in ATIS/V. In the development of ATIS/V, various aspects are contained in this allocation of responsibility, such as research initiatives. The allocation of responsibility between the public and private sectors in the supply chain is one of the important aspects which affect the development of ATIS/V.

Expertise, authority, and funding are thought necessary as important resources to realize the technical vision of ITS (Klein, 1996). The public sector's part in ATIS/V is one important factor affecting these three types of resources. To build ATIS/V efficiently, the public sector needs to cooperate with private companies that have expertise. As for authority, because in most cases, road networks are public property, coordination and cooperation among agencies which have authority over road networks are critical to deploy data collection infrastructure on roads. Regarding funding, because the public sector's parts of ATIS/V supply chain can be developed by public investment which tends to be larger than that of the private sector, the development of ATIS/V depends on which parts of the supply chain are the public sector's responsibilities and how much the public sector takes responsibility for the development.

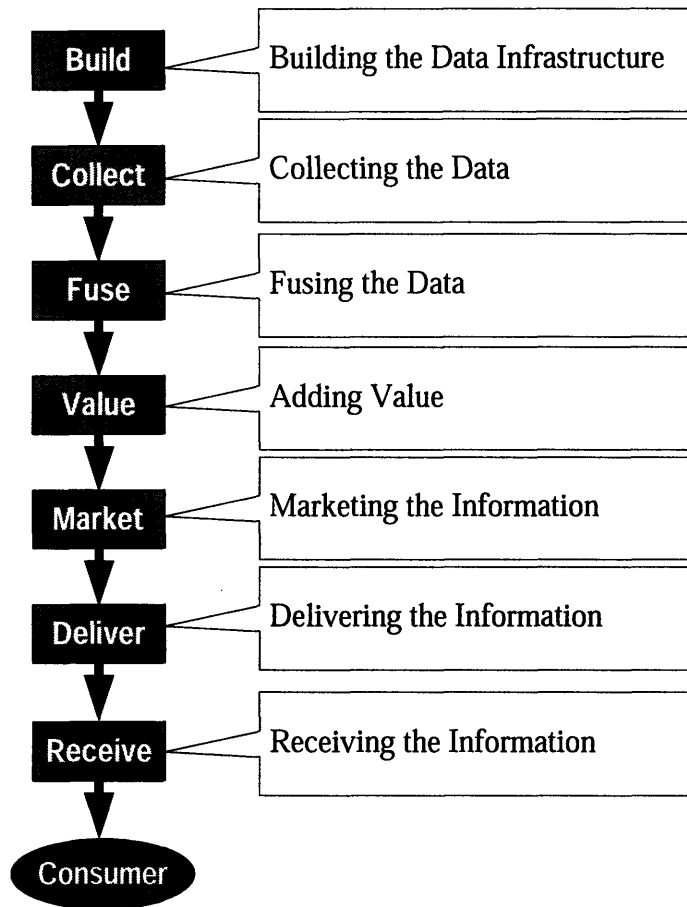
In a practical sense, there are various ways of implementing a supply chain among the public and private sectors. For example, a private traffic information service provider is provided with information collected by the public sector. However, generally the public sector plays an

important role in the initial part of the supply chain by investing money to set up an infrastructure to collect data. In contrast, the private sector tends to find business opportunities in the last part of the supply chain such as marketing and delivering information to end customers (McQueen et al., 2002).

Therefore, Section 3.1 analyzes the differences in the allocation of responsibility between the public and the private sectors in ATIS/V using a supply chain model. As a model to understand the supply chain structure of ATIS, there is a model presented by McQueen et al. (McQueen et al., 2002). Because the model is made for ATIS not for ATIS/V, a model with small modification from the McQueen model is used in the thesis. After the explanation of the new model, the differences between the three countries are analyzed in the following sections.

3.1. The Supply Chain Model for ATIS/V

Although the model presented by McQueen et al. is separated into six major activities, in the new supply chain model, a supply chain of ATIS/V consists of seven major activities as shown in Figure 3-1. The first activity is building the data infrastructure. Creating and maintaining an infrastructure to collect data for the traveler information system is included in this step. The next step, collecting the data, involves operating and managing the infrastructure which is built in the first step. Fusing the data is the third step and includes the collection and integration of data. The fourth is adding value. In this step, the integrated information is converted to information which can be sold to customers. In the fifth step, marketing and developing new information products, advertisements or promotion activities are performed. The sixth step is delivering the information in which delivery channels are selected and information is distributed. Until the sixth step, this new model is the same as McQueen model. However, the last step is added in the new model. In this step, traffic information is received by in-vehicle devices. Unlike other conventional ATIS, ATIS/V requires in-vehicle devices which can receive traffic information, process the information, and provide services to customers. Therefore, the supply chain of ATIS/V cannot be complete without in-vehicle devices.



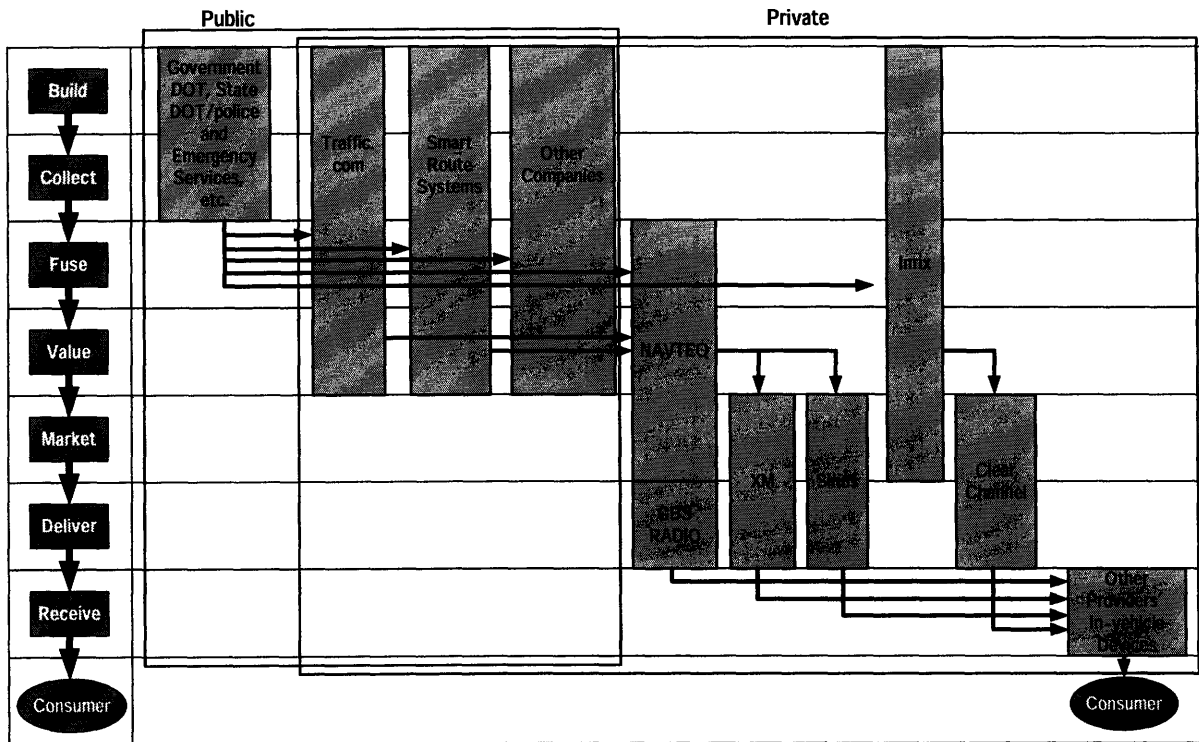
Source: McQueen et al., 2002, modified by author

Figure 3-1: ATIS/V Supply Chain Model

In the following sections, supply chains in the U.S., Germany and Japan are compared based on this supply chain model. To clarify how much the public or private sector supports or has the responsibility for ATIS/V in the supply chain, the analysis of the allocation of responsibility between the public and the private sectors in the supply chain model are focused on two parts, data collection and data distribution. Moreover, because the access to the traffic data collected by the public sector is an important element in the supply chain of ATIS/V, access to public data is also analyzed in the following sections. In addition, the existence of the public or private-driven ATIS/V is summarized.

3.1.1. The U.S.

In the U.S., there are many actors related to ATIS/V since each state has its own way of implementing ATIS. Because it is beyond the scope of this thesis to describe all of these actors, major actors related to ATIS/V are shown in Figure 3-2. Although there are many ATIS at the state or local level and many entities in those ATIS, only large entities are included in Figure 3-2.



Source: Author

Figure 3-2: Supply Chain Model of ATIS/V in the U.S.

Public Data Collection and Access to Public Data

Public-Private Partnership (PPP), which is a common way of collaboration between the public and the private sectors used in various countries, has been applied to ATIS in the U.S. The definition of PPP is as “an arrangement of roles and relationships in which two or more public and private entities coordinate/combine complementary resources to achieve their separate objectives through joint pursuit of one or more common objectives” (Lawther, 2005).

PPP involves state and local transportation agencies and private contractors. In recent federal transportation policy, due to the benefits of PPP, it has been recognized as an effective way to achieve national goals. One benefit is the potential of the private sector to provide a more efficient and cheaper service than the public sector. Another is that the expertise and funding of the private sector help the development of ATIS. Moreover, especially in ATIS cases, these services which are sold to individuals are considered to be what the private sector should handle rather than pure public services which are provided to public free of charge (Lawther, 2005).

There are many ways of implementing PPP since each public local agency has latitude concerning how to build PPP in its own area. Wandell classified into PPP models such as public controlled, public stimulated or funded, or private partnered (Lawther, 2005). In the case of PPP in Boston, SmartRoute Systems gets funding from the state which covers 70% of the total cost, and provides traffic information service for individuals via telephone at no charge (Schuman & Sherer, 2001). At the same time, SmartRoute Systems can get profits from selling information to other private companies or individuals. Although the effort of private companies can be utilized to widen the market, the market has not grown well so far. At the beginning, the public sector expected to share revenue which partner private companies would earn. However, the market of ATIS has not been extended as expected and private companies have not yet raised much revenue (Lawther, 2005).

In the PPP framework, generally the public sector provides traffic data to the private sector. However, the form of PPP is different in the federal, state or local government. Though the federal government has supported ITS from high perspective such as with financial supports or long term strategy and encouraged PPP, the federal government has not specified the structure of ATIS. In addition, each state or local government has strong authority and latitude to determine its own policy independently from the federal government. Therefore, state or local government has established its own ATIS and had its own way of public data acquisition and of access to the public data. Because each region or metropolitan area has its own need, ATIS which fits to the need of an area might be the best for the area. However, this approach would make it difficult to have a united-nationwide data collection network

because of the difference in many elements such as service contents, the type of collected information, data formats, and sharing of roles among many ATIS. Recently, some ATIS/V providers have started nationwide services. But, this difficulty might be an obstacle for private companies to make nationwide ATIS/V.

Private Data Collection

Because PPP involves the private sector as mentioned above, some private companies such as SmartRoute Systems and Traffic.com collect traffic data in the PPP framework. SmartRoute Systems makes agreements with some state or local governments to build and operate traffic information centers, and to provide traffic information service to the public with no charge such as regional 511 services (SmartRoute Systems, 2005); Traffic.com is also in PPP with federal, state, or local governments. Traffic.com gets public funding to set up its own sensors on the public rights-of-way, operates and maintains the network of sensors, provides traffic data to the public agencies, and shares gross revenues with the public sector (Traffic.com).

On the other hand, as a new movement in ATIS/V, a company named Inrix has started collecting traffic data without PPP. Although Inrix uses traffic data which is collected by the public sector as one source of traffic data, Inrix collects traffic data by itself. Because of technology development in the data collection, Inrix does not have to rely on traffic sensors set on the road and has adopted a new technology, a real-time GPS probe vehicle system with more than 500,000 commercial fleet (Inrix, 2007).

Public Data Distribution

Although the public sector in the U.S. participates in data collection, the public sector does not support data distribution. As shown in Figure 3-2, the public sector is in the data collection phase in the supply chain model of ATIS/V, but not in the data distribution. Although there are many applications of PPP in the U.S., none of them are made for ATIS/V: all of PPP applications are made for conventional ATIS such as highway advisory radio or telephone advisory services. That is, unlike in Germany and Japan, in the U.S. there is no ATIS/V operated by the public sector. However, because the public sector joins the data

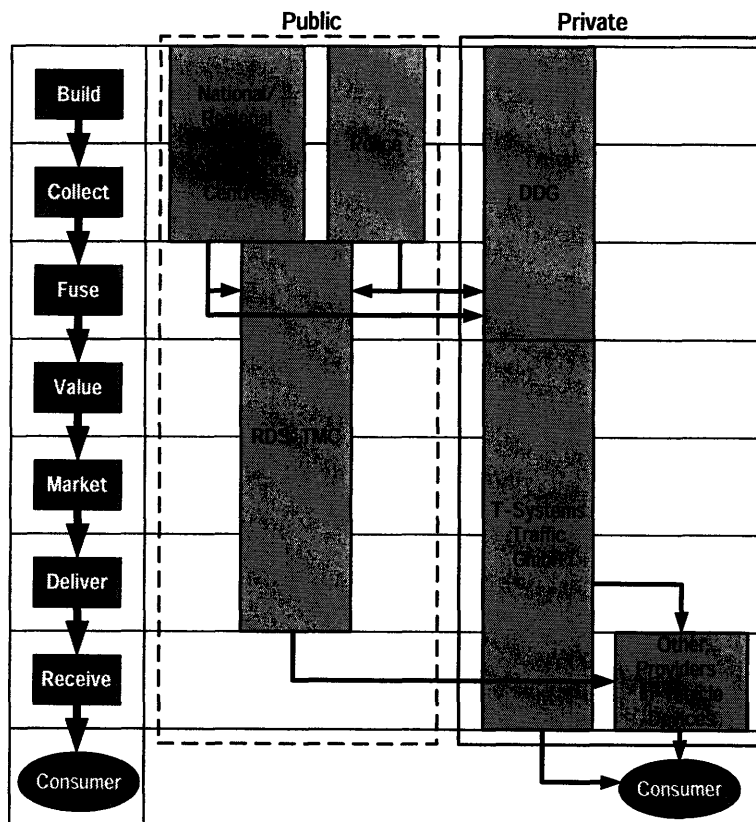
collection in the supply chain for conventional ATIS and collected data can be used in ATIS/V, it is said that the public sector participates in the data collection in the supply chain model of ATIS/V.

Private Data Distribution

There are some private companies providing ATIS/V. Some companies such as NAVTEQ acquire traffic data from some channels, including the public sector and other companies, which sell collected traffic data and fuse data by themselves. Some other ATIS/V providers such as XM Satellite Radio own distribution media and provide traffic information made by other companies. Additionally, various media such as FM radio or satellite radio are used.

3.1.2. Germany

Figure 3-3 provides the supply chain model of ATIS/V in Germany.



Source: Author

Figure 3-3: Supply Chain Model of ATIS/V in Germany

Public Data Collection and Access to Public Data

In Europe, RDS-TMC has been developed as a standard ATIS/V in the whole Europe and been implemented not only in Germany but also in other European countries. Therefore, the public sector in Germany collects traffic data by itself.

In Germany, the allocation of responsibility between the public and private sectors was clarified in the Federal Economic Forum Transport Telematics initiated by the Minister for Transport among policymakers from the federal government, the federal state and local authorities, and with leading representatives from private companies in 1995. In the Forum, it was decided that governments hold the responsibility to set policies and initiatives, and to provide basic information services related to the operation of the road infrastructure, but the private sector needs to plan, organize, and operate telematics service in competition (Federal Ministry of Transport, Building and Housing, 2004). After the creation of the Forum, a model contract about data provision from the public sector to the private sector was made. Developed in 1997, this model contract specified that a part of the public data is provided to the private sector free of charge (Fortin, Rupprecht, Beek, & Mulroy, 1998).

Private Data Collection

Based on the model contract for the installation of roadside equipment issued by the national transport ministry, the private sector is permitted to install and operate data collection systems by the public sector with an obligation to make it available to any service provider on equal terms (Austin, Walker, & Miles, 2002; Fortin et al., 1998). And a private company, Gesellschaft für Verkehrsdaten mbH (DDG), is established as a data collection company. In Germany, the public sector has encouraged private companies to join and compete in data collection phase of ATIS. However, there has not been competition in data collection stage of the supply chain. One private company, DDG was made in 1997 as a joint venture of T-Mobil (Deutsche Telekom) and Mannesmann Eurokom (the Autocom owner) in the collaboration in the traffic data collection stage between two companies, T-Mobile and Mannesmann Autocom, which are competing with each other in providing final products and services stage (Fortin et al., 1998). At this moment, DDG is a 100% subsidiary of T-Systems

Traffic GmbH which is a subsidiary of T-Mobile in 2004 (T-Systems Enterprise Services GmbH).

Public Data Distribution

Because RDS-TMC is a standard ATIS/V in Europe, Germany has a public nationwide ATIS/V, RDS-TMC. Traffic data distributed in RDS-TMC is received by in-vehicle devices such as car navigation systems with RDS-TMC compatibility which are provided by various electronics device manufacturers.

Private Data Distribution

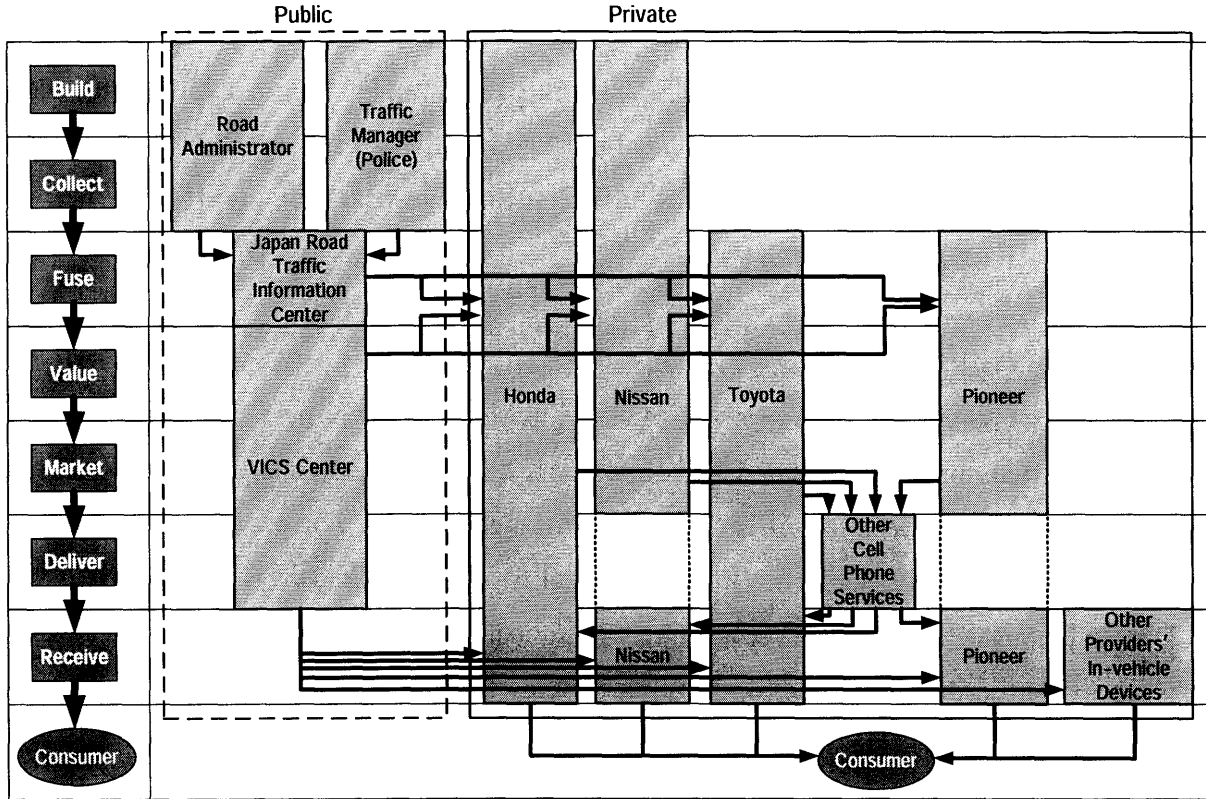
Some private companies have provided ATIS/V thus far. Though there has been only one data collection company, DDG, ATIS/V providers has conducted data processing, service provision, and dissemination of the information independently. For example, as of 1997, TEGARON Telematics GmbH, a joint venture of T-Mobile of Deutsche Telekom and debis Dimler-Benz Interservices, and Mannesmann Autocom provided TEGARON and PASSO, respectively (Fortin et al., 1998). Currently, T-Systems Traffic GmbH using data from DDG provides nationwide ATIS/V called TMCpro.

Other

Though this is not shown in Figure 3-3, states or local authorities have established its own services related to traffic information provision: for example, The Mobility Information Network in Baden-Württemberg, the Traffic Information Centre BAYERN INFO in Bavaria (Miles & Walker, 1998), and VMZ Berlin project in Berlin (Rupert et al., 2003). One reason for this phenomenon is the complexity of responsibilities for transport issues in Germany due to the federal structure of the German constitution. Regarding private-public cooperation, although national level cooperation is relatively restricted, some collaboration have been built at a regional or local level (Fortin et al., 1998).

3.1.3. Japan

In Figure 3-4, the supply chain model of ATIS/V in Japan is shown.



Source: Author

Figure 3-4: Supply Chain Model of ATIS/V in Japan

Public Data Collection and Access to Public Data

The nationwide data collection infrastructure has been built by the public sector and operated by a quasi-public corporation, Japan Road Traffic Information Center (JARTIC). JARTIC gathers traffic data from road administrator and traffic manager (police) and provides traffic data to the Vehicle Information and Communication System Center (VICS Center), another quasi-public corporation, serving the nationwide ATIS/V.

By the revision of the road traffic law in 2001, traffic data which was exclusively controlled by JARTIC was released to the private sector. Since then, private companies that get traffic data from JARTIC have been able to join the ATIS business by editing or using the

purchased traffic data (Ikoma & Satake, 2004). Although the public data can be provided to the private sector after the revision, the public data is not free. Private companies have to pay fees to JARTIC to get data.

Private Data Collection

No private companies have installed traffic sensor networks on the road. Because the public sector does not permit the right for the private sector to use roads, building sensor networks on the road is not feasible. However, because of the technology development, the probe vehicle system has become feasible and Honda and Nissan have built its own probe system (NISSAN MOTOR CO., LTD.).

Public Data Distribution

VICS Center distributes real-time traffic information nationwide. In the distribution, three media are used: radio wave beacons, infrared beacons, and FM multiplex broadcasting.

Private Data Distribution

There had been some restrictions for private companies to collect, edit, or provide traffic information. After the revision of the road traffic law in 2001, private companies have become permitted to provide ATIS/V and some companies such as automotive manufacturers and device manufacturers have started their own ATIS/V: because there are some inconveniences in VICS, private companies provide new ATIS/V beyond VICS.

3.2. Summary

As a part of this thesis, this chapter analyzes the allocation of responsibility between the public and the private sector in ATIS/V from the perspective of the supply chain, an important factor which affects the development of ATIS/V. The results are summarized in Table 3-1 and Table 3-2. In addition, types of existing ATIS/V in the three countries are summarized in Table 3-3. In the analysis of this chapter, as expected, large differences are found in the allocation of responsibility between the public and private sectors, in how much the public sector support ATIS/V in the supply chain, and in whether the public sector has the

responsibility to operate an ATIS/V in the three countries. The order of countries in the strength of the degree of dependence on the public sector can be the following: Japan, Germany, and the U.S.

Table 3-1: Summary of Allocation of Responsibility for Data Collection

	Allocation of Responsibility for Data Collection
U.S.	<ul style="list-style-type: none"> • The public sector has encouraged Public-Private Partnership. • Various types of regional or local data collection systems are built. • A private company has started to build own data collection network.
Germany	<ul style="list-style-type: none"> • The public sector has nationwide data collection network. • Some of public data is given without fees to the private sector. • The private sector has been encouraged to build its own data collection network. • One private company DDG has been established to collect data due to collaboration of some private companies.
Japan	<ul style="list-style-type: none"> • The public sector has nationwide data collection network. • Public data is sold to the private sector. • Some private companies have started to build its own data collection network.

Source: Author

Table 3-2: Summary of Allocation of Responsibility for Data Distribution

Allocation of Responsibility for Data Distribution	
U.S.	<ul style="list-style-type: none"> • The public sector does not have any data distribution services. • Some private companies have started nationwide data distribution services.
Germany	<ul style="list-style-type: none"> • As a standard of Europe, RDS-TMC has been provided by the public sector. • Some private companies have provided nationwide data distribution services.
Japan	<ul style="list-style-type: none"> • The public sector has a nationwide data distribution service, VICS. • Some private companies have provided nationwide data distribution services.

Source: Author

Table 3-3: Types of Existing ATIS/V: Public-driven or Private-driven

Countries	Public-driven ATIS/V	Private-driven ATIS/V
U.S.	-	X
Germany	X	X
Japan	X	X

Source: Author

In this chapter, the allocation of responsibility between the public and private sectors in the supply chain is analyzed using the new supply chain model for ATIS/V developed from McQueen's model of ATIS. In this analysis, the difference among the three countries is clarified. This difference is one important factor which affects the development of ATIS/V and causes the difference in the penetration of ATIS/V in the U.S., Germany, and Japan.

However, there are other factors. Therefore, further analysis is conducted in the following chapters to understand why ATIS/V in some parts of the world has more penetration than that

in others and what can be done to increase the penetration of those services. In Chapter 4, various factors in the penetration dynamics are identified and analyzed. As one of those factors, the allocation of responsibility between the public and private sectors in the supply chain identified in this chapter is discussed. Furthermore, this analysis of the supply chain of ATIS/V will be utilized in Chapter 5.

Chapter 4 Qualitative Analysis of the Difference in ATIS/V Penetration

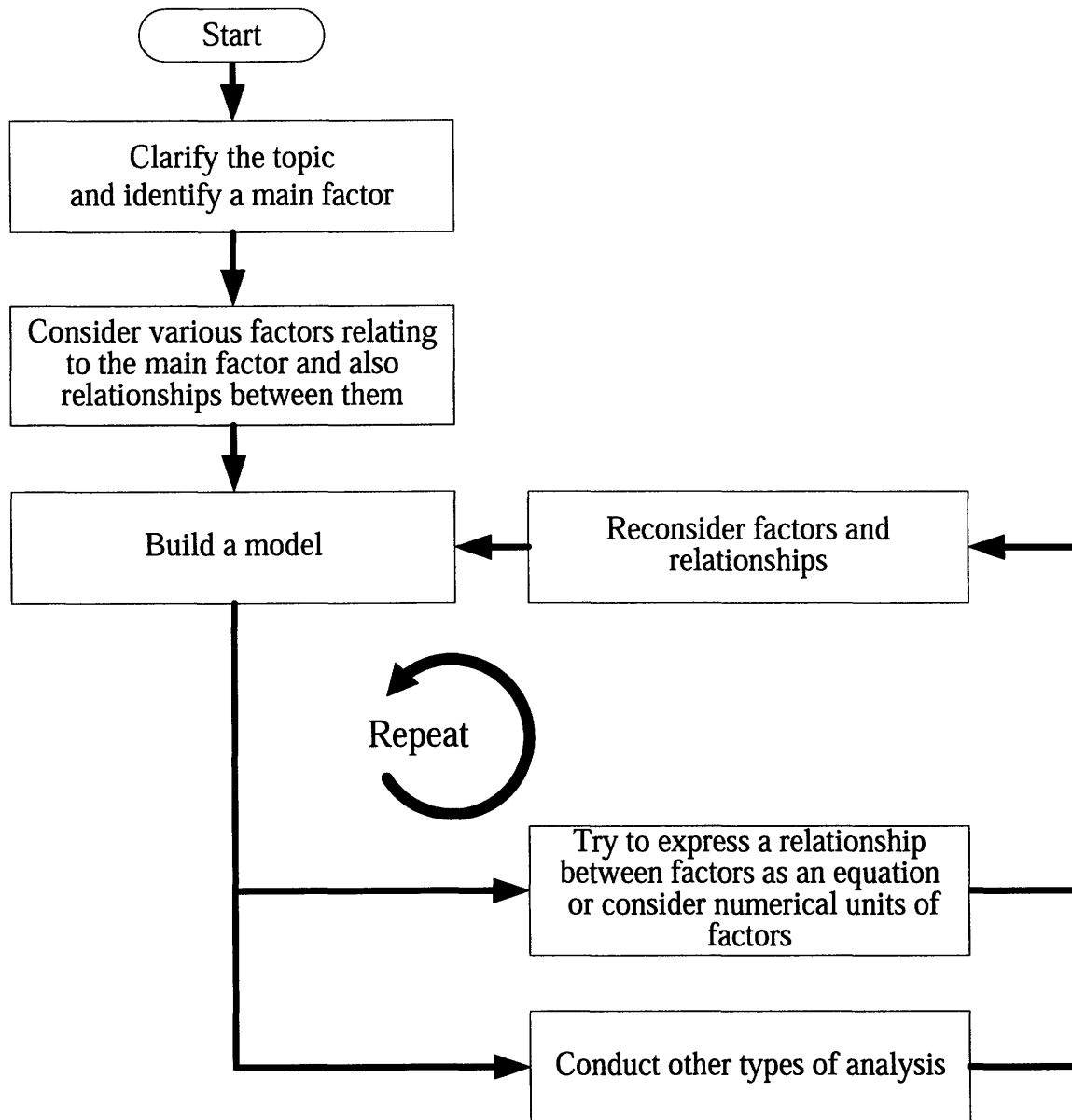
4.1. Methodology

In order to analyze the difference in the penetration among three countries, the U.S., Germany, and Japan, the system dynamics methodology is used to clarify complex relationship regarding penetration since it allows us to understand complicated structures and main causal relationships. The system dynamics methodology can be used not only qualitatively but also quantitatively. In this thesis, a qualitative analysis is conducted. Because a lot of assumptions or equations relating factors are necessary for quantitative analysis of a system dynamics model, it is too difficult within the scope of this thesis to calculate sufficiently convincing results from very complicated system dynamics model. On the other hand, the qualitative analysis can sufficiently provide an integrated understanding of the dynamics of the penetration and sources of the difference in the penetration of ATIS/V.

There are various ways of developing a model in system dynamics methodology. In this thesis, the following steps are conducted to make a penetration model as shown Figure 4-1. The first is clarifying the topic for which dynamics are to be described in a model. In this case, the topic is the penetration of ATIS/V. Therefore, the number of ATIS/V users is focused on as the main factor of the penetration of ATIS/V.

In the second step, various factors relating to the main factor and also relationships between them are considered. Because these factors and relationships are repeatedly re-considered and modified, the first trial to make a model will be at a macro scale. In repetitive processes, a factor may be divided into some sub-factors, or new factors may be added into the model, or new relationships may be added between new factors. Additionally, from the author's experience, trying to express a relationship between factors as an equation or considering numerical units of factors seems to be helpful to clarify a relationship. Moreover, in the research, new understandings or results from other analyses are usually found. These new findings are important to build a holistic view of the dynamics. In this thesis, to reflect the

findings from the analysis based on the supply chain model in Chapter 3, some factors, such as public sector's responsibility for data collection or data distribution, are added to the penetration model.



Source: Author

Figure 4-1: Process to Build a System Dynamics Model

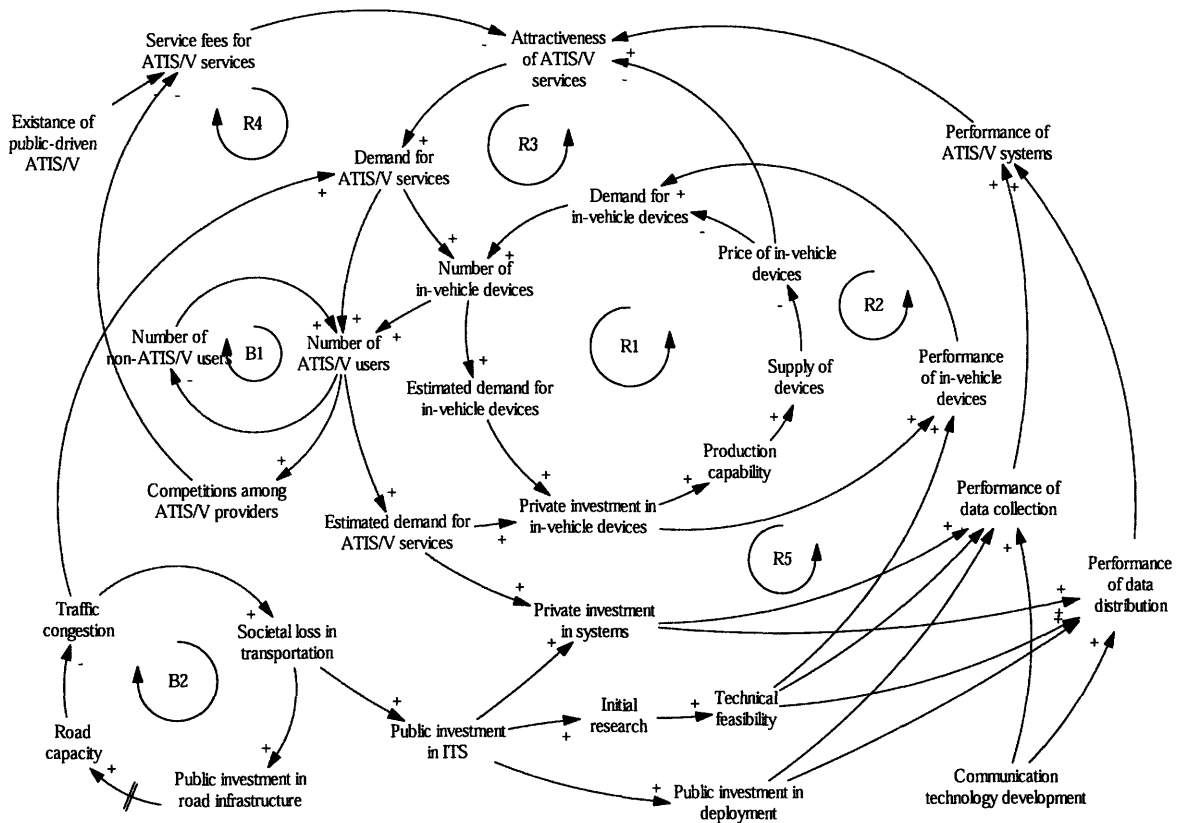
In brief, the most important thing is to refine the dynamics model repeatedly through the research. Based on the dynamics model of the penetration of ATIS/V which is conducted as

above, this section analyzes the difference in the penetration among three geographical areas: the U.S., Germany, and Japan.

First, in Section 4.2, the basic model including major factors in the penetration is presented. Because a system dynamics model of the penetration of ATIS/V becomes very complicated and prevents readers from understanding the model easily, the basic model provides the basic concept of the penetration first to simplify the understanding the penetration dynamics. For this reason, some factors are simplified in the basic model. However, because the basic model is not enough to cover all of elements of the penetration dynamics of ATIS/V, the detailed model will be provided in Section 4.3.

4.2: Basic Model of the Dynamics of the Penetration of ATIS/V

Figure 4-2 is the basic model of the dynamics of the penetration of ATIS/V. First, demand for ATIS/V services is one of the most critical sources of the penetration model since it directly relates to the number of ATIS/V users. Because the demand comes from the need to mitigate the bad effects of traffic congestion, the demand is directly related to the perceived situation of road traffic such as traffic congestion. Next, when demand for ATIS/V services increases, the number of ATIS/V and the estimated demand for ATIS/V services will increase. The estimated demand for ATIS/V services is necessary to increase private investment, one of the other important factors in the model: unless there is a profitable market with sufficient demand, private companies will not participate and the penetration enhancing loops will not work well.



Reinforcing Loop	Balancing Loop
R1: Supply and growth of in-vehicle devices market	B1: Limit of the continuous increase in the penetration
R2: In-vehicle devices development by private investment	B2: Societal problem about road traffic
R3: Interaction between demand for ATIS/V services and in-vehicle device market	
R4: Interaction between service fees for ATIS/V services and demand for ATIS/V services	
R5: ATIS/V systems development by private investment	

Source: Author

Figure 4-2: Basic Model of the Dynamics of the Penetration of ATIS/V

Even if there is huge potential demand for ATIS/V services, people will not pay for ATIS/V services when those services are not attractive. Customers have to purchase relatively expensive devices in order to receive real-time traffic data. Also most real-time traffic data providing services are not free. That is, in some cases, customers need to buy both in-vehicle devices and the information. Therefore, ATIS/V can be an expensive product and service combination. Unlike for ego-expressive or low-price products or services, customers usually

have perceived needs for products or services and are sensitive to services' quality. Therefore, customers make choices through the trade-off criteria between price and quality. That is, those two factors are connected to the attractiveness of ATIS/V services. Because users typically need to purchase in-vehicle devices and also to pay service fees, there are two factors regarding price in this model: price of in-vehicle devices and service fees for ATIS/V services.

Although many factors affect the attractiveness of ATIS/V services directly or indirectly, four series of flows contribute to it fundamentally. First, public investment enhances the attractiveness of ATIS/V services by increasing the performance of ATIS/V systems. There are two major flows by which public investment improve the performance of ATIS/V systems. One is initial research and the other is public investment in deployment. Initial research increases technological feasibility of ATIS/V systems. By this flow, the performance of in-vehicle devices, data collection, and data distribution are increased to the commercial level. Therefore, this flow is important in the early phase of the development. In contrast, public investment in deployment is used for the deployment of ATIS/V system. By this flow, developed technologies are implemented and ATIS/V services can be launched.

Any ATIS/V systems can be divided into two parts, data collection and data distribution, from the traffic data supply chain perspective. The two flows from public investment strongly affect the development of both parts. The development of data collection performance, such as the development of sensors, and the coverage of freeway, highway, or surface roads are important for the accuracy of provided real-time traffic data. Generally the investment in traffic sensor infrastructure mainly relies on public investment since the installation of traffic sensors on the roads in wide areas has huge costs and road infrastructure typically belongs to the public sector. Regarding data distribution, public investment can be used to build the communication network to distribute traffic data to in-vehicle devices. The public investment is determined according to the current situation of road traffic such as the amount of societal loss from traffic congestion or the road capacity. In addition to the two major flows, there is a flow from public investment in ITS to private investment in systems. This flow means the public support to the private sector to invest in systems.

Second, private investment is another important factor for the penetration of ATIS/V. There are two types of private investment which came from estimated demand for ATIS/V services: that for systems and that for in-vehicle devices. As shown in Reinforcing Loop 5, by investment in systems, private companies can increase the performance of ATIS/V systems since private companies can provide more sophisticated services than the public sector by adding traffic data collected by the private sector or by providing combined traffic data from different areas. On the other hand, private investment in in-vehicle devices develops the performance of in-vehicle devices. The increase in the performance improves the demand for in-vehicle devices and develops the in-vehicle devices market as shown in Reinforcing Loops 2. Reinforcing Loops 1 and 3 provide the other flow from the private investment in in-vehicle devices to the price of in-vehicle devices. In the two loops, the decrease in the price of in-vehicle devices, which caused by the increase in the supply of in-vehicle devices, results in the growth of in-vehicle devices market and the increase in the attractiveness of ATIS/V services by reducing the cost to have ATIS/V services, respectively. Although usually these loops do not work in the early stage of the industry development, once they start, the number of ATIS/V users increases rapidly since these loops are reinforcing loops.

Third, communication technology development also improves the performance of ATIS systems. Communication technology development enables probe vehicle systems, which enhances the quality of real-time traffic data. As advanced technologies to disseminate data, high speed data communication broadcasting, such as satellite radio, can enable sophisticated ATIS services in which drivers can receive more timely or detailed traffic data.

The fourth flow is Reinforcing Loops 4 which comes from the competitions among ATIS/V providers. A competition decrease service fees for ATIS/V services and the decrease in service fees increases the attractiveness of ATIS/V services. Service fees for ATIS/V services are affected by the existence of public-driven ATIS/V since public-driven ATIS/Vs provide services at a cheap price.

Balancing Loop 1 suggests that there is a limit to the continuous increase in the penetration

of ATIS/V. That is, although the number of ATIS/V users will increase rapidly at the beginning, the pace of the increase will slow due to the decrease in the number of people who do not have ATIS/V services. In addition, Balancing Loop 2 explains the societal problem from road traffic. Traffic congestion can be reduced by investment in the road infrastructure. However, building road infrastructure usually takes a long time.

In this section, major factors in the penetration model are clarified. Some factors are simplified to grasp the basic concept of the penetration easily. However, the basic model is not enough to cover all of major elements in the penetration of ATIS/V. In the following section, the detailed model covers all elements of the penetration dynamics.

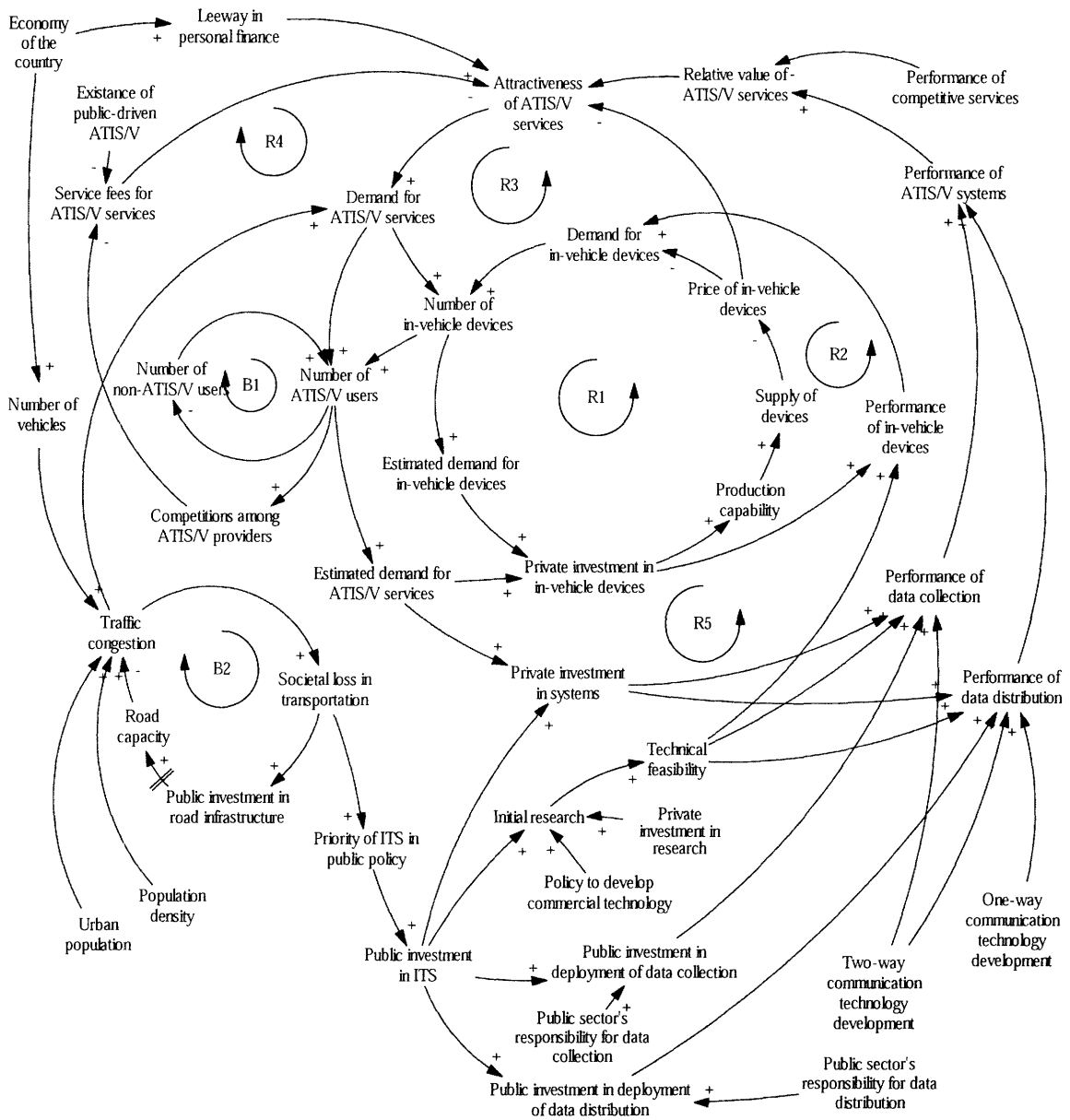
4.3. Detailed Model of the Dynamics of the Penetration of ATIS/V

In this detailed model, many external factors are added and also some factors in the basic model are separated into more factors.

An external factor added in the detailed model is the performance of competitive services. Here, competitive services means any ATIS services except ATIS/V: competitive ATIS/V services are not included. This external factor affects the relative value of ATIS/V services. This is critical for the development of ATIS services since people's recognition of value of ATIS/V depends on benefits of the service relative to the benefits of competitive services. That is, the attractiveness of ATIS/V from users' perspective can be changed by competitive services. If such competitive services are very attractive, ATIS/V services do not seem especially attractive.

Another big difference between the basic and detailed model is the flow of public investment. First, the priority of ITS in public policy and the policy to develop new industry are added as factors to determine public investment. Furthermore, the public sector's responsibility is added into two flows from public investment in deployment to data collection or distribution development. These additions indicate the difference in the public sector's responsibility for the development of ATIS/V. Furthermore, two factors, private investment in research and policy to develop commercial technology, are added to initial research.

Additionally, some other differences are added. First, communication technology development is divided into two-way and one-way communication technology. Second, as an external factor, the economy of the country is added. If the economy of a country is in good shape, it will increase personal income and also leeway in personal finance which stimulates private consumption will be increased. In addition, the number of cars will increase and traffic congestion will increase. Lastly, as other factors which increase traffic congestion, population density and urban population are added in the detailed model.



Reinforcing loop	Balancing loop
R1: Supply and growth of in-vehicle devices market	B1: Limit of the continuous increase in the penetration
R2: In-vehicle devices development by private investment	B2: Societal problem about road traffic
R3: Interaction between demand for ATIS/V services and in-vehicle device market	
R4: Interaction between service fees for ATIS/V services and demand for ATIS/V services	
R5: ATIS/V systems development by private investment	

Source: Author

Figure 4-3: Detailed Model of the Dynamics of the Penetration of ATIS/V

4.4. Analysis of Factors

Based on the system dynamics model shown in the previous section, in this section, major factors in the detailed model of the penetration of ATIS/V are analyzed. Each country will have its own strong or weak flow in the penetration model, and those differences result in the difference in the current penetration of ATIS/V.

As major factors in the detailed model, the following factors are analyzed in this section: population density, urban population, economic situation, number of vehicles, road capacity, traffic congestion, willingness to pay for ATIS/V, penetration effect of the allocation of the responsibility between the public and private sectors, public investment, private investment, data communication technology development, and competitive services.

4.4.1. Social Indicators

In this section, population density and urban population are investigated as basic social indicators. These social indicators can describe one aspect of the background of the situation of transportation such as traffic congestion in the three countries.

Population Density

Table 4-1 shows population density in the three countries. Not surprisingly, because the U.S. has a huge surface area, the population density of the U.S. is much lower than those of the other two countries. While the surface area of Japan is almost the same as that of Germany, the population density of Japan is much higher than that of Germany.

Table 4-1: Population Density

Indicators	U.S. (2005)	Germany (2005)	Japan (2005)
Population, total (million people)	296.5	82.5	128.0
Surface area (sq. km)	9,629,090	357,030	377,900
Population density (people per sq. km)	31	231	339

Source: The World Bank

Urban Population

Not only general population density, but also urban population is another important social factor related to transportation since high urban population (population concentration in cities) can worsen traffic congestion.

Table 4-2: Urban Population

	U.S. (2000)	Germany (2003)	Japan (2005)
Urban	79.2%	84.6%	66.0%
		(Including Semi-urban: 35.8%)	
Rural	20.8%	15.4%	34.0%

Source: Federal Statistical Office Germany, 2005a; Japanese Ministry of Internal Affairs and Communications Statistics Bureau, 2006; US DOT - Federal Highway Administration

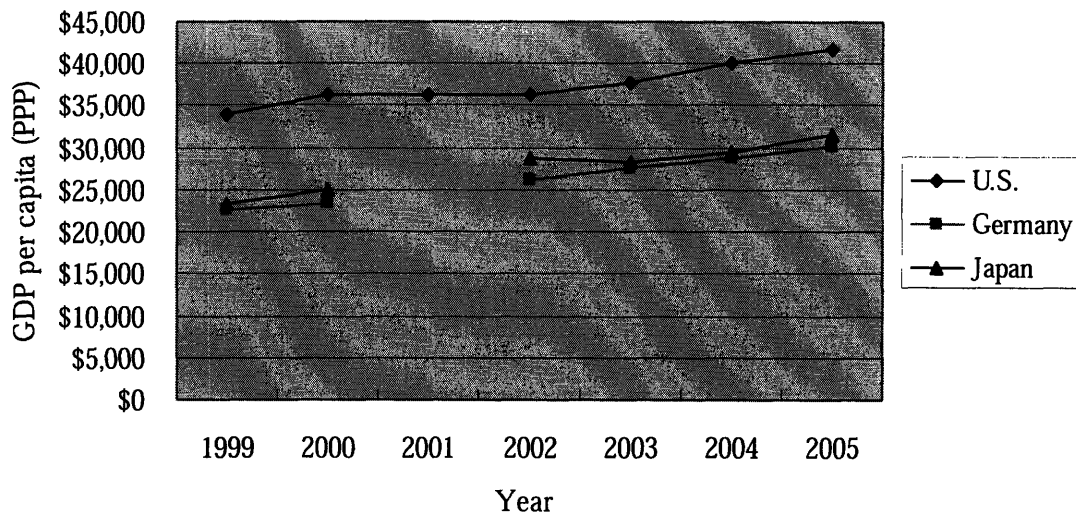
When we look only at the percentage of urban population in Table 4-2, the figure is larger in the U.S. and Germany than in Japan. However, this result may not correctly describe the real situation in the three countries. This phenomenon can be caused by the difference in the definition of urban area. Because the definition of urban area in Japan is much stricter than that in the U.S. and Germany, Japan might have the highest percentage of urban area residents. In the U.S., urban area is “core census block groups or blocks that have a population density of at least 1,000 people per square mile and surrounding census blocks that have an overall density of at least 500 people per square mile” (US DOT - Federal Highway Administration); 1,000 people per square mile is about 390 person/km². In Germany, urban area means an area with population density more than 1,250 person/km²: thresholds for semi-urban and rural area are 666 and 223 person/km², respectively (Federal Statistical Office Germany, 2005a). In Japan, “a Densely Inhabited District is defined as an area within a *shi*, *ku*, *machi* or *mura* that is composed of a group of contiguous Basic Unit Blocks each of which has a population density of about 4,000 inhabitants or more per square kilometer and whose total population exceeds 5,000” (Japanese Ministry of Internal Affairs and Communications Statistics Bureau). Furthermore, due to Japanese geographic characteristics, that is, its mountainous form, the Japanese population is concentrated in coastal areas. More than half of the population lives specifically in only three major

metropolitan areas, Tokyo, Osaka, and Nagoya. In addition, there are many regional centers with more than one million in population. Although the U.S. is showed to have the highest figure in the three countries in terms of the percentage of urban population calculated by each country with each definition, Japan or Germany may have a higher figure if the U.S.'s definition of urban population is used. In fact, because the Japanese threshold of urban area, 4,000 person/km², is about ten times stricter than the U.S.'s, 390 person/km², it seems to be reasonable to think that Japan may have a higher figure than the U.S.

In the investigation of social indicators, Japan has higher population density than the other two countries, and also in terms of urban population, Japan may have the highest figure of the three countries. Because these indicators are general and basic indicators, it is difficult to prove the strong relationship between these indicators and potential of traffic congestion. However, this result suggests that there has been more potential for traffic congestion in Japan than in the other two countries.

4.4.2. Economic Situation

Because ATIS/V is an expensive product and service, the economic situation affects the popularity of ATIS/V. To compare the economic situation at the individual level in the three countries, GDP (Gross Domestic Product) per capita at purchasing power parity (PPP) exchange rate, which measures per-capita wealth, is used as an economic indicator. As shown in Figure 4-4, GDP per capita in the U.S. is much higher than that in the other two countries. This indicator suggests that there is a large potential for an ATIS/V market in the U.S. In addition, generally the economic situation is improving in the three countries. Therefore, it seems that there is no special difficulty in the three countries in terms of the economic situation.



Source: CIA

Figure 4-4: GDP per Capita at Purchasing Power Parity

4.4.3. Road Traffic

The situation of road traffic, one basic factor of ATIS/V industry, should be clarified. Transportation is essential for social and economic life, and the social loss or personal stress caused from traffic congestion causes a demand for ATIS/V.

In this section, two factors in the three countries, the number of vehicles and the road capacity, are examined to grasp the difference in the situation of road traffic.

Number of Vehicles

Regarding the number of vehicles, Japan has a lower level of car ownership than the other two countries as shown in Table 4-3. These vehicles include truck and buses.

Table 4-3: Number of Vehicles Owned per Population

	U.S. (2005)	Germany (2005)	Japan (2005)
Vehicle in Use (thousand unit)	241,194	54,519	74,656
Car Ownership (vehicles/1000 people)	821	661	584

Source: Federal Statistical Office Germany, 2005b; Japan Automobile Manufacturers Association, INC., 2006; US DOT - Federal Highway Administration, 2006a

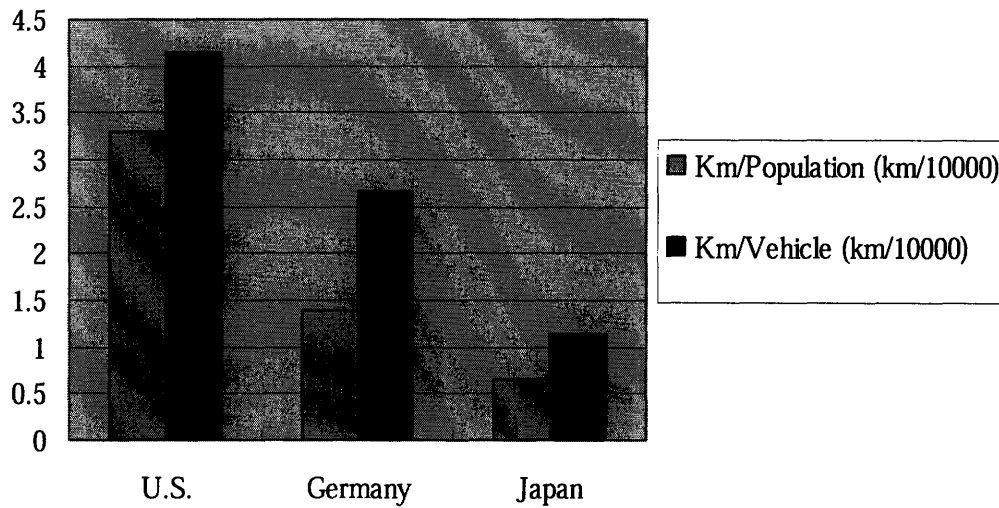
Road Capacity

Unlike Germany and Japan, the U.S. has a well developed road network as shown in Table 4-4. Furthermore, as Figure 4-5 shows, in terms of both km per population and km per vehicle, the U.S. has much better figures than Germany and Japan.

Table 4-4: Road Network

(Thousand km)	U.S. (2005)	Germany (2005)	Japan (2004)
Freeway and Expressway	91.5	12.2	7.3
Arterial Road	630.5	-	-
Collector Road	1,264.8	-	-
Federal roads	-	41	-
Länder roads/General national highways	-	86.7	54
District roads/Prefectural roads	-	91.6	129
Local Road/City, town and village roads	4406.3	-	997

Source: Federal Statistical Office Germany, 2005b; Japanese Ministry of Internal Affairs and Communications, Statistics Bureau & Statistical Research and Training Institute; US DOT - Federal Highway Administration, 2006a

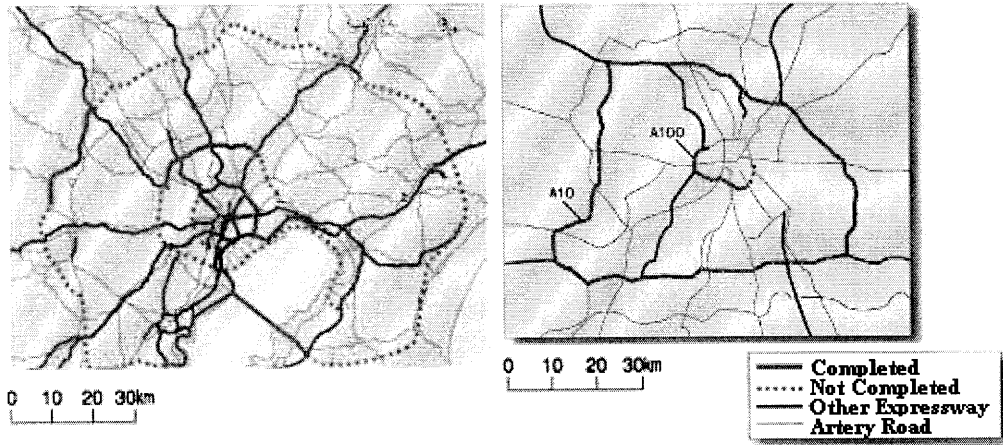


	U.S. (1999)	Germany (1999)	Japan (2002)
Length (km)	89,232	11,515	8,344
Km/Population (km/10000)	3.3	1.39	0.66
Km/Vehicle (km/10000)	4.15	2.66	1.14
Km/Land area (km/1000000 km ²)	95	323	221

Source: Japanese Ministry of Land, Infrastructure and Transport, Road Bureau

Figure 4-5: Highway Network

In contrast, the Japanese expressway network is relatively behind that of the U.S. and Germany. Especially the completion rate of three belt expressways in the Tokyo metropolitan area is far behind that of the other areas as shown in Figure 4-6. This delay in building the expressway system creates excessive traffic congestion in the Tokyo metropolitan area since much traffic has to pass through the center of the Tokyo metropolitan area (Japanese Ministry of Land, Infrastructure and Transport, Road Bureau). Furthermore, Japan's national highways are of the poor quality. Although the U.S.'s percentage of roads with more than four lanes is about 40%, the Japanese percentage is about 10% as shown in Figure 4-7.

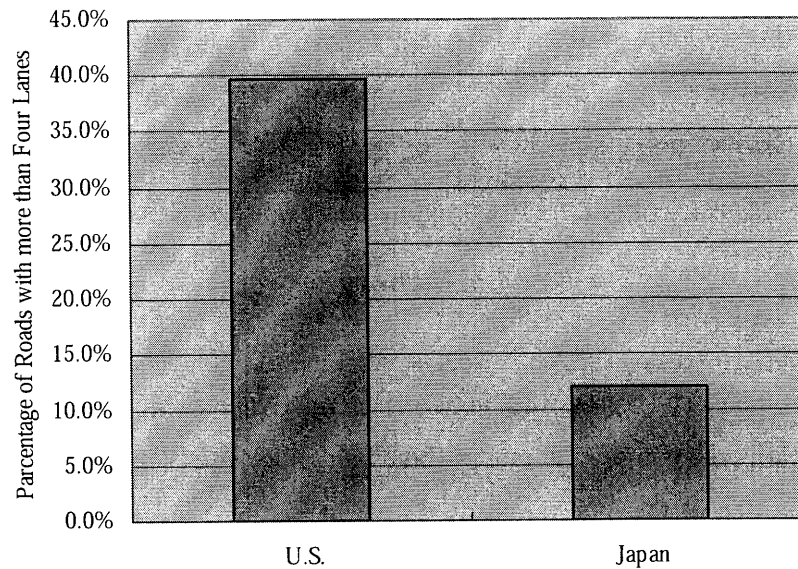


Tokyo: 23%

Berlin: 97%

Source: Japanese Ministry of Land, Infrastructure and Transport, Road Bureau

Figure 4-6: The Completion Rate of the Belt Highway System



Source: Japanese Ministry of Land, Infrastructure and Transport, Road Bureau

Figure 4-7: The Length of National Highway with More Than Four Lanes

From the analysis of road traffic among the three countries, it is found that the U.S. has the most well-developed road network with the largest number of vehicles, and that Japan has a smallest number of car ownership but the Japanese highway infrastructure is the worst in the

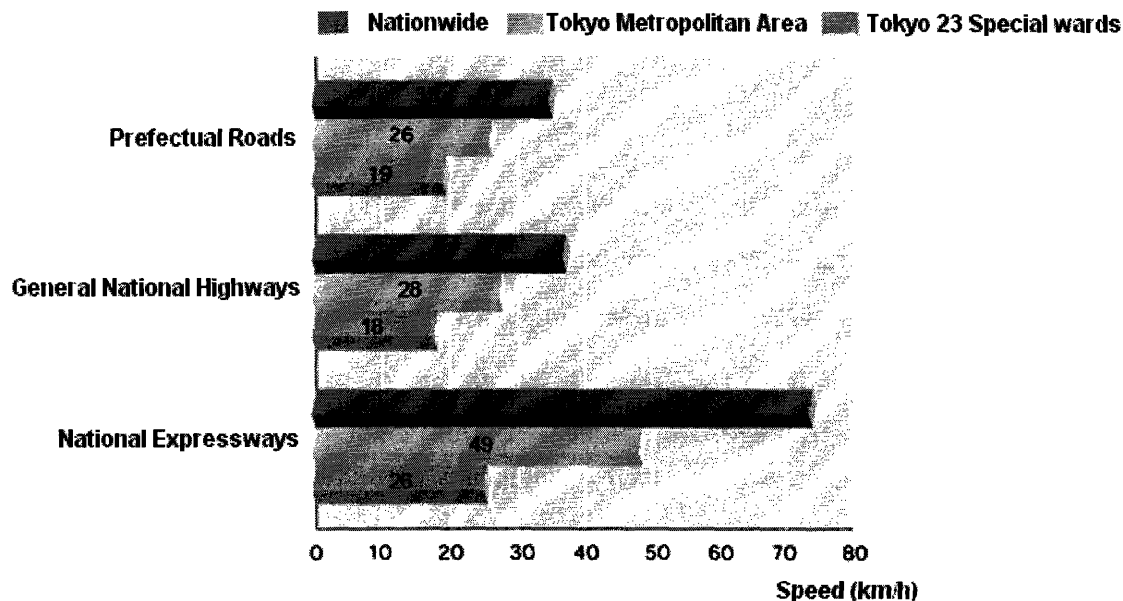
three countries in terms of length per vehicle. The capability of road networks is getting better in the following order: the U.S., Germany, and Japan.

4.4.4. Traffic Congestion

Traffic congestion is one of the major incentives to develop ATIS and ATIS/V since drivers in regions with more traffic congestion want ATIS to alleviate the impact of traffic congestion delay and control their time more than those in regions with less congestion.

In the U.S., congestion has grown in areas of any size and is becoming severe in larger areas. However, especially urban areas do not have enough capacity and traffic congestion in urban areas has been growing and becoming severer than in other areas. The 2005 Urban Mobility Report (Schrank & Lomax, 2005) shows that “congestion caused 3.7 billion hours of travel delay and 2.3 billion gallons of wasted fuel, an increase of 79 million hours and 69 million gallons from 2002 to a total cost of more than \$63 billion”. The report also warned that the current pace of improvement of transportation is not enough for forecast of major urban areas’ travel demand.

Although it is not easy to compare the level of congestion among the three countries, generally traffic congestion in two areas, Europe and Japan, has been considered worse than that in the U.S.: especially traffic congestion in Japan was thought considerably worse than in the U.S. (US DOT - Federal Highway Administration, 1996). Like in the U.S., in Japan traffic congestion in urban areas has become serious. Severe traffic congestion is a big problem too: by the calculation using the data from the Road Traffic Census 1997, time loss due to traffic congestion was about 30 hour/person in a year and total 12 trillion yen in a year (Japanese Ministry of Land, Infrastructure and Transport, 2004a). Especially in the Tokyo metropolitan area, vast amounts of traffic exist due to the heavy concentration of population and urban activities: time loss in the area is a third of national loss (Japanese Ministry of Land, Infrastructure and Transport, Kanto Regional Development Bureau, 2006) and the average speed in the area is far behind the national average as shown in Figure 4-8.



Source: Japanese Ministry of Land, Infrastructure and Transport, Kanto Regional Development Bureau, 2006

Figure 4-8: Average Driving Speed in the Tokyo Metropolitan Area

In the three countries that traffic congestion is becoming a serious problem. Although it is difficult to compare the level of traffic congestion among countries, it is generally recognized that traffic congestion in Japan is worse than in the other two countries. This seems reasonable since various factors relating to traffic congestion, such as higher population density and smaller highways length per vehicle, suggests that the situation of road transportation in Japan can cause traffic congestion more easily than in the other two countries.

4.4.5. Willingness to Pay for ATIS/V

Although it is difficult to examine the demand for ATIS/V and the attractiveness of ATIS/V services, willingness to pay can be used for an indicator of demand. Therefore, this section investigates willingness to pay for ATIS/V.

Unlike conventional ATIS, the flow of money in ATIS/V comes from individual customers. Although the information providers in conventional radio traffic information broadcast services get revenue from radio stations or advertisers without charging fees to drivers (Chan,

Malchow, & Kanafani, 1999), ATIS/V providers need to get revenue directly from the users of the information.

Generally, customers have to purchase devices which can receive the traffic information and pay monthly or annually service fee for the information. Therefore, the growth of ATIS/V depends heavily on the willingness to pay of individual customers. However, individuals' willingness to pay has not been high so far at least in Japan.

The sensitivity to the existence of service fees for ATIS/V was shown in Japan. The number of subscribers of Toyota's ATIS/V had not increased smoothly compared to the number of subscribers of Honda's ATIS/V when Toyota kept its stance to provide services with fees. However, after Toyota started providing some services without fees in May 2006, the number increased rapidly from 140,000 at the end of March 2006 to 300,000 at the end of June 2006 (Ashahi Shimbun, 2006). Another indication about willingness to pay is the success of VICS in Japan. In the VICS's billing system, VICS users do not need to pay service fee at all. Instead of the service fee, VICS users have to pay a royalty which is included in the price of the device. This billing structure eased the paying stress of users, and helped the increase in the penetration of VICS.

Although individual's willingness to pay in Japan seems low, the potential of the market for high quality real-time traffic information in the U.S. is shown by some studies about willingness to pay. Those studies show high need for AITS: 88% of people wanted ATIS in Harris' study (Harris & Konheim, 1995); in the analysis of a Bay Area traveler survey, 66% of respondents wanted traffic information and 73% of them, more people than expected, showed the willingness to pay for ATIS (Wolinetz, Khattak, & Yim, 2001). Although the high price elasticity was found in most surveys, consumers seemed to have some extent of willingness to pay (Wolinetz et al., 2001): New Jersey commuters valued basic corridor-specific services at \$3-\$4 per month (Beaton & Sadana, 1995); as relatively high demand holder, 78% of residents in New York would agree to pay a median of \$11 per month for dynamic information (Harris & Konheim, 1995). Furthermore, much higher willingness to pay was found in the survey for people who had the experience to use ATIS/V

(Mehndiratta, Kemp, Lappin, & Brand, 1999). Although the difference of the estimate of willingness to pay may depend on the type and quality of the service, the estimated willingness to pay ranged \$8-\$10, \$28-\$36, and \$8-\$20 per month in Seattle, Chicago, and Boston respectively. On the other hand, some surveys show the opposite results: “Less than 10% of internet respondents in Pittsburgh, and 27% in Philadelphia were willing to pay money for the traffic information” (Fekpe & Collins, 2003).

Willingness to pay is one of the most difficult factors to measure and to compare among the three countries. For instance, one study showed high willingness to pay to ATIS/V, but another showed the opposite. However, it can be said that there seems to be some willingness to pay for ATIS/V but it is not very high at least so far.

4.4.6. The Penetration Effect of the Allocation of the Responsibility between the Public and Private Sectors

As analyzed in Chapter 3, the allocation of responsibility between the public and private sectors in ATIS/V is totally different in the three countries. Since the amount of investment and how to invest differently affect the development of ATIS/V, the effect of the differences in the allocation of responsibility is analyzed in this section.

First of all, the existence of public-driven ATIS/V is a very important factor to differentiate the development of ATIS/V. As shown in Table 3-1, Table 3-2, and Table 3-3, in the U.S., although the public sector plays an important role in the development of the data collection by funding for the deployment traffic sensors on the road, the public sector does not provide ATIS/V by itself. On the other hand, the public sectors in Germany and Japan provide ATIS/Vs. If an expected demand for ATIS/V becomes large enough to encourage private companies to join the industry, the participation of the public sector may not affect the participation of the private sector, since even if there is no participation of the public sector, private companies will enter the industry voluntarily. However, when the market is small and its growth is unpredictable, the commitment of the public sector to ATIS/V can ease the risk of the private sector to participate since the risk of poor market response is borne by the public sector. For example, if the public sector in a country has a nationwide ATIS/V,

in-vehicle device manufacturers' hurdle of participation will be lower than a case without a public commitment. Therefore, the hurdle of the participation of the private sector in Germany and Japan seems to be lower than that in the U.S. In the U.S., some private sectors' commitment to support data distribution is necessary to the development of ATIS/V: this commitment is difficult to be made when the market is in the early phase.

Moreover, in the U.S., the public sector does not provide any ATIS/Vs, but instead of that, supports the national traffic information telephone service, 511 service: 511 was designated as a nationwide three-digit travel information telephone number in 2000 by the Federal Communications Commission (FCC) in response to USDOT's petition in 1999 (US DOT - Federal Highway Administration). This decision seems to be reasonable in terms of equity since the economical burden of 511 service is lighter than that of ATIS/V and more people can use 511 services than ATIS/V. Although the development of data collection for 511 services is beneficial for ATIS/V since the data collection can be utilized for ATIS/V as well, the existence of the strong competitive service has a negative impact to the development of ATIS/V in the U.S.

Second, the difference in the degree of dependence on the public sector in ATIS/V is also found in Chapter 3: the order of countries in the strength of the degree of dependence on the public sector is Japan, Germany, and the U.S. Relying on the public sector has a merit to have relatively huge funding to develop systems, but also has a demerit that the degree of the development depends on public policies.

4.4.7. Public Investment

Based on the structural characteristics of ATIS/V, the strength of both the public and the private sectors' investment in ATIS/V affects the progress of the development of ATIS/V. In the following two sections, the strength of both the public and the private sectors' investment in ATIS/V is analyzed.

Although conventional ATIS such as radio traffic reports has been developed independently regardless of the development of ITS, ATIS/V has been developed along with the

development of ITS. By following the path of ITS development in the three countries, this part analyzes the public investment and the public policy regarding the development of ATIS/V.

The U.S.

Research Phase

In the U.S., the start of ITS development was earlier than the other two countries, but the early research activity did not continue. As the early research program in the U.S., Electronic Route Guidance System (ERGS) was conducted by the Federal Highway Administration (FHWA) between 1967 and 1971. In this ITS prototype, vehicles equipped with on-board computers communicate with road infrastructure. However, this early development failed due to the denial of the funding from the transportation appropriations committee in Congress in 1971. Although the U.S. made the quickest start, this termination of development due to the lack of supports caused delay to some extent against Europe and Japan.

After the termination of research activities, the development of ITS resumed at the end of the 1980s. After ERGS, the U.S. did not make much progress in ITS development in the 1970s and the 1980s. However, the development of ITS was resumed by a non-official study team called Mobility 2000, which was organized in 1988. Mobility 2000 created the technical vision called IVHS (intelligent vehicle-highway systems) and also encouraged the participation of the public sector and industry. As a system relevant to ATIS of the four systems of IVHS, Advanced Driver Information Systems (ADIS) with the same technological vision of a vehicle-roadside communication with ERGS was conducted. In addition, in the early 1990s, the executive branch of the federal government including the FHWA, USDOT, and the first Bush administration, started to support ITS. Then IVHS AMERICA (Intelligent Vehicle Highway Society of America), renamed to ITS America in 1994, was established in 1990 as a not-for-profit organization to foster the use of advanced technologies in surface transportation systems.

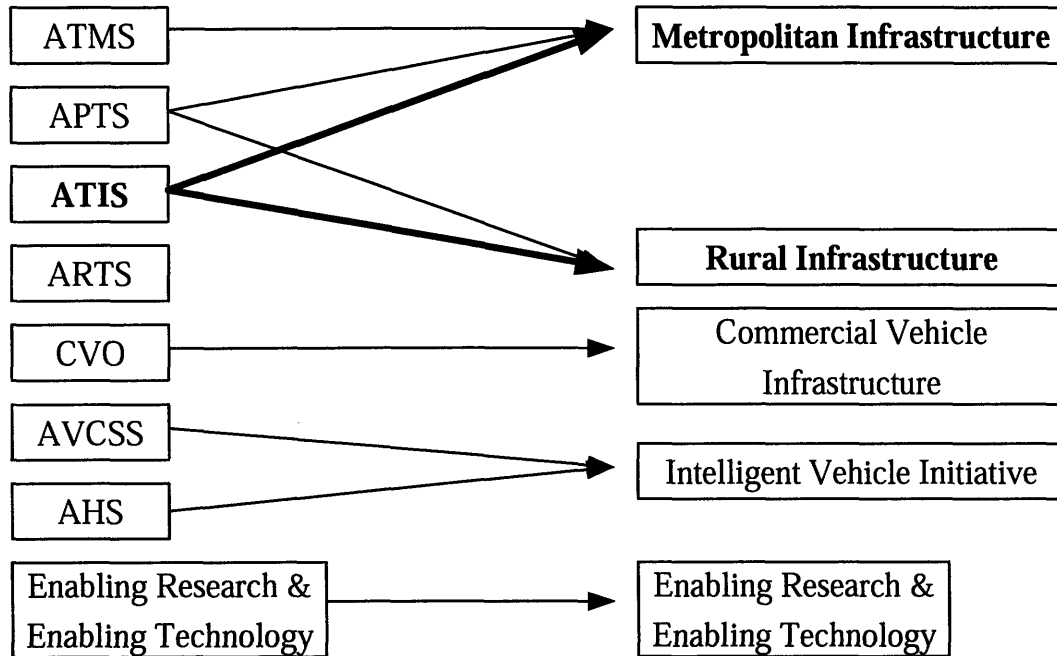
Since a new highway bill called the Intermodal Surface Transportation and Efficiency Act (ISTEA), the development of ITS has been officially supported. In 1991, ISTEA passed and

the development of ITS has been positioned as an important component in the transportation policy: under ISTEA, existing highway and transit infrastructure are required to be more efficient and safer, and intermodalism is emphasized (Maloney & Berler, 2000). Under ISTEA, ITS got \$659 million of public funding which was the largest funding in the world: the funding of U.S. ITS Program in 1992 increased ten times as much as that in 1991 (Klein, 1996). A lot of research projects have been conducted. Most of those research projects have been conducted at regional, state, or local level.

Since ISTEA was passed, the public sector has continued to support the development of ITS. At the beginning, as the grand design of ITS vision, the Strategic Plan for Intelligent Vehicle Highway Systems in the United States was produced by IVHS AMERICA in 1992. In 1995, The National ITS Program, which addresses goals, objectives, and milestones, was published by USDOT and ITS America. In the program, ATIS became a category included in the advanced metropolitan travel management systems, one of six broad areas of the program (Johnson, 1997). In 1996, a major ITS deployment goal, called Operation TimeSaver, was announced. Its goal was to reduce the delay of American travelers by at least 15 percent through deployment of ITS infrastructures in 75 of the nation's largest metropolitan areas by 2006. To support this goal, the USDOT launched the Metropolitan Model Deployment Initiative (MMDI) as an aggressive deployment of ITS at four urban sites: New York/New Jersey/Connecticut, Phoenix, San Antonio, and Seattle. In MMDI, 45% of the total 64 projects are traveler information projects: but some not all are related to ATIS/V (Alexiadis et al., 1998).

Deployment Phase

As an act following ISTEA, the Transportation Equity Act for the 21st Century (TEA-21) was enacted in 1998. This new act pushed ITS into the nationwide, integrated deployment phase from the research and field operational test phase. Under TEA-21, ITS projects authorized under ISTEA were restructured into two major areas, the Intelligent Infrastructure categories and the Intelligent Vehicle Initiative (US DOT - ITS Joint Program Office, 2003). As shown in Figure 4-9, ATIS was reorganized into Metropolitan ITS Infrastructure and Rural ITS Infrastructure in this structure.



Source: US DOT - ITS Joint Program Office, 2003, modified by author

Figure 4-9: Reorganization of Projects under TEA-21

Another important element of TEA-21 was the Intelligent Transportation Systems Deployment Program which consists of two programs, the ITS Integration Program defined in Section 5208 and the Commercial Vehicle Infrastructure Program in Section 5209. The program is a discretionary program to provide federal funding to the states and local jurisdictions. Federal funding can be used for each project as long as it does not exceed 50 percent of the cost of the project. Additionally, in this program, the private sector involvement, especially public-private partnerships, was encouraged.

In addition to the ITS deployment program, the Intelligent Transportation Infrastructure Program (ITIP) was authorized under Section 5117 of TEA-21 (Transportation Equity Act for the 21st Century, 1998): initially \$1.7 million was budgeted annually in order to build the Intelligent Transportation Infrastructure in the two largest metropolitan areas in Pennsylvania. In ITIP, USDOT awarded Traffic.com, under their former name, Argus Networks Inc., a task order worth approximately \$10 million for a demonstration initiative to build out an infrastructure in four metropolitan areas. TEA-21 allocated up to \$2 million in federal funds per metropolitan area, conditioned on \$0.5 million in non-federal matching funds in each

metropolitan area and an 80/20 federal to non-federal funding match overall. The first task order to Traffic.com allocated \$4 million to begin the creation of a digital sensor network in two metropolitan areas, Pittsburgh and Philadelphia. After that, the contract was amended to provide for an additional \$50 million to continue the deployment of their network in 25 additional metropolitan areas. That was by far the largest amount of money ever given to a company under the federal ITS program. In this program, Traffic.com can own the network and exclusive right to use the data commercially, but it needs to continue to provide traffic data to government agencies to keep owning these rights (Traffic.com).

After TEA-21 was started, one important movement relevant to ATIS was the start of 511, America's traveler information telephone number. In 1999, USDOT petitioned to the Federal Communications Commission (FCC) to designate a nationwide three-digit travel information telephone number. The American Association of State Highway and Transportation Officials (AASHTO) has established and leads a 511 Deployment Coordination Program with many other organizations including the American Public Transit Association (APTA) and ITS America, with support from USDOT (US DOT - Federal Highway Administration).

As the successor of TEA-21, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was enacted in 2005. Although ITS deployment started with TEA-21, SAFETEA-LU accelerates the transition from the research to the deployment phase. In order to handle increasing traffic congestion, SAFETEA-LU established three nationwide requirements for real-time information systems. First is the Real-Time Systems Management Information Program to establish capability in all states to provide real-time information. Second is the Transportation Technology Innovation and Demonstration (TTID) Program. Third is the nationwide development of 511 travel information. At this moment, the deployment of ITS infrastructures across the nation is in progress under SAFETEA-LU. Especially TTID is directly related to ATIS/V. It is an extension and expansion of ITIP initiated under TEA-21 with a contract with Traffic.com: 22 new congested areas were added; another opportunity was provided to 8 areas; awarding contracts are expanded on a competitive basis (US DOT - Federal Highway Administration, 2006b).

Germany

Research Phase

In Germany, the initial development of ITS has been lead by the private sector. In the 1970s, researchers at Bosch supported and planed a field test called ALI (Route Guidance and Information System for Drivers). With cooperation of other firms, Bosch and its partners conducted the ALI field test from 1979 to 1982. After the test, Bosch had focused on the development of in-vehicle devices which can operate without roadside infrastructure. Even though Bosch is a pioneer in ITS, Siemens would be a main contributor of deployment of ITS. Siemens lead by Von Tomkwitsch has developed a system called AUTO-SCOUT later renamed ALI-SCOUT which used infra-red communication between vehicles and roads. Then, beginning with Siemens's aggressive action, a city-wide field test called LISB (Leit- und Informationssystem Berlin, the Guidance and Information System, Berlin) conducted from 1985 to 1989 as the next step of the development. Both the public and private sectors participated in LISB and shared the cost. LISB proved the effectiveness of ALI-SCOUT system (Klein, 1996).

In addition, unlike the U.S., Germany had an agency which supported private companies to develop commercial technologies. The Federal Ministry of Research and Technology (MRT) provided public support and helped private companies in the research phase (Klein, 1996).

However, two events changed the environment for the development of ALI-SCOUT system. One was the reunification, a historically important change affecting all of Germany. It moved the use of the funding for transportation toward road construction in the East from other purposes. Another was the political change in Berlin and other cities. The new party in power was against ALI-SCOUT (Klein, 1996).

In contrast to the private sector's activities, the public sector had not supported the development of ITS well. At the deployment stage, there were some problems; the lack of public funds to implement the sensor network; the need of political approval to use public

infrastructure for the private sector. As a result, a proposed solution was the idea of establishing one sensor network operation company, in which German companies can participate. Then through cooperation with private companies, including electronics device manufacturers and automobile manufacturers, the CO-PILOT corporation was established to implement an ATIS/V in 1994 (Klein, 1996).

Because Germany is a country in Europe, the research projects at the European level have had a strong impact on the development of ITS in Germany. While ITS has been developed in Germany mainly by the private sector's initiative, pan-European approaches have started simultaneously. In the mid 1980s, European automakers started the PROMETHEUS program (Program for European Traffic with Highest Efficiency and Unprecedented Safety) in the pan-European EUREKA framework for industrial R&D: EUREKA was started in 1985 as a framework to develop commercial technology in order to increase Europe's competitiveness against the U.S. and Japan. The coalition was lead by Daimler. German automakers, defense firms, and institutes worked together. Eventually PROMETHEUS, a seven year program from 1986 to 1994 with estimated \$700 million cost, involved fourteen automobile manufacturers and some forty research institutes (Klein, 1996).

Another pan-European program called DRIVE (Dedicated Road Infrastructure for Vehicle Safety in Europe) started in 1988 by the European Commission of the European Union. Applying "telematics" technology to transport was the goal of the program. Later, DRIVE continued to DRIVE II, which started to conduct field tests in 1992. Both DRIVE and PROMETHEUS had the same vision; DRIVE was redundant. However, both programs were very broad and they could exist as complements: DRIVE focused on infrastructure systems; PROMETHEUS focused on vehicle systems. While the two programs were in progress, the European Road Transport Telematics Implementation Co-ordination Organization (ERTICO) was established as a non-profit independent corporation to help cooperation between the public and private sectors in 1991 (Klein, 1996). After DRIVE I and II, a series of EU framework research programs, 3rd, 4th, 5th, 6th, and 7th, has played an important role in ITS development of Europe so far.

In the 1992 Maastricht Treaty, the Trans-European Network (TEN) in transportation was defined and Directorate General for Transport (DG-VII) got the authority to promote the development. Under TEN, two sectors, Trans-European Transport Network (TEN-Transport) and Trans-European Telecom Network (TEN-Telecom) were established and many projects have been conducted. Regarding ATIS/V, RDS-TMC has been developed as a European standard and many of RDS-TMC field trials held between 1992 and 1994 (The European Broadcasting Union).

Deployment Phase

Since 1993, the federal government started tackling the introduction of transport telematics (Federal Ministry of Transport, Building and Housing, 2004). Then the Federal Economic Forum Transport Telematics, which involved many stakeholders from the public and private sectors, was initiated by the Minister for Transport in 1995 and allocation of responsibility between the public and private sectors was clarified.

At the European level, the introduction of RDS-TMC was recommended in 1995 as a priority action for the further development of the Trans European Road Network (TERN) in all EU Member States. With the support of DG-VII funding to implement RDS-TMC from 1996, the first operational RDS-TMC service started in a few EU member states including Germany in 1997 (The European Broadcasting Union). In 1997, a community strategy and framework for the deployment of road transport telematics in Europe was approved by the Council of the European Union and RDS-TMC was one prioritized action. Then some Memoranda of Understanding have been drawn up by EU countries and many key private sector actors instead of rigid European regulations. As of 1998, two major projects, FORCE (Enhanced Field Projects for Large Scale Introduction and validation of RDS-TMC Services in Europe) and ECORTIS (European Co-ORDination for the implementation of RDS-TMC Traffic Information Services) were in progress to support the development of RDS-TMC in the 11 EU Member States: the purposes of those programs include ensuring the compatibility of equipment or finalizing the development of RDS-TMC (COUNCIL OF MINISTERS OF TRANSPORT - EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT, 1998).

After that, road safety has been focused on as a goal of EU in the White Paper on European Transport Policy for 2010 published by the European Commission in September 2001: a very impressive target for road safety, a 50% reduction of road fatalities by 2010, was set (The eSafety Working Group for the Information Society DG, 2002). And eSafety started as “a joint industry-public sector initiative driven by the European Commission and co-chaired by ERTICO - ITS Europe and ACEA (Association of European Car Manufacturers), with the aim to promote the development, deployment, and use of Intelligent Vehicle Safety Systems to enhance road safety throughout Europe” (eSafety Support). In 2002, 28 recommendations suggesting possibilities and chances to improve safety on roads were published by the eSafety Working Group. Three of these recommendations related to real-time traffic and traveler information and one of the three is the support of the wider use of pan-European RDS/TMC network for safety-related traffic information. In addition, the Real-Time Traffic and Travel Information working group was established in 2003 as one working group in eSafety to support for the expansion of pan-European RDS/TMC network and to provide a report with the recommended actions to the European Commission on the status for RDS/TMC implementation. After presenting 12 recommendations in 2005, it completed the first task. However, the working group restarted in 2006 for further development and has conducted various activities including spreading and developing RDS/TMC (eSafetySupport).

Japan

Research Phase

First, the sectoral background which affected the initial development of ITS should be explained. In Japan, four industries and policy sectors were associated with ITS: the automotive, road transport, communications sectors, and the technology sector. Authority was fragmented. Regarding the nation’s road infrastructure, the National Police Agency (NPA) is in charge of urban roads, and the Ministry of Construction (MOC) is in charge of inter-urban expressways. In Japan, cooperation among ministries was difficult since each ministry tends to keep other ministries out of its well-defined authority. As a barrier regarding authority assembles, rivalries between NPA and MOC were a major factor (Klein, 1996).

In the context of the public sector in Japan, affected by ERGS, the early research program in the U.S., to some extent, Japan has started a similar program called the Comprehensive Automobile Control System (CACS) which also used on-board and roadside computers.

After CACS, though the involvement of the MOC and the NPA was a key to further ITS development, they were not willing to commit to ITS. At that time, Ministry of International Trade and Industry (MITI), whose institutional mission is to fund commercial technology development, had provided the funding for ITS and continued the development (Klein, 1996).

After that, due to the acquisition of communication infrastructure along expressways, the MOC changed its strategy and started the operational test called Road Automobile Communication System (RACS) which was carried out during 1984 to 1991. A series of field experiments with 91 road-side sets were conducted in a 350 km² study area between Tokyo and Yokohama from 1987 to 1988. Another important development related to ATIS/V in RACS was the start of the Digital Road Map Association through government funding to build a database for use as a standard for digital road maps (R, 1991). This development has helped the development of car navigation systems in Japan since digital mapping is an essential part of such systems. In contrast, the lack of this development makes it difficult to start car navigation services in the U.S. and Europe (Faculty of Science and Technology, Keio University).

After the launch of RACS, the NPA started its own field test due to the pressure from its rival's action, the MOC's RACS, and the availability of new communication medium called Teleterminal. In 1987, Advanced Mobile Traffic and Information and Communication System (AMTICS) was launched by the NPA. Following the ITS vision, the system provided traffic information to autonomous on-board systems. Both RACS and AMTICS have the same concept, providing traffic information to autonomous on-board systems. However, there is not technological compatibility between them since communication media used in those systems are different. After two field tests were conducted, AMTICS finished in three

years.

Because of the sectional fragmentation in public agencies, the research projects have been conducted separately. However, the research of ITS has been continued without termination and progressed more quickly than other countries with the support of MITI to continue the development of ITS. These research projects encouraged the technology development of car navigation systems which is one of the important elements of ATIS/V.

Deployment Phase

When AMTICS was finished, although technical development had progressed enough, there was an obstacle to make a single system since the two important agencies, the MOC and the NPA, did not want to collaborate with each other. Because of the industry's commitment to ITS and the lack of organized initiative among public agencies, the industry took initiative to proceed to the new unified system called Vehicle Information and Communication System (VICS) by proposing a planning organization called VICS Promotion Council to design the system and to create an organization to operate the system in 1991 (Klein, 1996). VICS became the first project in which agencies have collaborated each other (Uchida & Pursula, 2001). Since then, quite large amounts of public funding have been invested in the deployment of ITS including VICS and UTMS (Universal Traffic Management Systems) as shown in Table 4-5. After that, VICS started operation in April 1996 in the Tokyo Metropolitan area and expanded its service nationwide in 2003.

Table 4-5: The Budget for Deployment of ITS in Japan

	1995	1996	1997	1998	1999
NPA (million Japanese Yen)	20,244	24,192	27,492	24,083	25,767
MOC (million Japanese Yen)	23,561	34,695	40,500	48,272	59,200
MPT (million Japanese Yen)	230	675	975	900	1,800
Total (million Japanese Yen)	44,035	59,562	68,967	73,255	86,767

Source: Uchida & Pursula, 2001

After the start of VICS, though there has not been any major progresses about public-driven ATIS/V, ITS as a whole has been developed continuously. ITS has been recognized as a

national project gradually. In 1995, the principles of promoting ITS were included in "Basic Guidelines on the Promotion of an Advanced Information and Telecommunications Society" which was adopted by the Advanced Information and Telecommunications Society Promotion Headquarters headed by the Prime Minister. Then, five governmental bodies of that time jointly built a "Comprehensive Plan for Intelligent Transport Systems (ITS) in Japan" as a master plan of ITS in 1996. The importance of ITS as a national project continues by adopting the promotion of ITS in the e-Japan Priority Policy Program 2003, the IT Policy Package 2005, and the New IT Reform Strategy in 2006.

Summary of Public Investment

Although the way of supporting is different among the three countries, each has supported research projects. In Germany, a public agency, MRT, has supported research projects at the national level. Moreover, research projects at the European level have been conducted by EU member countries and Germany has been an important player in those projects. In the U.S., the federal government has led research projects with state or local government. In Japan, some national agencies have lead research projects.

Although all of the three countries supported research projects, there was a difference in the continuity of the public sector's investment. Although the U.S. has started ITS research first of the three countries, the development of ITS was stopped and was behind the other two countries in the 1970s and the 1980s due to the lack of policy to continue the research. On the other hand, the research of ITS has been conducted properly and continuously in Germany and Japan because of the continuous development program at the European level and the existence of agencies which support commercial technology development. Because some technological development steps such as field tests and operational tests are necessary to launch ATIS/Vs, the continuity of the research is important to conduct these steps continuously without delay and launch ATIS/V services smoothly. Therefore, the continuity of the research in Germany and Japan was a key for the early deployment of nationwide ATIS/V in the two countries, and this difference in the research phase affected the current difference in the development of ATIS/V.

The next point is that the timing when the shift from the research to the deployment phase happened was different among the three countries. In Japan, the deployment progressed after VICS project started in 1991. And its service started in 1996 and expanded nationwide in 2003. In Germany, the deployment also started in the early 1990s and RDS-TMC was launched in 1997. Lastly in the U.S., the deployment has been supported since TEA-21 was enacted in 1998 and in progress. Probably this difference in timing has been caused by the difference in the progress of research projects. However, this difference must be one of the essential factors which make the difference in the penetration of ATIS/V.

In all countries, ITS has been recognized as one important field to be developed. However, the timing when the development of ITS became a major national objective was different. In the U.S., ISTEA in 1991 was the beginning when the federal government supported ITS. In Germany, the federal government has addressed telematics since 1993. In Japan, in spite of early progress of ATIS/V, ITS became as a national project relatively late: it happened in 1995. It is interesting that the timing when ITS gained momentum as a national policy and the timing when ATIS/V started developing can be different. Because ATIS/V has been developed as one of the initial applications, this phenomenon could happen in Japan.

4.4.8. Private Investment

As with public investment in ATIS/V, private investment is an important factor affecting the development of ATIS/V. In this section, the difference in private investment is analyzed in two parts, investment in systems and in-vehicle devices. Here, systems include all parts in ATIS/V supply chain except in-vehicle devices. For example, data collection infrastructure, data processing centers, and data distribution infrastructure, are included in systems.

Systems

The U.S.

In the U.S., private investment has been encouraged in the public-private partnership (PPP) framework. Traffic.com has gotten an exclusive contract with the federal government under the Intelligent Transportation Infrastructure Program (ITIP), has invested money, and covers

many metropolitan areas, 17 major metropolitan areas as of 2005, with its traffic sensor networks.

Under contracts between public agencies and Traffic.com, Traffic.com provides data to the various federal, state and local agencies for non-commercial purposes such as research, planning, operations and congestion management. However, the federal, state and local government agencies may not provide the aggregated data to third parties for commercial purposes. Moreover, the state and local government agencies may not market, distribute or donate the privately collected real-time detailed data to non-governmental entities (Traffic.com).

Because the public sector does not hamper Traffic.com's commercial activities and Traffic.com has the exclusive right to market its traffic flow data for commercial purposes, the situation for the private sector may be better than that of Germany. However, there is a condition under this PPP framework in which Traffic.com needs to distribute a maximum of 10% of the related revenue to state or local government agencies or put the same amount of money in its systems (Traffic.com). In addition, although Traffic.com got the initial payments from government, it has the responsibility for deploying, operating and maintaining its sensor network without future government funding. Traffic.com can own the network and the exclusive right to use the data commercially, but it needs to continue to provide traffic data to government agencies to keep owning these rights (Traffic.com).

In the U.S., the PPP framework has led private investment in data collection by Traffic.com. However, the PPP framework in ITIP has a side effect - imperfect competition in the private sector. Although this development of ATIS by subsidies helped the private sector's participation and resulted in the early establishment of the new service and its market, it created disadvantages for all private companies except Traffic.com. ITIP did not make any regulations about prices and conditions of service about ATIS/V. However, ITIP actually affected entry conditions to data collection of ATIS/V since some extent of scale regarding infrastructure to collect data is necessary to provide traffic information service. If an entrant decides to have its own network to increase the quality of data, one of the huge barriers to

enter will be the cost of investment in a traffic sensor network. Even if the entrant tries to cover only one metropolitan area, the cost would not be small. In the nationwide business, the barrier becomes very difficult for entrants to overcome. Furthermore, Traffic.com gets advantages by building and owning sensor networks dedicated to travel information data collection. Because the quality of traffic information is essential in this business, high quality raw data collection and integration is the key to have high quality traffic information.

Recently this imperfect competition seems to be lightened due to the development of technologies. Several years ago, the methods to collect traffic data were limited and the sensor networks built with federal funding were very valuable. However, a probe vehicle system has become feasible due to technology development such as wireless communication. Actually, Inrix, established in 2004, has entered the market by this method and planned to expand its road coverage more than 47,000 miles and provide its service in 73 metropolitan areas as of December 2006 (Inrix, 2006).

Summarizing investment in data collection, there are two kinds of private investments. The first investment is encouraged by ITIP which caused imperfect competition. The other comes from the development of a new technology.

Another type of private investment is the participation in ATIS/V services. This kind of private investment has been active in recent years. Several nationwide ATIS/V services were started by some companies. XM Satellite Radio started the first ATIS/V named XM NavTraffic in the U.S. in October 2004: at the beginning, the service was provided to limited vehicles, the 2005 Acura RL and the 2005 Cadillac CTS (XM Satellite Radio, 2007). After the launch of XM NavTraffic, Clear Channel, Sirius Satellite Radio, and Navteq started their nationwide ATIS/Vs in January 2005, November 2005, and April 2006 respectively.

Germany

In Germany, as shown in Section 3.1.2, a huge amount of latitude has been given to the private sector to build and operate telematics services including ATIS/V. In other words, the public sector has expected the development of ATIS/V through competition among private

companies under unrestricted conditions. The public sector has carefully built such preferable condition for private companies' participation in the industry by allowing private companies to provide telematics services without special licenses (Federal Ministry of Transport, Building and Housing, 2004). Due to the effort of the public sector, a private data collection company DDG has been established by an alliance of some private companies. Although no competition among private companies has happened in data collection, competition has happened in providing services. As of 1998, TEGARON, a joint venture of T-Mobile of Deutsche Telekom and Daimler-Benz, and PASSO by Mannesmann Autocom have provided spoken telematics services with GSM phones: both companies did not have but planned dynamic navigation and route guidance (Fortin et al., 1998).

On the other hand, there has been a contradiction in Germany about policy for ATIS/V. Though the private participation in the industry has been encouraged by the public sector at the national level, at the same time at the Europe level, Germany has to have the public-driven ATIS/V, RDS-TMC, which must be a very strong competitor for private ATIS/V.

Japan

In Japan, because the public sector has a national ATIS/V called VICS, it has been difficult for the private sector to make a profit by ATIS/V. However, led by the growth of the market of car navigation systems, some automobile manufacturers and an electronics device manufacturer started two-way information telematics services including not only ATIS/V but also other services using cell phones in 1997 and 1998: first of all, Daimlers-Benz launched the Intelligent Traffic Guidance System (ITGS) which provided dynamic route guidance in 1997; Toyota Media Station started MONET (Mobile NETWORK) service in 1997; Honda Motor Co. begun Internavi service in 1998; Nissan initiated Compass Link in 1998. Those services are called the first generation telematics services in Japan (Faculty of Science and Technology, Keio University; ITS Research & Management Division, Highway Industry Development Organization, 1998). However, these first generation services did not succeed well. The lack of users' information technology literacy to use such telematics services, immature telecommunication technology, and the lack of understanding of the concept and

merits of telematics services were suggested as reasons for the failure (Kamio, 2004). As of October 2001, which is four years from the beginning, the total number of telematics subscribers had not increased much and was about 30,000. And ITGS stopped accepting new subscribers in spring of 2001 (Hansen, 2001).

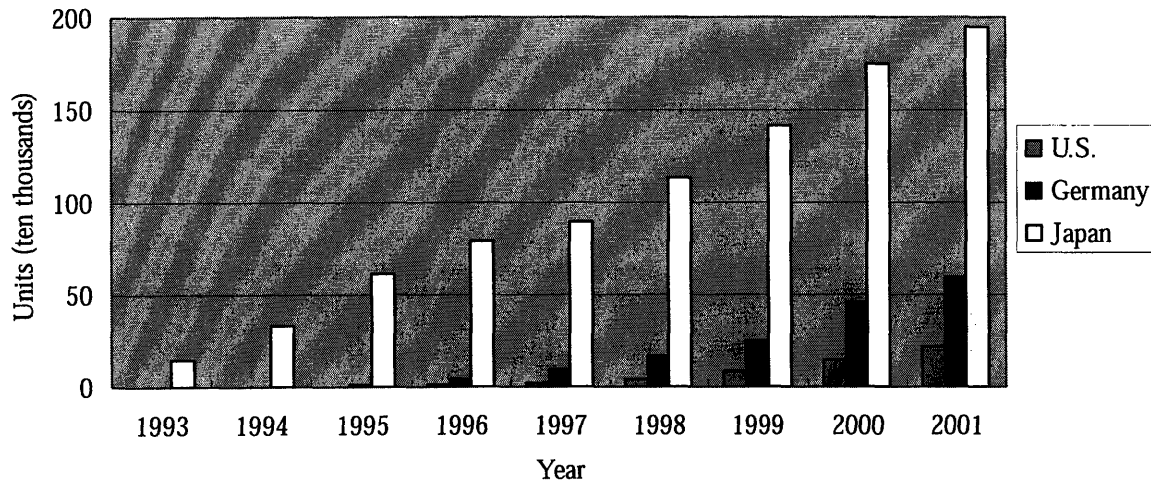
Due to the revision of the road traffic law in 2001, the private sector was allowed to provide high quality and value-added traffic information which differentiate their services from the public service, VICS. Until the revision, there had been a restriction of gathering, editing, and providing traffic information by private companies. Additionally, private companies had been prohibited from providing forecasts of traffic conditions since then.

Then as the second generation telematics services, the three automakers started providing their own new telematics services in 2002: Toyota's G-BOOK; Honda's Internavi Premium Club; Nissan's Carwings. In those services, ATIS/V is one of the key services. They have not invested to install traffic sensors on roads, but sophisticatedly processed traffic data provided by the public sector to provide higher quality traffic information than that of VICS.

Furthermore, the three companies have improved their ATIS/Vs. Honda provided the world's first ATIS/V using a probe vehicle system, named Internavi Floating Car System, and road congestion prediction function in 2003. Toyota launched G-BOOK ALPHA as an advanced version of its telematics service in 2005. In 2006, Nissan launched its third-generation Carwings service with a probe vehicle system (Nissan Motor Co., Ltd., 2006).

In-vehicle Devices

For ATIS/V, in-vehicle devices are an essential element in the supply chain. The development of an in-vehicle device market is a responsibility of the private sector. Figure 4-10 shows the market development of in-vehicle devices in the three countries.



Source: Faculty of Science and Technology, Keio University; Federal Ministry of Transport, Building and Housing, 2004; Japanese Ministry of Land, Infrastructure and Transport, Road Bureau, 2007; US DOT - ITS Joint Program Office, 1998a

Figure 4-10: Development of the Market of In-vehicle Devices

The U.S.

The start of the car navigation market in the U.S. was later than in the other two countries. Furthermore, the market has not developed smoothly.

In the U.S., electronics device manufacturers for automobile have been relatively weaker than those of Germany and Japan (Klein, 1996). In addition, because the need for safety and security applications has been bigger than that for real-time traffic information (Charles River Associates Incorporated, 1997), automobile manufacturers have supported safety and security applications such as Onstar services. Onstar, a subsidiary of General Motors, started its services in 1996 and its services have penetrated well in the U.S.: there were more than

4.5 million subscribers as of November 2006 (OnStar Corporation, 2006). In the Onstar system, services are provided without a display in the vehicles. Therefore, Onstar is not included in ATIS/V in the scope of this thesis.

However, the market for car navigation systems has certainly been expanding. J.D. Power and Associates reported that the number of models with factory-installed navigation systems grew nearly six times as much as that in 2000 and these systems' availability is expanding across a wide variety of vehicles, not only the luxury vehicles but also other vehicles (J.D. Power and Associates, 2006). Furthermore, as in Europe, in the U.S., demand for portable navigation devices such as PND has been growing rapidly in recent years. The sales in 2006 were expected to reach from 2.7 to 3 million units which is more than triple the sales in 2005 (Gilroy, 2006c). And also there is an estimation the sales will increase from 2 million in 2006 to 4 million in 2007 (TomTom, 2007).

Germany

In Germany, private companies have led research projects at the initial phase of ITS development: Bosch supported and planned a field test called ALI in the late 1970s, and has focused on the development of in-vehicle devices which can operate without roadside infrastructure. Siemens has developed a system called AUTO-SCOUT and led a city-wide field test called LISB in the 1980s (Klein, 1996). Moreover, the market for car navigation systems in Europe started in Germany. Germany has led the development of the market from the beginning. The private sector's investment has been strong. However, German market started later than Japanese market.

However, recently, the market for Personal Navigation Device (PND) has been expanding rapidly. The sales of portable navigation devices has been growing rapidly every year and been estimated to continue: from less than a half million units in 2004, the sales grew to 3.8 million units in 2005, to approximately 8 million unit in 2006, to 14 million unit in 2007 as an estimation (Gilroy, 2005; TomTom, 2006; TomTom, 2007).

Japan

In Japan, the market for car navigation systems developed much earlier than other two countries as shown in Figure 4-10. The automobile manufacturers led the commercialization of the first car navigation systems in the 1980s. Car navigation systems in the early days only provided the distance and direction to the destinations because digital maps have not developed well (Faculty of Science and Technology, Keio University). Devices with displays showing a map were introduced in 1987. After the Global Positioning System (GPS) became available in the early 1990s, some electronics device manufacturers provided many low-cost and easy-to-install post-assembly car navigation systems. It helped the expansion of the car navigation market considerably and dropped the price of those devices (Nakahara & Yamato, 1997).

In summary, in Japan, the investment in in-vehicle devices started earlier than in the other two countries and the market for devices grew quickly. In Germany, there has been the private investment in devices but the development of the device market has been far behind that of Japan. In the U.S., the status of manufacturers of electronics for automobiles and the different customer need, preferring safety and security applications, resulted in discouraging private companies from investing in in-vehicle devices for ATIS/V. Recently, the market for PND in Europe and the U.S. has been expanding quickly and the private companies' investment in devices has been active.

4.4.9. Data Communication Technology Development

Data communication technology development is an important factor in the development of ATIS/V since it affects the quality of ATIS/V services. There are two important characteristics of data communication technology. One is the data communication speed. High data communication speed enables ATIS/V providers to distribute detailed traffic information about broad areas to in-vehicle devices. The other is the direction of data communication: one-way or two-way communication. Although one-way communication such as radio broadcasting has been used as a main media so far, two-way communication can make a probe vehicle system feasible.

In the probe vehicle system, because additional traffic data, which cannot be collected by installed traffic sensors, is collected by vehicles with both two-way communication and probe compatible in-vehicle devices, the quality and the coverage of real-time traffic information are enhanced. To realize the probe vehicle system, vehicles need to have sensor devices. Furthermore, two-way communication is necessary to gather collected information for a data processing center. Because in-vehicle devices for ATIS/V can identify their locations using GPS technology, they are eligible to be sensors to collect traffic data. Therefore, two-way communication is a key element in the implementation of probe vehicle systems.

One important point about data communication technologies is the financial difficulty of building a data communication network. Although data communication technologies are very important for ATIS/V services, it is financially difficult to deploy a new communication infrastructure at local or nationwide level. Although the public sector can pay for the cost, it is unrealistic for ATIS/V providers in the private sector to invest much money in building such networks only for ATIS/V. Therefore, one reasonable solution for ATIS/V providers in the private sector is to utilize data communication networks existing in the market. Therefore, as an external factor, the development of data communication technologies affects the development of ATIS/V.

This section analyzes the development and diffusion of one-way and two-way communication technologies used in the three countries. Table 4-6 summarizes these technologies. Four technologies have been used as one-way communications in the three countries: analog FM radio broadcasting, digital radio broadcasting, satellite radio broadcasting, and radio wave beacon communication. As two-way communication technologies, two technologies are currently available for ATIS/V: cell phone digital data communication and infrared beacon communication. In the future, other technologies such as wireless LAN (Local Area Network) technologies, wireless MAN (Metropolitan Area Network) technologies including WiMAX (WiMAX Forum), and DSRC (Dedicated Short Range Communication), which has been designed for high-speed communications between

vehicles and the roadside, or between vehicles (US DOT, 2003), may be used for ATIS/V, but these new technologies have not been widely used so far.

Table 4-6: Communication Technologies in the U.S., Germany, and Japan

Communication Technologies	U.S.	Germany	Japan
One-way Communication			
• Analog FM Radio Broadcasting	X	X	X
• Digital Radio Broadcasting	X	X	X
• Satellite Radio Broadcasting	X		
• Radio Wave Beacon Communication			X
Two-way Communication			
• Cell Phone Digital Data Communication	X	X	X
• Infrared Beacon Communication			X

Source: Author

The U.S.

In the U.S., three one-way communications and one two-way communication are used for ATIS/V.

One-way Communication

- Analog FM Radio Broadcasting

First, analog FM radio broadcasting is one of the most popular data distribution technologies used in ATIS/V. Although analog FM radio broadcasting can be used not only as audio broadcast media but data broadcast media, it is used as the latter for ATIS/V. In the U.S., the Radio Broadcast Data System, which is almost the same as the Radio Data System (RDS) format used in Europe, is used to send traffic data with audio. This one-way broadcasting is an efficient and inexpensive medium for traffic information service. Although analog FM broadcasting is very popular and covers wide areas, its data transfer rate is not high. Therefore, it can be said that it is not suitable for more detailed advanced traffic information services.

- Digital Radio Broadcasting

To meet a need to send more detailed data, communication technologies with higher communication speed have been applied gradually. One of these technologies is digital radio broadcasting. Similar to analog FM radio broadcasting, data can be transferred simultaneously with audio and such data is used for ATIS/V. In the U.S., terrestrial digital radio has just started. A radio broadcasting company, Clear Channel, announced that it will start using HD (Hybrid Digital) Radio broadcast services for the real-time traffic service by the end of 2006 (Gilroy, 2006b). The popular terrestrial digital radio technology in the U.S. is the FM portion of In-Band, On-Channel (IBOC) technology which is recommended by the National Radio Systems Committee (NRSC). Because the data transfer rate of digital radio technology is 20 times faster than normal RDS network, this technology can provide more advanced services than analog radio technology: with digital radio technology, data can be sent at the rate of 1 to 33 kbps depending on the rate used for audio signal.

- Satellite Radio Broadcasting

Satellite radio broadcasting is a relatively new communication technology used in ATIS/V. As with other radio broadcast technologies, traffic data for ATIS/V can be sent with audio. Although satellite radio is not popular in Germany and Japan, it has become popular in the U.S. Because data is sent from satellites to wide area, it is a very efficient, one-way, nationwide data channel for vehicles, especially for a country with vast terrain such as the U.S. The data transfer rate of those systems is relatively higher than RDS: 64 kbps data channel is contained (The CAMP Vehicle Safety Communications Consortium consisting of BMW, DaimlerChrysler, Ford, GM, Nissan, Toyota, and VW, 2005). There are two satellite radio service providers in the U.S., XM Satellite Radio and Sirius Satellite Radio: XM Satellite Radio launched its nationwide services in November 2001 and had more than 7.1 million subscribers as of the end of the third quarter of 2006 (XM Satellite Radio, 2006c); Sirius Satellite Radio also had 5.1 million subscribers as of the end of the third quarter of 2006 (SIRIUS Satellite Radio, 2006). Then XM Satellite Radio and Sirius Satellite Radio started traffic information services in October 2004 and in November 2005, respectively. At

the beginning, those satellite radio receiver units in the vehicle were expensive options. However, the number of factory installed units is rapidly growing: in estimates for 2007, more than 1.8 million units will be installed in General Motors' vehicles (XM Satellite Radio, 2006b), and 0.65 million units will be installed in Honda's vehicles (XM Satellite Radio, 2006a).

Two-way Communication

- Cell Phone Digital Data Communication

A two-way communication technology used for ATIS/V is cell phone digital data communication. It seems to be the most suitable technology for the probe vehicle system at this moment since this technology has broad geographical coverage. In fact, a probe vehicle system using cell phone digital data communications launched in 2003 in Japan.

In the U.S., the penetration of digital mobile phones was relatively slow and digital service subscribers exceeded analog service subscribers in 1999. At that time, digital AMPS (Advanced Mobile Phone System), Cdmaone, GSM (Global System for Mobile Communications), iDEN existed (Federal Communications Commission, 2001). However, data transfer rate is very low. Now the most commonly used technology in the U.S. is CDMA (Code Division Multiple Access). As an advanced technology of CDMA, CDMA2000 1xRTT was introduced in 2002 with up to 70 kbps speed. Then a more advanced CDMA2000 1xEV-DO (Evolution-Data Optimized) (Rev.0) , whose speed is up to 700 kbps, was launched in 2003. Another major technology in the U.S. is GSM. As advanced GSM, GPRS (General Packet Radio Services), whose speed is up to about 60 kbps, started in 2001, and Enhanced Data rates for GSM Evolution (EDGE) , whose speed is up to 135 kbps, started in 2003 (Berlind, 2003). Then High Speed Downlink Packet Access (HSDPA) , providing average download speeds of 400-700 kbps, started in 2005 in limited markets, 16 cities (Stuart, 2006b). The development of cell phone data communication services in the U.S. has been slower than that in Japan and countries in Europe. However, at this moment, the data communication speed in the U.S. seems to be enough to realize probe systems.

Germany

Two one-way communications and one two-way communication are used in Germany.

One-way Communication

- Analog FM Radio Broadcasting

As with the U.S., analog FM radio broadcasting is used not only as audio broadcast medium but data broadcast medium in Germany. Traffic data can be transferred with audio by analog FM radio broadcasting in the Radio Data System (RDS) format.

- Digital Radio Broadcasting

As a technology of digital radio broadcasting, Digital Audio Broadcast (DAB) exists in Europe too. At this moment, however, DAB has not penetrated well. However, there is a possibility to penetrate broadly: Ondas forecasts that subscriber will increase to 0.38 million, 7million, and 36 million by the end of 2009, 2012, and 2019, respectively (VEGA RESEARCH Inc., 2006). In Germany, DAB started in 1999. Germany is one of the leading proponents of DAB: 82% coverage and over 160 stations broadcasting (World DMB Ltd., 2006). However, as of 2003, DAB has not developed well in most European countries due to the lack of receivers (Owen, 2004). Because devices compatible to digital radio are necessary to receive digital radio, digital radio is not popular at this time. However, it may be more popular than analog FM broadcasting in the future.

Two-way Communication

- Cell Phone Digital Data Communication

In Europe, each domestic cell phone market has developed differently in terms of penetration and services. Among the European countries, Germany is the largest market. Since 1992, the main stream in Europe has been GSM which is considered to be a 2G (the second generation) mobile phone system. GSM can be used as two-way data communication. However, its data transfer rate, 9.6 kbps, is not enough for advanced traffic information services. Since 2000, the called 2.5G (the second and half generation), GPRS has been popular. Although GPRS

has higher transfer rate than GSM and its theoretical rate is 115 kbps, its observed rate is up to 53.6 kbps, almost the same as an analog modem. In 2001, Vodafone Germany launched High-speed circuit-switched data (HSCSD). However, its technology is supported by only Vodafone and has almost the same data transfer rate as GPRS, 56 kbps. One technology with much faster data transfer than GPRS is EDGE technology: its transfer rate is 220 kbps. Only T-mobile, the largest mobile communications firm in Germany, has provided EDGE since 2006. Another technology, which is more popular than EDGE in Germany, is 3G (the third generation) technology, Universal Mobile Telecommunications Systems (UMTS), which was launched in 2004 by four major mobile operators. UMTS's data transfer rate is 384 kbps which is much faster than that of EDGE. Furthermore, as a more advanced technology of UMTS, HSDPA was launched in 2006 by three main operators and data transfer rate reached at 1 Mbps. In the future, HSDPA's data transfer speeds will be increased to 3.6 Mbps and another technology called high-speed uplink packet access (HSUPA) is planned to raise the speed to 20 Mbps in 2008 (Stuart, 2006a). The cell phone data communication services in Germany have been developed a little bit slower than that in Japan. However, its data communication speed has reached a high enough level for a probe vehicle system.

Japan

Japan has three one-way communications and two two-way communications.

One-way Communication

- Analog FM Radio Broadcasting

Analog FM radio broadcasting is used in Japan, too. In Japan, due to FM multiplex broadcasting technology, data of ATIS/V is sent to drivers simultaneously with audio in the same frequency band (Vehicle Information and Communication System Center).

- Digital Radio Broadcasting

In Japan, the experimental service of digital radio started in 2003 in the Tokyo and Osaka areas. As of April 2006, there were six channels in Tokyo and one channel has broadcasted VICS data (NHK (Japan Broadcasting Corporation)).

- Radio Wave Beacon Communication

Lastly, another one-way communication technology used in Japan is radio wave communication between vehicles and beacons installed on roads, mainly expressways. This technology can send data faster than analog FM radio broadcast: the data transfer rate of this technology is 64 Kbps. However, the transmission range of this technology, about 70m, is much narrower than that of FM radio broadcasting (Vehicle Information and Communication System Center). Therefore, to build a communication network by this technology, many beacons have to be located on roads. Although the other two technologies are mainly used for other services such as music, this application is dedicated to ATIS/V use in VICS.

Two-way Communication

- Cell Phone Digital Data Communication

Concerning cell phone digital data communication, Japan has been one of the leaders in the world. First, NTT DoCoMo started a digital mobile service which used Personal Digital Cellular (PDC) with 2.4 kbps in 1993. Then its speed was increased to 9.6kbps in 1996, and to 28.8kbps in 1997. In 1999, another technology called PHS (Personal Handy-phone System) provided 64 kbps data communication service. At the same time, cdmaone service also started with 64 kbps speed. In 2002, as advanced CDMA, CDMA2000 1xMC was introduced to deliver the speed of 144 kbps data communication. Furthermore, a more advanced CDMA2000 1x EV-DO was launched in 2003 to enhance speed to 2.4 Mbps. In 2001, NTT DoCoMo launched the world's first third generation UMTS network and achieved 384 kbps speed (NTT DoCoMo, 2006). In 2006, NTT DoCoMo started an advanced UMTS, HSDPA, and raised the data speed 10 times faster to 3.6 Mbps. In fact, mobile and PHS data communication have been used in ATIS/V services provided by some automakers: Honda provides special PHS cards for its services; Toyota provides "Data Communication Module" adopting CDMA2000 1x EV-DO (The Japan Corporate News Network, 2005).

- Infrared Beacon Communication

Infrared beacon communication has been adopted as one of the three communication methods in VICS in Japan. When a vehicle passes a beacon, which is located mainly on major ordinary roads, the vehicle can make two-way communication with the beacon. Although infrared communication seems not to be difficult technology, building a wide communication network is financially difficult since many infrared beacons needed to be installed, such as the case of radio wave beacons. In the VICS system, this technology is used only for ATIS/V, not for other objectives.

Summary of Data Communication Technology Development

Among various one-way and two-way communication technologies, two technologies, radio wave beacon communication and infrared beacon communication, are dedicated to ATIS/V use. As with the other technologies, making communication networks with these two technologies costs a great deal. Because the private sector typically cannot pay the cost, the public sector has invested in the networks with these technologies. However, the private sector has utilized communication technologies which are developed for other purposes.

The first communication technology available for the private sector was analog FM radio broadcasting. This technology has been popular and covers wide geographical area. Then new one-way communication technologies with a higher data transfer rate than analog FM radio broadcast were adopted for ATIS/V. Because the development of these high speed one-way communication technologies has been different among the three countries, adopted technologies for ATIS/V and the timing of service introduction differ in the three countries. The digital radio broadcasting seems to have been developed earlier in Europe than in the other two countries. However, even in Europe, the penetration of the technology has not increased greatly. As for satellite radio broadcasting, services with the technology have been expanding in the U.S. rapidly. As a result, satellite radio broadcasting has been used for ATIS/V. Because the technology has higher data transfer capability than analog FM radio broadcasting, ATIS/V with this technology has a potential to provide higher quality traffic information than that of analog FM radio broadcasting.

While one-way communication technologies have been developed, cell phone data communication technology, a two-way communication technology with high potential for ATIS/V, has been developed. As mentioned, because two-way communication technologies are a key element for probe vehicle systems, the development of cell phone data communication technology is important for the development of ATIS/V. In fact, in Japan, the most advanced country of the three in terms of cell phone data communication, a commercial probe vehicle system was launched earlier than in the other two countries. As the technology is developed, probe vehicle systems have been introduced in Germany and the U.S.

4.4.10. Competitive Services

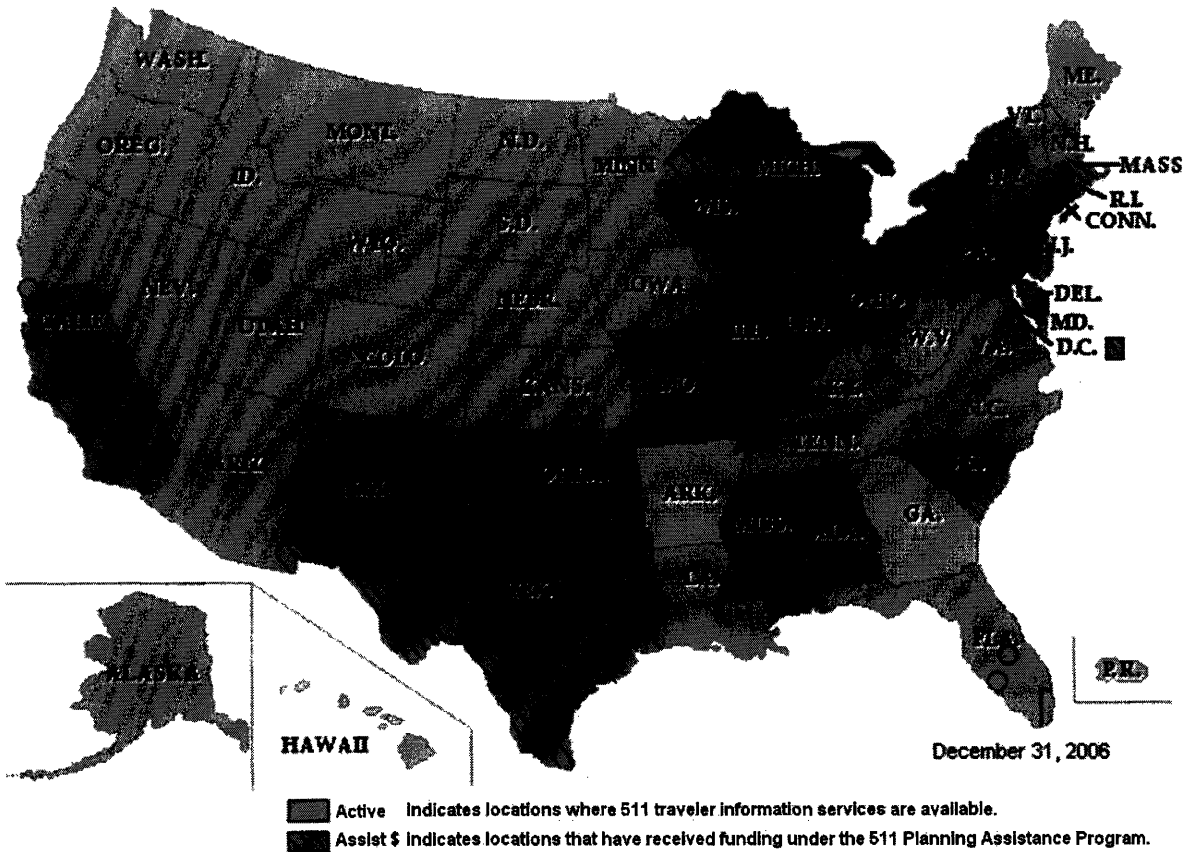
The last factor in this analysis is competitive services. Competitive services in this section represent any ATIS services except ATIS/V services. People's recognition of the value of ATIS/V depends on relative benefits of the service compared to the benefits of competitive services. For example, if there is no free traffic information service, more people will pay money for ATIS/V than if there is some free traffic information service. That is, the relative value of ATIS/V from users' perspective can be changed by competitive services. In other words, if there are some competitive services which satisfy people's need to some extent, the number of people who use ATIS/V will be reduced. Here, competitive services in the three countries are analyzed.

The U.S.

In the U.S., before ATIS/V appeared, people had been provided traffic information from conventional ATIS such as traffic reports for about fifty years: especially, radio traffic reporting services including Highway Advisory Radio have been used widely. For example, as of 1999, Metro, the largest provider of traffic report services in the U.S., provided traffic reports through 1,275 radio affiliates and 110 television affiliates in more than 60 U.S. market (Charles River Associates Incorporated, 1997).

Another type of traffic information providing services is telephone service. This type of service has been provided at least since the early 1990s. For example, SmartRoute Systems began telephone services in the Boston area in 1991 and in Cincinnati in 1995 (Charles River

Associates Incorporated, 1997). After that, the national traffic information telephone number, 511, was designated by FCC in 2000. The deployment of 511 services has been proceeding since then. In addition, in Section 5306 of SAFETEA-LU, the deployment of 511 services is supported as an important area for ITS: SAFETEA-LU showed the goal of implementation throughout the U.S. by September 30, 2010. As the result of this support, as of December 2006, 511 services are widely deployed as shown in Figure 4-11.



Source: US DOT - Federal Highway Administration, 2007

Figure 4-11: Deployment of 511

Web sites distributing traveler information are also becoming popular. As of April 1996, only 11 infrastructures provided traffic information via the Internet with personal computers (Oak Ridge National Laboratory). However, the number of agencies which provide information about freeways or arterial roads increased from 19 and 5 in 1997 to 44 and 31 in 1999 (Oak

Ridge National Laboratory; US DOT - ITS Joint Program Office, 1998b). In the 2004 national summary in the deployment statistics conducted by USDOT, 41 states answered that they have their own sites. Although various types of information, such as road restrictions and incidents, are disseminated by web sites, the number of states providing congestion and speed information is small: only 18 and 10 states provide these types of information respectively (US DOT - ITS Joint Program Office). Therefore, it can be argued that web site services penetrate well, but they did not compete with ATIS/V much in the U.S. at least until 2004.

However, recently private new web map services such as Microsoft's Live Search and Google's Google maps have appeared. These services have made it easier for people to have real-time traffic information.

In summary, people in the U.S. have traditionally used conventional ATIS such as traffic reports for a long time. Recently, telephone services including 511 and web site services are becoming popular. Unlike in Japan, the U.S.'s competitive services seem to be strong. First, the long-time custom of using conventional ATIS may not generate strong need for ATIS/Vs. Moreover, the public sector has strongly supported 511 services instead of operating ATIS/Vs. Especially this 511 services and web services have been strong competitors for ATIS/V so far and in the future.

Germany

It seems that there have not been any strong competitive services since there is no national three-digit number for traffic information like 511. However, regional or local ITS projects, such as Munich or Vellin, have been developed and traffic information is distributed in various media including the Internet and cell phones (Rupert et al., 2003).

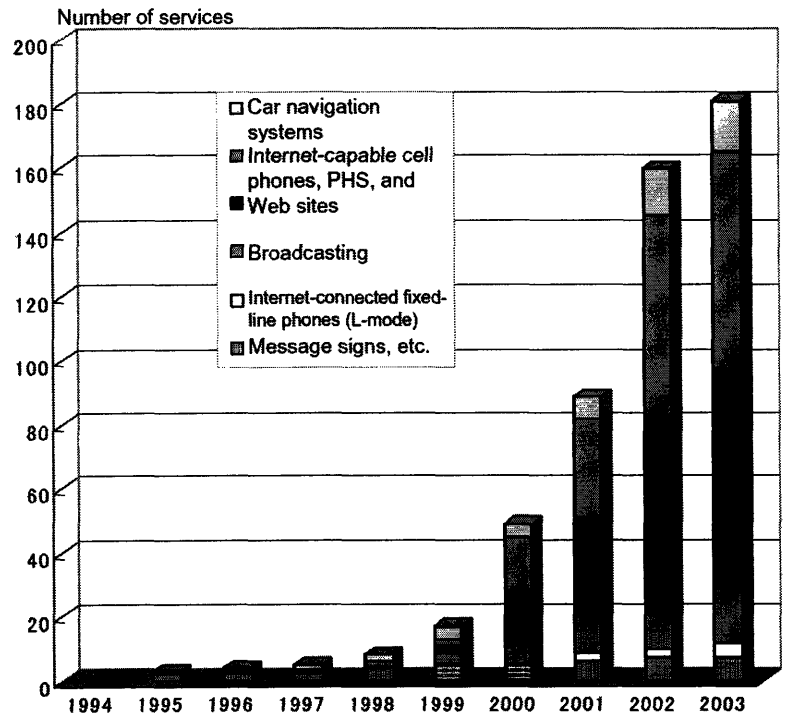
Japan

One of the competitive services is web sites providing traffic information. JARTIC, a quasi-public corporation operating the nationwide data collection infrastructure and providing traffic data to various companies including VICS Center, started providing traffic

information on its web site in 2000 (Ministry of Land, Infrastructure and Transport, Government of Japan, 2004).

In addition, by the revision of the road traffic law in 2001, traffic data which was exclusively controlled by JARTIC was released to the private sector. Since then, the number of traffic information services, especially web sites and internet-capable cell phones or PHS services, have been increasing as shown in Figure 4-12.

Although the number of road traffic information services has increasing since about 2001 along with the development of the Internet and cell phone services, because there are not many traffic information services until 2001, VICS, which has operated before then, might have been able to penetrate well while there were not major competitive services.



Source: Ministry of Land, Infrastructure and Transport, Government of Japan, 2004

Figure 4-12: The Number of Road Traffic Information Services Provided by Local Government Organizations, Private Businesses, etc.

Summary of Competitive Services

There have not been strong competitive services in Japan and Germany since there are no public sector supported alternative services like 511 in the two countries. Recently, the development of the Internet and cell phone technology in the three countries has made providing traffic information to the public easier than before, so traffic information services with these technologies has been increasing. However, this trend appeared relatively recently. Therefore, those new services may not be what harmed the development of ATIS/V in Japan and Germany because ATIS/V in the two countries started earlier than the trend. However, in the U.S., competitive services seem to be strong since there has been traditional ATIS for a long time. In addition to the 511 service, the strongest competitive traditional ATIS is free radio traffic information services. If people used to use such free services and were satisfied with them, they would not find high cost, quality ATIS/Vs attractive.

4.5. Analysis of Dynamics of the Penetration of ATIS/V

This section summarizes the analysis of factors in the detailed model of the penetration of ATIS/V, clarifies which flows in the detailed model are strong or weak in each country, and analyzes what causes the difference in the current penetration of ATIS/V in the three countries.

4.5.1. The U.S.

In the U.S., as shown in Figure 4-13, six flows strongly have worked in its dynamics of the penetration. The first five flows have worked positively to increase the penetration of ATIS/V. However, the last flow has negatively affected ATIS/V.

The first strong flow shown as Box 1 is related to public investment in deployment of data collection. Because both public investment in ITS and the public sector's responsibility for data collection are large, the public investment in deployment of data collection became strong and increased the performance of data collection. In contrast, though deployment in data collection has worked well, initial research regarding ATIS/V had not been conducted better than in the other two countries.

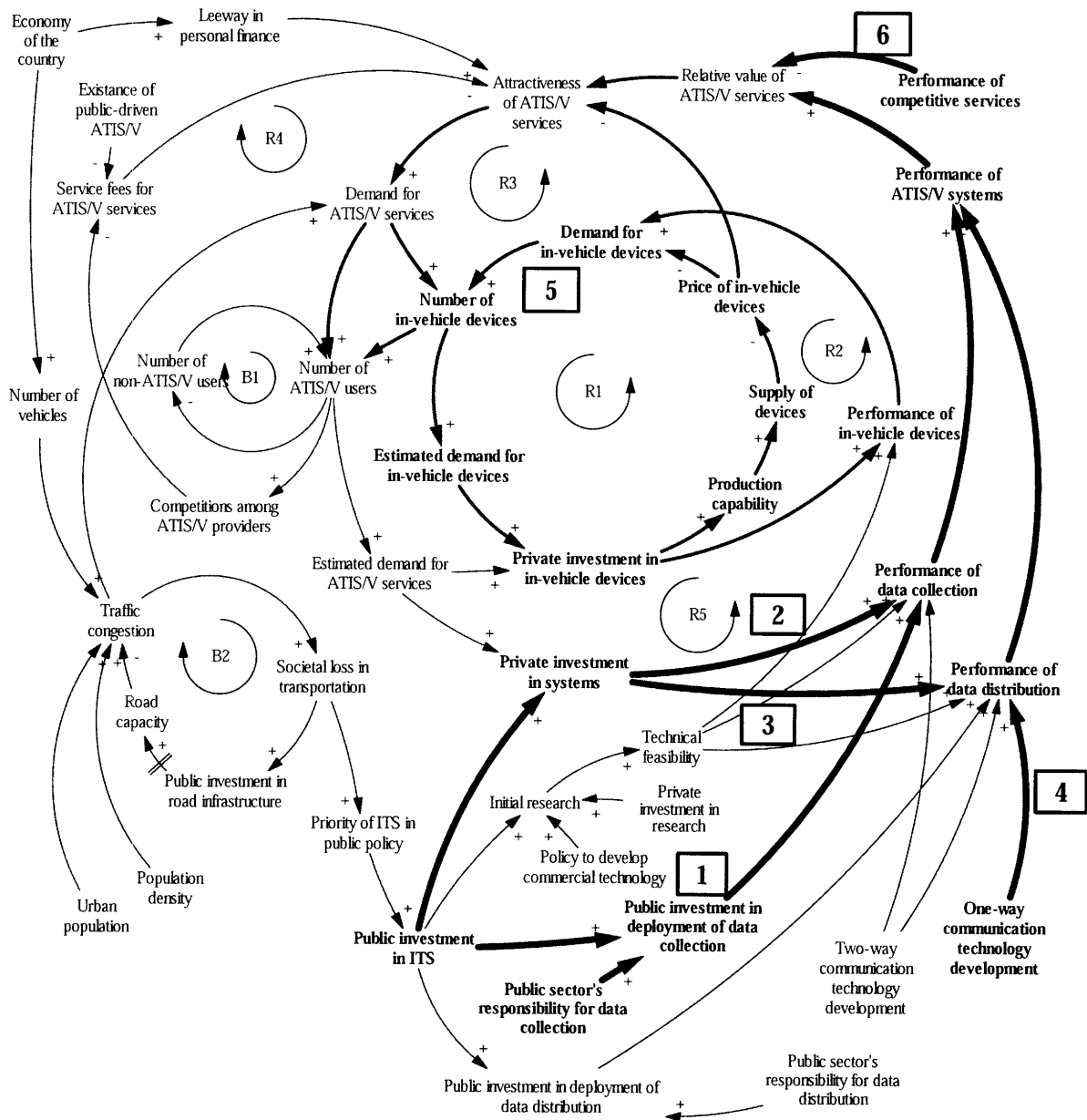
As shown Box 2, the second flow is a flow from private investment in systems to the performance of data collection. Regarding data collection, the federal government has given financial support to private companies to deploy traffic sensor networks. Therefore, private investment in systems was encouraged by the public investment in ITS and then increased the performance of data collection.

Third, shown by Box 3, a flow from private investment in systems to the performance of data distribution is also strong. Because the public sector does not support data distribution, a flow from private investment is necessary to launch ATIS/Vs in the U.S.

The fourth flow shown by Box 4 is the development of one-way communication technology. Due to the geographical characteristics of the U.S., satellite radio services have been developing. The technology has been utilized for ATIS/V.

Box 5 shows the fifth flow which has been working recently. It is the growth of the PND market. Because this flow is relatively new, it has not increased the penetration of ATIS/V as much as in the other two countries. However, this flow seems to be important and will work strongly to increase the penetration.

The last flow shown by Box 6 comes from the performance of competitive services. Traditionally, conventional ATIS has been well used in the U.S. Furthermore, the national telephone service, 511, has been supported as the national policy. Because of these competitive services, the relative value of ATIS/V services decreased.



Source: Author

Figure 4-13: ATIS/V Penetration Dynamics in the U.S.

4.5.2. Germany

In the dynamics of the penetration of ATIS/V of Germany, five series of strong flows, which support the development of ATIS/V, are found as shown in Figure 4-14. The first flows shown by Box 1 come from initial research. Like Japan, Germany continuously conducted initial research for ATIS/V with the support of an agency for encouraging the development of

commercial technologies, private companies, and the European level research projects. The initial research increased technical feasibility and enabled the early launch of the public-driven ATIS/V.

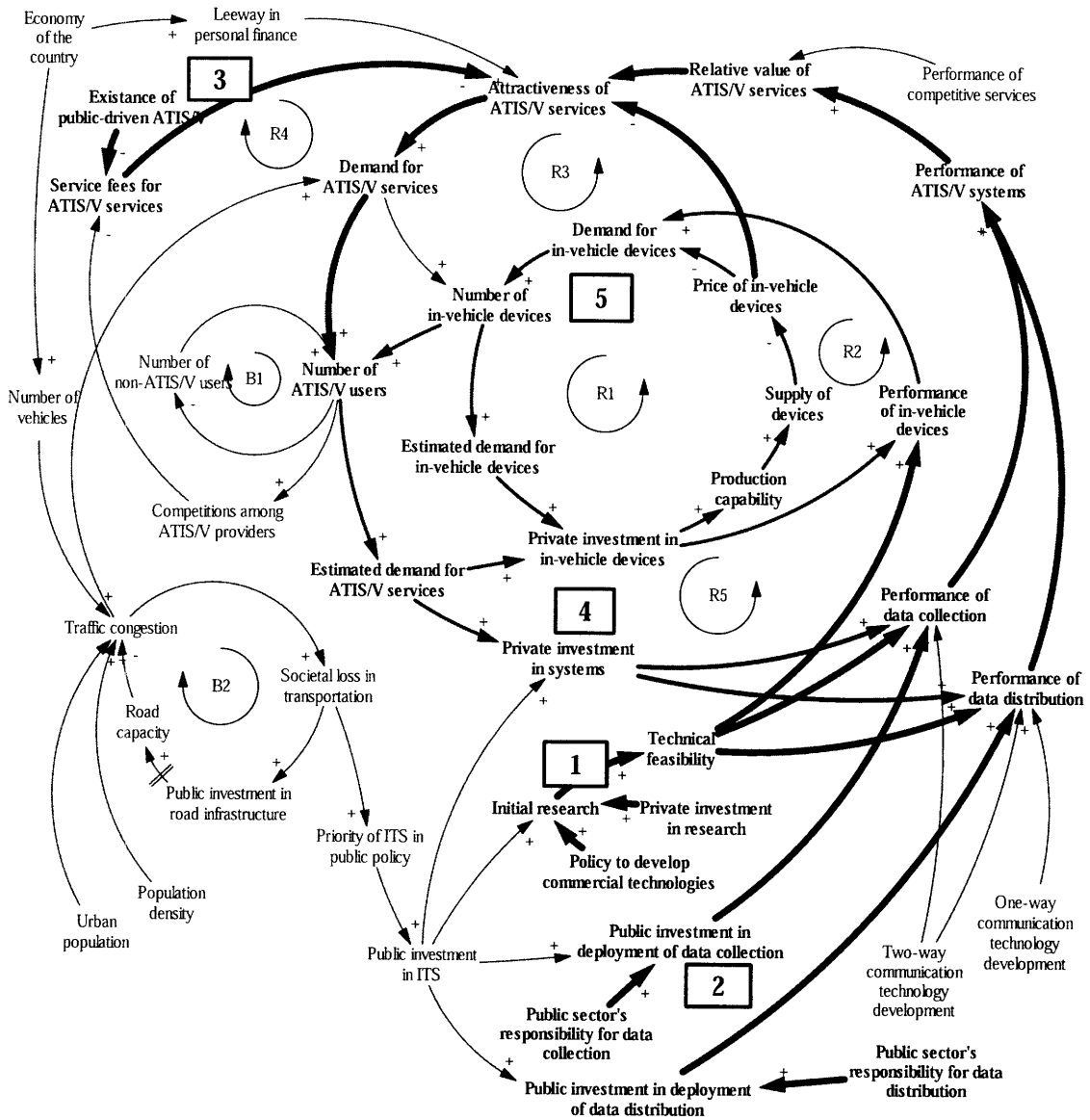
Second, Box 2 shows that the public investment in deployment of both data collection and data distribution strongly affected the development of ATIS/V. Because Germany needed a public-driven ATIS/V, RDS-TMC, as a European standard, its deployment was supported by the public sector. As a result, RDS-TMC was launched relatively early and the number of ATIS/V users started increasing.

Shown by Box 3, the third flow also relates to the public-driven ATIS/V. Because its service is free, the hurdle for people to have ATIS/V services was pushed down.

The fourth series of flows shown by Box 4 is the development of a private-driven ATIS/V by private investment. One private investment in systems is the establishment of private data collection company, DDG. Another private investment is the launch of the private-driven ATIS/V, TMCpro. These private investments resulted in having the private-driven ATIS/V the higher performance than the public-driven ATIS/V.

Lastly, shown by Box 5, the fifth flow is the growth of an in-vehicle device market. Its growth is not as fast as that in the Japanese market, but better than that in the U.S. Furthermore, lately, the PND market has been growing in Europe. As with the U.S., this growth is a new trend. In the near future, this flow may increase the penetration of ATIS/V rapidly.

As a whole, the dynamics in Germany has many similarities to Japan such as the continuity of initial research and the existence of a public-driven ATIS/V. However, the degree of the development of the in-vehicle device market is a big difference between the two countries. This seems to affect not only private investment in in-vehicle devices but also private investment in systems indirectly, and to cause the current difference in the penetration of ATIS/V.



Source: Author

Figure 4-14: ATIS/V Penetration Dynamics in Germany

4.5.3. Japan

First of all, because traffic congestion in Japan has been more severe than in the other two countries, there has been a huge demand for ATIS/V. Based on the strong demand for ATIS/V, several strong flows worked to increase the penetration of ATIS/V. The dynamics in Japan can be separated into two phases, the early phase and the later phase. The early phase means a time frame from the beginning year to the start of private-driven ATIS/V. The later

phase is a time frame from then to now. This section describes both of them separately.

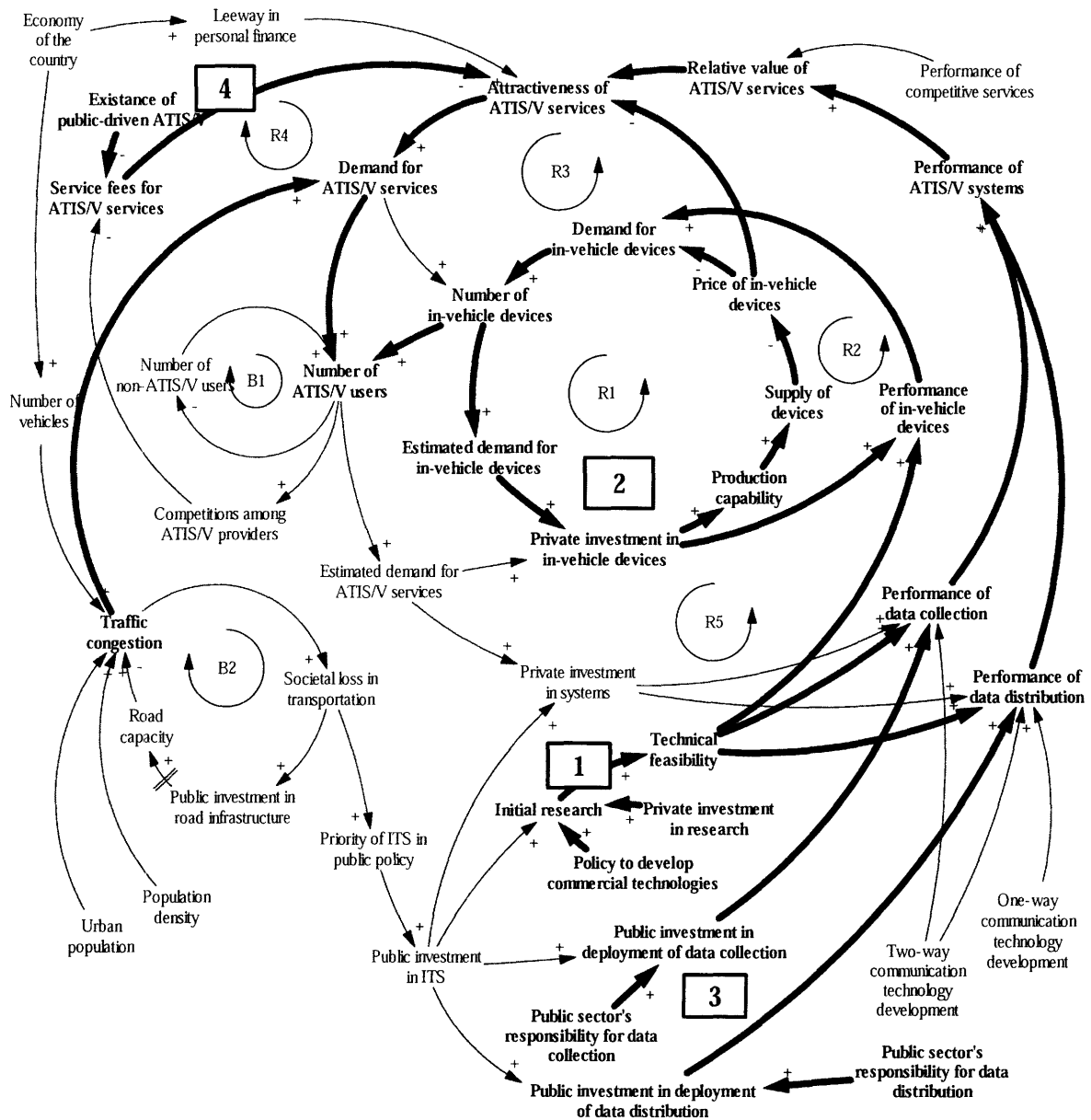
As shown in Figure 4-15, regarding the dynamics in the early phase, four series of flows mainly worked and resulted in the success of the early launch of the first ATIS/V and the increase in ATIS/V users. The first series of flows shown by Box 1 comes from initial research for ATIS/V. Public agencies conducted initial research continuously with private companies. This continuity of research smoothly increased technological feasibility of ATIS/V and led to the early launch of an ATIS/V. In these flows, MITI, with a policy to develop commercial technologies, played an important role in helping the continuity of research.

Shown by Box 2, the second series of flows is flows of the development of the in-vehicle device market caused by private investment. Private investment in in-vehicle devices started earlier than in the other two countries and the market for in-vehicle devices grew smoothly before the first ATIS/V started. Because the growth of the market caused the decrease in the price of in-vehicle devices and the increase in the potential users of ATIS/V, it was important for the development of ATIS/V.

Thirdly, Box 3 shows that flows regarding public investment in a public-driven ATIS/V, VICS, strongly worked for the early launch of the ATIS/V. Because the public sector in Japan had a huge responsibility for both data collection and data distribution, the public sector made strong investment in the deployment of both of them. Due to both the early completion of initial research and this strong public investment, the deployment for VICS was completed smoothly and a public-driven ATIS/V started earlier than in the other two countries.

Lastly, shown by Box 4, the existence of the public-driven ATIS/V helped to increase the attractiveness of ATIS/V services. Because the public-driven ATIS/V provides ATIS/V services without service fees, users' reluctance to have ATIS/V services has been reduced and the number of users increased. To sum up, the four strong series of flows worked positively for the penetration of ATIS/V. As the result, the penetration of ATIS/V smoothly

increased in the early phase.



Source: Author

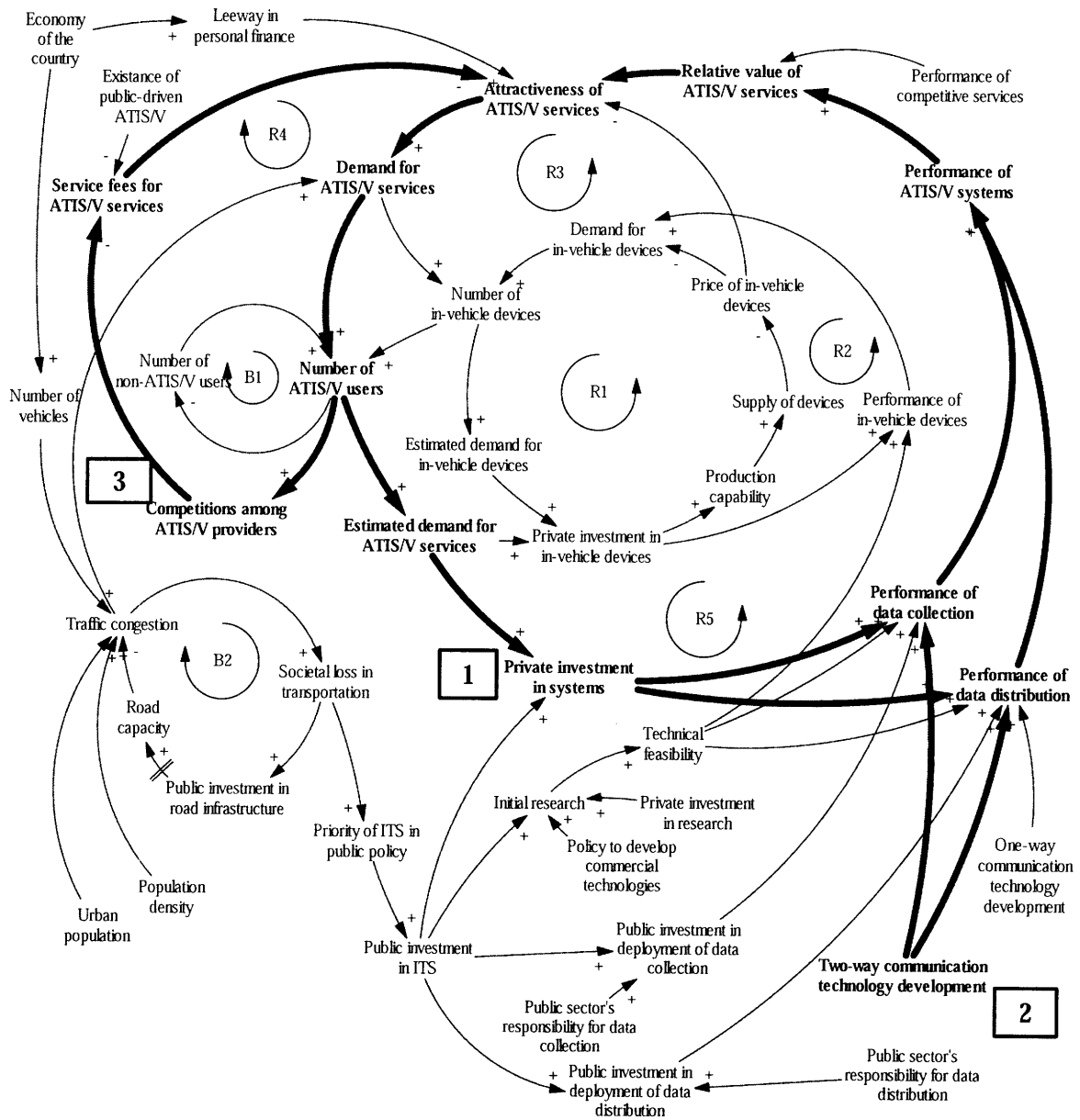
Figure 4-15: ATIS/V Penetration Dynamics in Japan in the Early Phase

In the later phase, private-driven ATIS/Vs have accelerated the increase of the penetration of ATIS/V in Japan. As shown in Figure 4-16, there are three strong factors in this dynamics. The first factor shown by Box 1 is private investment in systems: because of that,

private-driven ATIS/Vs were launched. These ATIS/Vs have higher performance and more advanced services than those of VICS, the public-driven ATIS/V.

Shown by Box 2, the second factor is the development of two-way communication technology. This development enables ATIS/V providers to build high performance ATIS/V systems.

Last, as Box 3 shows, because some private companies joined in the ATIS/V business, competition has begun. Perhaps, due to the competition, at this moment, many private-driven ATIS/Vs' services are provided free of service fees, at least for a certain time from the date of purchase. In Japan, through both the early and later phases, the penetration of ATIS/V became higher than in the other two countries.



Source: Author

Figure 4-16: ATIS/V Penetration Dynamics in Japan in the Later Phase

4.6. Policy Implications

In this section, five policy implications for both the public and private sectors are suggested from the analysis regarding the penetration of ATIS/V in the three countries.

1. From the public sector viewpoint, having a public-driven ATIS/V as in Germany and

Japan seems to be a better option than PPP in order to increase the penetration of ATIS/V. It is clear that the responsibility of the public sector for development of ATIS/V is very important. Although there are several ways the public sector plays its role such as PPP and operating the public-driven ATIS/V, there is no single rule which can be the best for any country or area. However, especially in the comparison of the three countries in this thesis, having a public-driven ATIS/V in Germany and Japan seems to be a better option than PPP in the U.S. First, because the deployment of infrastructure for ATIS/V needs a huge amount of money and typically it is difficult for private companies to invest much money in uncertain business, a case in which the public sector totally pays the cost seems to be better than a case in which some private companies are involved. If there are any companies with strong commitment to the business, PPP or other ways can be a reasonable option for the public sector. Second, the public-driven ATIS/V can provide its services at a cheap price, for example without service fees. The low service fees remove users' reluctance to have ATIS/V services and help the penetration increase. If the penetration increases, various values for the public are generated. The increase in the penetration reduces traffic congestion, increases the productivity of the society by reducing time and energy losses, and increases the safety and comfort by reducing drivers' stress whether or not drivers have ATIS/V services.

2. Although the public sector can support the development of an ATIS/V industry and such support is important for this industry in the early phase, when this market grows enough and private companies start participating in this market, the public sector needs not to hamper but to encourage the participation of private companies and a competition among them. Shown in both in Germany and Japan, the same development path of ATIS/V has been working well. In this path, a public-driven ATIS/V is established first, and then private-driven ATIS/Vs with additional values are started later. In the early phase of the ATIS/V industry, it is generally difficult for private companies to make a profit since the initial cost of ATIS/V such as infrastructure is huge. Therefore, at the beginning, the public sector should lead the development of the industry. After the industry grows enough for private companies to invest, the public sector needs to take care not to hinder the participation of private companies or a competition among them. For example, when the ATIS/V market is in the embryonic stage, the public sector can or should provide subsidization to some private companies to generate a

positive externality like the case of federal funding for Traffic.com in the U.S. However, once the market grows, the public sector should consider whether the subsidization caused a poor situation such as unbalanced competition.

3. Shown in the dynamics in the U.S., competitive services can hamper the development of ATIS/V. Therefore, the public sector needs to think about the competitive relationship among various ATIS applications. For example, if the public sector decides to support ATIS/V, the public sector should not support other competitive services since such support has negative effects on the development of ATIS/V. As this example suggests, the public sector should never forget that public support for a service can block the growth of competitive services. In the U.S., since ATIS/V is not supported by the federal government, its support to other services such as 511 is not unreasonable. However, if the public sector supports two competing services, neither may develop well.

4. Any entities planning to start ATIS/V services should pay attention to the development of communication technology. One important finding from the analysis is that the improvement of the performance of ATIS/V system heavily depends on the development of communication technology. Furthermore, it is difficult for ATIS/V providers to control the development of communication technology since this development is typically driven by some factors outside of the ATIS/V business. For example, the development of the third generation cell phone network could not have been driven by anyone except telecommunication providers. Therefore, either the public or private sector which plans to implement ATIS/V needs to consider the development of communication technology in the future.

5. Service fees for ATIS/V should be kept cheap especially at the beginning of the development of the ATIS/V industry. The analysis of willingness to pay in this thesis shows that willingness to pay for ATIS/V does not seem high. In addition, both Germany and Japan increased the number of ATIS/V users by providing services without service fees. Because monthly or annually service fees cause users to be reluctant to have ATIS/V services, a way not to show these fees should be used. For example, in VICS, a royalty is included in the

price of the in-vehicle device. Providing services without fees as trial services for a certain fixed period can be another way.

4.7. Summary

In this chapter, the difference in the penetration of ATIS/V is analyzed by focusing on the dynamics of the penetration with system dynamics methodology. Although the system dynamics methodology can be used in quantitative analysis, only qualitative analysis is conducted in this thesis. In the qualitative analysis, a dynamics model of the penetration of ATIS/V is built and factors of the model in the three countries are examined. As a result, differences in the dynamics among the three countries are clarified. These differences are reasons why the penetration of ATIS/V differs in the three countries. Lastly, policy implications to develop ATIS/V effectively are suggested in this section.

The analysis in this chapter shows a holistic view of the dynamics of how the ATIS/V industry develops. Although this analysis of the dynamics is beneficial to find important factors to develop the industry or policy implications from a macro-perspective, concrete activities and relationships among stakeholders on micro level was not examined here. Therefore, in the next chapter, the possibility of alliances among stakeholders to make better ATIS/Vs and increase the penetration of ATIS/V is analyzed. Furthermore, another motivation of the analysis in the next chapter is to answer why and how private investment in some countries is larger than in the others. In this chapter (Chapter 4), it is found that the private investment is very important for the development of ATIS/V and strong private investment has been conducted in some countries. However, the analysis in this chapter does not sufficiently answer this question.

Chapter 5 Analysis of the Possibility of Alliances among Stakeholders

In this chapter, the possibility of alliances among stakeholders to improve ATIS/V and increase the penetration of ATIS/V is studied based on stakeholder analysis. An alliance for ATIS/V is of potential value for two reasons. First, because ATIS/V requires various technologies such as sensor infrastructure, telecommunication networks, and in-vehicle devices and there are many stakeholders who are interdependent, alliances among stakeholders are useful when a company needs to make a business plan for ATIS/V to join the industry. Second, alliances among stakeholders can provide the potential to make better ATIS/Vs which has cost advantages or higher quality service capability than those without alliances.

Identifying and understanding stakeholders is necessary to build alliances. In this chapter, after stakeholders in ATIS/V are identified, value exchanges among stakeholders and possible roles in the supply chain of ATIS/V are summarized as a framework to explore strategic alliances between stakeholders. Then, some current ATIS/Vs are analyzed as cases and stakeholders involved in these alliances are clarified. Finally, strategies for alliances are considered in a case of highway service operators.

To build good ATIS, some studies have been conducted. For example, ITS America made an action guide for creating public-private business plans in 1998 (ITS America, 1998). It clarified issues which should be considered to make a business plan for ATIS such as leadership, prospective participants, infrastructure, and revenue. Then five business models, public-centered operations, contracted operations, contract fusion with asset management, franchise operations, and private, competitive operations, were provided. Furthermore, how to create a plan was also included. Also McQueen et al. summarized public and private sectors' stakeholder types and objectives and gave instructions about what steps should be taken to build a business plan. Moreover, they covered relevant elements such as ATIS technologies, the ATIS supply chain model, and ATIS business model (McQueen et al., 2002). Although these are beneficial guides for making a business plan, they do not have

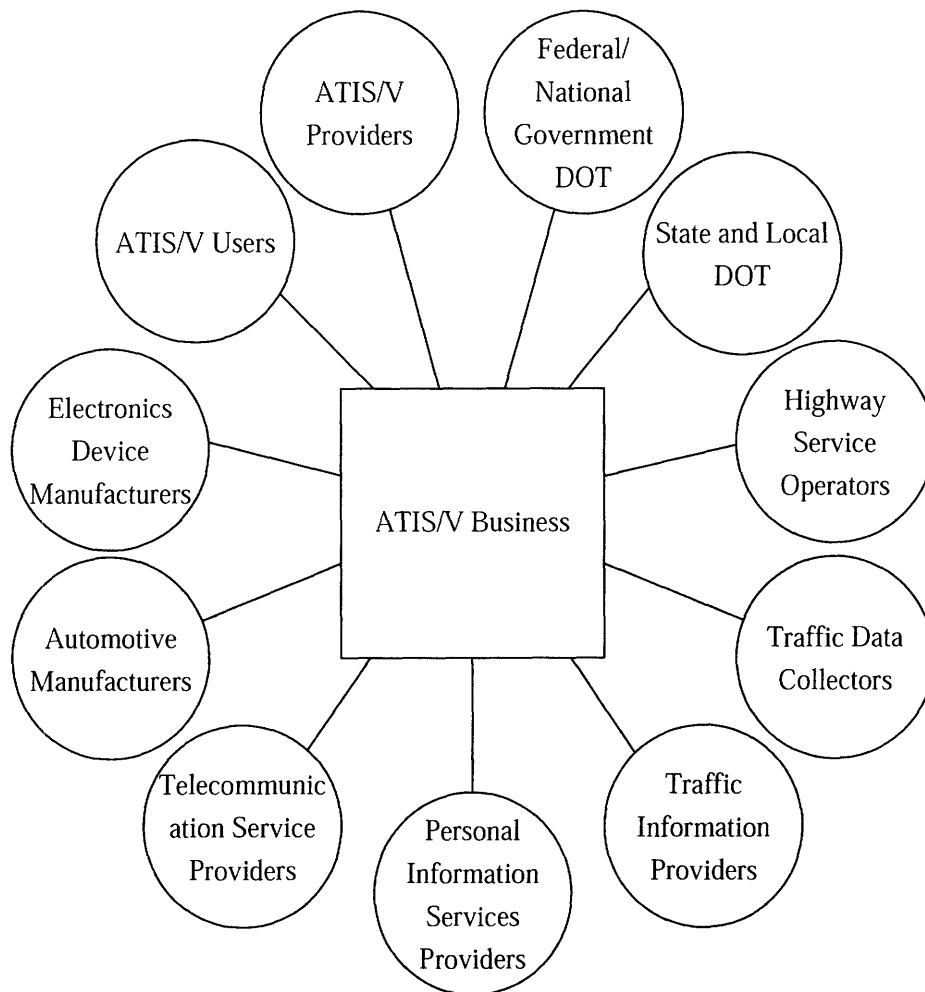
concrete examples for ATIS/V. The detailed stakeholder analysis in this thesis could help stakeholders to make a good business plan for ATIS/V.

5.1. Stakeholder Identification

Stakeholders can be defined as “any group or individuals who directly or indirectly affect or is affected by the level of achievement of an enterprise’s value creation processes” (Nightingale, 2006). For this thesis, the enterprise in the definition should be replaced by ATIS/V providers. In this section, stakeholders for operating ATIS/V are identified. Although other actors can influence the development of ATIS/V such as agencies which have authority over telecommunication standards or funding for commercial technology development, these actors are not included in this chapter. Although they can support and encourage the development phase of ATIS/V, once ATIS/V has started, ATIS/V has to be independent of that support. That is, regarding long-term health of ATIS/V, those actors do not have influence. Also they cannot enter into a strategic alliance. Therefore, in this chapter, stakeholder analysis focuses on stakeholders for operating ATIS/V.

Stakeholders who can play important parts in ATIS/V business are identified in Figure 5-1 and Table 5-1. Stakeholders are shown in the circles. Stakeholders are identified basically by their roles. Because one entity can play multiple roles, ATIS/V can be built by a small number of entities. Although one actor can play all the roles in ATIS/V, typically one actor becomes a leading player and collaborates with other partners to provide an ATIS/V. Because ATIS/V requires a wide range of expertise and authority, and huge cost (Klein, 1996), it is difficult for one company to provide all of them by itself and cost sharing among many companies becomes a reasonable solution.

In addition, theoretically, all stakeholders except two, federal/national government DOT and state and local DOT, can be the public sector or the private sector. Therefore, which entities participate, how all the roles are divided among participants, and what kind of ATIS/V is made depend on the context of each area such as the power balance among stakeholders in the area or economic flexibility and resources of each stakeholder.



Source: Author

Figure 5-1: Stakeholders in the ATIS/V Business

Table 5-1: Stakeholder Identification

Stakeholders	Description	Examples
ATIS/V Providers	They are in charge of ATIS/V and provide ATIS/V services to users.	XM Satellite Radio, Clear Channel, VICS Center
Federal/National Government Department of Transportation	Usually, this agency takes responsibility for national transportation policy and has huge budget and authority over major highway network.	USDOT, Ministry of Land, Infrastructure and Transport of Japan
State and Local Departments of Transportation	These agencies have responsibility for regional or local transportation policy and authority over road network in its own area. They can have their own policies and develop their own infrastructures.	The New York State Department of Transportation
Highway Service Operators	They operate highway systems and have authority over them. Electric toll control system operators can be included. They do not focus on ATIS/V as their business but can play a part in ATIS/V.	Brisa, The Massachusetts Turnpike Authority
Traffic Data Collectors	They collect traffic data from roads. They make their revenue mainly by providing traffic data they collect.	Traffic.com, DDG
Traffic Information Providers	They get collected traffic information, fuse data, and produce real-time traffic data which is served to customers.	Traffic.com, Smart Route Systems, Navteq
Personal Information Service Providers	They purchase real-time information and provide the traffic information and their other information in their information services.	Weather Channel

Telecommunication Service Providers	They make a profit by providing telecommunication service such as radio broadcasting, cell phone service, wireless communication service, etc.	XM Satellite Radio, Clear Channel, cell phone service providers
Automotive Manufacturers	They provide automotives and optional devices including car navigation systems.	GM, Ford, Toyota, Honda
Electronics Device Manufacturers	They provide in-vehicle devices to customers directly in the aftermarket or indirectly via automotive manufacturers.	Sony, Pioneer, TomTom, Garmin, Denso
ATIS/V Users	They have in-vehicle devices and ATIS/V services.	-

Source: Author

5.2. Stakeholder Value Exchange

Stakeholders in ATIS/V business join and collaborate in the business because each of them has its own expected value from the business and deliverable value to the business. That is, each stakeholder exchanges value in ATIS/V business. In this section, the value exchange of each stakeholder is identified. The value exchange of ATIS/V providers, federal or national government department of transportation, state and local departments of transportation, highway service operators, traffic data collectors, traffic information providers, personal information service providers, telecommunication service providers, automotive manufacturers, electronics device manufacturers, and ATIS/V users are summarized in Table 5-2 to Table 5-12, respectively. Although concrete names of some entities are in these tables as stakeholders, those entities are just examples of stakeholders and not a complete list.

Table 5-2: Value Exchange of ATIS/V Providers

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • Revenue from the sales of ATIS/V • A means to differentiate the company from competitors in its original business 	<p><u>ATIS/V Providers</u> XM Satellite Radio¹, Clear Channel², VICS Center</p>	<ul style="list-style-type: none"> • Planning • Management • Coordinate partners • Marketing • User feedback

Source: Author

Table 5-3: Value Exchange of Federal/National Government Department of Transportation

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • Reduction of societal loss caused by traffic congestion in the nation 	<p><u>Federal/National Government Department of Transportation</u> USDOT, Ministry of Land, Infrastructure and Transport of Japan</p>	<ul style="list-style-type: none"> • The right to set traffic sensors on roads • Funding for traffic sensor infrastructure

Source: Author

¹ Although XM Satellite Radio is a telecommunication service provider, it provides ATIS/V to users as an ATIS/V provider. Therefore, it is in both Table 5-2 and Table 5-9.

² As with XM Satellite Radio, Clear Channel is in both Table 5-2 and Table 5-9.

Table 5-4: Value Exchange of State and Local Departments of Transportation

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> Reduction of societal loss caused by traffic congestion in the state or local area. 	<p><u>State and Local Departments of Transportation</u></p> <p>The New York State Department of Transportation</p>	<ul style="list-style-type: none"> The right to set traffic sensors on roads Funding for traffic sensor infrastructure

Source: Author

Table 5-5: Value Exchange of Highway Service Operators

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> Peak traffic reduction due to efficient use of highways Savings of investment in the highway capacity enhancement by reducing peak traffic User satisfaction from ATIS/V for highway users Revenue from collected traffic data 	<p><u>Highway Service Operators</u></p> <p>Brisa, The Massachusetts Turnpike Authority</p>	<ul style="list-style-type: none"> The right to set traffic sensors on highways Traffic information collected on highways Traffic information collected on electric toll collection system

Source: Author

Table 5-6: Value Exchange of Traffic Data Collectors

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • Revenue from collected traffic data 	<p><u>Traffic Data Collectors</u> Traffic.com, DDG</p>	<ul style="list-style-type: none"> • Traffic information collected on roads

Source: Author

Table 5-7: Value Exchange of Traffic Information Providers

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • Revenue from real-time traffic information 	<p><u>Traffic Information Providers</u> Traffic.com, Smart Route Systems</p>	<ul style="list-style-type: none"> • Real-time traffic information

Source: Author

Table 5-8: Value Exchange of Personal Information Services Providers

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • Real-time traffic information • A means to differentiate the company from competitors in its original business 	<p><u>Personal Information Services Providers</u> Weather Channel</p>	<ul style="list-style-type: none"> • Payment for real-time traffic information

Source: Author

Table 5-9: Value Exchange of Telecommunication Service Providers

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • Revenue from the data communication • A means to differentiate the company from competitors in its original business 	<p><u>Telecommunication Service Providers</u> XM Satellite Radio³, Clear Channel⁴</p>	<ul style="list-style-type: none"> • Data distribution media network • User location data (for probe vehicle systems)

Source: Author

Table 5-10: Value Exchange of Automotive Manufacturers

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • A means to differentiate the company from competitors in its original business • A means to get customer information which is used for customer relationship management marketing 	<p><u>Automotive Manufacturers</u> GM, Toyota</p>	<ul style="list-style-type: none"> • In-vehicle device distribution channel • User feedback

Source: Author

³ Although XM Satellite Radio is a telecommunication service provider, it provides ATIS/V to users as an ATIS/V provider. Therefore, it is in both Table 5-2 and Table 5-9.

⁴ As with XM Satellite Radio, Clear Channel is in both Table 5-2 and Table 5-9.

Table 5-11: Value Exchange of Electronics Device Manufacturers

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • Revenue from the sales of products • A means to differentiate the company from competitors in its original business 	<p><u>Electronics Device Manufacturers</u></p> <p>Sony, Pioneer, TomTom, Germin, Denso</p>	<ul style="list-style-type: none"> • In-vehicle devices for ATIS/V • User feedback • Budget for device development

Source: Author

Table 5-12: Value Exchange of ATIS/V Users

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • ATIS/V services 	<p><u>ATIS/V Users</u></p>	<ul style="list-style-type: none"> • Payment for ATIS/V services

Source: Author

5.3. Stakeholders' Role in the Supply Chain

This section clarifies which stakeholder can play which roles in the supply chain of ATIS/V. Table 5-13 summarizes each stakeholder's possible roles in the supply chain of ATIS/V, which is explained in Section 3.1. In the table, "X" indicates a possible step of the supply chain. In this clarification of stakeholders' role, possible steps are what stakeholders can contribute to the supply chain within their own businesses. Therefore, this table does not show the limitation of the ability of each stakeholder. For example, if an automotive manufacture decides to start its own ATIS/V, it may be able to play other roles such as fuse, value, or market roles as traffic information providers by themselves.

Table 5-13 shows that there are many possible combinations of stakeholders which cover the whole of the supply chain of ATIS/V. For example, a traffic data collector, a traffic information service provider, a telecommunication service provider, and an electronics device manufacturer can make an alliance covering the entire supply chain. This example consists of four types of stakeholders. However, the number of stakeholder types in an alliance can be different. Another alliance can be made by fewer or more stakeholders.

Table 5-13: Stakeholders' Possible Steps in the Supply Chain

Stakeholders	Steps in the Supply Chain						
	Build	Collect	Fuse	Value	Market	Deliver	Receive
ATIS/V Providers	X	X	X	X	X	X	X
Federal/National Government Department of Transportation	X	X	X	X	X	X	-
State and Local Departments of Transportation	X	X	X	X	X	X	-
Highway Service Operators	X	X	-	-	-	X	-
Traffic Data Collectors	X	X	-	-	-	-	-
Traffic Information Providers	-	-	X	X	X	-	-
Personal Information Service Providers	-	-	-	-	-	-	-
Telecommunication Service Providers	X	X	-	-	-	X	-
Automotive Manufacturers	-	-	-	-	-	-	X
Electronics Device Manufacturers	-	-	-	-	-	-	X
ATIS/V Users	X	X	-	-	-	-	-

Source: Author

ATIS/V Providers

They may play all roles by themselves or collaborate with other stakeholders to serve ATIS/Vs to users.

Federal/National Government Departments of Transportation

It can cover all steps except the receive step. Because it has the authority over the roads, it can build and operate the sensor network on the roads. Like VICS of Japan, it can provide a public-driven ATIS/V by gathering traffic data and making real-time traffic information by itself. Moreover, if it installs communication media on the roads such as microwave beacons or infra-red beacons, it can also deliver real-time traffic information to users by itself. Lastly, because in-vehicle devices are usually consumer electronics devices and the public sector's participation in the market can hinder the competition in the private sector, the receive step cannot be supported by federal/national government departments of transportation.

State and Local Departments of Transportation

As with federal/national government department of transportation, they can play all roles except the receive role since they are in the public sector.

Highway Service Operators

They can support the build, collect, and deliver steps in the supply chain. They might have or be permitted the authority over the roads and are in charge of highway services including construction, maintenance, operation, and traffic management of highway networks. If they have authority over the highway networks or are permitted to install traffic sensors on the highway networks, they can build and operate traffic sensor networks on their highway networks. Similar to the traffic sensor network, communication networks on the highway network such as microwave beacons can be provided by them. Furthermore, some highway service operators have electric toll systems. In such cases, they might be able to utilize electric toll systems for ATIS/V.

Traffic Data Collectors

Traffic data collectors can participate in ATIS/V alliances in the build and collect steps. Although traffic data collectors can cover the same two steps as highway service operators, traffic data collectors do not make their profits by providing highway services but by selling traffic data they collect. One technology which has been conventionally used is traffic sensors installed on roads: Traffic.com in the U.S. and DDG in Germany are examples which use the technology. Recently due to technology development, a real-time GPS probe vehicle technology has been used. Inrix in the U.S. has its own commercial fleet.

Traffic Information Providers

Traffic information providers fuse traffic data and add value, and also conduct marketing. They provide traffic information which is delivered to end-users via various methods, not only ATIS/V. Some companies such as Traffic.com and Inrix act as not only traffic information providers but also traffic data collectors. However, in the scope of the definition of traffic information providers in this thesis, traffic information providers do not cover the build and collect steps.

Personal Information Service Providers

These stakeholders do not support any steps in ATIS/V supply chain. They do provide traffic information in their business. But they do not appear in this supply chain. If they purchase traffic information from traffic information providers, such transactions support the operation of ATIS/V financially.

Telecommunication Service Providers

Telecommunication service providers can play the build, collect, and deliver roles. First, they provide media to deliver traffic information to users. There are various types of technologies which are used to deliver traffic information including FM radio broadcasting, satellite radio broadcasting, and cell phone network. In addition, a new technology in which cell phone service providers can support the build and collect steps is set to be introduced in 2007. TomTom announced on October 2006 that it will collaborate with Vodafone Netherlands and

start using the technology in which signals continuously sent from mobile phones to their nearest base stations are used to identify mobile phone users' location and the location data is used to retrieve traffic information (TomTom).

Automotive Manufacturers

Since automotive manufacturers have a huge influence in ATIS/V by selling in-vehicle devices to customers, they play an important role in the receive step. ATIS/V is important for them since ATIS/V is an application for vehicles that can make vehicles more attractive to consumers.

Electronics Device Manufacturers

Electronics device manufacturers can provide in-vehicle devices for consumers. They sell their products directly to customers or via automotive manufacturers' distribution channels by providing original equipment manufacturing products.

ATIS/V Users

Because of technology development, users can support the build and collect steps in the supply chain. If users have devices which can identify their location or detect traffic data and can provide their information, they can be a part of a probe vehicle system. In Honda Internavi Premium Club, users who have a car navigation unit act as a part of the system by providing traffic data to Honda. In this ATIS/V, users are provided a free ATIS/V service. Therefore, users will not provide data for compensation. However, by providing traffic data to Honda, users can get more sophisticated traffic information from Honda since Honda can make high quality data by processing data gathered from users.

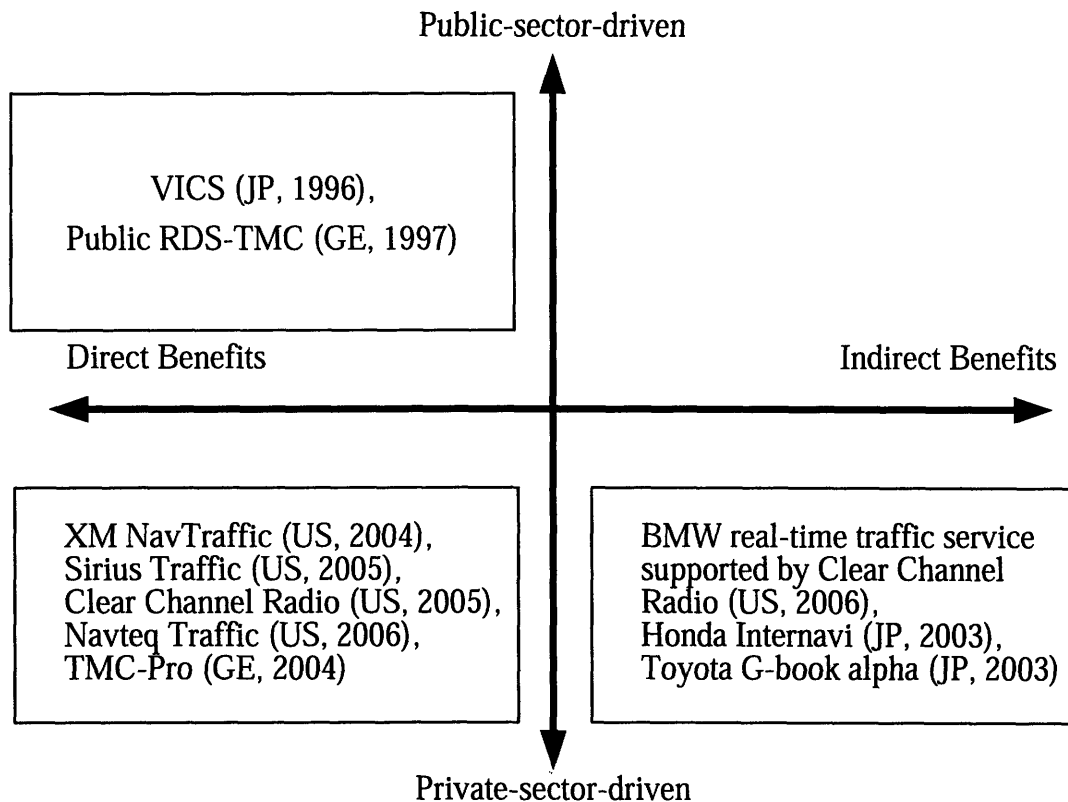
5.4. Classification of ATIS/V by Types of Benefits to ATIS/V Providers

As discussed above, stakeholders in ATIS/V have different values. Also, the public sector and the private sector have different objectives for ATIS/V. Therefore, various types of ATIS have been operated with different objectives. In this section, many ATIS/Vs are classified by their objectives.

Figure 5-2 shows classification of ATIS/V in two dimensions: drive sector and types of benefits. The public sector needs to provide benefits for the public from ATIS/V with consideration of environment, economics, and social factors (McQueen et al., 2002). Reducing traffic congestion for the public is the public sector's benefit, and the benefit is directly derived from ATIS/V. That is, objectives of the public-driven ATIS/V are direct benefits coming from ATIS/V. Therefore, the public-driven ATIS/V is located in the upper-left corner in Figure 5-2.

On the other hand, the private sector's objectives lead to making a profit. Private companies have two ways of making a profit: (1) from ATIS/V itself and (2) from their own original business by adding value to their own business and differentiating the company from competitors by having ATIS/V. Because making a profit directly from ATIS/V can be said to be a direct benefit from ATIS/V, private-driven ATIS/V whose main objective is making a profit, such as XM NavTraffic, is located in the lower-left part of Figure 5-2. Due to the expectation of the increase in demand and the improvement of service quality from technology development, several ATIS/Vs in that category were launched in the U.S. in recent years.

On the other hand, some ATIS/V providers do not have to make profits directly from ATIS/V itself. In other words, these ATIS/V providers make profits indirectly from ATIS/V. They increase profits from their own business by using ATIS/V. ATIS/V that is used as a complementary part of other businesses, such as Honda Internavi Premium Club service or BMW's real-time traffic service supported by Clear Channel, is shown in the lower-right corner of Figure 5-2. If providing ATIS/Vs generates enough benefits to ATIS/V providers' original business, they can run ATIS/Vs as a complementary business for their original business. Because there is a trend in which products such as automobiles or car navigation systems become commoditized, the need to differentiate themselves from competitors increases. Therefore, ATIS/Vs with the latter objective may increase. So far, some automotive manufacturers and electronics device manufacturers have provided ATIS/V to differentiate themselves: especially in Japan, ATIS/V has been used as a tool of differentiation (Kamio, 2004).



Source: Author

Figure 5-2: Classification of ATIS/V by Benefits Type

At least so far people generally do not have much willingness to pay for ATIS/V. In other words, there has been difficulty operating an ATIS/V to make profits from it. This seems to be one reason why private-driven ATIS/V has not become popular. However, an ATIS/V operated for adding value to a business and differentiating itself may be able to provide its service cheaper than an ATIS/V whose objective is making a profit from its service since it does not need to raise money from ATIS/V services. Therefore, the increase in this kind of ATIS/V will help increase the penetration of ATIS/V.

5.5. Case Study: Alliances for ATIS/V

Based on the identification of stakeholders in ATIS/V and their possible roles in the supply chain, this section analyzes some cases of alliances for ATIS/V and clarifies what kinds of

stakeholders are involved in alliances. Because many types of stakeholders and their possible roles in the supply chain are identified, a huge possibility of alliances is found. That is, there are many possible combinations. As long as the whole of the supply chain of ATIS/V is covered by the alliance, the number of stakeholder types in an alliance can be different. An alliance can consist of a few types of stakeholders, and another alliance can be realized by many types of stakeholders. Furthermore, because there are many entities in each type of stakeholders, the many alliances can be possible beyond the combination of stakeholder types. For instance, an ATIS/V provider may prefer an alliance with many telecommunication service providers over another alliance with one telecommunication service provider. In addition, there are some types of ATIS/V which have different objectives as classified in Figure 5-2. Because such objectives affect what are the best alliances for stakeholders, this is also another factor increasing the flexibility of alliances.

Because of this huge flexibility, examining all combinations of stakeholders is beyond the scope of this thesis. Thus, this thesis analyzes some alliances in reality as a case study. Among many ATIS/Vs, two major ATIS/Vs, XM NavTraffic and Honda Internavi Premium Club, described in Table 5-14, are selected. And alliances in the two ATIS/Vs are analyzed in this section.

Table 5-14: ATIS/Vs for the Case Study

Name of ATIS/V	Country	Type	Main Player
XM NavTraffic	U.S.	Private-driven, Direct benefit driven	Telecommunication Service Provider
Honda Internavi Premium Club	Japan	Private-driven, Indirect benefit driven	Automotive manufacturer

Source: Author

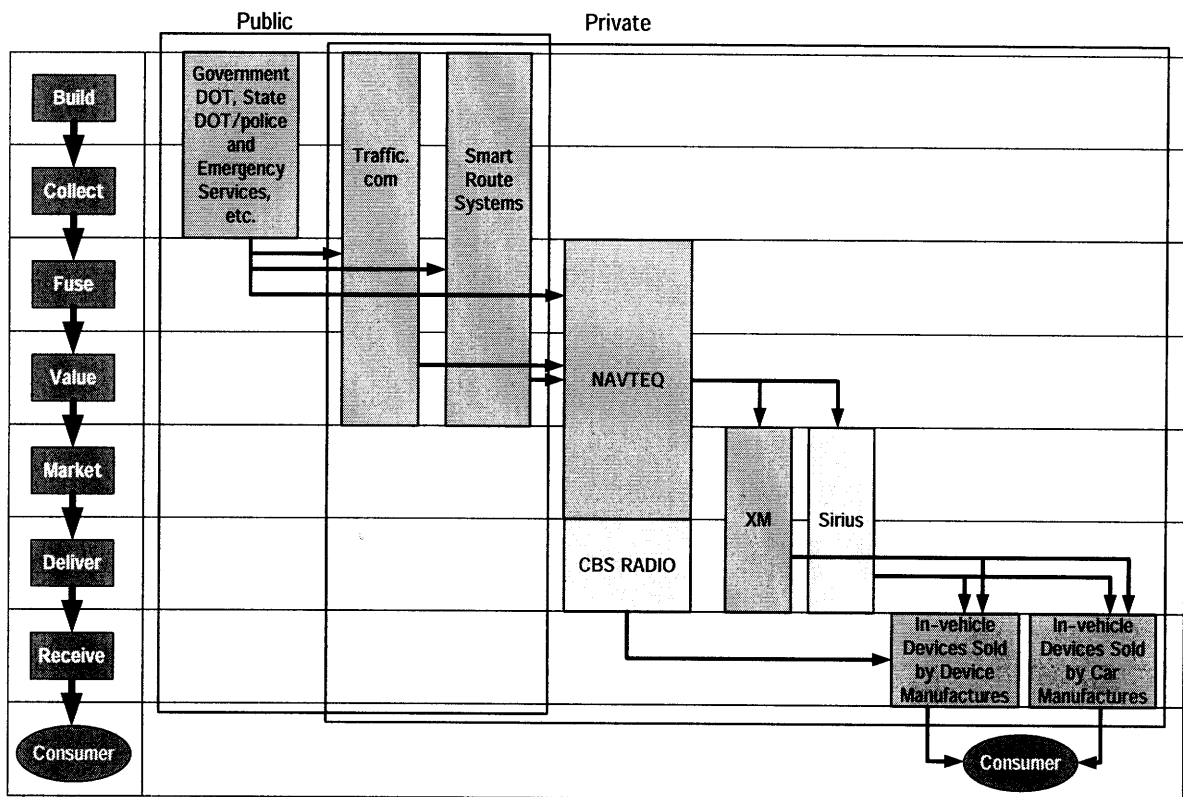
Alliance for XM NavTraffic

XM NavTraffic in the U.S. is categorized as private-driven direct benefit type ATIS/V since making a profit is its objective. XM Satellite Radio's business is a satellite radio business: it provides satellite radio broadcast services to users and charges subscription fees. Moreover, it

sells XM radio receivers which are produced by device manufacturers. Because XM service covers wide geographical area, it is suitable for vehicles: as of 2005, more than 140 new vehicles in the U.S. can have XM radio service (XM Satellite Radio). Based on this background, XM Satellite Radio started its ATIS/V, XM NavTraffic, in 2004 as one service using satellite radio broadcasting.

As shown in Figure 5-3, in this supply chain model, there are many traffic data collectors, such as Traffic.com, and one traffic information provider, Navteq, gathers traffic data and provides traffic information to downstream. Navteq provides traffic information to several ATIS/V providers including Navteq itself. XM Satellite Radio collaborates with and gets traffic information from Navteq and covers only two steps in the supply chain, market and deliver. Although there is only one traffic information provider in this model, three telecommunication service providers, XM Satellite Radio, Sirius Satellite Radio, and CBS radio, providing ATIS/V data to users. There has been competition among telecommunication service providers and to some extent the competition motivates them to provide ATIS/Vs as a method to differentiate themselves from competitors. However, because all XM Satellite Radio, Sirius Satellite Radio, and Navteq's ATIS/V use the same source, Navteq, there seems not to be much difference in traffic information provided by them. At the last step of the supply chain, XM Satellite Radio collaborates with both car manufacturers and device manufacturers which sell in-vehicle devices to users. For these car manufacturers and device manufacturers which will not provide ATIS/V by themselves, XM NavTraffic can be a way to add value to their own products or services. Therefore, the collaboration between them is beneficial for both sides.

This case shows that a telecommunication provider can provide ATIS/V without having many steps in the supply chain. In addition, in this case, there are no companies which cover many steps by themselves. In contrast, various stakeholders, which entail few steps, collaborate with each other.



ATIS/V	Main player	Collaborators
XM	Telecommunication	Traffic Information Providers (Navteq),
NavTraffic	Service Provider (XM Satellite Radio)	Automotive Manufacturers (GM, Honda, etc), Electronics Device Manufacturers

Source: Author

Figure 5-3: The Alliance for XM NavTraffic in the Supply Chain

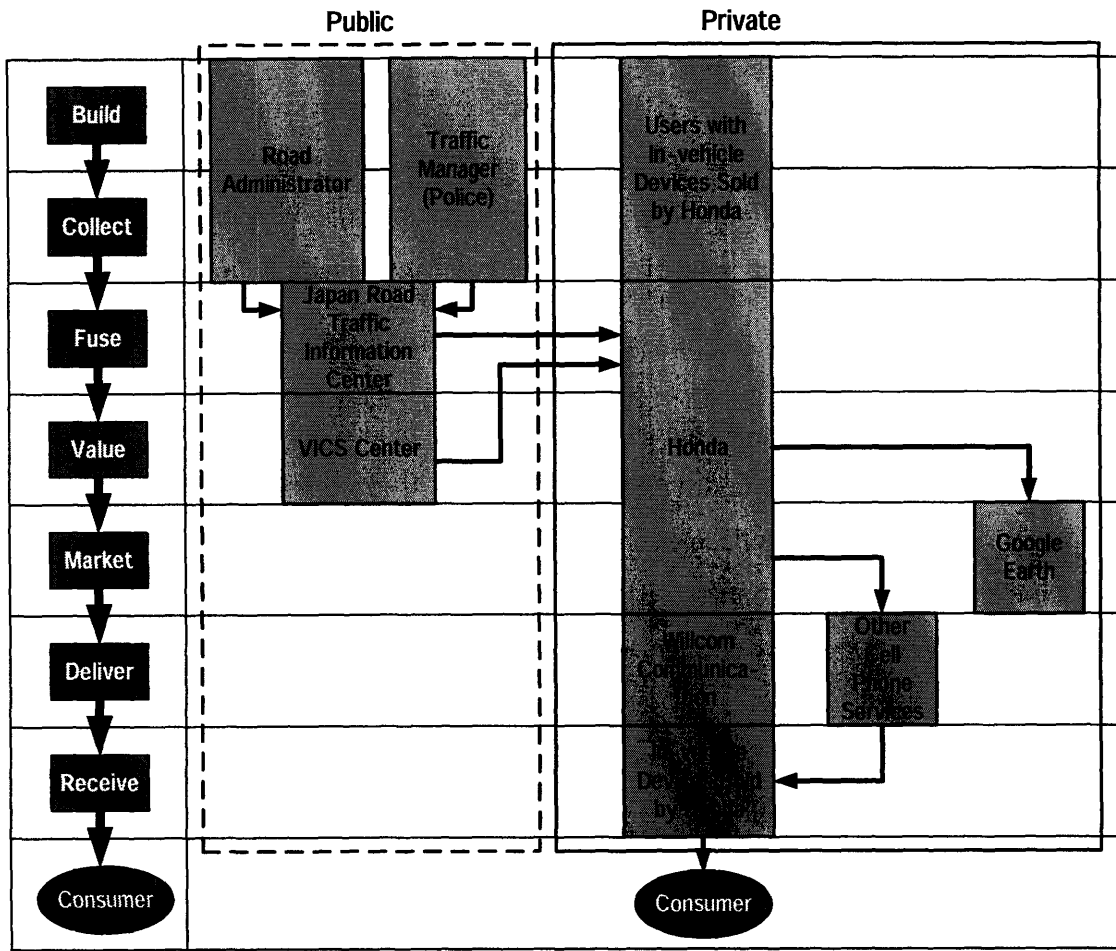
Alliance for Honda Internavi Premium Club

This ATIS/V provided in Japan is categorized as a private-driven indirect benefit type ATIS/V since the objective of ATIS/V in Honda Internavi Premium Club is not to make a profit by the service. Honda provides telematics service called Honda Internavi Premium Club and ATIS/V is one of the components of the service.

As shown in Figure 5-4, Honda’s system covers the whole supply chain model by itself.

Honda introduced the brand-new probe vehicle system in which users' in-vehicle devices work as sensors. Therefore, the build and collect steps are supported by users with in-vehicle devices which are sold by Honda. Then Honda gathers traffic data from various sources not only VICS, which can be bought by any companies, but also Honda's users, and makes sophisticated traffic information including prediction of traffic congestion. The traffic information is delivered by Willcom's network or other cell phone service networks. Users can choose to use either a Willcom's communication card sold by Honda or their own cell phone. Lastly, traffic information is received by in-vehicle devices dedicated to Honda's system. As a new trial outside of the ATIS/V supply chain for demonstration of Honda's probe system, Honda published traffic congestion data generated only by its probe vehicle system three times a day from its homepage without fee. The data is formatted to be used in Google Earth, which is a software provided by Google Inc. Therefore, people who have Google Earth can see the quality of the probe system.

This case shows that Honda built up its own supply chain by covering all supply chain steps by itself through collaborating with Willcom, device manufacturers, and users. In order to provide more advanced ATIS/V than other providers as a method to differentiate Honda from other car manufacturers, Honda built its own probe system for collecting traffic data only for itself and provided the ATIS/V only via in-vehicle devices sold by itself.



ATIS/V	Main player	Collaborators
Honda Internavi Premium Club	Automotive manufacturer (Honda)	Electronics Device Manufacturers, Telecommunication Service Providers (Willcom, other cell phone service providers), The public sector (Japan Road Traffic Information Center, VICS Center), Personal Information Service Providers (Google Earth), User

Source: Author

Figure 5-4: The Alliance for Honda Internavi Premium Club in the Supply Chain

Summary of Case Studies of Alliances of ATIS/V

In this section, two totally different ATIS/Vs are analyzed. The analysis shows that there can be many types of alliances. Even if a company cannot support many steps by itself like XM Satellite Radio, the company can provide an ATIS/V by collaborating with other stakeholders. On the other hand, like the example of Honda, a company can provide an ATIS/V by covering many steps by itself.

Another implication is that types of alliances depend on the objectives of stakeholders. If the objective of having an ATIS/V is to differentiate a company from competitors, building up its own supply chain and limiting collaborations with others seems to be rational. In contrast, if another company's objective is to increase the users of its ATIS/V services and to increase its profit, collaborating with as many partners as possible also seems reasonable.

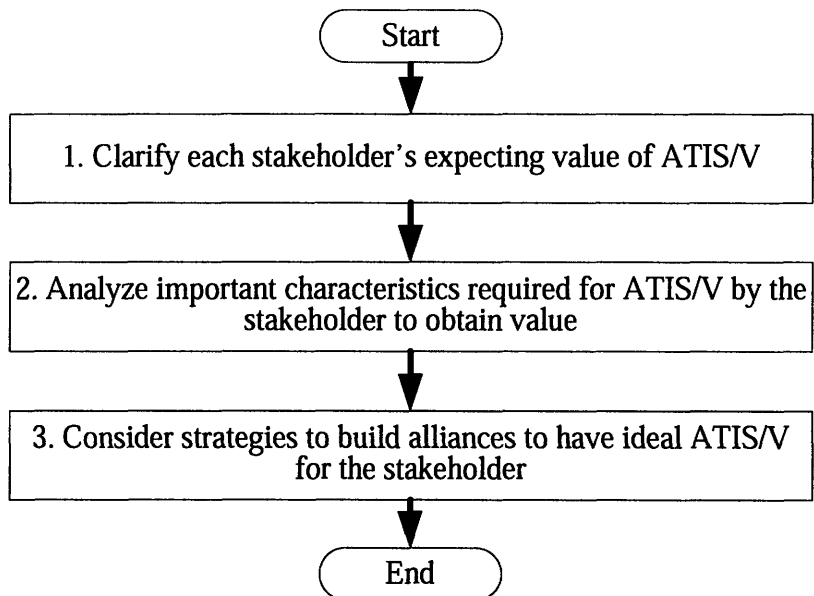
5.6. Case Study: Stakeholder Strategies for Alliance

Whether stakeholders make an alliance to have an ATIS/V or not depends on whether each stakeholder can create and retain value for itself. Because there are various types of stakeholders and also there are many companies in a each category of stakeholder, there must be various strategies for how each type of stakeholder or each company should act to establish an alliance for ATIS/V. In this section, as an example of analysis of how a stakeholder should establish an alliance among stakeholders, the strategies that highway service operators can employ to establish a preferable alliance from highway service operators' point of view are examined. As shown in Table 5-5, examples of highway service operators include Brisa and the Massachusetts Turnpike Authority. Their actions are considered in the three steps shown in Figure 5-5.

Table 5-5: Value Exchange of Highway Service Operators

Value expected from ATIS/V business	Stakeholders	Value Contributed to ATIS/V business
<ul style="list-style-type: none"> • Peak traffic reduction due to efficient use of highways • Savings of investment in the highway capacity enhancement by reducing peak traffic • User satisfaction from ATIS/V for highway users • Revenue from collected traffic data 	<p>Highway Service Operators Brisa, The Massachusetts Turnpike Authority</p>	<ul style="list-style-type: none"> • The right to set traffic sensors on highways • Traffic information collected on highways • Traffic information collected on electric toll collection system

Source: Author



Source: Author

Figure 5-5: Steps to Consider a Stakeholder's Action to Build a Preferable Alliance

First, because each stakeholder has to make its own value by participating in an alliance, each stakeholder's value expectations from ATIS/V should be clarified. In highway service operators' case, because the mission of highway service operators is to provide drivers safe and efficient highway service, the value for highway service operators is not just to increase traffic on highway networks but to enable drivers to have smooth, safe, and comfortable drives on the highway networks. According to this understanding, peak traffic reduction has the biggest value among the four possible expected values from ATIS/V shown in Table 5-5.

Second, important characteristics required for ATIS/V by the stakeholder to obtain value should be analyzed. For highway services operators, high number of ATIS/V users is an important characteristic since increasing the number of ATIS/V users as much as possible is necessary to effectively reduce peak traffic by ATIS/V. Drivers with ATIS/V will tend to avoid traffic congestion, and traffic on the highway network will be dispersed by the behavior of drivers with ATIS/V. Then traffic congestion on the highway network will be mitigated. The more people have ATIS/V, the more drivers avoid traffic congestion. Therefore, a high number of ATIS/V users should be realized for highway services.

Lastly, actions to build alliances to have preferable ATIS/V for the stakeholder should be considered. In this case, there seems to be three possible actions. First, by providing high quality traffic data on highway networks, highway service operators may be able to encourage other private companies to start ATIS/Vs. Traffic data on highway networks is a basic and important component of ATIS/V, and high quality highway traffic data will lead to the high performance of ATIS/V services. If highway service providers can provide such data, a hurdle to start ATIS/V will be lowered and some other companies, such as automotive manufacturers or traffic information providers, will join alliances to have ATIS/V.

Second, since electronic toll collection (ETC) systems can be an efficient way to collect traffic data, highway service operators should consider utilizing such systems. Highway service operators can provide traffic data by installing sensors on their own highway networks or making use of their ETC systems to collect traffic data. Especially, a data

collection system by utilizing ETC systems might be able to be a relatively cheap way to build data collection systems since it is a utilization of systems which were originally built for ETC. For instance, in the Chicago metropolitan area, ETC system is used as a source of traffic data as with two other sources, loop detectors and radar sensors, and an estimated travel time is provided via dynamic message signs and a website (US DOT - Federal Highway Administration, 2005). If a highway service operator has an ETC system, the ETC might be used for data collection. Further, if a highway service operator does not have any ETC systems, the operator can make an ETC which can be used not only for toll collection but also data collection. Therefore, when highway service operators consider the implementation of ETC systems, it seems to be worth considering utilizing the ETC systems not only for toll collection but also traffic data collection.

Third, highway service operators should not limit providing traffic data to a particular partner company but provide to any companies which want to use traffic data. Because the high number of ATIS/V users is preferable for highway service operators, it is better for highway service operators to provide traffic data to as many ATIS/V providers as possible to develop the ATIS/V industry. This strategy might not be satisfactory in terms of the revenue which is generated by providing traffic data. However, the number of ATIS/V users seems to be more important than such revenue.

In this section, through three steps, highway service operators' possible strategies to build the ideal ATIS/V for them are analyzed. This analysis is conducted based on an assumption in which their investment in establishing an ATIS/V has a rationale for them. However, it is not always true. In some cases, ATIS/V may not provide much value for highway service providers. Perhaps, it depends on their business environment. For example, if it is difficult to enhance highway capacity in urban areas, reducing peak traffic by ATIS/V might be a better option than widening highway in the urban areas. Therefore, at the beginning, highway service operators have to analyze their environment and to judge whether they will take action to establish alliances for ATIS/V or not.

5.7. Policy Implications

From the analysis in this chapter, two policy implications for stakeholders in the ATIS/V business are suggested in this section.

First, to make a desirable alliance for ATIS/V, each stakeholder should understand other stakeholders and also clarify its own actions. For that purpose, stakeholder analysis, ATIS/V classification by types of benefits, and steps to clarify actions described in this chapter can be used. There are many possibilities as to how stakeholders collaborate since many types of stakeholders can participate in ATIS/V and also every company can act beyond its own business as an ATIS/V provider. After reviewing actual alliances in case studies, some examples of alliances are emphasized in this thesis. Those examples do not limit the possibilities of alliances, but encourage stakeholders to make creative collaborations. Because each country or each local area must have a different context such as the transportation situation, the allocation of responsibility between the public and private sectors, and the development path of ATIS/V, beneficial alliances differ in each area. In this situation, stakeholder identification, stakeholder value exchange, and stakeholders' roles in the supply chain can be a beneficial tool to understand stakeholders in each area and to formulate effective alliances in each context.

Second, because ATIS/V can be used as a differentiation method, private companies should consider whether they can have ATIS/V for such a purpose. Although so far willingness to pay for ATIS/V has not been high and the number of users for non-free ATIS/Vs has not increased very much, some ATIS/V providers have started providing ATIS/Vs for differentiation. If competitors have not provided any ATIS/V services, starting ATIS/V for differentiation can be a good strategy for a company.

5.8. Summary

This chapter started with the stakeholder analysis. In the analysis, stakeholders in the ATIS/V business are identified, and each stakeholder's value exchange and possible steps in the supply chain of ATIS/V are clarified. Next, various ATIS/Vs are classified by types of

benefits to ATIS/V providers and a trend in which ATIS/V can be used as a differentiation method is shown. Then, based on the understanding of these important contexts for making alliances, alliances in two current ATIS/Vs are examined. Lastly, through an example of highway service operators, stakeholder strategies for alliance are suggested.

As suggested in policy implications (Section 5.7), there are many possibilities for how stakeholders collaborate and there is no absolutely best alliance for any countries or areas. Therefore, after understanding stakeholders and other contexts in each country or each local area, stakeholders need to work together to formulate ideal alliances for them. The analysis in this chapter may help them to formulate alliances. In addition, the possibility of ATIS/V as a differentiation method is suggested as one option worth considering from the private company viewpoint.

Chapter 6 Conclusion

6.1. Conclusion

In the context of current transportation in which traffic congestion is increasing and becoming a serious problem, one solution is ATIS, which enables travelers to make better choices about transportation and have less frustrating driving experiences by providing valuable real-time traffic information with use of information and communication technologies. Currently various types of ATIS services are provided, such as radio traffic reporting services, websites, and dial-in telephone services.

Among such ATIS applications, more advanced real-time traffic information system, which provides sophisticated traffic information to drivers via in-vehicle devices such as car navigation systems or personal navigation devices, has been becoming popular. This thesis calls this ATIS/V and focuses on not the whole range of ATIS but on ATIS/V as a promising solution.

ATIS/V can help mitigate traffic congestion and should be valuable to individual drivers. Therefore, high penetration of ATIS/V is desirable. However, in some countries, ATIS/V has not been accepted by drivers as well as it has in other countries: ATIS/V is more popular in Japan than in the U.S. or countries in Europe. Given this situation, three questions become the motivations of this study: (1) why does ATIS/V in some parts of the world have more penetration than in others, (2) what can be done to increase the penetration of ATIS/V, and (3) what kinds of strategic alliances among stakeholders can help to make better ATIS/Vs.

In order to answer these three research questions, this thesis analyzes three countries, the U.S., Germany, and Japan, as the three most developed automobile markets in Chapter 3 and Chapter 4 to identify prominent factors in each country that cause the difference in, and to find ways to increase, the penetration of ATIS/V. As a methodology to clarify the difference among the three countries, the system dynamics methodology is used. This methodology can be used not only qualitatively but also quantitatively by conducting numerical simulation. In

this thesis, only qualitative analysis, which can provide a holistic understanding of the dynamics of the penetration and sources of the difference in the penetration of ATIS/V, is conducted. Additionally, as a method to analyze ATIS/V, a new supply chain model, which is developed based on a model presented by McQueen et al., is also used in this thesis. This model divides the supply chain of ATIS/V into seven layers such as collecting data or delivering information, and is helpful to understand the difference in ways of implementing a supply chain among the public and private sectors.

In addition, in Chapter 5, stakeholder analysis and case studies are conducted to explore better alliances among stakeholders. In this stakeholder analysis, stakeholders in the ATIS/V business are identified, and each stakeholder's value exchange and possible steps in the supply chain of ATIS/V are clarified. Moreover, ATIS/Vs are classified by types of benefits to ATIS/V providers. Then, case studies regarding stakeholder alliances in two current ATIS/Vs and highway service operators' stakeholder strategies for alliance are conducted.

In this section, we discuss answers to the three questions.

(1) Why does ATIS/V in some parts of the world have more penetration than in others?

The analysis conducted in this thesis shows that there are many factors which affect the dynamics of the penetration of ATIS/V and result in the difference in the penetration of ATIS/V. Prominent factors which are important to explain the penetration of ATIS/V are traffic congestion, initial research such as research and development before deployment, public investment in a public-driven ATIS/V, the existence of the public-driven ATIS/V, the in-vehicle device market, private investment in systems, two-way communication technology development, competition among ATIS/V providers, and the performance of competitive services. This thesis concludes that the strengths or weaknesses of these prominent factors are reasons why the difference in the penetration of ATIS/V occurred in the three countries.

In the dynamics in the three countries, many strong flows which positively or negatively work are shown.

- Severe traffic congestion in Japan has led to the demand for ATIS/V.

- The success of initial research and a strong public investment in a public-driven ATIS/V are shown in both Germany and Japan.
- The existence of a public-driven ATIS/V in Germany and Japan has worked well to increase the number of ATIS/V users.
- The development of the in-vehicle device market in Japan is one of the major reasons of the high penetration in Japan.
- The advent of private-driven ATIS/Vs due to private investment in systems is an important step to further development of the ATIS/V industry.
- The development of a two-way communication technology, cell phone data communication, made advanced ATIS/Vs feasible in Japan.
- A competition among ATIS/V providers in Japan lowered the service fees for ATIS/V services and the hurdle for users to get ATIS/V services.
- Lastly, in the U.S., the high performance of competitive services, such as the national telephone service, 511, seems to be an obstacle for ATIS/Vs to attract drivers.

(2) What can be done to increase the penetration of ATIS/V?

As fundamental requirements to increase the penetration of ATIS/V, ATIS/V's quality need to be improved, the price for ATIS/V services should be lowered, and ATIS/V services need to be attractive enough for drivers. Because each country or area has its own situation with prominent factors, what stakeholders can do must be different. However, in this section, five suggestions to increase the penetration of ATIS/V are given from the understanding of the dynamics of the penetration of ATIS/V in the three countries.

- From the public sector viewpoint, having a public-driven ATIS/V as in Germany and Japan seems to be a better option than PPP as a way to support ATIS/V development in the early phase. Many possibilities exist in terms of how the public sector plays its role for ATIS/V development. However, for two reasons, having a public-driven ATIS/V seems to be better. One reason is that the deployment of infrastructure for ATIS/V needs a huge amount of money and typically it is difficult for private companies to invest much money in uncertain conditions. The other is that a public-driven ATIS/V

can generally provide its services at a cheap price. This suggestion is for the early phase of ATIS/V development. In the later phases, this suggestion may not be suitable since the private sector can play an important role for ATIS/V development.

- When a market of ATIS/V grows enough and private companies start participating in this market, the public sector should not hamper them, but should encourage the participation of private companies and competition among them. In Germany and Japan, a public-driven ATIS/V was established first, and then private-driven ATIS/Vs with additional values were started later. Because the participation of private companies is a typical step to develop ATIS/V in a country, the public sector should not obstruct but help it.
- The public sector needs to think about the competitive relationship among various ATIS applications. Because ATIS/V is not the only solution to reduce traffic congestion, the public sector may choose to support not only ATIS/V but also other ATIS applications. In such cases, supporting other solutions may have a negative impact on the development of ATIS/V. Therefore, the public sector needs to consider the relationships between these solutions.
- The development of communication technology affects the development of ATIS/V. And it is difficult for ATIS/V providers to control the development of communication technology. Hence, ATIS/V providers should consider the development of communication technology.
- Service fees for ATIS/V should be kept cheap especially at the beginning of the development of the ATIS/V industry. The analysis of willingness to pay shows that it does not seem high. Furthermore, the increase in the number of ATIS/V users in both Germany and Japan seems to be supported by ATIS/V without service fees.

(3) What kinds of strategic alliances among stakeholders can help to make better ATIS/Vs?

Through the analysis of various ATIS/V in this thesis, it can be said that there is no absolute best alliances that work in any country or area. In contrast, the fact that there are many possibilities to create alliances for ATIS/V is clarified. Because the contexts in terms of ATIS/V, such as the situation of traffic congestion, the structure of industries in a country,

the development of communication technologies, and the development path of ATIS/V, differ in countries or areas, stakeholders need to understand such contexts and their own and others' benefits from ATIS/V to establish alliances suitable to each country or area. The analysis in Chapter 5 may help them to formulate ideal alliances.

In addition, one option, which is worth considering, is the use of ATIS/V as a differentiation tool. Private companies have two ways of making a profit from ATIS/V: (1) from ATIS/V itself and (2) by adding value to their own business and differentiating the company from competitors by having ATIS/V. In the latter case, private companies can use ATIS/V as a complementary part of other businesses and attract more customers than competitors. Moreover, because there is a trend in which products such as automobiles or car navigation systems become commoditized, the need to differentiate themselves from competitors increases. Hence, as a differentiation tool, ATIS/V can be a promising option for private companies. Even if it is difficult to make profits from ATIS/V itself, ATIS/V can create benefits for stakeholders by using it for differentiating themselves from competitors in their own business.

6.2. Future Research

This thesis analyzed ATIS/V by several methodologies. However, further study of ATIS/V should be conducted beyond this study to understand and improve ATIS/V and to reduce traffic congestion. This section suggests three areas for future research.

First, the comparison between ATIS/V and other solutions for traffic congestion needs to be conducted to find the best solution for reducing traffic congestion in each country. This thesis focuses on ATIS/V and does not compare ATIS/V with other solution for traffic congestion. Because ATIS/V can be an expensive option for people since it may require relatively high cost for both in-vehicle devices and service fees, ATIS/V cannot be a good solution for people with low income. That is, from the perspective of equity, ATIS/V may be inferior to other solutions. As a solution for reducing traffic congestion, ATIS/V needs to be compared with other solutions from various perspectives.

The second opportunity is a quantitative analysis of a system dynamics model of the penetration of ATIS/V. Because the analysis in this thesis is a qualitative analysis, the understanding of relationships between factors and the strength of each relationship is subjective. Although the qualitative analysis provides an integrated understanding of the dynamics of the penetration and sources of the difference in the penetration of ATIS/V, a quantitative analysis has the potential to provide more precise and objective understanding of relationships between factors.

Third, deeper study of strategic alliances can be beneficial to find optimal alliances to make better ATIS/Vs. Although this thesis examines many alliances, all possible combination of strategic alliances among stakeholders are not covered. Because the contexts of each type of stakeholders differ among countries, it might be difficult to conduct a general analysis of those possible combinations. However, such deeper study will help stakeholders understand benefits and make better alliances.

This thesis has studied ATIS/V, which has been becoming popular and can be a useful solution for traffic congestion, and examined what should or can be done to increase the penetration of ATIS/V. It is hoped that the product of this thesis will have some value for ATIS/V stakeholders and contribute to mitigating the problem of traffic congestion.

Abbreviation and Terminologies

2G:	The second generation
2.5G	The second and half generation
3G:	The third generation
AASHTO:	American Association of State Highway and Transportation Officials
ACEA:	Association of European Car Manufacturers
ADIS:	Advanced Driver Information Systems
AHS:	Automated Highway System
ALI:	Route Guidance and Information System for Drivers
AMPS:	Advanced Mobile Phone System
AMTICS:	Advanced Mobile Traffic and Information and Communication System
APTA:	American Public Transit Association
APTS:	Advanced Public Transportation Systems
ARTS:	Advanced Rural Transportation Systems
ATIS:	Advanced Traveler Information Systems
ATIS/V:	Advanced Traveler Information Systems for Vehicles
ATMS:	Advanced Traffic Management Systems
AVCSS:	Advanced Vehicle Control and Safety Systems
CACS:	Comprehensive Automobile Control System
CDMA:	Code Division Multiple Access
CVO:	Commercial Vehicle Operations
DAB:	Digital Audio Broadcast
DDG:	Gesellschaft für Verkehrsdaten mbH
DG-VII:	Directorate General for Transport
DOT:	Department of Transportation
DRIVE:	Dedicated Road Infrastructure for Vehicle Safety in Europe
DSRC:	Dedicated Short Range Communication
ECORTIS:	European Co-ORDination for the implementation of RDS-TMC Traffic Information Services
EDGE:	Enhanced Data rates for GSM Evolution
ERGS:	Electronic Route Guidance System
ERTICO:	European Road Transport Telematics Implementation Co-ordination Organization
EV-DO:	Evolution-Data Optimized
ETC:	Electronic Toll Collection
FCC:	Federal Communications Commission
FORCE:	Enhanced Field Projects for Large Scale Introduction and validation of RDS-TMC Services in Europe
FHWA:	Federal Highway Administration
GDP:	Gross Domestic Product
GPRS:	General Packet Radio Services
GPS:	Global Positioning Systems
GSM:	Global System for Mobile Communications
HD Radio:	Hybrid Digital Radio

HSCSD:	High-speed circuit-switched data
HSDPA:	High Speed Downlink Packet Access
HSUPA:	High-Speed Uplink Packet Access
IBOC:	In-Band, On-Channel
ISTEA:	Intermodal Surface Transportation Efficiency Act
ITIP:	Intelligent Transportation Infrastructure Program
ITGS:	Intelligent Traffic Guidance System
ITS:	Intelligent Transportation Systems
ITS America:	Intelligent Transportation Society of America
IVHS:	Intelligent Vehicle Highway Systems
IVHS AMERICA:	Intelligent Vehicle Highway Society of America
IVI:	Intelligent Vehicle Initiative
JARTIC:	Japan Road Traffic Information Center
LISB:	Leit- und Informationssystem Berlin, the Guidance and Information System, Berlin
MAN:	Metropolitan Area Network
MITI:	Ministry of International Trade and Industry
MMDI:	Metropolitan Model Deployment Initiative
MOC:	Ministry of Construction
MONET:	Mobile NETwork
MRT:	Federal Ministry of Research and Technology
MPT:	Ministry of Posts and Telecommunications
NPA:	National Police Agency
NRSC:	National Radio Systems Committee
PDA:	Personal Digital Assistant
PDC:	Personal Digital Cellular
PHS:	Personal Handy-phone System
PND:	Personal Navigation Device
PPP:	Public-Private Partnership
PPP:	Purchasing Power Parity
PROMETHEUS:	Program for European Traffic with Highest Efficiency and Unprecedented Safety
RACS:	Road Automobile Communication System
RDS:	Radio Data System
RDS-TMC:	Radio Data System - Traffic Message Channel
SAFETEA-LU:	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
TEA-21:	Transportation Equity Act for the 21st Century
TEN:	Trans-European Network
TEN-Telecom:	Trans-European Telecom Network
TEN-Transport:	Trans-European Transport Network
TERN:	Trans European Road Network
TTID:	Transportation Technology Innovation and Demonstration
UMTS:	Universal Mobile Telecommunications Systems
USDOT:	United States Department of Transportation
UTMS:	Universal Traffic Management Systems

VII: Vehicle Infrastructure Integration
VICS: Vehicle Information and Communication System

References

- Adler, J. L., & Blue, V. J. (1998/6). Toward the design of intelligent traveler information systems. *Transportation Research Part C: Emerging Technologies*, 6(3), 157-172.
- Alexiadis, V., Carter, M., DeBlasio, A., Inman, V., Perez, B., St-Onge, C., et al. (1998). *Metropolitan model deployment initiative national evaluation strategy* No. FHWA-JPO-99-041). Washington, DC: US DOT Federal Highway Administration.
- Ashahi Shimbun. (2006). *Toyota, offensive in car navigation communication: Subscriber tripled in four years (Japanese)*., 2006, from <http://www.asahi.com/business/update/0808/146.html>
- Austin, J., Walker, J., & Miles, J. (2002). *Appendix B: European comments on US ATIS update report (ATIS practices in Europe and north America A report on comparative analysis)*from <http://ops.fhwa.dot.gov/travelinfo/resources/atlantic/atlappb.htm>
- Beaton, W., & Sadana, A. (1995). Demand for a pre-trip ATIS conditioned upon Communications Media: A stated-choice analysis. Paper presented at the *5th Annual Meeting of ITS America*,
- Berlind, D. (2003). *The best products from comdex*. Retrieved March 10, 2007, from http://techupdate.zdnet.com/techupdate/stories/main/berlind_comdex2003.html
- Brandenburger, A., & Nalebuff, B. (1996). *Co-opetition*. New York: Doubleday.
- Chan, S., Malchow, M., & Kanafani, A. (1999). *The market for traffic information : A study of industry structure and prospects* No. UCB-ITS-PRR-99-17). Berkeley, CA: California PATH Program, Institute of Transportation Studies, University of California at Berkeley. from <http://repositories.cdlib.org/its/path/reports/UCB-ITS-PRR-99-17>
- Charles River Associates Incorporated. (1997). *User acceptance of ATIS products and services: A report of qualitative research*

CIA. *The world factbook.*, 2006, from

<https://www.cia.gov/cia/publications/factbook/index.html>

COUNCIL OF MINISTERS OF TRANSPORT - EUROPEAN CONFERENCE OF
MINISTERS OF TRANSPORT. (1998). *MODERN TECHNOLOGY IN TRANSPORT:
Progress report on implementation* No. CEMT/CM(98)3). Copenhagen, Denmark: from
<http://www.cemt.org/online/docspdf/cm9803e.pdf>

DENSO EUROPE B.V. *Navigation -Denso Europe - markets & products - automotive
components*. Retrieved April 30, 2007, from

<http://www.denso-europe.com/Navigation--1002010000000001.aspx>

eSafety Support. *eSafetySupport.org: About eSafety support*. Retrieved March 12, 2007, from
http://www.esafetysupport.org/en/esafety_activities/about_esafety_support/

eSafetySupport. *eSafetySupport.org: Real-time traffic and travel information (RTTI)*.

Retrieved March 12, 2007, from

http://www.esafetysupport.org/en/esafety_activities/esafety_working_groups/real-time_traffic_and_travel_information_rtti_.htm

Faculty of Science and Technology, Keio University. (a). *ITS lectures: Car navigation
systems, technological approaches to construction of ITS, lecture no. 10, masao shibata,
maebashi institute of technology, December 8, 1999*. Retrieved March 10, 2007, from
http://www.its-lectures.ae.keio.ac.jp/english/10_1208/1208Be.html

Faculty of Science and Technology, Keio University. (b). *ITS lectures: ITS service
development (2), approaches to construction of ITS in social systems, lecture no. 4, jun
shibata, sumitomo electric industries, ltd., October 13, 1999*. Retrieved March 10, 2007,
from http://www.its-lectures.ae.keio.ac.jp/index_j.html

- Faculty of Science and Technology, Keio University. (c). *ITS lectures: Telematic business, approaches to construction of ITS in social systems, lecture no. 12, mitsutu kameyama , NISSAN, July 7, 2003*. Retrieved March 10, 2007, from http://www.its-lectures.ae.keio.ac.jp/2003/2003_m_12e.pdf
- Federal Communications Commission. (2001). *In the matter of implementation of section 6002(b) of the omnibus budget reconciliation act of 1993* No. FCC-01-192)
- Federal Ministry of Transport, Building and Housing. (2004). *Transport telematics - developments and success stories in Germany*. Berlin: from http://www.bmvbs.de/Anlage/original_971906/Transport-Telematics-Developments-and-Success-Stories-in-Germany.pdf
- Federal Statistical Office Germany. (2005a). *Press release, 30 may 2005: About 15% of the population of Germany live in the countryside.*, 2007, from <http://www.destatis.de/presse/englisch/pm2005/p2370021.htm>
- Federal Statistical Office Germany. (2005b). *Transport.*, 2006, from http://www.destatis.de/themen/e/thm_verkehr.htm
- Fekpe, E., & Collins, S. (2003). *Evaluation of intelligent transportation infrastructure program (ITIP) in pittsburgh and philadelphia, pennsylvania*Battelle. from http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//13777.html
- Fortin, M., Rupprecht, S., Beek, F. o. d., & Mulroy, T. M. (1998). *The WELL-TIMED study, volume 2 national reports*. Brussels: from <http://www.rupprecht-consult.de/download/wtfnreport.pdf>
- Garmin Ltd. *Garmin: Nüvi 200*. Retrieved April 9, 2007, from <http://www.garmin.com/products/nuvi200/>

- General Motors Corporation. *Cadillac STS: Car web site: Photo gallery*. Retrieved April 9, 2007, from <http://www.cadillac.com/cadillacjsp/model/gallery.jsp?model=sts&year=2007>
- Gilroy, A. (2005). Portable nav to slow after 2006, study finds. *TWICE: This Week in Consumer Electronics*, 20(15), 39-39.
- Gilroy, A. (2006a). Can portable GPS spur fixed nav unit sales? *TWICE: This Week in Consumer Electronics*, 21(1), 44-44.
- Gilroy, A. (2006b). Clear channel traffic to debut on HD radio. *TWICE: This Week in Consumer Electronics*, 21(1), 64-64.
- Gilroy, A. (2006c). Handheld GPS finding its way to 3x sales growth in 2006. *TWICE: This Week in Consumer Electronics*, 21(14), 32-32.
- Hansen, P. (2001). Telematics: No profits yet. *Automotive Industries*, 181(1), 16.
- Harris, P., & Konheim, C. (1995). Public interest in, and willingness to pay for, enhanced traveler information as provided by IVHS in the new york metropolitan area. Paper presented at the *5th Annual Meeting of ITS America*,
- Honda Motor Co., Ltd. (2003). *Honda launches HDD voice-activated navigation system; world's first 'floating car data' system also introduced*. Retrieved March 13, 2007, from <http://world.honda.com/news/2003/4030918.html>
- Honda Motor Co., Ltd. *Internavi premium club : Internavi VICS*. Retrieved March 13, 2007, from <http://www.premium-club.jp/technology/t1.html>
- Ikoma, T., & Satake, S. (2004). *Direction of traffic information business: Suggestions for japan from cases in foreign countries (in Japanese)* No. July 2004 vol.12)Nomura Research Institute, Ltd. from <http://www.nri.co.jp/opinion/region/2004/pdf/ck20040703.pdf>

- Inrix. (2006). *Inrix expands real-time traffic flow coverage to 73 U.S. markets & 47,000 miles of road*. Retrieved March 12, 2007, from http://www.inrix.com/news_FlowCoverage_05Dec2006.asp
- Inrix. (2007). *Inrix traffic technology*. Retrieved February 5, 2007, from <http://www.inrix.com/techdustnetwork.asp>
- Intelligent Transportation Society of America. *ITS technologies.*, 2007, from http://www.itsa.org/its_technologies/c9/What_is_ITS/ITS_Technologies.html
- ITS America. (1998). *Choosing the route to traveler information systems deployment: Decision factors for creating public-private business plans, an action guide*
- ITS Research & Management Division, Highway Industry Development Organization. (1998). *ITS-review Japan* No. Number 6)from http://www.hido.or.jp/ITSHP_e/Rev/pdf/rev6.pdf
- J.D. Power and Associates. (2006). *2006 PRESS RELEASES: Navigation usage and satisfaction study*. Retrieved March 10, 2007, from <http://www.jdpower.com/corporate/news/releases/pressrelease.asp?ID=2006244>
- Japan Automobile Manufacturers Association, INC. (2006). *Motor vehicle statistics of Japan* from http://www.jama-english.jp/publications/motor_vehicle_statistic2006.pdf
- Japanese Ministry of Internal Affairs and Communications Statistics Bureau. *Explanation of terms.*, 2007, from <http://www.stat.go.jp/english/data/kokusei/2000/terms.htm#Densely%20Inhabited%20Districts>
- Japanese Ministry of Internal Affairs and Communications Statistics Bureau. (2006). *2005 population census.*, 2007, from <http://www.stat.go.jp/data/kokusei/2005/kihon1/00/hyodai.htm>

- Japanese Ministry of Internal Affairs and Communications, Statistics Bureau & Statistical Research and Training Institute. *12-1 roads, 12 transport, Japan statistical yearbook.*, 2007, from <http://www.stat.go.jp/english/data/nenkan/1431-12.htm>
- Japanese Ministry of Land, Infrastructure and Transport. (2003). *ITS handbook 2003-2004, section 2 ITS applications and deployment, installation of VICS (vehicle information and communication system) to all vehicles.*, 2007, from <http://www.its.go.jp/ITS/2003HBook/p36-37.pdf>
- Japanese Ministry of Land, Infrastructure and Transport. (2004a). *ITS hand book, appendix, roles of ITS.* Retrieved February 1, 2007, from <http://www.its.go.jp/ITS/2003HBook/p68-91.pdf>
- Japanese Ministry of Land, Infrastructure and Transport. (2004b). *ITS hand book, section 1 constructing a common platform, deployment of smartway.* Retrieved February 10, 2007, from <http://www.its.go.jp/ITS/2003HBook/p08-27.pdf>
- Japanese Ministry of Land, Infrastructure and Transport, Kanto Regional Development Bureau. (2006). *The status of traffic congestion in Tokyo metropolitan area.*, 2006, from http://www.ktr.mlit.go.jp/3kanjo/whats/traffic_jam.htm
- Japanese Ministry of Land, Infrastructure and Transport, Road Bureau. (a). *Delay of deployment of highway networks.* Retrieved March 13, 2007, from <http://www.mlit.go.jp/road/ir/ir-data/jroad04/03-03.html>
- Japanese Ministry of Land, Infrastructure and Transport, Road Bureau. (b). *International comparison of highway infrastructure.*, 2006, from <http://www.mlit.go.jp/road/ir/ir-data/jroad04/03-02.html>
- Japanese Ministry of Land, Infrastructure and Transport, Road Bureau. (c). *International comparison of the length of national highway with more than four lanes.*, 2006, from <http://www.mlit.go.jp/road/ir/ir-data/jroad04/03-07.html>

- Japanese Ministry of Land, Infrastructure and Transport, Road Bureau. (2007). *VICS/Navigation*. Retrieved February 10, 2007, from <http://www.mlit.go.jp/road/ITS/>
- Johnson, C. M. (1997). The national ITS program: Where we've been and where we're going. *Public Roads*, 61(2), 6-9.
- Kamio, H. (2004). *Automobile ITS revolution! (in Japanese)* (1st Edition ed.). Tokyo, Japan: DIAMOND, Inc.
- Klein, H. (1996). *Institutions, innovation, and information infrastructure: The social construction of intelligent transportation systems in the U.S., Europe, and Japan*. Unpublished doctoral dissertation, Massachusetts Institute of Technology.
- Lappin, J. (2000). *Advanced traveler information service (ATIS): What do ATIS customers want?* U.S. Department of Transportation, Research and Special Programs Administration.
- Lawther, W. C. (2005). Public-Private partnerships in transportation policy: The case of advanced traveler information systems. *International Journal of Public Administration*, 28(13), 1117-1134.
- Levinson, D. (2003/2). The value of advanced traveler information systems for route choice. *Transportation Research Part C: Emerging Technologies*, 11(1), 75-87.
- Lexus, a Division of Toyota Motor Sales, U.S.A., Inc. *LS / overview*. Retrieved April 9, 2007, from <http://www.lexus.com/models/LS/>
- Magellan Navigation, I. *Product detail*. Retrieved April 9, 2007, from <http://www.magellangps.com/products/product.asp?segID=408&prodID=1875>
- Maloney, C., & Berler, D. (2000). *National intelligent transportation systems program plan: Five-year horizon* No. FHWA-OP-00-008) from http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE/11943.pdf

- McQueen, B., Schuman, R., & Chen, K. (2002). *Advanced traveler information systems*. Boston, MA: Artech House.
- Mehndiratta, S. R., Kemp, M. A., Lappin, J. E., & Brand, D. (1999). What advanced traveler information system information do users want? evidence from in-vehicle navigation device users. [Electronic version]. *Transportation research record, 1679*, 41-49.
- Miles, J. C., & Walker, A. J. (1998). *The WELL-TIMED study, volume 1 main report*. Brussels: from <http://www.rupprecht-consult.de/download/wtforeport.pdf>
- ITS enter the second stage ITS enter the second stage: 1. development of ITS: Smartway Project Advisory committee, ITS enter the second stage ITS enter the second stage: 1. development of ITS: (2004). from <http://www.its.go.jp/ITS/Smartway/proposal2004/its2ndstage1.pdf>
- Nakahara, T., & Yamato, N. (1997). ITS development and deployment in Japan. *Intelligent Transportation System, 1997. ITSC 97. IEEE Conference on*, Boston, MA, USA. 631-636. from <http://ieeexplore.ieee.org/ie14/5329/14437/00660547.pdf?arnumber=660547>
- NHK (Japan Broadcasting Corporation). *NHK/digital - digital audio broadcast (in Japanese)*. Retrieved March 19, 2007, from <http://www.nhk.or.jp/digital/radio/index.html>
- Nightingale, D. (2006). *ESD.61J/16.852J class presentation, MIT, September 18, 2006*
- NISSAN MOTOR CO., LTD. *NISSAN CARWINGS: The fastest route search (in Japanese)*. Retrieved April 11, 2007, from <http://drive.nissan-carwings.com/WEB/GUIDE/FUNCTION/SAISOKU/index.htm>
- Nissan Motor Co., Ltd. (2006). *Nissan to launch vehicle navigation service with net access*. Retrieved March 13, 2007, from http://www.nissan-global.com/EN/NEWS/2006/_STORY/060929-01-e.html

Moving toward the integration of ATMS and ATIS in Japan: Moving toward the integration of ATMS and ATIS in Japan: presentation at the 74 th Transportation Research Board (TRB) Annual Meeting (1995).

NTT DoCoMo, I. (2006). *Development of cell phone data communication speed (in Japanese)* No. 40)NTT DoCoMo, Inc.

Oak Ridge National Laboratory. (a). *U.S. department of transportation metropolitan intelligent transportation systems infrastructure deployment tracking database - FY96*. Retrieved March 16, 2007, from <http://itsdeployment.ornl.gov/scripts/foxweb.exe/c:/InetPub/wwwroot/iti96/metro/techno?>

Oak Ridge National Laboratory. (b). *U.S. department of transportation metropolitan intelligent transportation systems infrastructure deployment tracking database 1999 survey results: Search regional multimodal traveler information*. Retrieved March 16, 2007, from http://itsdeployment.ornl.gov/its99/multimodal_search.html

Ogawa, K. (2006). *Tech-on, car electronics, exploding small size car navigation market in Europe from the report of Yano research institute ltd. (in Japanese)* (<http://techon.nikkeibp.co.jp/article/NEWS/20060509/116873/> ed.)Nikkei Business Publications, Inc.

OnStar Corporation. (2006). *OnStar wins popular Science's 2006 best of What's new award*. Retrieved March 13, 2007, from http://209.235.195.221/releases_detail.php?ItemID=345

Owen, R. G. (2004). DIGITAL RADIO BROADCASTING – which standards will prevail? *21. Meeting the AG Digitally Radio*, from http://www.lpr-online.de/aktuelle_dokumente/eureka_owen.pdf

- Pioneer Electronics (USA) Inc. *Pioneer electronics - AVIC-Z2 - the pinnacle of powerful navigation and multimedia*. Retrieved April 9, 2007, from http://www.pioneerelectronics.com/pna/v3/pg/product/details/0,,2076_310069681_423070352,00.html
- R, E. D. (1991). *An American observation of IVHS in Japan*. Ann Arbor, MI: The University of Michigan Press.
- Rupert, B., Wright, J., Pretorius, P., Cook, G., Hutchinson, K., Kell, W. T., et al. (2003). *Traveler information systems in Europe* No. FHWA-PL-03-005)Office of International Programs FHWA/US DOT (HPIP).
- Schrank, D., & Lomax, T. (2005). *THE 2005 URBAN MOBILITY REPORT* Texas Transportation Institute.
- Schuman, R., & Sherer, E. (2001). *ATIS U.S. business models review (report prepared for US department of transportation)*from http://ops.fhwa.dot.gov/travelinfo/resources/atis_bm.htm
- SIRIUS Satellite Radio. (2006). *News releases: SIRIUS satellite radio passes 5.1 million subscribers*. Retrieved February 10, 2007, from <http://investor.sirius.com/ReleaseDetail.cfm?ReleaseID=213347&cat=general&newsroom=>
- SmartRoute Systems. (2005). *SmartRoute systems - public sector*. Retrieved March 3, 2007, from <http://www.smartroute.com/PubSect.htm>
- Sterman, J. (2000). *Business dynamics : Systems thinking and modeling for a complex world*. Boston: Irwin/McGraw-Hill.
- Stuart, D. A. (2006a). *Mobile and wireless services and service providers in Germany, 2006 update* No. G00143401)Gartner, Inc.

Stuart, D. A. (2006b). *Mobile and wireless services and service providers in the united states, 2006* No. G00139093) Gartner, Inc.

The CAMP Vehicle Safety Communications Consortium consisting of BMW, DaimlerChrysler, Ford, GM, Nissan, Toyota, and VW. (2005). *Vehicle safety communications project task 3 final report identify intelligent vehicle safety applications enabled by DSRC* No. DOT HS 809 859). Washington, D.C.: US DOT.

The eSafety Working Group for the Information Society DG. (2002). *Final report of the eSafety working group on road safety* from http://ec.europa.eu/information_society/activities/esafety/doc/esafety_library/esafety_wg_final_report_nov02.pdf

The European Broadcasting Union. *RDS-TMC: What is it all about?* Retrieved March 10, 2007, from <http://www.rds.org.uk/episode/rdstmcbrochure.htm>

The Japan Corporate News Network. (2005). *Toyota announces next-generation telematics service G-BOOK ALPHA* The Japan Corporate News Network. Retrieved March 13, 2007, from http://www.japancorp.net/Article.Asp?Art_ID=9850

The World Bank. *WDI data query.*, 2007, from <http://devdata.worldbank.org/data-query/>

TMC Forum. (a). *Germany.* Retrieved March 11, 2007, from http://tmcforum.ertico.webhouse.net/en/about_tmc/tmc_services_today/germany.htm

TMC Forum. (b). *What is traffic message channel (TMC)?* Retrieved March 11, 2007, from http://www.tmcforum.com/en/about_tmc/what_is_tmc/

TMC Forum. (2005). *TMC in the US of A.* Retrieved March 11, 2007, from http://www.tmcforum.com/en/about_tmc/tmc_news/tmc_in_the_us_of_a.htm

- TomTom. (a). *TomTom mobility solutions*. Retrieved 2007, March 10, from <http://www.mobility.tomtom.com/index.php?>
- TomTom. (b). *TomTom, portable GPS car navigation systems - TomTom GO 910*. Retrieved April 9, 2007, from <http://www.tomtom.com/products/product.php?ID=268&Lid=4>
- TomTom. (2006). *TomTom news: Third quarter results release 2006*. Retrieved March 13, 2007, from <http://www.tomtom.com/news/category.php?ID=4&NID=309&Year=2006&Language=4>
- TomTom. (2007). *TomTom news: Reports fourth quarter and full year results 2006*. Retrieved March 13, 2007, from <http://www.tomtom.com/news/category.php?ID=4&NID=340&Language=4>
- Total Traffic Network. *Real time traffic*. Retrieved March 11, 2007, from <http://www.realtimetrain.net/>
- Toyota Motor Corporation. (2006). *News release April 06, 2006: Free service to car navigation with G-BOOK ALPHA compatibility (in Japanese)*. Retrieved March 10, 2007, from http://www.toyota.co.jp/jp/news/06/Apr/nt06_016.html
- Traffic.com. *Annual report 2005*
- Transportation Equity Act for the 21st Century, 5117 (1998). Retrieved February 10, 2007, from <http://www.fhwa.dot.gov/tea21/h2400-v.htm#5117>
- T-Systems Enterprise Services GmbH. *TMCpro: Unternehmen*. Retrieved March 9, 2007, from <http://www.tmcpro.de/Unternehmen0.html?id=30#>
- Uchida, T., & Pursula, M. (2001). *Japanese ITS strategy and 3G mobile communications in ITS*. Helsinki University of Technology Transportation Engineering).

- US DOT. *What is ITS?*, 2007, from http://www.its.dot.gov/its_overview.htm
- US DOT. (2003). *ITS standards advisory: Dedicated short range communications (DSRC)*. Retrieved March 27, 2007, from http://www.standards.its.dot.gov/Documents/advisories/dsrc_advisory.htm
- US DOT - Federal Highway Administration. (a). *511 - what is it?* Retrieved March 17, 2007, from <http://www.fhwa.dot.gov/trafficinfo/511what.htm>
- US DOT - Federal Highway Administration. (b). *Census 2000 population statistics, U.S. population living in urban vs. rural areas.*, 2007, from <http://www.fhwa.dot.gov/planning/census/cps2k.htm>
- US DOT - Federal Highway Administration. (1996). *Development of human factors guidelines for advanced traveler information systems and commercial vehicle operations: Literature review* No. FHWA-RD-95-153) from <http://www.fhwa.dot.gov/tfhrc/safety/pubs/95153/index.html>
- US DOT - Federal Highway Administration. (2005). *Travel time messaging on dynamic message signs - Chicago, IL* No. FHWA-HOP-05-049) from http://www.ops.fhwa.dot.gov/publications/travel_time_study/chicago/chicago_ttm.htm
- US DOT - Federal Highway Administration. (2006a). *Highway statistics 2005.*, 2006, from <http://www.fhwa.dot.gov/policy/ohim/hs05/index.htm>
- US DOT - Federal Highway Administration. (2006b). *Transportation technology innovation and demonstration program - FHWA traveler information*. Retrieved March 10, 2007, from <http://ops.fhwa.dot.gov/travelinfo/ttidprogram/ttidprogram.htm>
- US DOT - Federal Highway Administration. (2007). *511 America's traveler information telephone number*. Retrieved March 17, 2007, from <http://www.fhwa.dot.gov/trafficinfo/511.htm>

- US DOT - ITS Joint Program Office. *ITS deployment statistics FY2005 - survey results*. Retrieved March 16, 2007, from <http://www.itsdeployment.its.dot.gov/SurveyOutline1.asp?SID=swti>
- US DOT - ITS Joint Program Office. (1998a). *Developing traveler information systems using the national ITS architecture* No. FHWA-JPO-98-031)from <http://www.fhwa.dot.gov/tfhrc/safety/pubs/its/architecture/devtravel.pdf>
- US DOT - ITS Joint Program Office. (1998b). *Tracking the deployment of the integrated metropolitan intelligent transportation systems infrastructure in the USA: FY 1997 results* No. FHWA-JPO-99-001)Oak Ridge National Laboratory.
- US DOT - ITS Joint Program Office. (2003). *2003 intelligent transportation systems (ITS) projects book* from http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/13631.html
- VEGA RESEARCH Inc. (2006). *Telematics research group news: September 6, 2006*. Retrieved February 10, 2007, from <http://trgvega.cocolog-nifty.com/trg/2006/week36/index.html>
- Vehicle Information and Communication System Center. (a). *Beacon & FM broadcasting*. Retrieved March 15, 2007, from <http://www.vics.or.jp/english/vics/beacon.html>
- Vehicle Information and Communication System Center. (b). *Data & links: Media attribute*. Retrieved March 15, 2007, from http://www.vics.or.jp/english/data/media_list.html
- Vehicle Information and Communication System Center. (c). *VICS HOME PAGE*. Retrieved March 11, 2007, from <http://www.vics.or.jp/english/index.html>
- WiMAX Forum. *WiMAX forum - WiMAX home*. Retrieved March 27, 2007, from <http://www.wimaxforum.org/home/>
- Wolinetz, L. D., Khattak, A. J., & Yim, Y. (2001). *Why will some individuals pay for travel information when it can be free? analysis of a bay area traveler survey*. Unpublished Master thesis, The University of North Carolina at Chapel Hill.

- World DMB Ltd. (2006). *Country profile: Germany*. Retrieved February 10, 2007, from http://www.worlddab.org/country_profile.php?id=11
- XM Satellite Radio. *2005 annual report* from <http://library.corporate-ir.net/library/11/115/115922/items/199733/XMAR05.pdf>
- XM Satellite Radio. (2006a). *News room: American Honda to equip more than 650,000 vehicles with XM satellite radio for 2007*. Retrieved February 10, 2007, from http://xmradio.mediaroom.com/index.php?s=press_releases&item=1392
- XM Satellite Radio. (2006b). *News room: General motors to build more than 1.8 million vehicles with factory-installed XM satellite radio in 2007*. Retrieved February 10, 2007, from http://xmradio.mediaroom.com/index.php?s=press_releases&item=1397
- XM Satellite Radio. (2006c). *News room: XM satellite radio announces subscriber additions for the third quarter 2006*. Retrieved February 10, 2007, from http://xmradio.mediaroom.com/index.php?s=press_releases&item=1362
- XM Satellite Radio. (2007). *XM NavTraffic home*. Retrieved March 9, 2007, from <http://www.xmradio.com/navtraffic/index.xmc>
- Yang, H. (1998/4/1). Multiple equilibrium behaviors and advanced traveler information systems with endogenous market penetration. *Transportation Research Part B: Methodological*, 32(3), 205-218.
- Yang, H., & Meng, Q. (2001/12). Modeling user adoption of advanced traveler information systems: Dynamic evolution and stationary equilibrium. *Transportation Research Part A: Policy and Practice*, 35(10), 895-912.
- Yin, Y., & Yang, H. (2003/2). Simultaneous determination of the equilibrium market penetration and compliance rate of advanced traveler information systems. *Transportation Research Part A: Policy and Practice*, 37(2), 165-181.