Institutional Design for IVHS in Osaka:

Applying the Concept of ISTEA in Japan

by

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Abstract

In an infrastructure for the Intelligent Vehicles Highway Systems (IVHS), the Japanese public corporations that deal with expressways, such as the Hanshin Expressway Public Corporation (HEPC), have played an important role in the development of Japan's IVHS. Large cities in Japan have lagged behind the expressway public corporations in creating traffic control systems, because they face governmental jurisdiction and do not have appropriate national funding systems for IVHS. The flexibility features of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) that was instituted in the USA provide a good model for resolving these issues.

This thesis discusses three proposals, applying the concept of ISTEA to Japanese funding systems in order for large cities to develop the kind of traffic control systems that HEPC has achieved. The first proposal concerns the application of the concept of ISTEA to Japan, which is comprised of two methods: 1) transferring highway funds to IVHS; and 2) strengthening the City Planning Council of the designated cities; the second relates to the development of public-private partnerships; and the third involves the utilization of the developer's share in the IVHS cost.

This thesis concludes that effective implementation and operation of IVHS require combinations of these methods. For the short term, the combination of transferring highway funds to IVHS and establishing public management with private sector operation will help to implement and operate IVHS. For the long term, to strengthen the City Planning Council of the designated cities, changes in related laws will be required as well as a decentralization of national power for the allocation of funds. For both short term and long term, using the developer's share in the IVHS cost will allow its implementation without using public money.

Thesis Supervisor: Joseph M. Sussman
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Table of Contents

Title.......... 1
Abstract.......... 2
Acknowledgments.......... 3
Table of Contents.......... 4
List of Figures 6
List of Tables 7

Chapter 1 Introduction.......... 8

Chapter 2 The Current State of IVHS in the Hanshin Expressway.......... 11
2.1 Introduction and Concept of IVHS.......... 11
2.2 The Hanshin Expressway Public Corporation.......... 12
2.3 The Current State of IVHS in the Hanshin Expressway.......... 19
2.3.1 Traffic Information Systems.......... 20
2.3.2 Information Processing Systems.......... 21
2.3.3 Motorist Information Systems.......... 22
2.3.4 Entrance Control Systems.......... 26
2.3.5 Accident Detection Systems.......... 27
2.4 Summary.......... 28

Chapter 3 Why IVHS has been Intensively Developed in the Hanshin expressway.......... 29
3.1 Introduction 29
3.2 Heavy Traffic Condition 29
3.3 Drivers' Complaints 32
3.4 Strong Financial Resources 34
3.5 Competition between the Two National Agencies 36
3.6 Effective Public-Private Partnerships 37
3.7 Summary 38

Chapter 4 Why Local Governments Need to Work on IVHS 39
4.1 Introduction and Current Condition in Osaka 39
4.1.1 Population in Osaka 41
4.1.2 Movement of People 41
4.1.3 Automobile Traffic 43
4.2 Motivation for Developing IVHS in Osaka 44
4.2.1 Osaka Comprehensive Transportation Policy 44
4.2.2 Difficulties in Construction Highways in Urban Areas.......... 53
4.2.3 New Urban Development in the 21st Century 59
4.2.4 The Coming of an "Ultra-Aged Society" 62
4.3 Summary 63

Chapter 5 Problems Facing Local Governments 66
5.1 Introduction 66
5.2 Lack of Funding Systems for IVHS 66

5.3 Jurisdictional Issues 68
5.3.1 The Agreement of 1990 between HEPC and NPA 68
5.3.2 The VICS Project 70
5.4 Retraining 77
5.5 Summary 78

Chapter 6 How Local Governments Should Implement IVHS 80
6.1 Introduction 80
6.2 Current Japanese Funding Systems for Urban Infrastructure 81
6.2.1 Government Ordinance-Designated City System 81
6.2.2 Current Funding Systems for Infrastructure 83
6.3 Concept of the Flexibility in ISTEA 88
6.3.1 Intermodal Flexibility 89
6.3.2 Regional Decision Making 89
6.4 Applying the Concept of ISTEA to Japan 90
6.4.1 Transfer Highway Funds to IVHS 91
6.4.2 Strengthen the City Planning Council 94
6.5 Development of Public-Private Partnerships 95
6.5.1 Privatization of Existing Public Sectors 96
6.5.2 Public Management with the Private Sector Operation 97
6.5.3 Private Sector Funded by Public Sector 98
6.6 Developer's Share in the IVHS Cost 100
6.7 Evaluation of Each Method 102
6.8 Summary 104

Chapter 7 Hypothetical Case Study 106
7.1 Introduction 106
7.2 Assumption 106
7.2.1 Scale of the City 106
7.2.2 Traffic Conditions 107
7.2.3 Institutional Conditions 108
7.2.4 Governmental Jurisdiction 109
7.2.5 Developmental Policies of the City 110
7.2.6 The Circumstances Affecting the City 111
7.3 Future Development of IVHS 113
7.4 Combination of the Four Methods 115
7.5 Summary and Possible Problems 118

Chapter 8 Conclusion 120
8.1 Summary of Each Chapter 120
8.2 Fundamental Conclusion 126

Reference 130

List of Figure

Figure 2.1	The Metropolitan Osaka Area	13
Figure 2.2	The 1993 Fiscal Year Budget of HEPC	17
Figure 2.3	The Network of the Hanshin Expressway	18
Figure 2.4	Vehicle Detection Device	20
Figure 2.5	TV Camera	20
Figure 2.6	Automatic Vehicle Identifier	21
Figure 2.7	Traffic Control Center	21
Figure 2.8	Variable-Graphics Sign Board	24
Figure 2.9	Roadside Radio	24
Figure 2.10	Traffic Information Terminal	25
Figure 2.11	Variable-Message Sign Board	25
Figure 2.12	Automatic Telephone Service	25
Figure 2.13	Travel Time Information Board	26
Figure 3.1	Hanshin Expressway Network	31
Figure 3.2	Portable Ramp (called the Mini Way)	32
Figure 3.3	General Account of Osaka City for Fiscal Year 1991	35
Figure 4.1	Movement of People	42
Figure 4.2	Modal Split in Osaka	42
Figure 4.3	Railway Development in Osaka	46
Figure 4.4	Automated Guide Transit called the New Tram	47
Figure 4.5	Street Condition in “Senba” District	50
Figure 4.6	A Real-Time Guided parking System	52
Figure 4.7	Variable-Message Sign Boards	52
Figure 4.8	Location of Air Monitoring Stations	56
Figure 4.9	Yearly Average Concentration of Major Air Pollutants	56
Figure 4.10	Change in Land Price	58
Figure 4.11	Image Photo of “Technoport Osaka” and Osaka Teleport	59
Figure 5.1	Integration of RACS and AMTICS into VICS	72
Figure 5.2	Three Possible Transmissions in VICS	72
Figure 6.1	Government Ordinance-Designated Cities	82

List of Tables

Table 2.1	Comparison of the Four Urban Expressways	15
Table 2.2	The Total Expenditure and Length of HEPC	17
Table 2.3	Number of Established Traffic Control Systems until Fiscal 1993	19
Table 2.4	Comparison of Traffic Conditions before and after Entrance Control	27
Table 3.1	Traffic Condition from 1969 to 1989 in the Hanshin Expressway	30
Table 3.2	Congestion of the Hanshin Expressway	32
Table 4.1	Comparison of the Large Japanese Cities	40
Table 4.2	Population of Osaka City	41
Table 4.3	Modes of Transportation for Access to Railways in Osaka	43
Table 4.4	Change in Automobile Traffic of Osaka City	44
Table 4.5	Linkage between the National and Osaka City Government	48
Table 4.6	The Number of Parked Cars before/after the Parking System	53
Table 4.7	The Number of Illegally parked Cars on Streets in Osaka City	53
Table 4.8	The Number of Automobiles Registered in Osaka City	55
Table 4.9	National Air Quality Standards	55
Table 4.10	Comparison of Aged Population	63
Table 5.1	Four Functions of VICS	73
Table 5.2	Cost/Benefit Analysis	75
Table 6.1	Comparison of Osaka City and Osaka Prefecture	83
Table 6.2	Current Funding System to the Designated City	85
Table 6.3	Current Funding System to Prefecture Government	86
Table 6.4	Proposed Funding System for IVHS in the Designated City	93
Table 6.5	Comparison of the Three Public-Private Partnerships	100
Table 6.6	Evaluation of Four Methods	103
Table 7.1	Modal Split in Toru City and Osaka City	107
Table 7.2	Combinations of Four Methods	116

Chapter 1 Introduction

Although the situation is changing rapidly, in an infrastructure for the Intelligent Vehicles Highway Systems (IVHS), Japan currently appears to be ahead of other countries of the world.[1] The public corporations that deal with expressways, such as Hanshin Expressway Public Corporation (HEPC), have played an important role in the development of Japan's IVHS.

HEPC, which is administratively linked to the Ministry of Construction, operates the urban expressway networks in the Osaka metropolitan area. By using a toll road system, HEPC has been working on IVHS research and implementing traffic control systems using Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS).

Large cities in Japan face difficulties in constructing highways in urban areas due to the high price of land and environmental issues. It is time for local governments of the big cities to better utilize the existing highway networks in urban areas by using new technology that IVHS provides. Unfortunately, these large cities have lagged behind the expressway public corporations in creating traffic control systems because they face governmental jurisdiction and do not have appropriate funding systems for IVHS from the national government.

Since three national agencies can be considered responsible for IVHS, its development has fallen under governmental jurisdiction. The Ministry of Construction (MC) is responsible for the construction and supervision of highways and expressways. The National Police Agency (NPA) is responsible for traffic control. The Ministry of Posts and Telecommunications (NPA) is responsible for radio frequency allocation. Among the three, MC and NPA

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[1] Ervin, Robert D., *An American observation of IVHS in Japan*, The University of Michigan, 1991

have competed with each other for control of IVHS and have prevented local governments from developing IVHS by not granting them funds. As a result, local governments lack enough national funds to implement IVHS in urban areas. Japanese funding systems are centralized; the power to allocate funds to local governments is controlled by each national agency causing inflexibility in the use of these funds.

The flexibility features of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) that was instituted in the USA provide a good model for resolving these issues. The purpose of the ISTEA program is to intensively develop the intermodal transportation system across the USA in the time period between fiscal year 1992 and fiscal year 1997.

The innovative point of ISTEA lies in the flexibility in the use of highway funds. The ISTEA program includes flexibility features where funds made available from the Highway Trust Fund can be made available for transit as well as highway projects. Furthermore, ISTEA provides the Metropolitan Planning Organization (MPO) with the power to select the projects involving funds allocated to large urbanized areas. The flexibility features of ISTEA will offer Japanese city governments more opportunities for developing and deploying IVHS.

Furthermore, public-private partnerships also play an important role in developing IVHS in urban areas. To date, road repair or new road construction has not required high technology and has just followed highly structured procedures. IVHS requires new approaches. Development of public-private partnerships will also provide local governments with opportunities to deploy IVHS in urban areas.

This thesis seeks to propose an institutional design by applying the concept of ISTEA to Japanese funding systems in order to develop the kind of traffic control systems in urban areas that HEPC has achieved. First, this thesis identifies to what degree HEPC has achieved traffic control systems using ATMS and ATIS (Chapter 2), and discusses what encouraged HEPC to intensively develop such advanced traffic control systems (Chapter 3).

Second, this thesis addresses whether large Japanese cities should implement traffic control systems similar to those that HEPC has (Chapter 4), and points out problems faced by the city governments when they try to implement these systems (Chapter 5). The discussion centers on Osaka City in the hope that it will be used as a model for other Japanese cities facing similar transportation problems.

Third, after introducing the current Japanese funding systems for infrastructure and the concept of ISTEA, this thesis discusses and compares three proposals for the implementation of IVHS by Japanese city governments (Chapter 6). The first proposal concerns the application of the concept of ISTEA to Japan, which is comprised of two methods: 1) transferring highway funds to IVHS; and 2) strengthening the City Planning Council of the designated cities; the second relates to the development of public-private partnerships; and the third involves the utilization of the developer's share in the IVHS cost.

Finally, this thesis uses a hypothetical case to illustrate how to approach the question of combining the above four methods (Chapter 7). Combination I is designed for short-term implementation, and Combination II for long-term implementation. Furthermore, this thesis summarizes each chapter and provides a fundamental conclusion (Chapter 8).

Chapter 2 The Current State of IVHS in the Hanshin Expressway

2.1 Introduction and Concept of IVHS

This chapter describes the concept of Intelligent Vehicles Highways Systems (IVHS) and identifies the current condition of IVHS developed by the Hanshin Expressway Public Corporation (HEPC) in Japan. HEPC is a quasi-government body, playing an important role in developing IVHS. IVHS developed by HEPC is now recognized as one of the most advanced traffic control systems in the world,[2] although the international situation is changing rapidly.

To date, highways and railroads have been the main infrastructure to support various urban activities in large cities. Large cities, such as Tokyo and Osaka, currently face various social needs such as conservation of the environment, and safe and rapid transportation. IVHS will be an important new option for infrastructure in urban areas. According to the strategic plan for IVHS in the US by IVHS America, in urban areas IVHS consists of five categories and their functions are as follows.[3]

1. Advanced Traffic Management Systems (ATMS)

ATMS consists of a surveillance system and a traffic management center. A surveillance system detects traffic conditions and communicates it to the traffic management center. The traffic management center analyzes the information. The analyzed information is used to: 1) manage the system by selecting ramp metering rates, adjusting signal timing, re-routing traffic, and managing incidents, and 2) advise people about traffic conditions.

2. Advanced Traveler Information Systems (ATIS)

ATIS equipment in vehicles, at home, and on surface streets will provide

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[2]Hanshin Expressway Public Corporation, *Traffic Control System*, a public information brochure, 1993, Trans. Toru Takahashi

[3] IVHS AMERICA, *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States*, May 20, 1992

transportation users with information on traffic conditions, routes and schedules.

3. Advanced Vehicle Control Systems (AVCS)

AVCS will improve the driver's control to make travel safer and more efficient. In the long run, movements of all vehicles on special highways will be automatically controlled.

4. Commercial Vehicle Operations (CVO)

To improve the safety and efficiency of commercial vehicles and fleet operations, CVO will be created by integrating the technology functions of ATMS, ATIS, and AVCS.

5. Advanced Public Transportation Systems (APTS)

To improve public transit services, APTS will be created by integrating the technological functions of ATMS, ATIS, and AVICS. For instance, components of APTS are: 1) highway/transit integration; 2) automated bus control systems; and 3) advanced fixed rail control systems.

This paper discusses how city governments in Japan incorporate ATMS and ATIS in urban areas. In this paper IVHS is defined as ATMS and ATIS only.

2.2 Hanshin Expressway Public Corporation

The Hanshin Expressway Public Corporation (HEPC) operates the urban expressway networks using a toll road system in the metropolitan Osaka area. As shown in Figure 2.1, the metropolitan Osaka area refers to the urban area closely related to Osaka, geographically, socially, and economically. The area is undergoing a large growth in population, industry, and economic progress. The metropolitan Osaka area covers a total area of 7,800 square kilometers within a radius of about 50 to 60 km from the center of Osaka. The population totaled about 16.9 million as of 1990, making it one of the biggest metropolitan areas in the world.

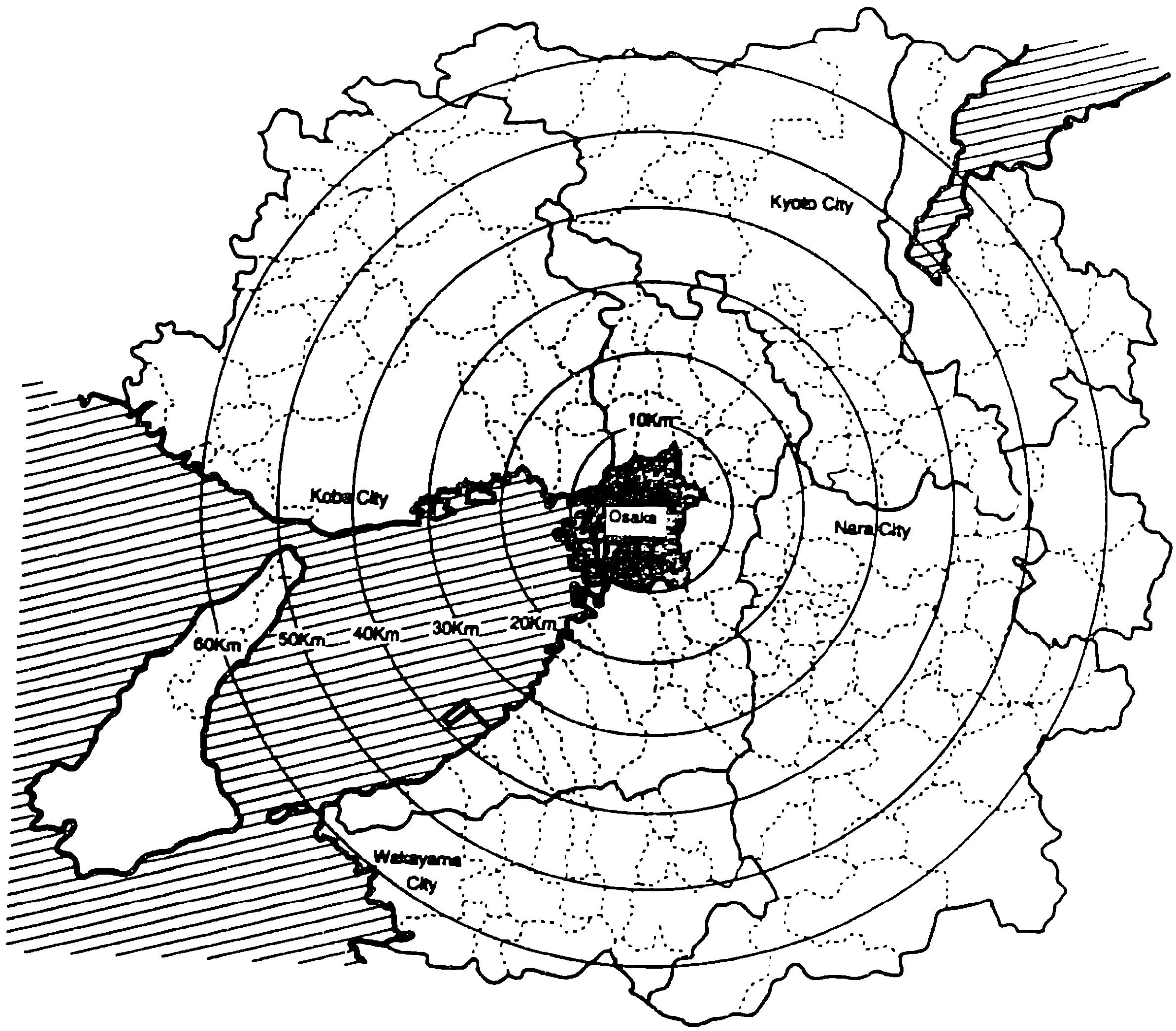

Figure 2.1 The Metropolitan Osaka Area

A toll road system was established in 1952 in order to meet the demand for highway construction. In the 1950's, the Japanese highway network was considered decades behind that of the US and European countries.[4] The Japanese government had to improve its road system at a very fast pace

4 The Ministry of Construction, *Roads in Japan*, 1991

within a limited government budget. As a result, the Japanese government decided to create a toll road system. In the toll road system, highway construction costs come from toll revenues from road users, and monetary resources are borrowed and funded by the national and local governments. Having decided upon this system, the Japan Highway Public Corporation, which operates the nationwide express networks, was established in 1956. The Tokyo Metropolitan Expressway Public Corporation, which operates the urban expressway network in the metropolitan Tokyo area, was established in 1960.

When the Japanese government established the Tokyo Metropolitan Expressway Public Corporation, the government thought that only the metropolitan Tokyo area needed urban expressway networks and that urban expressway networks for other metropolitan areas could wait due to financial problems. In those days, automobile traffic in the Osaka area had increased significantly, and was causing severe congestion and frequent accidents. The need for an urban expressway was keenly felt, so the Osaka City government established the "Council for the Development of the Hanshin Area Expressway," consisting of congressmen, councilmen, and executive city officials who were to address traffic problems in Osaka and petition the Japanese government to create an expressway in the metropolitan Osaka area. As a result, in 1962 the Hanshin Expressway Public Corporation (HEPC) was established. After the establishment of HEPC, the Japanese government expanded its approval and two urban expressway public corporations were established: the Nagoya and Fukuoka Expressway Public Corporations.

Table 2.1 compares four urban expressways. The length of the Hanshin and Tokyo Metropolitan Expressway is much greater than that of any other expressway. Furthermore, the average number of vehicles per day and per kilometer on the Hanshin is the greatest of the four. This severe traffic congestion is one of the reasons why HEPC has felt encouraged to develop traffic control systems more intensively than any other expressway public corporation.

Table 2.1 Comparison of the Four Urban Expressways

	Length	Vehicles/day	Vehicles/day kilometer
Hanshin	157.9	830	5,300
Tokyo	231.4	1,041	4,500
Nagoya	30.3	110	3,600
Fukuoka	63.0	166	2,640
[Units:	km	vehicles/day	vehicles/day kilometer]

Source: Highway Research Committee, *Highway and Vehicles*, January 1994

These public corporations have been administratively linked to the Ministry of Construction (MC) whose minister is a member of the Prime Minister's cabinet. Financially, these corporations are funded by MC and local governments where each expressway is located. For instance, HEPC is funded by MC, three prefectural governments, Osaka City, and other two cities. According to HEPC's 1993 fiscal information[5], these local governments, as well as MC, funded $74 million in HEPC.

HEPC is based on the Hanshin Expressway Public Corporation Act. HEPC can conduct the following business in the metropolitan Osaka Area:

1) construction and maintenance of the toll expressway
2) the redevelopment project related to the construction of the expressway
3) construction of surface streets related to expressway construction
4) research about the expressway
5) construction of buildings under the elevated expressway.

[5] Hanshin Expressway Public Corporation, *The Job of the Hanshin Expressway Public Corporation 1993*, a public information brochure, 1993, Trans. Toru Takahashi

The plans of the Hanshin Expressway are adopted by the national and local governments through the City Planning Decision Process that the City Planning Law requires (discussed in Chapter 6). The process of the adoption is as follows:

1) Local governments prepare the draft plan about the toll expressway. The draft plan is open to public inspection, and is then discussed in the City Planning Council which the City Planning Law requires.
2) After the discussion, MC examines the plan and approves it. The plan is then adopted and announced officially.

After the adoption of the plan, MC designates HEPC to implement the toll expressway. HEPC, instead of local governments, can then begin to construct the toll expressway.

Figure 2.2 shows the HEPC's 1993 fiscal budget. The total year revenue is $5.32 billion. About 72% of the total revenue comes from HEPC's bonds and loans from local and national governments. About 22% comes from toll revenues which are approximately $1.2 billion. In terms of total expenditure, HEPC invests about 45% or $2.4 billion in constructing new expressway networks. Currently HEPC has $21.4 billion in bonds and loans that should be returned for 30 years, though HEPC has already returned $11.8 billion in bonds and loans. These bonds and loans were used for expressway construction. As a result, HEPC must spend about 45% of the total expenditure for returning the loans annually. Since HEPC has borrowed money from the national and locai governments on the basis of the toll road system whenever it has constructed a new expressway, HEPC must continue to return loans.

Adjusting for inflation, the total expenditures of HEPC increased by about 2.5 times between 1984 and 1992 as shown in Table 2.2, while the expressway length increased 1.27 times and the average number of vehicles per day increased 1.22 times during the same period. However, the budget of fiscal year 1993 decreased by 1.8%, compared to the expenditures of the previous fiscal year due to the recession of the Japanese economy that made tax revenues of the national and local governments decreased. Since HEPC accepted loans and funding from the national and local governments, the governments reduced the amount of loans and funds.

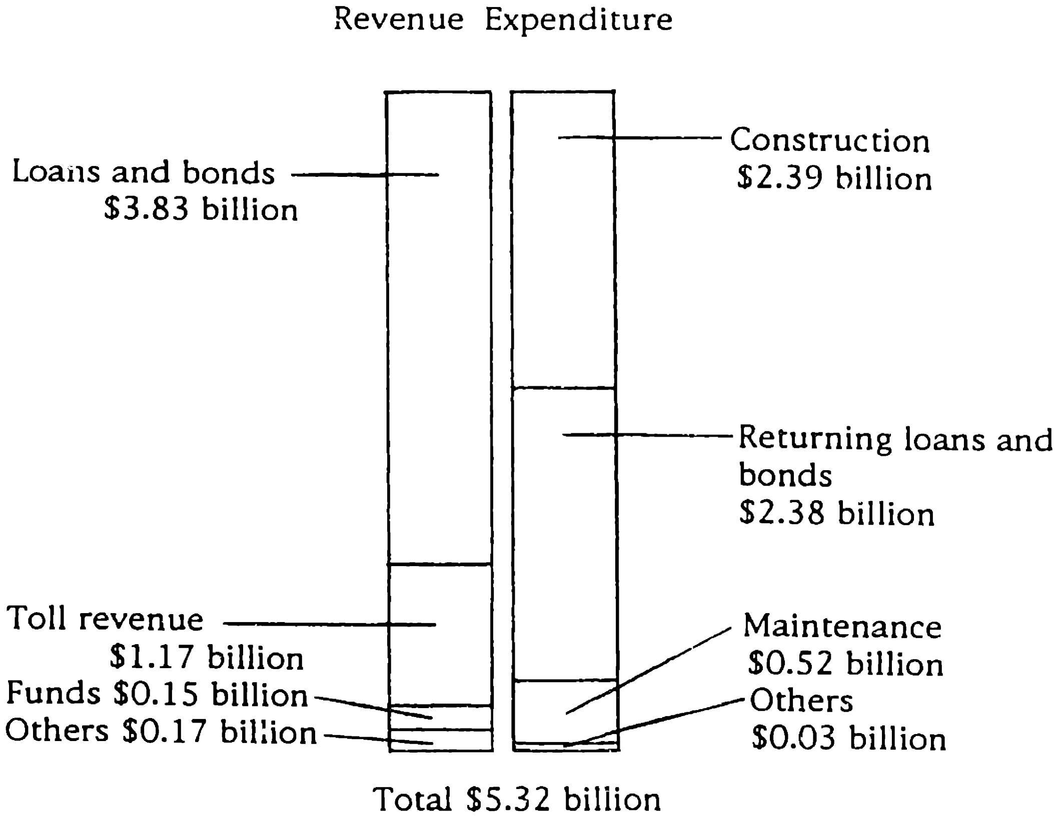

Figure 2.2 The 1993 Fiscal Year Budget of HEPC

Table 2.2 The Total Expenditure and Length of HEPC

Fiscal year	'84	'85	'86	'87	'88	'89	'90	'91	'92
The total expenditures [$ billion]	2.19	2.43	2.75	3.13	3.44	4.11	4.33	5.03	5.42
Expressway length [km]	124.1	129.3	138.5	138.5	143.5	143.5	152.8	157.9	157.9
Average number of vehicles/day [100 vehicles]	6799	6970	7203	7431	7685	7717	8055	8211	8283

At present, this expressway is being extended to comprise 13 routes covering 157.9 km. (See Figure 2.3) The average number of vehicles per day on this expressway is approximately 830,000 vehicles. The toll revenues in 1993 reached $1.2 billion. Currently HEPC is constructing the "Wangan Route" connecting Osaka with the new "Kansai International Airport" that will open in September, 1994. After the construction of the Wangan Route covering 56 km, it is predicted that one million vehicles will use the Hanshin Expressway daily.

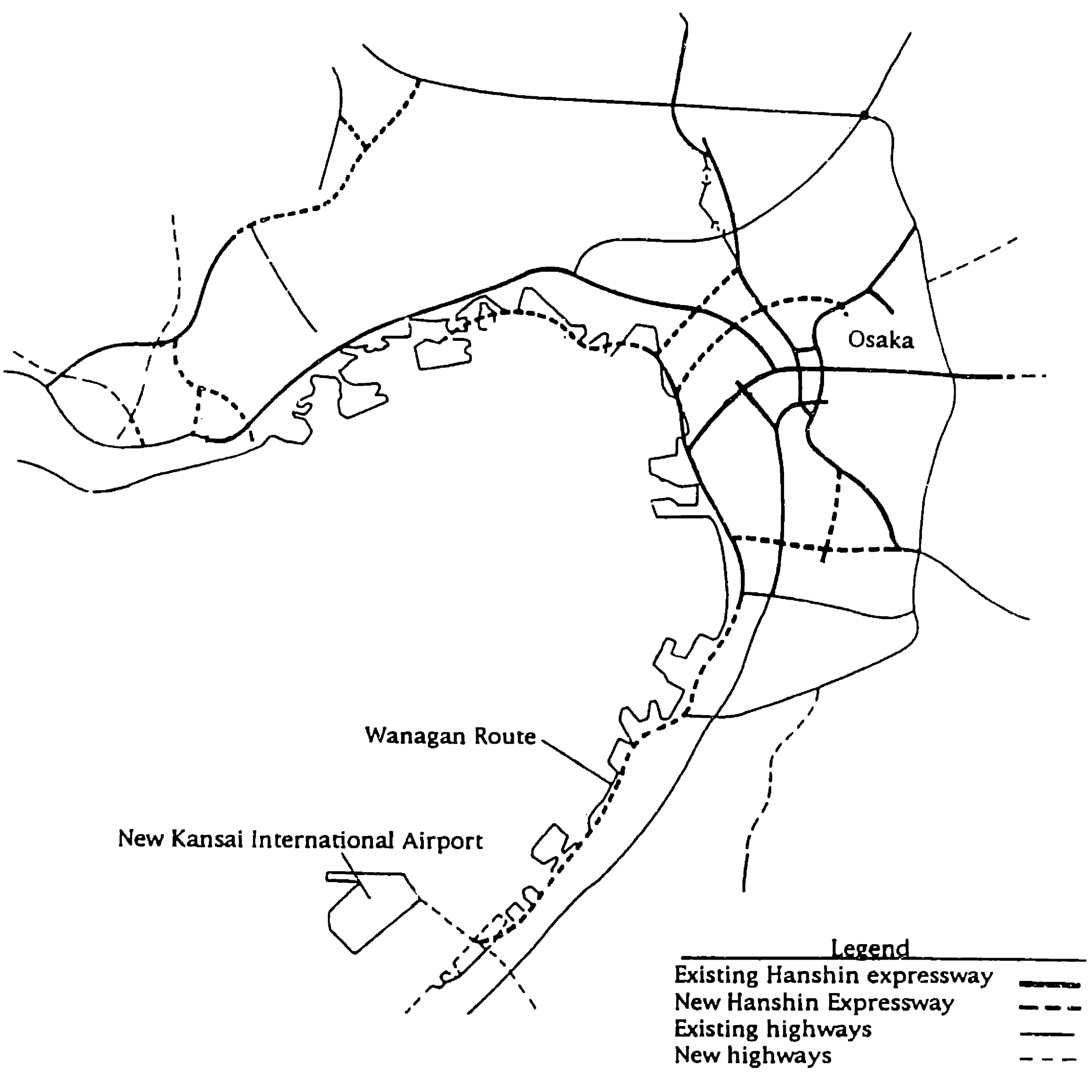

Figure 2.3 The Network of the Hanshin Expressway

According to the survey conducted by Osaka City in 1993, the average daily traffic volume on the Hanshin Expressway was about 4.5 million vehicle kilometers per day and on the surface streets in Osaka City it was about 15.5 million vehicle kilometers per day. The Hanshin Expressway's share of the traffic volume was 22%, although its share of highway length was only about 2% (the length of the Hanshin Expressway inside Osaka City is 93 km and the surface streets in Osaka City add up to about 3,880 km). These figures indicate that the Hanshin Expressway is essential to Osaka's highway system for supporting social and economical activities in Osaka City.

2.3 The Current State of IVHS in the Hanshin Expressway

The Hanshin Expressway Public Corporation (HEPC) has developed Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) to make driving more efficient, safer, and more comfortable. ATMS and ATIS developed by HEPC consists of five systems:

1) traffic data collection systems
2) information processing systems
3) motorist information systems
4) entrance control systems
5) accidents detection systems.[6]

Table 2.3 shows the number of currently established such traffic control systems. This section discusses the current state of these systems.

Table 2.3 Number of Established Traffic Control Systems until Fiscal 1993

Variable-message sign board	302
Variable-graphics sign board	4
Travel information board	111
AVI	10
TV camera	152
Vehicle detection devices	1,319
Roadside radios	25
Traffic information terminal	2

Source: Hanshin Expressway Public Corporation, *Traffic Control System*, 1993

6 Hanshin Expressway Public Corporation, *Traffic Control System*, a public information brochure, 1993 , Trans. Toru Takahashi

2.3.1 Traffic Information Collection Systems

The traffic information collection systems is comprised of vehicle detection devices, TV cameras, and automatic vehicle identifiers (AVI). Vehicle detection devices are used for collecting traffic volume, TV cameras are used for monitoring the expressway visually, and AVIs are used for reading license plates and tracking travel time between the two AVIs.

Vehicle detection devices

Shown in Figure 2.4, ultrasonic sensors detect passing vehicles to calculate traffic volume, road occupancy, and mean vehicle speed. HEPC uses ultrasonic sensors because of their ease of installation and maintenance. An ultrasonic sensor is installed every 500 meters along the expressway.

TV cameras

Shown in Figure 2.5, TV cameras provide visual information on traffic conditions and are controlled remotely from the traffic control centers. About 60 percent of the Hanshin Expressway network is monitored by these cameras.

Automatic vehicle identifiers (AVI)

Shown in Figure 2.6, AVIs are installed along the major routes to read Japanese license plates and to calculate the time a vehicle takes to pass two fixed points along the expressway.

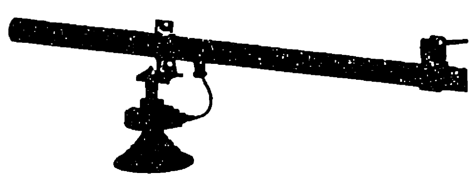

Figure 2.4 Vehicle Detection Device

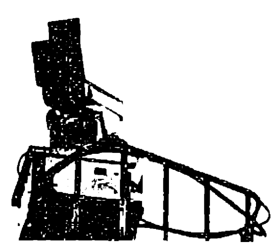

Figure 2.5 TV Camera

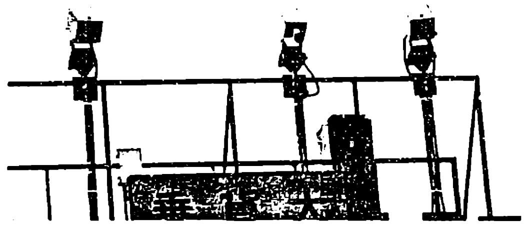

Figure 2.6 Automatic Vehicle Identifier

2.3.2 Information Processing Systems

Traffic data collected by traffic information collection systems is transmitted to the traffic control center where it is processed and changed into traffic information available to drivers by computer systems. This traffic control center also controls motorist information systems, entrance control systems, and accident detection systems. Shown in Figure 2.7, traffic control center is equipped with main computers for data processing and traffic surveillance equipment and console desks for control operation. The efficient HEPC's traffic control system on the Hanshin Expressway results from its advanced traffic control center.

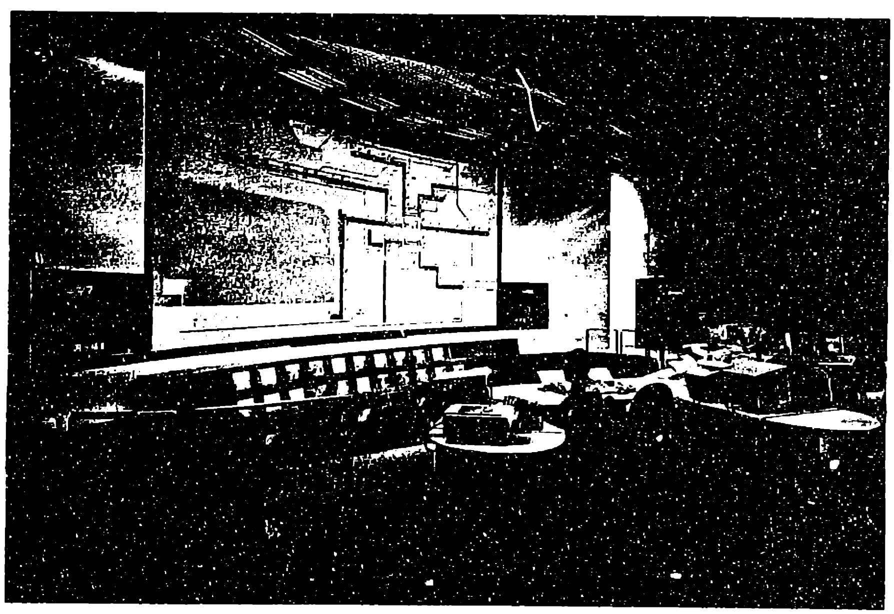

Figure 2.7 Traffic Control Center

Computer systems

The computer system consists of two central processing units (one of which is a back-up) and seven sub-processing units (two of which are back-ups). The other functions are: 1) central processing unit; 2) data collecting system sub-computer; 3) information transmission system sub-computer; 4) audio system sub-computer; 5) information exchange system sub-computer; and 6)operation system sub-computer.

Traffic surveillance equipment

Traffic surveillance equipment consists of a graphic panel, a large screen, TV monitors, and CRT data displays. The graphic panel displays traffic conditions in three stages: light off, orange lights, and red lights. It also displays the location of traffic obstructions. The large screen displays an enlarged image of any of the TV monitors or CRT data displays. CRT data displays show data on traffic, road, and motorist information board condition, and can retrieve data up to 48 hours old.

Console desk

The console desk controls motorist information boards, TV cameras, and CRT data displays. It also handles traffic flow onto the expressway by restricting the number of vehicles allowed through toll booths.

2.3.3 Motorist Information Systems

Traffic information processed by the traffic control center, such as information about traffic congestion and travel time, is provided by motorist information systems. These systems enable drivers to select the best route and prevent further congestion by encouraging detours to feeder roads. According to the HEPC's survey,[7] the average time that drivers spend on the expressway is about 13 minutes. If drivers use another surface route, it will take them about 33 minutes. By paying the five-dollar toll, drivers can save about 20 minutes. Once they enter the

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[7]Hanshin Expressway Public Corporation, *The Job of the Hanshin Expressway Public Corporation 1993,* a public information brochure, 1993, Trans. Toru Takahashi

traffic congestion on the Hanshin Expressway, they often cannot save the 20 minutes and therefore waste the five-dollar toll. As a result, drivers who use the Hanshin Expressway are very sensitive to congestion reports which help them determine in advance whether or not they will select the expressway. Motorist information systems can provide drivers about to use the expressway with significant traffic information before they reach the toll booth. These systems also provide drivers already on the expressway with its current traffic conditions. All visual and audio information is updated every five minutes. The motorist information systems consist of six sub-systems:

Variable-graphics sign boards

Shown in Figure2.8, boards provide drivers on the expressway with clear, color-coded road maps and indications of congested areas and blocked routes.

Roadside radios

Shown in Figure 2.9, roadside radio antennas broadcast local computer-edited traffic information on the AM band at 1620 Hz. This radio information service is currently available over one-third of the entire expressway network. This roadside radio system is for drivers on the expressway.

Traffic information terminals

Shown in Figure 2.10, traffic information terminals are installed at two commuter parking areas on the expressway. These terminals provide drivers with traffic information by using data displays, graphics, monitor screens, and voice messages.

Variable-message sign boards

Shown in Figure 2.11, variable sign boards are installed along the expressway and feeder roads close to expressway entrances. They provide drivers on the expressway or before the entrances with information on congestion and traffic obstructions.

Automatic telephone service

Shown in Figure 2.12, the computer at the traffic control center provides a 24-hour traffic information service using a recording.

Travel time information boards

Shown in Figure 2.13, travel time information boards are installed at most of toll booths and on feeder roads close to expressway entrances. These boards display the time a vehicle will take to reach a major destination. The travel time is calculated as follows:

(a) Based on the data collected by the ultrasonic sensors, which are installed every 500 meters, the computer at the control center calculates the mean vehicle speed in each 500-meter section.

(b) The time a vehicle traveling at that mean speed takes to cover 500 meters is calculated.

(c) The travel times for each 500-meter section are added together to provide the total travel time to specific destinations.

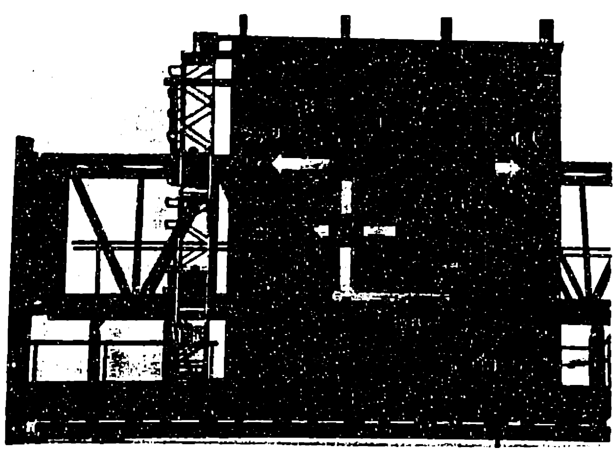

Figure 2.8 Variable-Graphics Sign board

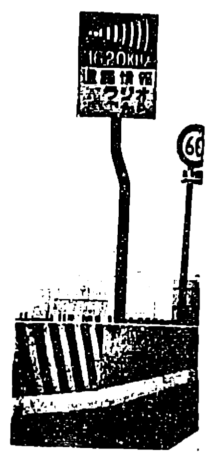

Figure 2.9 Roadside Radio

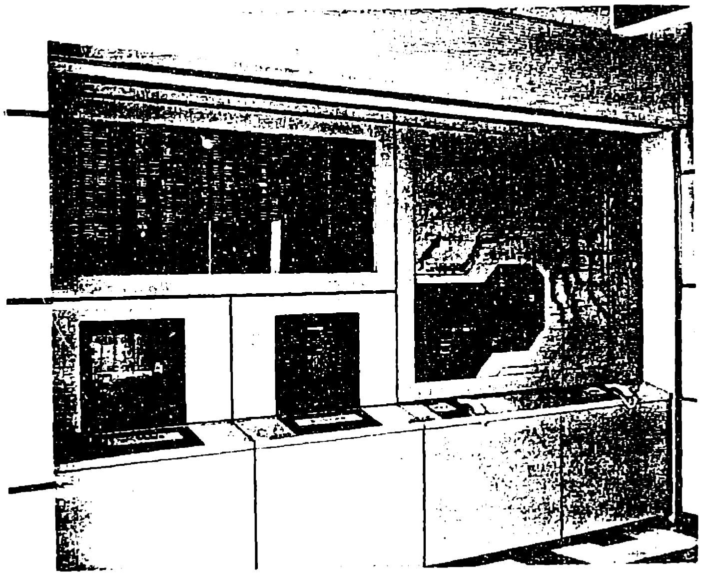

Figure 2.10 Traffic Information Terminal

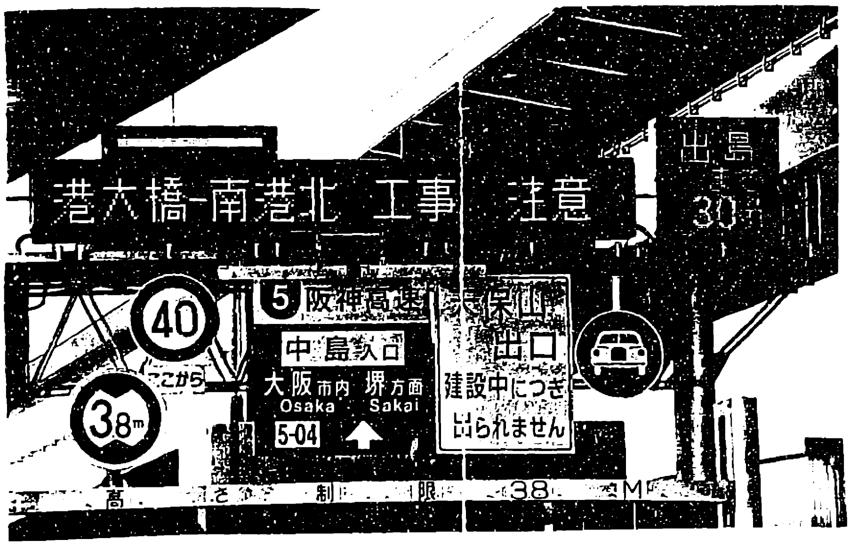

Figure 2.11 Variable-Message Sign Board

Figure 2.12 Automatic Telephone Service

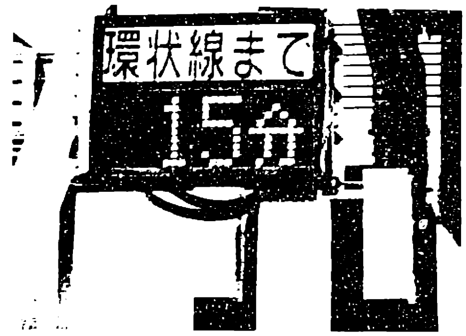

Figure 2.13 Travel Time Information Board

Before using the Hanshin Expressway, drivers can obtain information on the expressway's traffic conditions from variable-message sign boards, travel time information boards, and an automatic telephone service; or they can choose an alternative route and estimate their travel time on the basis of their daily commuting experience. After they compare the travel time on an alternative route with the travel time on the Hanshin Expressway, and calculate how much time can be saved by paying the five-dollar toll, they will be able to make the appropriate decision. Drivers already on the expressway can also get information on traffic conditions by variable-graphics sign boards, variable-message sign boards, roadside radios, and traffic terminals in order to decide whether to remain on it.

2.3.4 Entrance Control Systems

To mitigate traffic congestion, HEPC has been using entrance control systems since 1980. HEPC uses uniform toll systems where drivers pay five dollars at each entrance and can use any routes within the Osaka metropolitan area. Therefore, the entrance control systems are effective to control traffic volume on the expressway. If traffic congestion occurs on a section on the expressway, traffic flow onto the expressway is controlled by restricting the number of vehicles allowed through toll booths or by closing some toll booths all together.

Shown in Table 2.4, HEPC compared the traffic conditions of 1979 with 1984. In 1980 the new route of the Hanshin Expressway was open. There was an increase in traffic volume which resulted in a higher frequency of traffic congestion. However, the average length of congestion time decreased, underlining the effectiveness of the entire control system.

Table 2.4 Comparison of Traffic Conditions before/after Entrance Control

Item	1979	1984	Fluctuation
Average number of vehicles (vehicles/day)	383,831	477,149	24% increase
Frequency of congestion (times/year)	4,929	7,203	46% increase
Average time of congestion (hours/congestion)	2hr. 3min.	1hr. 40min.	12% decrease

2.3.5 Accident Detection Systems

According to past accidents records by HEPC, serious car accidents often occur at curves with poor visibility. To cope with this problem, HEPC is now developing automatic accident detection systems on curves in the expressway. The first two accident detection systems came into service in 1992. This system automatically detects car accidents and reports the incident immediately to upstream drivers to prevent secondary accidents. The incident is also reported to the traffic control center to take quick action.

The accident detection systems consist of on-road cameras, an image processor at the transmission tower, variable-message sign board, and the central processor at the traffic control center. The cameras are installed in the areas where car accidents occur frequently. Images are sent from cameras to the transmission tower that analyzes whether or not an accident has occurred. If an accident is detected by the transmission tower, an emergency sign is sent to the control center and the variable-message sign boards which warn upstream drivers.

2.4 Summary

This chapter introduced the concept of IVHS, discussed the history of HEPC, and identified the current state of traffic control systems developed by HEPC. While on the expressway, drivers can receive current information about traffic conditions using these systems and can then decide whether to remain on the expressway or not. Before using the Hanshin Expressway, drivers can choose an alternative route and estimate their travel time on the basis of their daily commuting experience; or they can choose the Hanshin Expressway and consult the sign boards there that predict the travel time while on it. After they compare the travel time on an alternative route with the travel time on the Hanshin Expressway, and calculate how much time they can save by paying the five-dollar toll, they will be able to decide whether to select the Hanshin Expressway.

In the next chapter, this thesis discusses what encouraged HEPC to develop such advanced traffic control systems intensively.

Chapter 3 Why IVHS Has Been Intensively Developed in the Hanshin Expressway

3.1 Introduction

The Hanshin Expressway Public Corporation (HEPC) has been working on IVHS research since 1967, and has implemented Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) starting in 1969. With a new infrastructure for IVHS, this public corporation appears to place Japan well ahead of other countries. The following circumstances pressured or encouraged HEPC to intensively develop ATMS and ATIS:

1) heavy traffic congestion
2) drivers' complaints
3) strong financial resources
4) competition between the two national agencies
5) effective public-private partnerships.

3.2 Heavy Traffic Congestion

The steady increase of traffic congestion encouraged HEPC to accelerate the pace of development of IVHS. In 1964, when the Hanshin Expressway opened, it covered 3.1 km and was used by approximately 5,000 vehicles per day. With the gradual expansion of the expressway network, traffic volume had continued to increase. Now about 830,000 vehicles per day use the expressway network, which covers 157.9 km.

According to HEPC, traffic congestion is defined as an average traveling speed of less than 30 km/h (19 mile/h) with a duration of at least 30 minutes. This 30 km/h is based on a HEPC survey,[8] which shows that speeds less than 30 km/h make about 50% of the drivers feel that traffic is congested. As shown

[8] Hanshin Expressway Public Corporation, *Traffic Control System*, a public information brochure, 1993, Trans. Toru Takahashi.

in Table 3.1, with the increase of traffic volume on the expressway, the incidence of traffic congestion increased 14.5 times between 1969 and 1989. In 1989, there were 14,597 occurrences of traffic congestion, an average of 40 per day. According to the HEPC survey of the three main causes of traffic congestion on the expressway, about 80 % of traffic congestion results from recurring congestion (the heavy traffic volume that occurs predictably throughout the day), 7% from traffic accidents, and 6% from maintenance work. These figures are very different from those of the US, because about two-thirds of traffic congestion in the US results from traffic accidents. Table 3.1 shows that in the 1970s traffic accidents increased slightly. However, since 1983 traffic accidents have shown a great increase.

Table 3.1 Traffic Condition from 1969 to 1989 in the Hanshin Expressway

	1969	1975	1981	1985	1989
Average number of vehicles per day [100,000 vehicles]	1.77 (1.0)	4.01 (2.3)	5.86 (3.3)	6.97 (3.9)	7.72 (4.4)
Expressway length [km]	74.1 (1.0)	90.9 (1.2)	117. 6 (1.6)	129.3 (1.7)	143.5 (1.9)
Congestion frequency [times per year]	1,004 (1.0)	5,936 (5.9)	10,526 (10.5)	14,006 (14.0)	14,597 (14.5)
Accidents [times per year]	1,491 (1.0)	2,114 (1.4)	2,897 (1.9)	5,463 (3.7)	7,699 (5.2)

Note: Figures in parentheses denote the ratio of 1969 figures.

To alleviate daily recurring congestion, HEPC has been constructing more exits and expanding the ATMS and ATIS programs. This congestion tends to occur at specific areas. As shown in Figure 3.1, the Hanshin Expressway consists of radial and loop facilities with limited entrances and exits. According to the HEPC survey, about 60% of drivers using the Hanshin Expressway use the loop route of the expressway. The number of vehicles per day using the loop route reached 140,000 in 1993; the six lanes in the loop were insufficient to manage the volume of traffic. As a result, congestion frequently occurs on the loop route and the radial line feeding into it. To mitigate the daily congestion, HEPC developed the entrance control system, which controls traffic flow onto the expressway by restricting the number of toll booths or by closing toll booths all together. As shown in Table 3.2, recurring congestion has not increased greatly since 1988 due to the effectiveness of the entrance control system.

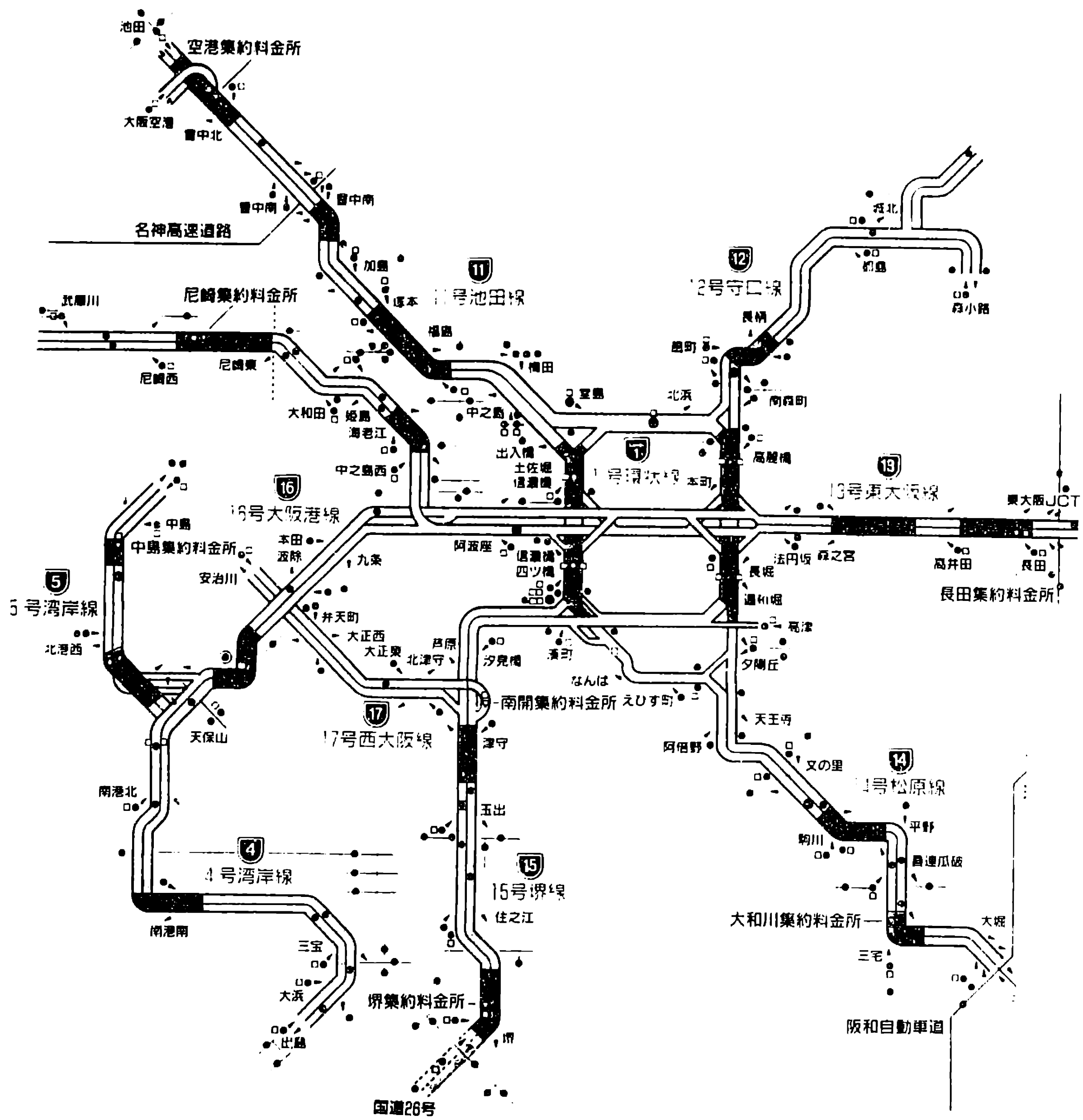

Figure 3.1 Hanshin Expressway Network

Table 3.2 Congestion of the Hanshin Expressway

	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92
Frequency	68	74	79	79	88	101	110	118	128	111	113	112	119
										[100 times per year]			
Time length of recurring congestion	124	134	145	159	174	198	219	265	307	293	327	292	297
										[100 hours per year]			

To decrease congestion caused by traffic accidents, HEPC is now developing accident detection systems (see Chapter 2). HEPC also makes an effort to mitigate the troubles caused by maintenance work. For example, the duration of a road repair is kept to a minimum by using advanced machinery and an intensive workforce that HEPC's contractors provide. Second, in order for traffic to continue uninterrupted, a portable ramp called the Mini Way is placed over the work area[9] (see Figure 3.2). Since there are many residential buildings in Osaka along the elevated expressway and the noise disturbs the residents, HEPC does not do maintenance work at night.

Figure 3.2 Portable Ramp (called the Mini Way)

3.3 Drivers' Complaints

The Hanshin Expressway has a uniform toll system, so that drivers can pay once and use any of the expressway's routes inside the Osaka Metropolitan

[9] Hanshin Expressway Public Corporation, *The Job of the Hanshin Expressway Public Corporation 1993*, a public information brochure, 1993, Trans. Toru Takahashi.

area. As already discussed in Chapter 2, drivers using the Hanshin Expressway can save about 20 minutes by paying the five-dollar toll. Once drivers enter the traffic congestion on the Hanshin Expressway, they cannot save the 20 minutes and will waste the five-dollar toll. Therefore, drivers are sensitive to traffic congestion information that will help determine whether or not they should use the expressway. According to the HEPC survey, about 90% of drivers are concerned with travel time to reach a major destination. If they obtain information about traffic congestion on the Hanshin Expressway before using it, about 50% of the drivers will select alternative route, such as, surface roads.

The decision to select the Hanshin Expressway or an alternative route is as follows. Drivers can choose to use alternative routes, and estimate their travel time on the basis of their daily commuting experience. Or they can choose the Hanshin Expressway with sign boards that provide predicted travel time on the Hanshin Expressway. Before drivers enter the Hanshin Expressway, they compare the predicted travel time on the Hanshin Expressway with travel time on alternative routes, and calculate how much time can be saved by paying the five-dollar toll. Some drivers will select the Hanshin Expressway, if they think that they can save 10 minutes by paying the toll. Others will select the Hanshin Expressway, if they think that they can save 5 minutes by paying the toll. The selection depends on each individual's time value.

Furthermore, since exits on the expressway are limited, once drivers on the expressway face traffic congestion, they can not easily escape by using alternative routes. To make matters worse, the frustration of drivers who face heavy traffic congestion on the expressway can cause traffic accidents.[10] With the ATMS and ATIS systems, not only are drivers on the expressway informed about the nature and duration of the congestion, but drivers about to use the expressway are given estimated length of time to specific destinations in order to make informed choices about their routes. These details mitigate drivers' anxiety, and therefore reduce the chance of accidents and complaints.

3.4 Strong Financial Resources

In order to explain the strong financial resources of HEPC, this section compares its financial resources with those of Osaka City, since Osaka City has the second largest budget in Japan (only Tokyo has a larger budget) and its detailed financial information is available. HEPC constructs new expressways by using toll revenue as well as bonds and loans from national and local governments. Local governments construct new freeways by using local taxes and funds from the national government. Compared to prefectural or municipal governments, HEPC can invest more money in the construction of new expressways and the maintenance of the existing expressway. HEPC can allocate part of its maintenance budget to the development of ATMS and ATIS.

As already discussed in Chapter 2, about 45% of the total expenditure, $2.39 billion, is used for constructing new expressways, although HEPC must spend about 45% of the total expenditure for paying back loans and bonds. About 10% of the total expenditure, $0.55 billion, is used for research and development and maintenance work; ATMS and ATIS are funded from some of this sum. HEPC can use $ 2.94 billion for constructing new additions totaling 82 km and for maintaining the existing 157.9 km expressway

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10 VICS Conference, *Vehicle Information and Communication System*, VICS Symposium, Tokyo, November 1993, Trans. Toru Takahashi

network. Figure 3.3 shows the 1991 fiscal financial information for Osaka[11]. The total year revenue was 1,536 billion Japanese yen or about $14 billion. About 46% of the total revenue came from city taxes and about 14% came from national funds.

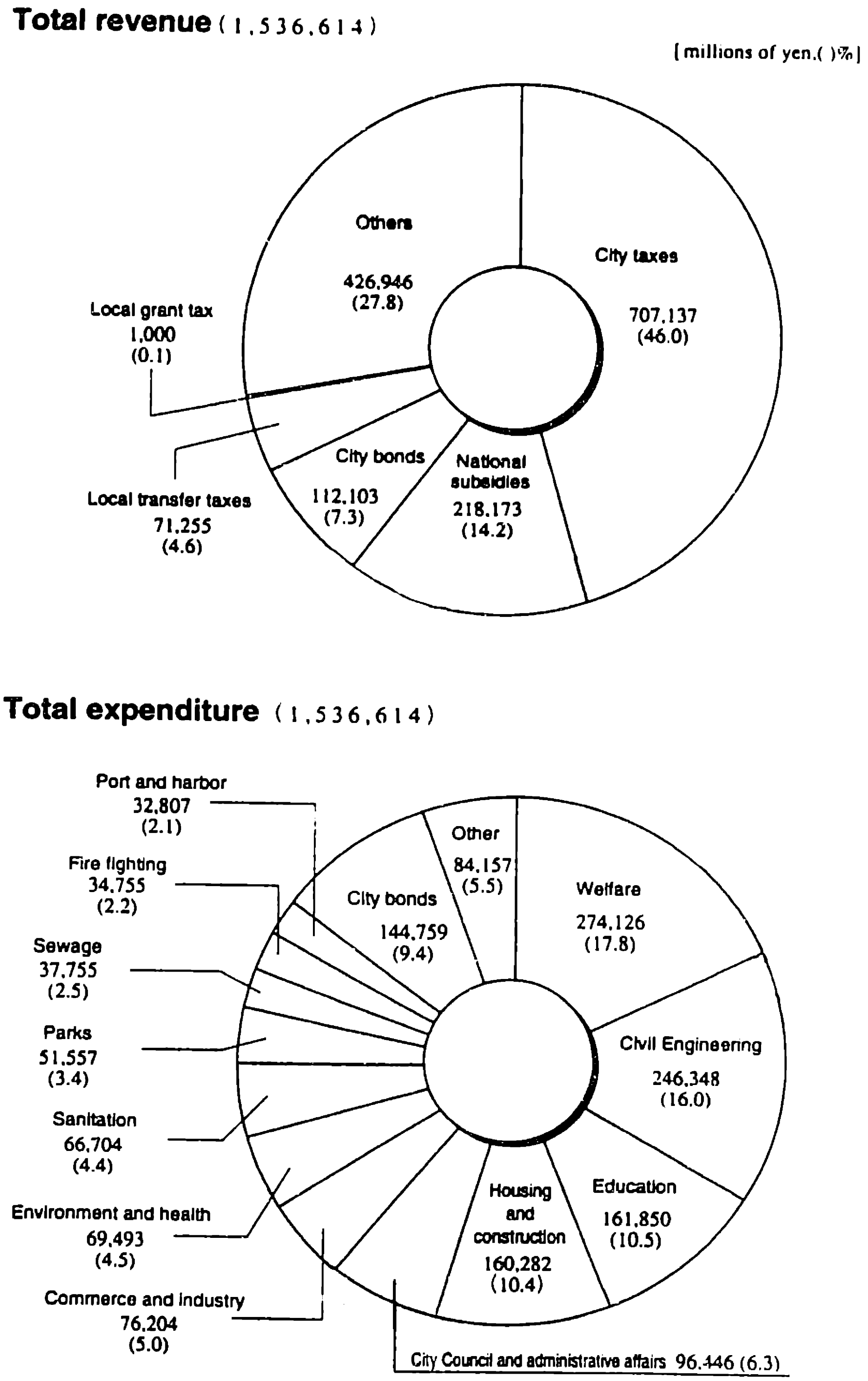

Figure 3.3 General Account of Osaka City for Fiscal Year 1991

11 Osaka City, *An outline of the Osaka City Administration*, a public information brochure, 1991.

In terms of the total expenditure, welfare expenditure shared the biggest part of the total expenditure, which was about 18%. The expenditure for highway construction and maintenance was 246 billion Japanese yen or about $2.2 billion. The expenditure for the HEPC expressway is greater than that for highways in Osaka, even though Osaka has the second largest budget among Japanese local governments. Furthermore, Osaka City government must invest this $2.2 billion in constructing 140 km of highways and in maintaining many highways and feeder roads. Osaka City government can not afford to develop ATMS and ATIS without appropriate funds from the national government. Therefore, strong financial resources of HEPC render HEPC capable of bearing a substantial financial burden for the development of IVHS.

3.5 Competition between the Two National Agencies

IVHS is a new field and does not have its own national agency. Therefore, the authority to deal with an infrastructure for IVHS is split between three national agencies:

1) the Ministry of Construction (MC), which is responsible for the construction and supervision of highways and expressways
2) the National Police Agency (NPA), which is responsible for traffic control
3) the Ministry of Posts and Telecommunications (MPT), which is responsible for radio frequency allocation.

Among these three agencies, MC and NPA have competed against each other to develop IVHS.[12]

In the US, the Department of Transportation plays an important role in researching and deploying the IVHS program. However, in Japan, the Ministry of Transport (MT) plays a minor role in IVHS. MT is responsible

12 Ervin, R., "An American Observation of IVHS in Japan.", The University of Michigan, 11-13, 1991.

for the approval of vehicle equipment for safety and pollution acceptability. The main responsibility of MT includes the construction and supervision of railways.

The competition between MC and NPA goes back to the time when HEPC was established. Both competed to manage traffic control on the expressway. Eventually, MC and NPA reached an agreement that MC would be responsible for expressway traffic control and that NPA would be responsible for surface street traffic control. This agreement resulted from the fact that the expressway public corporations, such as HEPC, are administratively linked to MC and do not come under the jurisdiction of NPA.

However, if either agency develops traffic control systems more advanced than the other, the other agency will lose its jurisdiction over traffic control and the traffic control systems of that agency might be integrated into the advanced system. Therefore, the competition has inspired separate development of traffic control systems in each jurisdiction.

The competition or rivalry with NPA has been positive because it has served to encourage MC to develop ATMS and ATIS on the expressway. On the other hand, the rivalry motivated NPA to implement advanced traffic control systems on surface streets. NPA's traffic control system is confined within specific areas to mitigate traffic congestion at special intersections.

3.6 Effective Public-Private Partnerships

ATMS and ATIS are valuable markets for private sector companies such as electronic and automotive companies. The private sector has been innovating new technology for ATMS and ATIS in order to get contracts from the public sector. Due to efforts of the private sector, the technology for ATMS and ATIS has been available.

For instance, HEPC has organized a special research committee for developing traffic control systems. Omron Corporation, Fujitsu Corporation, and Matsushita Electronics Corporation have taken part in this committee and have provided new technology available to ATMS and ATIS. These private corporations have contributed to the development of ATMS and ATIS since this committee was formed in 1981. Effective public-private partnerships have developed ATMS and ATIS in HEPC.

3.7 Summary

Advanced Traffic management systems (ATMS) and Advanced Traveler Information Systems (ATIS), developed by HEPC, are now recognized as two of the most advanced traffic control systems in the world.[13] This chapter discussed the reasons that pressured or encouraged HEPC to intensively develop such systems: 1) heavy traffic congestion, 2) drivers' complaints, 3) strong financial resources, 4) competition between MC and NPA, and 5) effective public-private partnerships.

In the next chapter, this thesis discusses whether the large cities should adopt the kind of advanced traffic control systems that HEPC has achieved.

13 Hanshin Expressway Public Corporation, *Traffic Control System*, a public information brochure, 1993, Trans. Toru Takahashi

Chapter 4 Why Local Governments Need to Work on IVHS: Osaka as a model

4.1 Introduction and Current Condition in Osaka

Large cities in Japan have lagged behind the expressway public corporations in creating traffic control systems using Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS). To date, they have been committed to developing public transportation systems and to constructing conventional highways. From now on, they should begin to implement ATMS and ATIS in urban areas in order to better utilize existing highways. Here, the discussion centers on Osaka as a model for other cities facing similar transportation problems, air pollution problem, and high price of real estate.

Table 4.1 compares thirteen of the largest cities in Japan. Osaka is the second largest commercial city in Japan (Tokyo is the first). Except for Tokyo, these twelve large cities are called the government ordinance-designated cities that have the same power as the governor (the designated city system is discussed in more detail in Chapter 6). The Metropolis of Tokyo consists of the 23 special wards and their peripheral small cities, both of which the Governor of Tokyo controls. The other prefectures where the designated cities are located are governed separately by a mayor for the designated city and a governor for the rest of the prefecture. Since the discussion about Osaka City will be applied to other large cities, this thesis focuses on Osaka City.

As do other large cities, Osaka has a comprehensive transportation policy[14] that aims at: 1) ensuring easy movement of people and goods; 2) enhancing daily efficiency; and 3) promoting urban activities without detracting from

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[14] Office of the Mayor of Osaka City, *Osaka City Comprehensive Plan for the 21 st Century*, a public information brochure, March, 1991, Trans. Toru Takahashi

a pleasant urban environment. This basic concept of the comprehensive transportation policy in each large city is similar. To achieve this policy, Osaka has been improving traffic facilities for both public transportation and private vehicles. As a result, its public transportation systems are now recognized as one of the advanced transportation systems in the world.[15] However, for private vehicles, using the new technology of ATMS and ATIS will be essential for efficient utilization of existing highways as well as new highway construction. After introducing the current traffic conditions in Osaka, this chapter discusses the motivation for developing IVHS in Osaka.

Table 4.1 Comparison of the Large Japanese Cities

City	Area	Population	Wards	City employees	Budget	Tax revenues
	km^2				Millions of yen	Millions of yen
Sapporo	1,121.18	1,671,765	9	17,755	617,000	230,903
Sendai	788.05	918,378	5	10,592	297,494	143,180
Chiba	272.54	837,183	6	8,065	–	–
Kawasaki	142.77	1,173,606	7	12,947	425,577	239,914
Yokohama	431.57	3,220,350	16	31,733	1,067,197	578,197
Nagoya	326.37	2,154,664	16	32,460	828,651	441,238
Kyoto	610.21	1,461,140	11	18,374	531,800	234,361
Osaka	220.37	2,623,831	24	46,172	1,428,800	720,783
Kobe	543.98	1,465,149	9	19,781	766,289	248,15
Hiroshima	739.94	1,085,677	8	10,937	444,841	181,251
Kitakyushu	481.96	1,026,467	7	11,691	414,841	141,654
Fukuoka	336.39	1,237,107	7	10,097	480,692	197,813
Tokyo	617.76	8,227,979	23	82,165	2,237,818	871,692

Notes:
1. Figures for Tokyo are aggregated for 23 special wards.
2. Figures for Chiba are as of April 1992.
3. Areas as of October 1,1989
4. Population and wards as of October 1990
5. Number of city employees as of April 1990
6. Budget shows the original budget general account for fiscal year 1990. Tax revenues show the adjusted revenues for fiscal year 1989.

15 Transportation Bureau of Osaka City, *Urban Transportation and Subway System in Osaka*, a public information brochure, 1990

4.1.1 Population in Osaka

Osaka has an area of 220.37 square kilometers, extending 19.5 km from east to west and 20.2 km from north to south. Most of the city is urbanized. Osaka City's population, following its peak of 3.16 million in 1965, decreased by approximately 500,000 for 15 years until 1980. The city took various measures to attract people back into Osaka, and this resulted in a stable population from 1980. In 1990, there were 2.62 million people living in Osaka City (see Table 4.2). On the other hand, people living in the metropolitan Osaka area increased dramatically from 11.3 million in 1965 to 16.9 million in1990.

Table 4.2 Population of Osaka City

year	1965	1970	1975	1980	1985	1990
population	3.16	2.98	2.78	2.65	2.64	2.62

[Units: millions of people]

4.1.2 Movement of People

The "Keihanshin Urban Area Transportation Council," whose members consist of six prefectures (Osaka, Kyoto, Hyogo, Nara, Wakayama, and Shiga), two large cities (Kyoto and Kobe), and Osaka City, has conducted person-trip surveys every decade since 1970. The purpose of this survey is to understand the comprehensive transportation situation in urban areas. Figure 4.1 shows the traffic flow of people. There were about 11.4 million trips per day in Osaka City in 1990. This figure includes trips to and from Osaka and within Osaka; it includes public transportation, private vehicles, taxis, pedestrians and bicyclists. This figure increased from 10.6 million in 1970 to 11.4 million in 1990, although the population decreased from 2.98 million to 2.62 million during the same period. Approximately 50% of all trips were made in a particularly crowded downtown area which occupies

18% of the city area. Figure 4.2 shows the modal split of transportation. In 1990, the modal split by railway is 32.2% of all trips and 16.8% by car. About 6 million person-trips use railways per day. In Osaka there are six private railway companies, including JR West, and municipal subways to deal with such a huge passenger load.

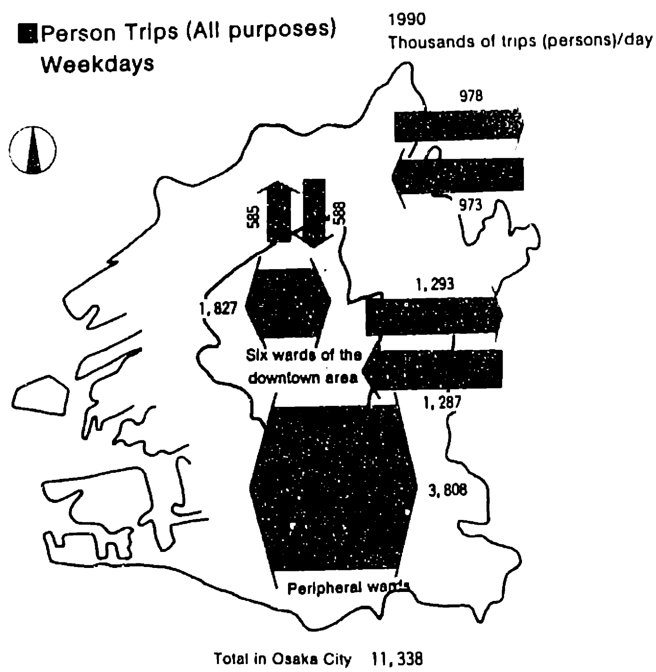

Figure 4.1 Movement of People

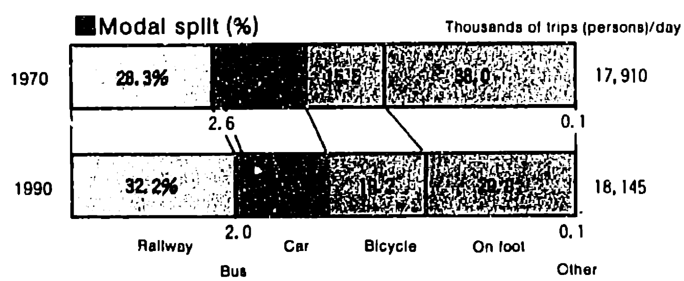

Figure 4.2 Modal Split in Osaka

Table 4.3 shows the change in modes of transportation to and from railway stations. The use of bicycles rapidly increased from 16,000 trips per day in1970 to 374,000 trips per day in 1990. The use of buses significantly decreased from 438,000 trips per day to 204,000 trips per day during the same period. Figure 4.2 also shows that the modal split by bicycle increased from 15.5% in 1970 to 19.2% in 1990, but that bus share decreased from 2.6% in 1970 to 2.0% in 1990. This situation points to two traffic problems: 1) lack of parking space for bicycles at railway stations, and 2) poor quality of bus service (delayed bus service due to the traffic congestion).

Table 4.3 Modes of Transportation for Access to Railways in Osaka

	Bus	car	Bicycle	walking	Total
1970	438 (9.0%)	69 (1.4%)	16 (0.3%)	4,357 (89.3%)	4,481 (100%)
1990	204 (3.5%)	47 (0.8%)	374 (6.4%)	5,217 (89.3%)	5,842 (100%)

[Units: 1,000 person trips per day]

4.1.3 Automobile Traffic

In order to devise an effective city planning policy for resolving urban transportation problems caused by increased vehicle usage, Osaka City has conducted the "Vehicle Origin-Destination Survey." Table 4.4 shows the change in traffic volume during the period between 1962 and 1985. The city's automobile traffic grew two times from 1.47 million car trips per day to 3 million car trips per day. Of those, intra-city traffic was 1.7 million car trips per day while inflow/outflow traffic was 1.38 million car trips per day in 1985, a significant increase.

Table 4.4 Change in Automobile Traffic of Osaka City

	1962	1965	1968	1974	1977	1980	1985
Traffic volume	1,477 (1.0)	1,754 (1.19)	2,399 (1.62)	2,693 (1.82)	2,745 (1.86)	2,850 (1.93)	3,083 (2.09)
Intra-city traffic	1,128 (1.0)	1,255 (1.11)	1,623 (1.44)	1,705 (1.51)	1,552 (1.38)	1,664 (1.47)	1,699 (1.51)
Inflow/ Outflow Traffic	349 (1.0)	499 (1.43)	776 (2.22)	988 (2.83)	1,193 (3.42)	1,186 (3.40)	1,384 (3.97)

[Units: 1000 car trips per day]

Notes: Figures in parentheses denote the ratio of 1960 figures.

Currently, about 70% of private vehicles traffic is primarily business-related. About 20% are for commuters and the remaining 10% for others. Thus, the use of automobiles for business represents a very high share of road traffic in the city.

4.2 Motivation for Developing IVHS in Osaka

The Osaka City government will be motivated to promote traffic control systems using ATMS and ATIS because of: 1) achievement of Osaka's comprehensive transportation policy, 2) difficulties in highway construction in urban areas, 3) new urban development for the 21st century, and 4) the coming of an "ultra-aged society." This section discusses the four reasons. Since other cities also face the similar situation, these discussions can be applied to other cities.

4.2.1 Osaka Comprehensive Transportation Policy

The development of urban transportation in Osaka is based on a comprehensive transportation policy. In 1970, the first Osaka comprehensive transportation policy was framed in order to show how the city would promote urban transportation systems. Since then Osaka City government has revised it almost every decade in response to social needs. The concept of this transportation policy is not to make piecemeal improvement for railway lines, bus routes, highways, etc., but to establish a comprehensive traffic system to ensure that various means of transportation function as a part of the total transportation system in a coordinated way. The main priorities are:

1)improvement of attractive public transit

2) road improvement and achievement of smooth traffic flow.

Osaka City annually expends monetary resources on public transportation and road improvement at the ratio of approximately 6 : 4, based on its previous expenditure results. For instance, according to expenditures for fiscal year 1991, the expenditure for public transportation such as bus and rapid transit services, was 320 billion Japanese yen, or $2.9 billion, and for road improvement it was 246 billion Japanese yen, or $2.2 billion. The expenditure ratio between public transportation and road improvement was about 5.7 : 4.3.

(1) Improvement of attractive public transit

Osaka's comprehensive transportation policy states that Osaka City should:

(a) improve transit services by expanding the railway network which is comprising the core of public transportation (see Figure 4.3)

(b) promote increased mass transit use by improving the comfort and attractiveness of public transportation by upgrading stations and train cars

(c) promote more convenient connections between railway lines and buses, so that passengers can enjoy a integrated service coordinating the railway network with bus routes.

Following this priority, the Osaka City Government has been constructing urban rapid-transit railways, called subways, although they also operate above ground. Currently, there are seven subway lines, covering 104.3 km. In addition, Osaka City has been making efforts to develop new technologies for a more economical and safer transportation system in order to automatically monitor and control subways. In 1981, the Osaka City government constructed the "New Tram," which is a fully automated guideway transit system (see Figure 4.4). This system relies on electrically-driven trains with rubber tires on wheels to run on viaducts. Only one conductor rides on this New Tram that is automatically controlled by a main computer center.

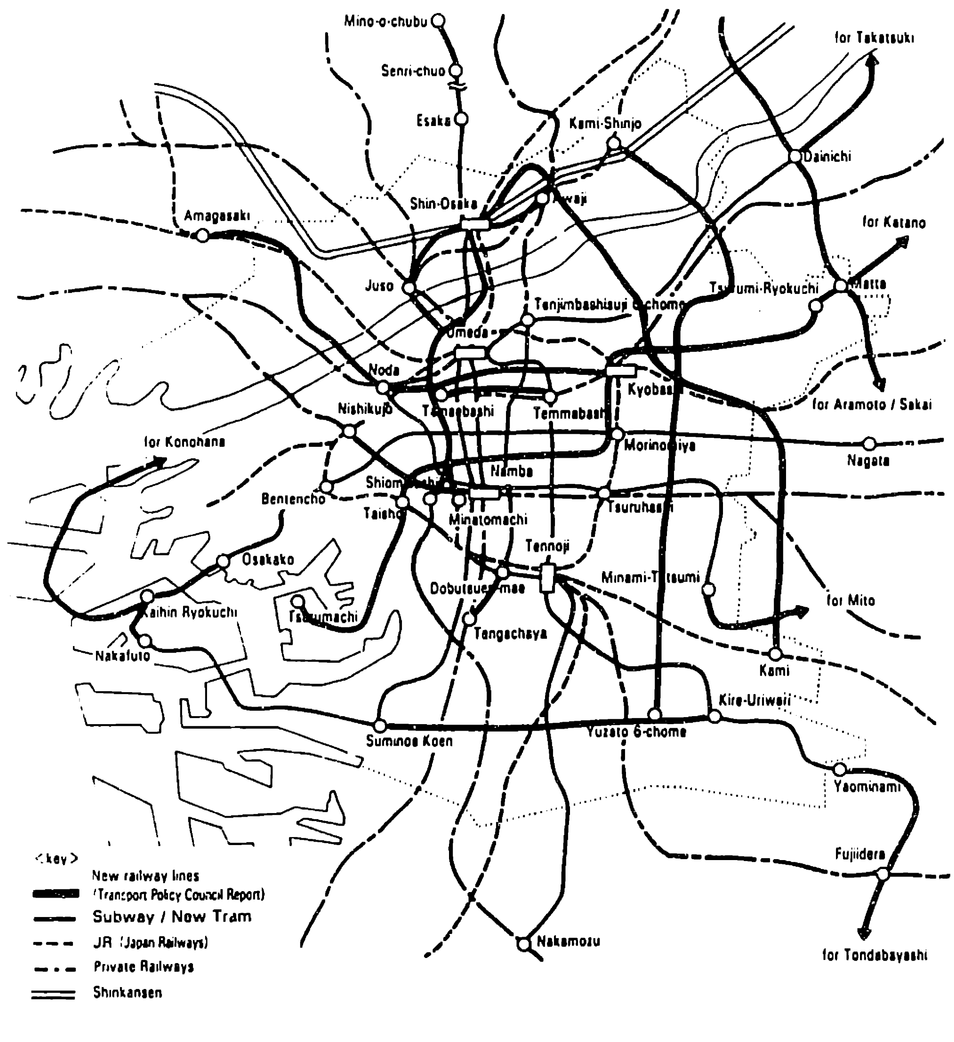

Figure 4.3 Railway Development in Osaka

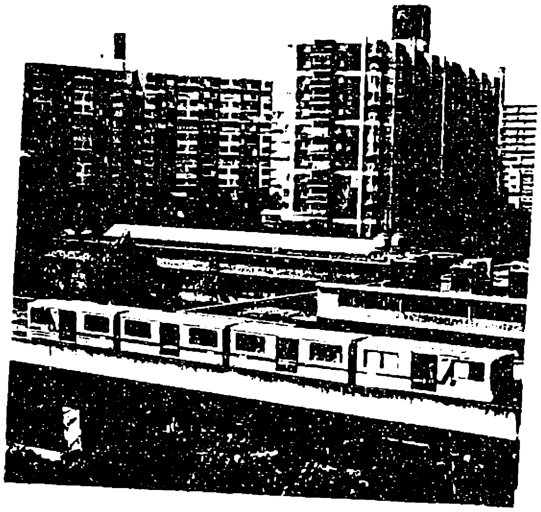

Figure 4.4 Automated Guideway Transit Called the New Tram

The development of the public transportation system in Osaka was possible because of the government funding system. The Ministry of Transport (MT) has responsibility for the construction and supervision of railways. One-third of the construction cost is paid by MT funds. Another one-third comes from the city government and the last one-third from the railway company. In the Osaka City government, the Transportation Bureau has responsibility for subway, bus, and "New Tram" services. This bureau has special accounts for constructing and operating these transport facilities like railway companies. The Transportation Bureau in Osaka is financially linked to MT (see Table 4.5).

As already discussed, the number of bus passengers decreased. The Transportation Bureau of Osaka City makes efforts to attract more bus passengers by adopting bus only lane, traffic signals for bus priority, and bus location indicators that inform bus passengers where the next bus is and when it will arrive. Osaka City expects that these bus location systems will be integrated into a comprehensive traffic control systems.

Table 4.5 Linkage between the National and Osaka City Government

National Government	Osaka City Government
Ministry of Construction (MC)	Planning Bureau Public Works Bureau
Ministry of Transport (MT)	Transportation Bureau
Ministry of Posts and Telecommunications (MPT)	Branch of MPT
National Police Agency (NPA)	Branch of NPA

Note: No bureaus related to MPT and NPA exist within Osaka City Government, because MPT and NPA have their own branches.

(2) Road improvement and achievement of smooth traffic flow

Osaka's comprehensive transportation policy states that Osaka City should:

(a) construct more new highways in harmony with the urban environment,

(b) construct roads that are safe and pleasant for pedestrians to safeguard pedestrian rights in the face of increasing automobile use,

(c) promote functional improvement of highways through proper highway maintenance, effective traffic control, and development of sophisticated traffic information systems.

Following this priority, first, the Osaka City government has been constructing arterial, feeder, and special roads. In the city's downtown area, arterial roads run in north-south and east-west directions at intervals of about 500 m; farther from the core, they are situated at intervals of about 1 km. Feeder roads are located at frequent intervals to implement arterial roads and are for the convenience of the inhabitants of the residential areas. Special roads are for the exclusive use of pedestrians and bicycles. The Ministry of Construction (MC) allocates funds for two-thirds of the road construction and maintenance cost. Local governments are responsible for the rest one-third. In Osaka City the Planing Bureau is responsible for the road planning and the Public Works Bureau is responsible for the implementation of the plan. These bureaus are linked to MC (see Table 4.5).

The next step is to improve the highway function through advanced traffic control and sophisticated traffic information systems. It is time to develop these systems in urban areas to achieve the goal of a comprehensive transportation policy. In 1991 Osaka City started a real-time guided parking system, which was not funded by the national government. Illegally parked cars have been one of the most urgent traffic problems in large Japanese cities including Osaka. The social pressure to immediately resolve this problem has motivated Osaka City and other cities to implement this system. Osaka City expects that the guided parking system will be also integrated into a comprehensive traffic control system in the near future. The real-time guided parking system in Osaka is as follows.

A Real-time Guided Parking system

The downtown area, called the "Senba" district, has been a commercial core of Osaka since the 1800s. The "Senba" district is surrounded by main arteries with widths of about 40 meters. However, the street condition inside the "Senba" district is poor (see Figure 4.5). Although the road networks were built in grids, the width of the roads is about 7 meters. Along the streets, there are many 5- or 6-story buildings which make it impossible to widen the streets. Under such conditions, illegally parked cars cause bottlenecks on streets and significantly decrease traffic capacity. As a result, illegally parked cars have impeded commercial activities. In addition, on-street parking increases both the car accident rate and the volume of exhaust gas related to stopping and starting of vehicles. On-street parking not only causes traffic problems but also contributes to the deterioration of urban scenery and damages the city's image.

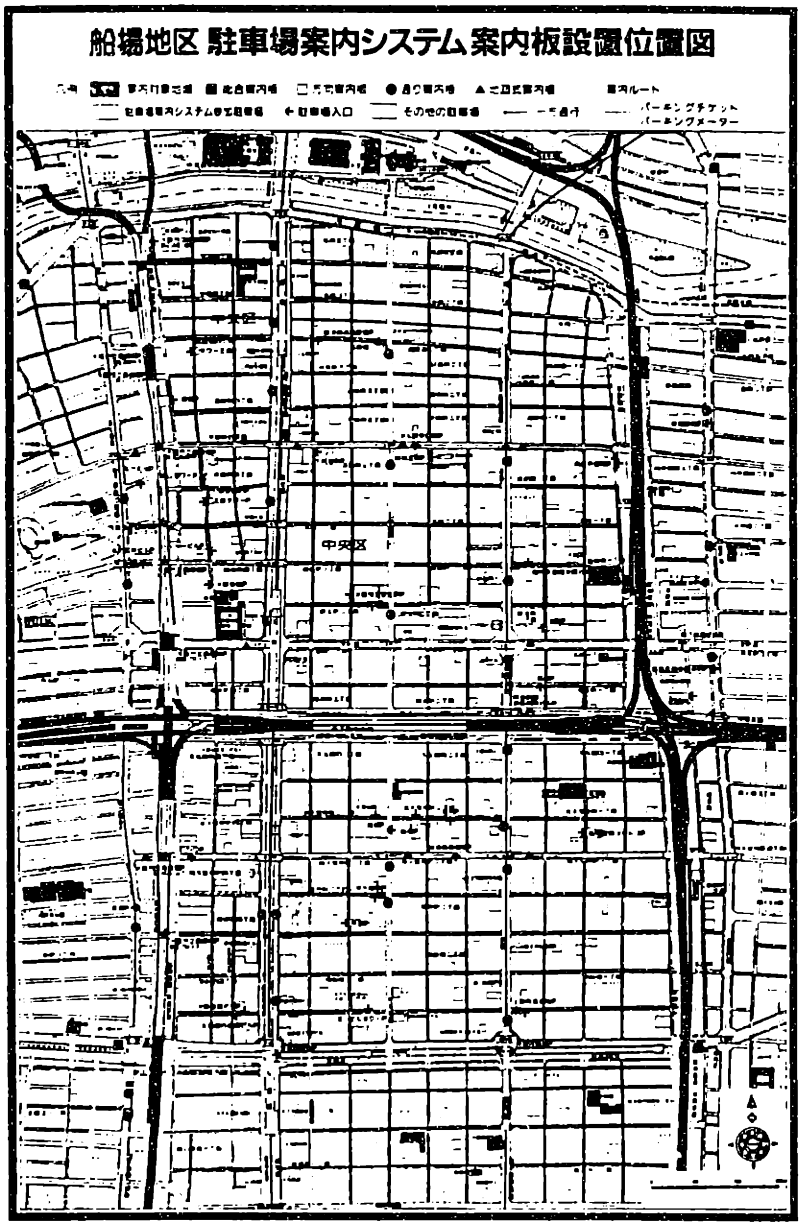

Figure 4.5 Street Condition in "Senba" District

To decrease illegally parked cars on streets, the Osaka City government has begun to implement three parking measures. First, to limit the parking demand, unnecessary and non-urgent use of automobiles is discouraged by promoting the use of public transportation facilities. Second, the Osaka City government has requested that the Osaka Prefecture Police Agency maintain tighter control of illegally parked cars. As a third measure, the real-time guided parking system was designed to promote the effective use of public parking garages, since only about 60% of the parking capacity is used now.

In 1991, the Osaka City government implemented the real-time guided parking system[16] that displayed the availability of parking garages to drivers in downtown Osaka (see Figure 4.6). The system consists of variable-message sign boards and a control center, linked by a communication network. Information about how many spaces are available is sent from the parking garages to the main computer in the control center, where the information is processed. The main computer then sends the information to the variable-message sign boards, which display either a "full" or "available" signal (see Figure 4.7).

After Osaka City started this guided parking system, the efficiency of the public parking garages increased by an average of 10% (see Table 4.6). Table 4.7 shows that the number of illegally parked cars between 13:00 and 16:00 on a weekday decreased by 12.3 % between 1989 and 1991 and that 86.6 % of street-parked cars were illegally parked in 1989, and 85.9 % in 1991.

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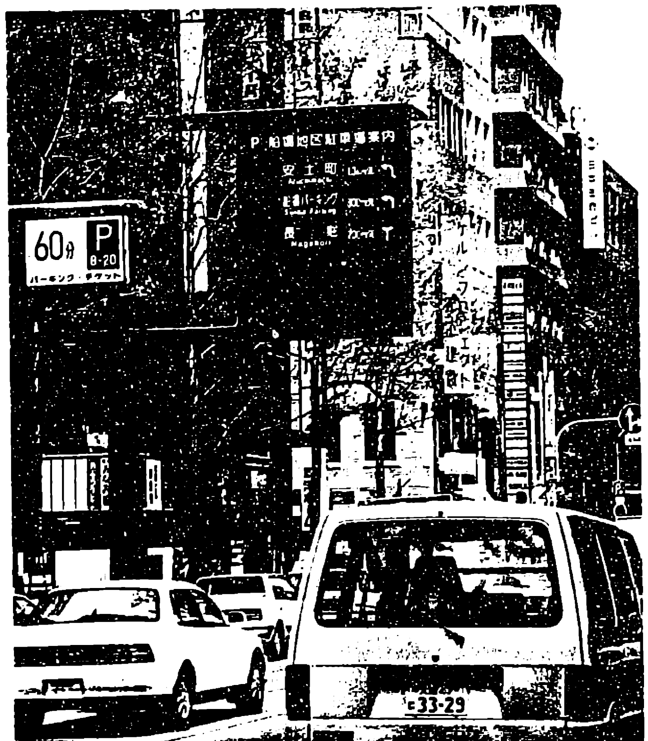
[16] Public Works Bureau of Osaka City, *A real-time guided parking system*, a public information brochure, 1992, Trans. Toru Takahashi



Information Panel showing name, location and vacancy of parking lot

Figure 4.6 Real-Time Guided Parking System

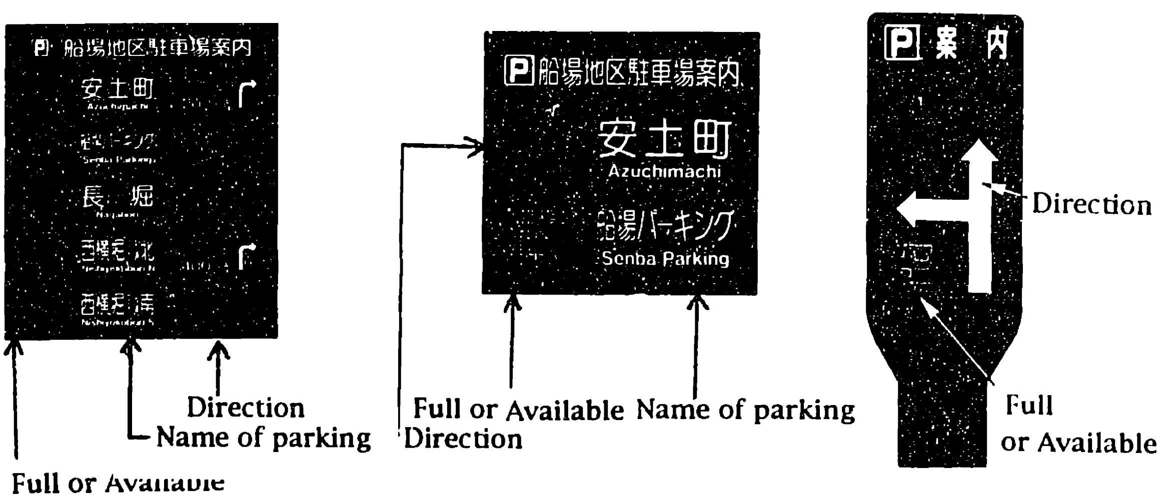


Figure 4.7 Variable-Message Sign Boards

Table 4.6 The Number of Parked Cars before/after the Parking System

Name of parking	Before	After	Fluctuation
"Azuchi" parking	205	231	+26
"Ngahori" parking	1,617	1,730	+113
"Senba" parking	619	730	+111
Total	2,441	2,691	+250

Note: Figures denote an average number of parked cars per day. The guided parking system guides drivers to three municipal parking garages and thirty-seven private parking suppliers in "Senba" district. The number of parked cars in the private parking suppliers is confidential. Here, the number of parked cars in the municipal garages is shown.

Table 4.7 The Number of Illegally Parked Cars on Streets in Osaka City

	Street-parked vehicles	Illegally street-parked vehicles
1989	216468	187432
1991	191294	164416
Fluctuation	11.7% decrease	12.3% decrease

Note: The above data was gathered by various police stations during a set period on weekdays; April 11 to May 10, between 13:00 and 16:00, in 1989 and 1991.

4.2.2 Difficulties in Constructing Highways in Urban Areas

It is difficult for city governments to construct elevated or surface highways in downtown areas of large cities for the following reasons:

1) the preservation of the environment, such as air quality

2) the high price of land.

City governments currently make efforts to construct highways to mitigate traffic congestion. However, before carrying out the construction, they face many obstacles and the process is very time-consuming. There are two solutions to mitigate traffic congestion in urban areas: 1) construction of underground highways, and 2) efficient utilization of existing highways.

In constructing underground highways in urban areas, local governments do not have to acquire the right-of-way and the related buildings. They only need to acquire the underground rights which are almost half of the entire land price. Although costs for underground highway construction are huge, they are almost equal to the ones for surface highway construction which needs to acquire the right-of-way. In addition, city governments can control exhaust gas by constructing ventilation buildings that can clean the gathered exhaust gas. The other solution is to utilize existing highway networks in urban areas by using the new technology that ATMS and ATIS provide in order to supplement highway construction. Therefore, the preservation of the environment and the high price of land will motivate large cities to construct underground highways and to develop traffic control systems for efficient utilization of existing highways.

(1)The Environmental Condition

From the late 1960s to early 1970s, Osaka was confronted with serious air pollution by sulfur dioxide from factories. Since the middle 1970s, traffic conditions aggravated by rapidly growing motorization have resulted in serious pollution by nitrogen dioxide. As shown in Table 4.8, the number of cars registered in Osaka increased 4.2 times between 1962 and 1991.

Automobile pollution problems are typical of big cities. In 1969 the Air Quality Standards were established in Japan for concentrations of sulfur dioxide, a major air pollutant, followed by standards for carbon monoxide, suspended particulate matter, and nitrogen dioxide (see Table 4.9). Osaka City has maintained 24-hour air pollutant concentration monitoring systems since 1965. Today, 24-hour air monitoring systems are functioning in 26 locations (see Figure 4.8). Data collected by these systems is transmitted via telemetry to the Environmental Pollution Control Center for instant analysis of the pollution condition of each location. If the concentration of air pollutants exceeds air quality standards, Osaka City will address that air pollution problem by encouraging drivers to refrain from using vehicles and to divert to public transportation.

Table 4.8 The Number of Automobiles Registered in Osaka City

Year	1962	1968	1977	1980	1985	1991
No. of cars registered	211,564 (1.00)	404,949 (1.91)	675,412 (3.19)	683,200 (3.23)	753,114 (3.56)	893,445 (4.22)

Notes: Figures in parentheses denote the ratio of 1962 figures.

Table 4.9 National Air Quality Standards

Substance	Standard values
Sulfur dioxide	Daily average of hourly values shall not exceed 0.04 ppm, and hourly values shall not exceed 0.1 ppm.
Carbon monoxide	Daily average of hourly values shall not exceed 10 ppm, and average of hourly values in eight consecutive hours shall not exceed 20 ppm.
Suspended particulate matter	Daily average of hourly values shall not exceed 0.10 mg/m^3, and hourly values shall not exceed 0.20 mg/m^3.
Nitrogen dioxide	Daily average of hourly values shall be within the range between 0.04 ppm and 0.06 ppm or below

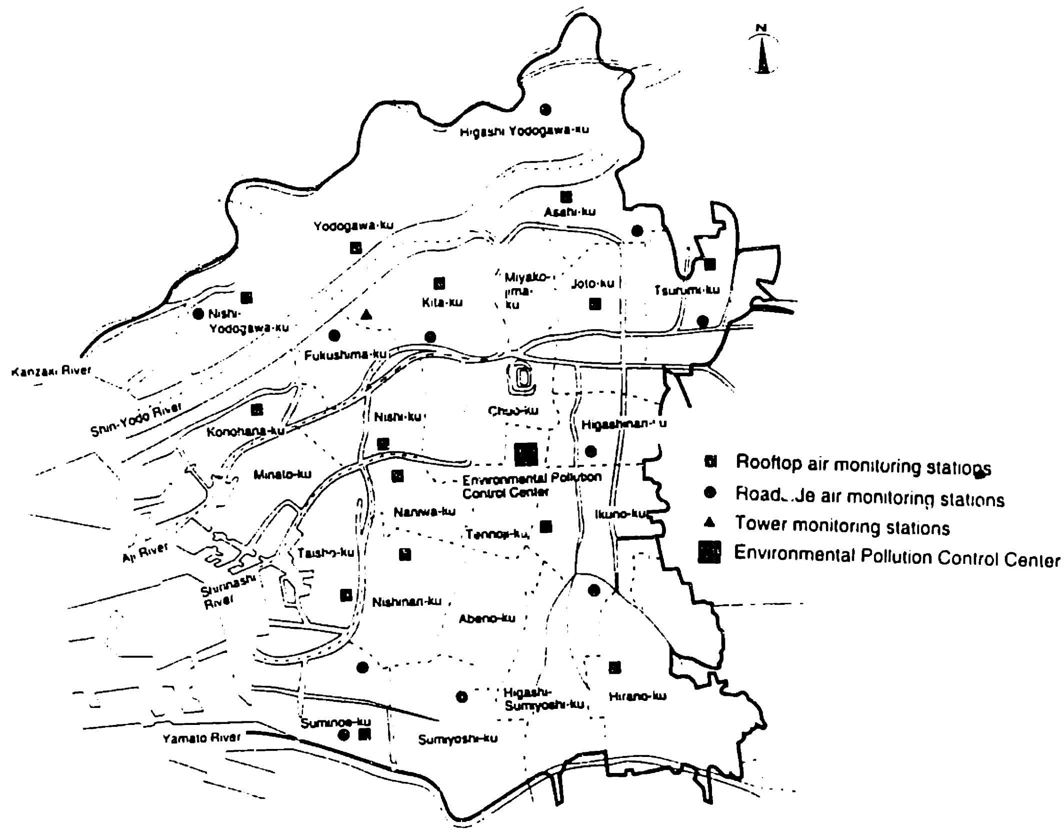


Figure 4.8 Location of Air Monitoring Stations

Figure 4.9 shows that yearly average concentrations of sulfur dioxide and carbon monoxide in Osaka City have decreased sharply. However, nitrogen dioxide and suspended particulate matter have not decreased. The concentration levels of nitrogen dioxide and suspended particulate matter did not met Air Quality Standards.

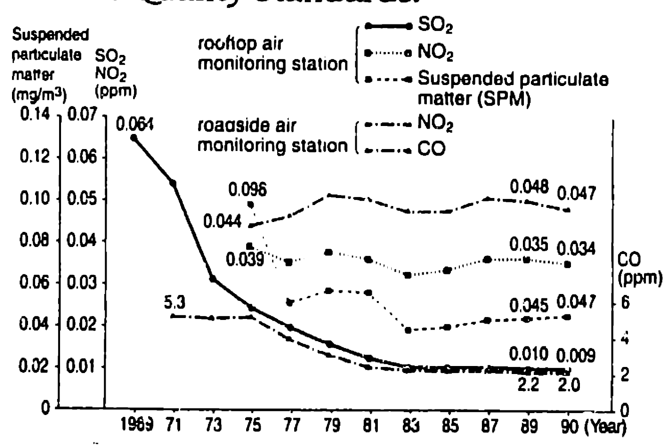


Figure 4.9 Yearly Average Concentration of Major Air Pollutants

To meet those standards, Osaka City has been working on:[17]

(a) promoting a comprehensive transportation policy

Efforts will be made to restrain the growth of automobile traffic by promoting a comprehensive transportation policy including IVHS, so that the total traffic volume will be limited to 22 million vehicles kilometers per day by the year 2000 (the current figure is 20 million vehicles kilometers per day). This goal now makes new highway construction difficult.

(b) tightening exhaust gas regulations

Regulation for diesel, gasoline, and LPG (Liquefied Petroleum Gas) cars will be tightened. In particular, diesel trucks are the worst offender and their share of nitrogen oxides exhaust exceeds all vehicles models. Therefore, tightening regulation for diesel trucks should be promoted as soon as possible.

(c) promoting cars that meet national air quality standards

Loans for cars, such as electric and methanol cars, which meet air quality standards will be available.

(d) educating the public about the environment

Environmental education for drivers, citizens, and school children will be promoted.

In 1984, the Japanese cabinet adopted a policy of requiring environmental impact assessments in order to predict and assess how implementation of a project would affect the environment. Following this policy, local governments must conduct environmental impact assessments before carrying out construction of highways, railways, and other facilities that can have an impact on the surrounding environment. After the assessments, necessary steps must be taken to avert damage and protect the environment. The necessary steps can include abandonment of the

[17] Environment and Public Health Bureau of Osaka City, *Environment Quality in Osaka City*, a public information brochure, 1990

entire project, if its consequences are expected to be disastrous to its surroundings. Therefore, current pollution problems and the environmental impact assessments make highway construction difficult in urban areas. Still, local governments need to construct new highways, in order to support social and economical activities in large cities. A balance between highway construction and the preservation of the environment is essential. One answer is the utilization of existing highways using new technology that ATMS and ATIS provide. Smoother traffic flow provided by these systems would yield lower emission levels as well as increase the traffic capacity of the existing highway networks.

(2) High Price of Land

Besides environmental problems, the high price of land makes highway construction difficult. As shown in Figure 4.10, the price of land increased about 5 times between 1980 and 1991, because of speculative transactions. Real estate companies, insurance companies, and banks invested money in real estate in order to get large profits by selling it at a higher price. These transactions raised the price of land between 1989 and 1991. To control and supervise land price, Osaka City government now requires submission of a report for transactions with a minimum of 100 square meters.

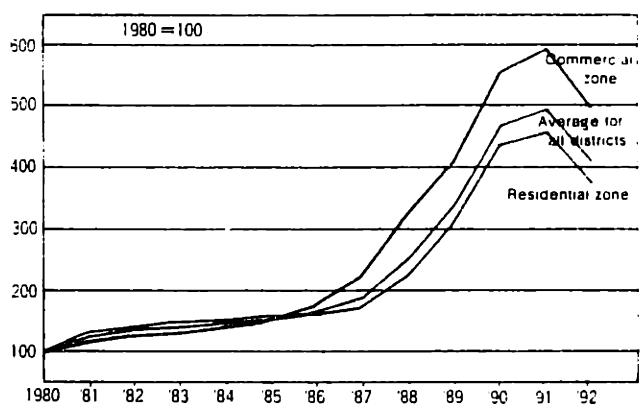


Figure 4.10 Change in land price

The cost of highways includes the cost of constructing the facilities and the cost of acquiring the right-of-way. In the USA, the ratio between the facility construction cost and the acquisition cost is about 9:1 or 8:2. In Japan, the ratio is about 5:5 or 4:6. The price of land in a commercial area in Japan is more than $10,000 per square meter. Since the amount of space is limited and valuable in urban areas, it is necessary to improve the efficiency of existing highways.

4.2.3 New Urban Development in the 21st Century

Some large cities, such as Tokyo and Osaka, are promoting plans that would use newly reclaimed lands to create new urban areas for development. For instance, Osaka City government is developing its project "Technoport Osaka"[18] in the littoral zone, with the aim of creating a new city that will guide the future development of metropolitan Osaka (see Figure 4.11). The area consists of: 1) the 395 acre "Nanko District"; 2) the 556 acre "Hokko North District"; and 3) the 964 acre "Hokko South District", totaling 1,915 acres. Part of "Nanko District" has already completed reclaiming land and constructing infrastructure. Some of the land was sold to developers and there are now buildings. Such a large area will require extensive public transportation and highway systems.

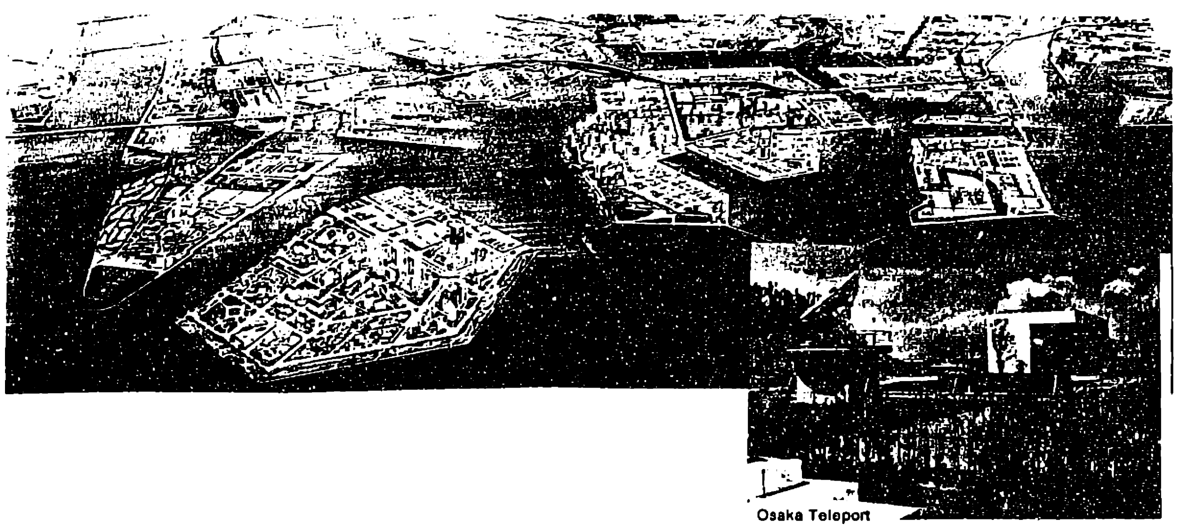


Figure 4.11 Image Photo of "Technoport Osaka" and Osaka Teleport

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18 Port and Harbor Bureau of Osaka City, *Technoport Osaka*, a public information brochure, 1991, Trans. Toru Takahashi

The new city will be built to have three key functions: 1) the development of advanced technology, 2) international trade function, and 3) information and communication function. These are new concepts, which go beyond the conventional concept that residential and commercial development is the main purpose of urban development.

(1) Advanced technology development function

A group of research institutes, called the industrial park, is and will be constructed in the Technoport Osaka project in order to develop advanced technology of highly promising industries. Some of them are already constructed and operated. This industrial park includes research institutes of electronics, biotechnology, new materials, computer science, and so on.

(2) International trade function

In order for Osaka to develop a world business and financial center, the Technoport Osaka project is expected to provide facilities for trade and business transactions of the world, above all in the Asia/Pacific regions.

(3) Information and communication function

The Technoport Osaka project will be developed as an information and communication base in Japan in order to meet the demands of an information-oriented society. The main facilities for supporting the information and communication function in this project is "Osaka Teleport," which is the information base equipped with a parabolic antenna for transmitting and receiving the radio waves from communication satellites. The Osaka Teleport, which includes computer centers, parabolic antennas, its power supply facilities, and an administrative building, has been completed and the communication has been in service since 1988.

The Osaka Media Port Corporation (OMP), which is a electronic communication company established by Osaka City , the Kansai Electronics Company, and other private companies, constructed the Osaka Teleport and also operates and maintains its facilities. Another business of OMP includes building optical fiber networks which utilize municipal subway lines and private railroad lines. At present, OMP has about 200 km optical fiber network in metropolitan Osaka. As a result, the Osaka Teleport is directly connected with the center of Osaka City and other nearby cities through the optical fiber network, as well as cities in the world through satellite communication systems. It is hoped that OMP will play an important role to help Osaka City to operate IVHS (this is discussed in Chapter 6).

In order to support the above two functions, the Osaka Teleport, by using these worldwide information and communication facilities, is planning to provide four sets of information systems: a) economic information system, b) technological information system, c) international trade information system, and d) comprehensive information distribution system.

(a) Economic information system

This system aims at networking financial agencies such as banks and stock exchange markets in order to obtain up-to-date economic information of world finance and trade, and to provide this information 24 hours a day in an attempt to strengthen the financial and trade functions.

(b) Technological information system

This system is not only for furthering the information exchange of new technologies and the promotion of technological information among research institutes, but also for realizing the data base and promoting new technical development in order to cope with the rapid development of advanced technologies.

(c) International trade information system

This system aims at collecting, accumulating and processing information inside and outside Japan related to trading transactions and providing information related to corporations, thus making it possible to cope with the wider expansion and specialization of trade structure as well as trying to promote trade transactions.

(d) Comprehensive information distribution system

This system is for controlling one-dimensional information related to distribution, for linking the transportation systems of land, sea and air, and for providing the distribution information service with more efficiency and reliability. There is a possibility that ATMS and ATIS will be built in this system because traffic information will also be provided by this system.

4.2.4 The Coming of an "Ultra-Aged Society"

It is estimated[19] that by the year 2020, one in four Japanese citizens will be over the age of 65. The term, "ultra-aged society" is used to refer to the phenomenon of a large elderly population. Currently 14% of the population in Japan is over the age of 65. As shown in Table 4.10, the percentage will increase to 16.9% in 2000 and 25.2% in 2020, which is a much faster rate of growth than in the USA and Sweden.

Therefore, the national and local governments in Japan must prepare the infrastructure for the ultra-aged society as soon as possible. There are two reasons for the coming of ultra-aged society: 1) the decrease of birth rate, and 2) the increase of the average life span. In Japan, the average birth rate, which denotes how many children a woman has in her whole life, is now 1.54 children although it was 2.1 in 1970. At a birth rate of less than 2.0 children, total population can be statistically calculated to decrease. The Japanese government is now encouraging larger families, because it wants to avoid the drop of labor force. The average life span is now about eighty years, although it was sixty-three in 1950 and seventy in 1970.

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19 United Nations, *World Population Prospects 1988*,

Table 4.10 Comparison of Aged Population

Year	1950	1985	2000	2020
Japan	4.9	10.3	16.9	25.2
America	8.1	11.9	12.8	17.3
Sweden	10.3	17.9	17.6	22.8

Note: Figures denote percentage(%) of overall population

In the ultra-aged society, the number of elderly drivers will increase. Traffic information that elderly drivers will be able to recognize and understand more easily will be required. New technology that ATMS and ATIS provide will effectively help to guide elderly drivers to their destinations by avoiding congestion routes. In the long term, automatically controlled vehicles will also help elderly people remain mobile in urban areas.

4.3 Summary

This chapter discussed the following motivations for developing IVHS in Osaka: 1) Osaka's comprehensive transportation policy, 2) difficulties in highway construction due to poor environmental conditions and the requirement for impact studies as well as the high price of land, 3) new urban development for the 21st century, and 4) the coming of the ultra-aged society.

Osaka has 2.6 million inhabitants and during the day time another almost 1 million enter for business, etc., making a total of 3.7 million. About 32% of all trips are by railway and about 17% are by car. Osaka City has adopted a comprehensive transportation policy to promote its urban transportation systems. The concept of this transportation policy is not to make piece-meal improvement for railway lines, bus routes, highways, etc., but to establish a comprehensive traffic system to ensure that various means of transportation function as a part of a total integrated system. One of the main priorities is to develop traffic control systems using ATMS and ATIS in order to promote functional improvement of highways. The implementation of ATMS and ATIS is necessary for achieving the overall goal of a comprehensive transportation policy.

In Japan, large cities, such as Tokyo and Osaka, face difficulties when planning and constructing highways in downtown areas; laws to protect the environment and the high price of land are impediments. Pollution from nitrogen dioxide and suspended particulate matter is a serious problem and should be resolved immediately. Osaka City is making efforts to limit the total traffic volume to at least 22 million vehicles kilometers per day by the year 2000 (the current figure is 20 million vehicles kilometers per day). In 1984 an environmental impact assessment system was established in order to predict and assess how implementation of such projects would affect the environment. The environmental impact assessments add to the cost and time required before highway construction is allowed. In order to support social and economic activities in large cities, a balance between highway construction and the preservation of the environment is essential. Applying ATMS and ATIS efficiently to the existing highway networks can help achieve that balance. Smoother traffic flow provided by these systems will yield lower emission levels as well as increase the traffic capacity of the existing highway networks. The high price of land also makes highway construction difficult in urban areas. Approximately half of the construction cost is the cost of acquiring the right-of-way. Since the amount of space is limited and valuable in urban areas, it is necessary to improve the efficiency of existing highways.

Osaka City is promoting its 21st century "Technoport Osaka" project based on three key functions: 1) the development of advanced technology, 2) international trade function, and 3) information and communication function. Achievement of traffic control systems using ATMS and ATIS will be included in the third function, information and communication function.

Furthermore, it is estimated that by the year 2020, one in four Japanese citizens will be over the age of 65. Currently 14% of the population in Japan is over the age of 65. The percentage of elderly will increase to 16.9% in 2000 and 25.2% in 2020, which is a much faster rate of growth than in the US and European countries. Therefore, the national and local governments in Japan must prepare the infrastructure for the ultra-aged society as soon as possible. As part of the infrastructure, ATMS and ATIS will effectively help elderly drivers on highways in urban areas.

The factors above mentioned will motivate Osaka City as well as other cities to develop traffic control systems in the near future. In the next chapter, this thesis points out the problems that arise when large cities try to implement the kind of advanced traffic control systems that the Hanshin Expressway Public Corporation has achieved.

Chapter 5 Problems Facing Local Governments

5.1 Introduction

As Prof. Sussman notes, "The essential concept of IVHS was a simple one: to marry dramatic improvements in the high technology world of information systems, communications, sensors, and advanced mathematical methods with the world of conventional surface transportation infrastructure."[20] Prof. Sussman also foresees that in the US, this marriage of new technologies with conventional infrastructure will generate several issues:

1) the evolution of new technologies for IVHS
2) organization change for operating IVHS
3) institutional challenges in developing an effective public-private partnerships for IVHS.

Some of the issues will apply to Japan.

This chapter discusses the problems faced by local governments in Japan when they try to implement Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) in urban areas. These problems are:

1) the lack of national funds for IVHS
2) jurisdictional issues
3) staff retraining

This discussion centers on Osaka City and the Hanshin Expressway Public Corporation (HEPC) as a model for other cities that might try to implement these systems.

5.2 Lack of Funding Systems for IVHS

As discussed in Chapter 3, the authority to deal with IVHS is split between three national agencies: 1) the Ministry of Construction (MC), 2) the National

20 Joseph M. Sussman, "Intelligent Vehicle Highway Systems", Construction Business Review 60-65, May/June 1993

Police Agency (NPA), 3) the Ministry of Posts and Telecommunications (MPT). Among the three, MC and NPA have competed with each other to develop IVHS. If either agency develops traffic control systems more advanced than the other, the other agency will lose its jurisdiction over traffic control and the traffic control systems of that agency might be integrated into the advanced system. Therefore, the competition has inspired separate development of ATMS and ATIS in each jurisdiction. That is, the rivalry with NPA has encouraged MC to develop these systems on its expressways. Also, the rivalry has motivated NPA to implement traffic control systems which help to mitigate traffic congestion at special intersections. Furthermore, MC and NPA have prevented local governments from developing IVHS by not granting funds for IVHS.

Large Japanese cities have been making efforts to develop new technologies for a more economical and safer public transportation service. The Japanese public transportation system has evolved as a result of the urgent need for public transportation and because there was an already existing funding system for public transportation from the Ministry of Transport (MT). MT is responsible for the construction and supervision of railroads. Since MT has regarded the Advanced Public Transportation Systems (APTS) as part of railroad facilities, APTS is funded by MT. Both social need and appropriate funding systems have encouraged Japanese city governments to develop public transportation and APTS.

These factors should also be applied to the development of ATMS and ATIS. The need for ATMS and ATIS in big cities will be huge in the near future. However, appropriate funding systems for ATMS and ATIS do not yet exist. With appropriate funding systems for ATMS and ATIS, large cities would be able to construct and maintain traffic control systems using ATMS and ATIS.

5.3 Jurisdictional Issues

Traffic control systems using ATMS and ATIS are under the jurisdiction of two national agencies. One is the Ministry of Construction(MC), which constructs and supervises highways and expressways. The other is the National Police Agency (NPA), which is in charge of traffic control on highways. MC and NPA have agreed that MC is responsible for the traffic safety equipment and that NPA is responsible for traffic control equipment. Since ATMS and ATIS can be considered both traffic safety and control equipment, the development of ATMS and ATIS has fallen under the jurisdiction of both MC and NPA. As a result these two national agencies competed with each other for traffic control. The development of traffic control systems using ATMS and ATIS on the Hanshin Expressway, however, is an exception. Following an agreement of 1962 between MC and NPA, MC has been responsible for traffic control on the expressway and NPA has been responsible for traffic control on surface streets. Therefore, HEPC has faced few difficulties in implementing traffic control systems on the expressway. However, to deal with traffic control for the 1990 International Flower and Greenery Exhibition, HEPC coordinated their traffic data with the data collected by NPA. Before then, HEPC collected traffic data and managed the expressway under the supervision of MC. NPA collected surface street data within special areas and managed them.

5.3.1 The Agreement of 1990 between HEPC and NPA

The main access route to the site of the international exhibition was the existing Hanshin Expressway and the new municipal subway. Between April 1 and September 30, HEPC and NPA had to coordinate traffic control around the site in order to deal with the arrival of dignitaries from all over the world. Consolidation of data was necessary to control traffic. Before the international exhibition started, HEPC and NPA had agreed on how they would consolidate data. The agreement of 1990 is summarized as follows:

(1) How data will be exchanged

HEPC and NPA will exchange data by connecting computer processing units to both traffic control centers. HEPC and NPA will provide the equipment for making this connection and will be responsible for maintenance of that equipment within their own jurisdictions. The terminal board of the "Umeda Ramp" traffic control system will be a boundary between the jurisdictions.

(2) Contents of data

If HEPC needs data on surface streets, NPA will provide traffic data on surface streets close to the Hanshin Expressway. In turn, if NPA needs data on the Hanshin Expressway, HEPC will provide it.

(3)How cost will be shared

Since cost will depend on the amount of data requested, the one who requests data will be responsible for the cost of providing the facilities necessary for obtaining that data. Each agency will be responsible for the maintenance of the facilities necessary to obtain data within their own jurisdictions.

The interesting point of this agreement is that HEPC must provide NPA with almost all of its traffic data on the expressway, although NPA will provide HEPC with only part of its data. This is a little unfair. In addition, the maintenance cost of connecting facilities, such as fiber optics networks and computer processing units, depends on where the facilities will be located, although the agency who requests the data is responsible for its cost. For instance, if HEPC needs traffic data on a surface street close to its ramp and the connecting facilities are needed on the surface street, HEPC will have to pay for the facilities and NPA will then provide and maintain the facilities because they will be within NPA territory and jurisdiction and will therefore become part of NPA's properties.

There was no expiration date given for this agreement. Therefore, even after the exhibition, HEPC and NPA continued making efforts to consolidate their data and to implement the total traffic control on both the expressway and special surface streets.

In the past, MC and NPA have competed with each other for traffic control. However, their policies have recently changed from competition to cooperation. The international exhibition motivated HEPC and NPA to cooperate with regard to traffic control and to expand their cooperation. The agreement of 1990 between HEPC and NPA shows that city governments will be able to participate in the development of traffic control systems if they solve territory, construction, maintenance, and property issues. Therefore, the agreement will be a good example for city governments to learn how to cooperate with NPA and MC.

5.3.2 The VICS Project

The other example of the cooperation between MC and NPA is the Vehicle Information and Communication Systems (VICS) program, which is one of the Advanced Traveler Information Systems (ATIS), and is discussed in more detail later in this section. Before the VICS program was started, MC researched the project of Road/Automobile Communication System (RACS) and NPA studied Advanced Mobile Traffic Information and Communication System (AMTICS).

(1)RACS

The MC started RACS with 25 private companies in 1986. The purpose of RACS was to create a roadside beacon-based driver navigation and information system using two-way communication. RACS consists of three components: 1) on-board equipment, 2) roadside beacons, and 3) a central control center.

RACS uses microwaves to connect on-board equipment with roadside beacons and cable to connect roadside beacons with a central control center. RACS adopted a highly localized transmission system of microwaves that provides spot-coverage of the roadway. In this system beacons are built along the roadside about every 2 miles. Each beacon covers a 65-meter-long piece of roadway for communication purposes. Data communication is possible only when vehicles pass within this covered area. The passing time is so short (about 3 second) that a high level of data communication capacity is required.

(2)AMTICS

NPA started AMTICS in 1987. AMTICS is similar to RACS, except for the communication interface. The AMTICS data link is by means of a one-way broadcast of traffic data from a cellular system of teleterminals operating at 900 MHz. An uplink capability is possible by expanding the function of the teleterminal systems. However, the communication from vehicles to the teleterminals was not required in the basic design.

(3)Integration of RACS and AMTICS into VICS

In 1991 the Vehicle Information and Communication System (VICS) was started to better integrate RACS and AMTICS (see Figure 5.1). MC and NPA reached an agreement to cooperate in the construction and operation of Advanced Traveler Information Systems. Since the crucial issue of radio frequency allocation is under the jurisdiction of the Ministry of Posts and Telecommunications(MPT), MPT also joined the VICS program. Figure 5.2 shows the three transmission systems proposed by each agency for VICS:

1) the 900 MHz teleterminal system proposed by NPA
2) the FM Multiplex proposed by MPT
3) microwave beacons proposed by MC.

These three national agencies had researched these systems individually until now.

The VICS project[21] was organized by about two hundred private companies such as the Toyota Motor Company and the Sumitomo Electronics Company. MC, MPT and NPA participated in the VICS project as advisors. In the VICS project the three agencies and about two hundred private companies are divided into three overlapping research committees: 1) a project-research committee to research how to share the cost of VICS implementation and operation, 2) a technology-research committee to study transmission, and 3) an experiment committee to carry out VICS experiments in special areas.

Year 1986 1987 1988 1989 1990 1991 1992 1993 1994

RACS

AMTICS

VICS

Figure 5.1 Integration of RACS and AMTICS into VICS

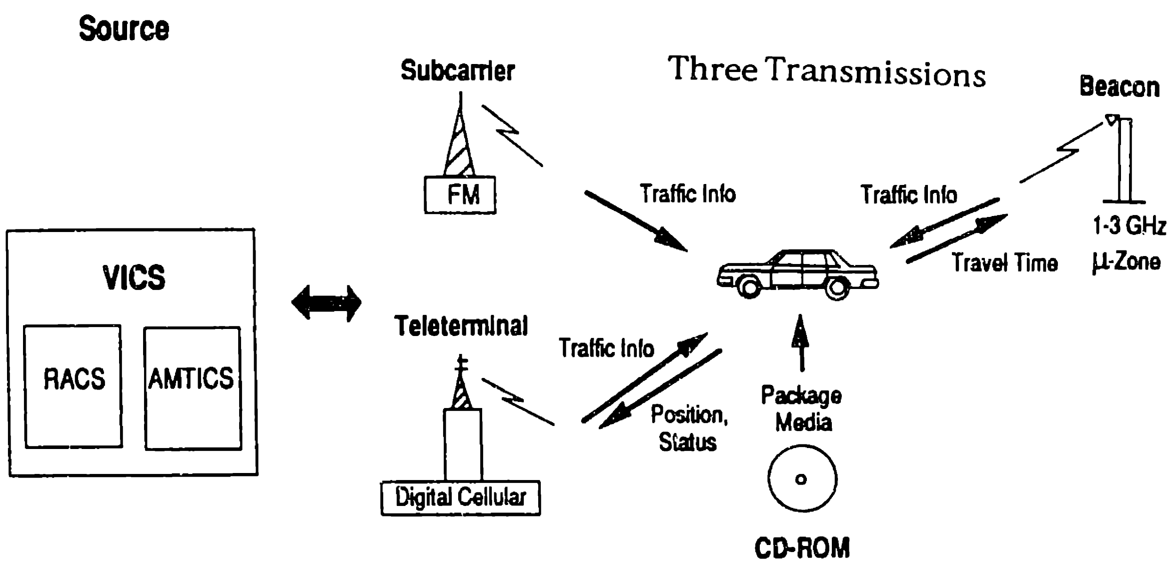

Figure 5.2 Three Possible Transmissions in VICS
Source: *An American Observation of IVHS in Japan*

[21] The VICS Conference, *Vehicle Information and Communication System*, VICS Symposium, Tokyo, November 1993, Trans. Toru Takahashi

There are four VICS functions: 1) to collect data, 2) to process data, 3) to provide data, and 4) to utilize data (see Table 5.1). The first function, collecting data, will be conducted by MC and NPA. They already have the facilities for collecting traffic data, such as travel time, traffic congestion, traffic accidents, and so on. In order to reduce cost, VICS will utilize the existing facilities of MC and NPA.

Table 5.1 Four Functions of VICS

	Function	Who will conduct/utilize
Function I	Collecting data	MC, NPA
Function II	Processing data	The VICS Center
Function III	Providing data -Teleterminal system -FM Multiplex -Beacons	The VICS Center
Function IV	Utilizing data	Drivers with navigation devices

Note: The VICS Center that will start up VICS does not yet exist. The VICS Center will provide drivers who have navigation devices with data through the teleterminal system, FM Multiplex and beacons. These transmission facilities will be built by MC, NPA, and MPT.

Source: *Vehicle Information and Communication System Symposium Text*, Tokyo, November 1993

The second function, processing data, will be conducted by a new organization, called the VICS Center. The new center will process collected data and will start up VICS. However, it is not clear who will organize the new center and how the new center will promote VICS.

The third function, providing data, will also be conducted by the new center. The new center will provide traffic data by using microwave beacons, FM Multiplex and teleterminal system. These transmission facilities are hoped to be built by each national agency. Private companies have already developed the transmission technologies and have proposed their own technology systems to MC, NPA, and MPT.

The fourth function, utilizing data, will be for vehicles with navigation equipment to guide the drivers through heavy traffic areas and through unknown areas. Japanese auto makers have already been selling navigation devices since 1987. The retail price is from $2,000 to $4,000, and about 300,000 navigation units have been sold.[22] The first navigation system had dead-reckoning computation with map-matching capabilities; however, drift errors of 5% to 10% of the travel distance were common. In order to correct the drift errors, the current navigation system has a global positioning system that receives information about the vehicle's location from satellites. The beacon and teleterminals are for the sake of providing absolute correction.

Technologies provided by private companies are available to implement VICS. The problem is who will operate and maintain the new VICS Center. Another problem is that VICS is not fair to drivers using existing facilities managed by MC and NPA. These facilities were built to provide all drivers with traffic information and to better control traffic. However, VICS currently is not for all drivers but only for wealthy drivers who can afford expensive navigation devices. Current traffic control systems operated by HEPC provide all drivers with traffic information related to the expressway.

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22 The VICS Conference, Vehicle Information and Communication Systems, VICS Symposium, Tokyo, November 1993, Trans. Toru Takahashi

Private companies that are members of the VICS project conducted a cost/benefit analysis to justify public investment in the VICS Center (see Table 5.2).

Table 5.2 Cost/Benefit Analysis

Cost Analysis

	Who will share	Cost (billion Japanese yen)
Collecting data	MC, NPA	-
Processing data Operating VICS	?	30
Building transmission facilities	MC, NPA, MPT	370
Utilizing data	Drivers with navigation devices	900
Total		**1,300**

Benefit Analysis

Saving travel time	
Drivers with navigation devices	2,380
Drivers without navigation devices	2,360
Saving fuel consumption	290
Improving traffic safety	a
Preserving the environment	b
Stimulating industry	c
Total	**5,030+a+b+c** [billion Japanese yen]

Note: The benefits for improving traffic safety, preserving the environment, and stimulating industry cannot be expressed figures. There is no report about how saving travel time and fuel consumption were calculated in the symposium text.

Source: *Vehicle Information and Communication System Symposium Text*, Tokyo, November 1993

According to the cost/benefit analysis, the cost for implementing VICS is about 130 billion Japanese yen or $1.2 billion, and the benefit for VICS is 500 million Japanese yen or $4.5 billion. The ratio is 1 : 4. The cost consists of operating the new VICS Center (30 billion Japanese yen), building beacons (370 billion Japanese yen), and purchasing navigation devices (900 billion Japanese yen). The anaiysis assumed that the number of navigation devices purchased would be 18 million in ten years; the number is currently 300,000 units, and that the price of the device would be $400; the current price ranges from $2,000 to $4,000. The benefits consist of saving travel time and fuel consumption. This analysis was conducted for motivating public sectors to aggressively invest in VICS. Therefore, the ratio of cost/benefit is suspected to be high.

(4) The VERTIS Project

In parallel with the VICS project, the Vehicle Road and Traffic Intelligent Society (VERTIS) was started in January, 1994 by private companies.[23] The main members of VERTIS include automobile and electronics companies. The purpose of VERTIS is to determine international standards for ATIS facilities, such as transmission devices, data processing units, and navigation devices, by cooperating with the IVHS America and the European Road Telematics Implementation Coordination Organization. Private companies are very concerned about the international standards for ATIS facilities, because their products will have to meet standards to be marketable and profitable.

VICS deals with domestic research and deployment of ATIS, and VERTIS is involved at the international level, such as international standards for ATIS and international conferences. VERTIS will make arrangements for the 1995 IVHS international conference to be held in Japan.

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23 Highway Research Committee, Highway and Vehicles, March 1994, Trans. Toru Takahashi

This section discussed jurisdictional issues related to the implementation of IVHS. Governmental jurisdictional issues have prevented city governments from taking part in traffic control systems in urban areas. The current change from competition to cooperation, such as the agreement of 1990 between HEPC and NPA related to traffic control and the VICS project coordinated by private companies, will help to develop traffic control systems in urban areas, although city governments must still resolve serious problems about who will be responsible for IVHS construction and operation costs, who will operate these systems, and whose property IVHS will become.

5.4 Retraining

Besides the lack of funding systems for IVHS and governmental jurisdictional issues, city governments face problems of retraining their staffs to begin operating traffic control systems using ATMS and ATIS.

Until now, highway construction and maintenance have not required new technology and follow highly structured procedures, except for the construction of underground or undersea highways. However, IVHS is a new field. IVHS requires skilled staffs to operate computer and telecommunication systems as well as have expertise about traffic control. Training and support mechanisms are necessary for improving highway staffs.

Retraining will be a minor issue in Japanese city governments, compared to US local governments. Most Japanese workers stay with the same companies until they retire. However, American workers have a tendency to change their jobs. Therefore, appropriate training programs will be effective for Japanese city governments but not for US local governments. According to the report by the Volpe National Transportation System Center[24], " a problem government agencies face is retaining personnel after they attain some degree of experience. For instance, in Oakland County, Michigan—where in excess of $10 million has been spent on an ATMS project—there were only two experts trained to support the system, and one of them recently left the organization." Spending time and money on retraining staffs is necessary for implementing IVHS in Japan and the USA. However, frequent turnover among US workers will make this problem more difficult in the USA.

5.5 Summary

This chapter discussed three problems facing city governments: 1) lack of funding systems for IVHS, 2) governmental jurisdictional issues, and 3) retraining of staffs. In order for city governments to develop traffic control systems using ATMS and ATIS, both social demand and funding systems are essential. The social demand for ATMS and ATIS will be tremendous in large cities, however, appropriate funding systems do not yet exist.

Traffic control systems are under the jurisdiction of two national agencies: the Ministry of Construction (MC), and the National Police Agency (NPA). In the past, MC and NPA have competed with each other for traffic control. However, their policies have recently changed from competition to cooperation. The international exhibition held in Osaka motivated the Hanshin Express Public Corporation (HEPC) supervised by MC and the Osaka Prefecture Police Agency of the NPA to cooperate with regard to traffic control and to expand their cooperation. As another example of their cooperation, MC and NPA started the Vehicle Information and Communication Systems (VICS) program. The change from competition to cooperation will

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24 Volpe National Transportation Systems center, *Institutional Impediments to Metro Traffic management Coordination*, September 1993

provide city governments with good opportunities to develop traffic control systems in urban areas, although they must still resolve serious problems related to the jurisdictional issues.

The third problem is to retrain staffs. Traffic control systems using ATMS and ATIS are a new field for city governments. Future staffs will need not only expertise in traffic control but also skills in operating computer and telecommunication systems.

In order to overcome the lack of funding systems for IVHS and governmental jurisdiction, institutional changes as well as cooperation of the national and local governments will be required. Furthermore, the retraining of staff for operating IVHS will cause organizational changes. Private companies have the technologies to implement IVHS. The problem is how the national and local governments will cooperate to achieve IVHS in urban areas.

In the next chapter, this thesis proposes how local governments will implement IVHS in urban areas.

Chapter 6 How Local Governments Should Implement IVHS

6.1 Introduction

As already discussed in Chapter 5, to implement IVHS, local governments need to overcome three problems:

1) the lack of national funds for IVHS,
2) governmental jurisdictional issues,
3) the retraining of staff.

The lack of a funding system for IVHS and governmental jurisdictional issues are dependent upon traditional Japanese bureaucratic practices. To date, the Ministry of Construction (MC) and the National Police Agency (NPA) have competed with each other for the responsibilities of traffic control. If either agency develops traffic control systems more advanced than the other, the other agency will lose its jurisdiction over traffic control and the traffic control systems of that agency might be integrated into the advanced system. Therefore, this competition in the national level has inspired separate development of traffic control systems.

Furthermore, MC and NPA have prevented local governments from participating in the development of IVHS by not granting them funds. However, the current change from competition to cooperation between these two national agencies will help to develop comprehensive traffic control system in urban areas using Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS). It is a good time for city governments to start participating in traffic control systems in urban areas, although they must still resolve problems related to the jurisdictional issues, such how to share the construction and operation costs, responsibility for the operation, and property issues. Since ATMS and ATIS are new fields for local governments, technical expertise from private companies will be needed to begin operating these systems.

There are three possible solutions to these three problems. The first is the application of the concept of ISTEA—the Intermodal Surface Transportation Efficiency Act of 1991 that was instituted in the USA—to Japan. The flexibility of ISTEA will provide city governments with more opportunities for developing and deploying IVHS in urban areas. The other two possible solutions are: 1) the development of public-private partnerships, and 2) an increase in the developer's share of the IVHS cost. After introducing the current Japanese funding system and the concept of ISTEA, this chapter discusses and compares these three solutions. The discussion centers on Osaka City as a model of other designated cities

6.2 Current Japanese Funding Systems for Urban Infrastructure

Before discussing the current funding systems for infrastructure in urban areas, this section describes the government ordinance-designated city system, which allows large cities, such as Osaka and Yokohama, to have the same power and responsibilities as the prefecture governments. The government ordinance-designated plays an important role when this thesis discusses current funding systems and the application of the concept of ISTEA to Japan.

6.2.1 Government Ordinance-Designated City System

It had long been argued that a special system should be provided for large cities that, unlike small cities, have complex and varied administrative responsibilities, due to their greater population and industry. This argument led to an amendment to the Local Autonomy Law of 1956 which allocated prefectural responsibilities to large cities, thus giving rise to the system of the government ordinance-designated city, hereafter referred to simply as a "designated city."

At present, the designated cities are Osaka, Sapporo, Sendai, Yokohama, Chiba, Kawasaki, Nagoya, Kyoto, Kobe, Hiroshima, Kitakyushu, and Fukuoka (see Figure 6.1). (The Metropolis of Tokyo is not one city, but rather consists of the large 23 special wards and their peripheral small cities, all of which are controlled by the Governor of Tokyo, thus the largest city in Japan, Tokyo is not a designated city.) These designated cities have received special powers in the areas of: 1) assignment of responsibilities, 2) administrative supervision, 3) organization, and 4) finance.

First, the following responsibilities closely related to the lives of residents have been transferred from the prefectures to the designated cities: 1) social welfare responsibilities, 2) responsibilities regarding the environment and public health, and 3) responsibilities regarding improvement of the city infrastructure such as city planning, roads, subways, and others. Second, although coordination and communication with the prefecture government are and will be maintained, the designated cities are not supervised by the prefecture governments, but are supervised directly by the national government. Third, to apportion responsibilities pertaining to the mayor's authority, administration of large cities can be executed efficiently and properly by dividing the district into wards as specified by regulations, establishing ward offices, and establishing an election administration committee. Fourth, financial responsibilities have been assigned to the designated cities.

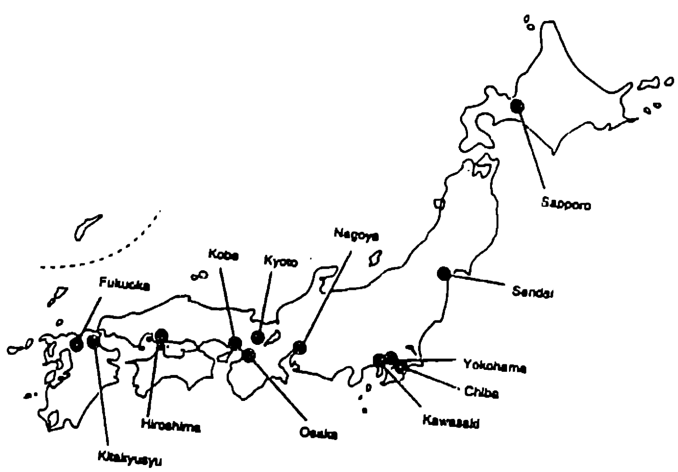

Figure 6.1 Government Ordinance-Designated Cities

The designated cities accept funds from the national government, not from the prefecture governments, when constructing highways, transit, and other public facilities. In the USA, there are conflicts between the state and large city governments in terms of the allocation of funds (for example, between Chicago and the state of Illinois). In Japan, however, there are few conflicts between the prefecture and the designated city governments. The mayor of the designated has the same power as the governor. For instance, Osaka City has an area of 220.37 square kilometers and 2.6 million inhabitants. Its general account budget is about 143 billion Japanese yen. On the other hand, Osaka prefecture, except for Osaka City, has an area of 1663.47 square kilometers and 5.9 million inhabitants. Its budget is about 158 billion Japanese yen. The budget per one in'·abitant and the budget per one square kilometer in Osaka City are greater than those in Osaka Prefecture (see Table 6.1).

Table 6.1 Comparison of Osaka City and Osaka Prefecture

	Area	Population	Budget	Budget/person	Budget/area
Osaka City	220.37	2.6	143	55,000	649
Osaka Prefecture	1663.47	5.9	158	26,800	95
Units:	square kilometers	million people	billion Japanese yen	Japanese yen per person	million Japanese yen per square kilometer

6.2.2 Current Funding Systems for Infrastructure

(1) Highway

In Japan, there are two kinds of funding systems for highways. One is based on the Highway Law for construction of rural highways, and the other is based on the City Planning Law for urban highway construction. Large cities such as Tokyo and Osaka have been building highways according to the City Planning Law. In contrast to the US, in Japan only the national government can establish laws.

The first City Planning Law was instituted in 1922. Although there have been many minor revisions (the latest in 1992), the last major revision was made to the current City Planning Law in 1968. The purpose of the law is "to help realize the sound development and systematic improvement of cities by fixing the substance of city planning and the procedure for deciding it, providing restrictions concerning city planning, facilitating city planning implementation, and addressing other necessary matters relative to city planning." [25]

The City Planning Law requires the establishment of a plan for the city's activities concerned with the following categories of facilities:

1) roads, urban-transit railroads, parking places, and other traffic facilities
2) parks, green areas, plazas, cemeteries, and other open spaces for public use
3) sewer systems, waste treatment facilities, refuse incineration facilities, and other supply and treatment facilities
4) group housing facilities (dwelling for 50 or more families per housing estate 1 hectare or more in area and passages and other facilities attached to them)
5) other facilities fixed by the relevant Cabinet Order.

In terms of implementing the highway plan that was fixed by the City Planning Law, the law requires that about two-thirds of construction costs be funded by the Ministry of Construction (MC). These funds are transferred from MC to the local governments, which are responsible for the remaining construction costs. The ratios of funds for implementing other facilities are also regulated individually. Table 6.2 shows the ratio of sharing highway construction costs. The designated city pays one-third of the construction costs. Unlike the designated cities who must bear the

25 City Bureau, Ministry of Construction, *The City Planning Law*, 1993, Trans. Toru Takahashi

entire one-third independently, small cities share only one-ninth of the costs and the prefecture takes responsibility for the remaining two-ninths (see Table 6.3). Furthermore, there are no national funds for ATMS and ATIS because the facilities for these systems are not regarded as the highway facilities.

(2) Transit

The Ministry of Transport (MT) is responsible for construction and supervision of railroads. Railroad construction including subways is based on the Railway Law. The Railway Law requires that one-third of the construction costs be funded by MT. Another third comes from local governments and the last third from railroad companies (see Table 6.2). Advanced Public Transportation systems (APTS) are regarded as one of the railroad facilities. As a result, there are national funds for APTS.

Table 6.2 Current Funding System to Designated City

	Highway	ATMS & ATIS	Transit	APTS
National government	2/3 from MC	-	1/3 from MT	1/3 from MT
Designated city	1/3	-	1/3	1/3
Railroad company	-	-	1/3	1/3

Note: 1. Designated city, such as Osaka and Yokohama, refers to a government ordinance-designated city which is not supervised by prefecture government, but is supervised directly by the national government.
2. ATMS refers to Advanced Traffic Management Systems.
3. ATIS refers to Advanced Traveler Information Systems.
4. APTS refers to Advanced Public Transportation Systems.
5. ATMS and ATIS are not regarded as one of the highway facilities.
6. APTS is regarded as one of the transit facilities. As a result the cost for APTS is included in transit construction cost.
7. MC refers to the Ministry of Construction.
8. MT refers to the Ministry of Transport.

Table 6.3 Current Funding System to Prefecture Government

	Highway	ATMS &ATIS	Transit	APTS
National government	2/3 from MC	-	1/3 from MT	1/3 from MT
prefecture government	2/9	-	1/3	1/3
Small city	1/9	-		
Railroad company	-	-	1/3	1/3

Note: 1. Prefecture and small city government are responsible for one-third of the highway construction cost.
2. Prefecture and small city government have responsibility for one-third of the transit construction cost.
3. The ratio of sharing the construction cost depends on how many small cities are related to the project.

(3) City Planning Decision Process

Local governments are required to plan highways following the City Planning Law's decision process when constructing highways and accepting funds from MC. If local governments do not need funds from MC, they are not required to follow this decision process. On the other hand, when a new railroad is constructed and passes under or over roads supervised by MC, the City Planning Law requires that the railway company plan its railroad following the City Planning Decision Process. Since it is impossible to construct railways in urban areas without passing under or over roads, most railway companies are required to follow this process. The only exceptions are: (1) railroads constructed before the City Planning Law was instituted, and (2) JR Hokkaido, JR East, JR Central, JR West, JR Shikoku, and JR Kyusyu, which collectively were previously called the Japanese National Railway (JNR).

The decision process outlined by the City Planning Law has 6 levels which are summarized below:

1. Preparation of the draft plan

Draft plans for highways must incorporate opinions of affected residents and city councilmen.

2. Public announcement

After official announcement, he draft plan must be open to public inspection for two weeks.

3. Local city planning council

The draft plan must be discussed by the local city planning council, consisting of the mayor, city councilmen, professors, and representatives of the Ministry of Construction, the Ministry of Transport, and the National Police Agency.

4. Approval of the Ministry of Construction

After discussion by the local city planning council, MC must examine the plan and approve it.

5. Adoption of the plan

After approval by MC, the plan is adopted and announced officially.

At each of the above levels, two important issues are always discussed: the impact of infrastructure construction on the environment, and the opinion of the residents.

6. Implementation

If MC determines that the plan has a high priority and decides to implement it, local governments will be granted their funds.

When railroad companies construct new facilities, they need to follow the City Planning Decision Process, except for the implementation process, in order to pass over or under roads of MC. The railroad companies also need to follow the procedures required by the Railway Law in order to accept funds from MT.

When local governments construct highways in urban areas, they must follow the City Planning Law. The problem with this decision process is that there is a time lag between the adoption of the highway plan and its implementation. The adoption of the plan does not guarantee that it will be immediately implemented. During the time lag, the land is not bought by the city because it has received no funds from MC. At the same time, residents suffer a great loss in property value.

For instance, there is a plan for an artery road, which is called the "Nanbakatae" line, in downtown Osaka. The plan of this artery road was established in 1950. However, its implementation was not yet started because there are many owners of land and buildings within the site of the planning artery road and the implementation needs huge costs. Furthermore, the City Planning Law regulates the buildings within the site of the planning roads. The owners are allowed only to rebuild up to three-floor temporary buildings that can be removed easily. The owners have been waiting for its implementation for 40 years!

The adoption of the highway plan is based on social needs and city planning theory. On the other hand, the timing of implementation is within MC's discretion on the basis of its budget. At the implementation level of the decision process, the power to allocate funds to local governments is centralized, and therefore inflexible.

6.3 Concept of the Flexibility in ISTEA

The flexibility feature demonstrated in the American ISTEA program will help to resolve some of Japanese problems and to develop IVHS in Japanese urban areas. The first feature is intermodal flexibility. Funds made available from the Highway Trust Fund can be used for transit and highway projects including IVHS. The second is regional decision making. ISTEA empowers the Metropolitan Planning Organization (MPO) to select the projects which should be funded, so the intermodal flexibility is exercised at the regional (not the national) level. These features are described in more detail below.

6.3.1 Intermodal Flexibility

Of the six categories of ISTEA funding for highways[26]—Interstate Construction (IC), Interstate Maintenance (IM), National Highway System (NHS), Bridge Replacement and Rehabilitation (BR), Congestion Mitigation and Air Quality (CMAQ), Surface Transportation Program (STP)—three NHS, CMAQ, and STP have intermodal flexibility features. Under NHS, $21 billion over six years (1992-1997) is available. States can use these funds for transit projects that meet specific requirements. 50 percent of NHS funds can be transferred to STP without federal approval and up to 100 percent of NHS funds can be transferred to STP with federal approval. Under CMAQ, $8 billion is available to be used in Clean Air Act nonattainment areas for transportation projects that have air quality improvement benefits. If a state has no Clean Air Act nonattainment areas, then 100 percent of CMAQ funds can be used for STP. Under STP, $23.9 billion is available for public transit, highway, and other transportation improvement such as IVHS.

6.3.2 Regional Decision Making

The intermodal flexibility is exercised at the regional level. In order to maximize mobility of people and goods and to minimize the fuel consumption and air pollution associated with transportation, it is essential to promote various modes of transportation programs comprehensively in urban areas. To carry out this objective, intensive capital investment in

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26 American Public Transit Association, *Federal Transit Act Amendments of 1991 and Related Provisions of Other Titles of the Intermodal Surface Transportation Efficiency Act of 1991: Summary of Provisions*, December 8, 1991

urban areas is needed. However, state governments try to construct highway networks uniformly, and city governments in urban areas focus on the development of urban transportation. There is a conflict between these two levels of government. To coordinate each policy, the Metropolitan Planning Organization (MPO) has been empowered under ISTEA[27].

MPO is a quasi-government body, including local elected officials, officials of agencies which administer major modes of transportation in the metropolitan area, and appropriate state officials. MPO is designated in each urban area with a population of more than 50,000 by agreement among the Governor and the units of local governments which together represent at least 75 percent of the affected population. Each metropolitan area covers at least the existing urban area, the contiguous area expected to become urbanized within 20-year forecast period, and Clean Air Act nonattainment areas for ozone or carbon monoxide. MPO is required to provide coordinated transportation planning for the entire metropolitan area, including long-range and financial plans.

6.4 Applying the Concept of ISTEA in Japan

While the Japanese funding system is different from the American one, the concept of ISTEA provides a good example for creating an appropriate funding system for IVHS in Japan. After WW II, the current Japanese funding system was created. The centralization of power to allocate funds has contributed to the achievement of good transportation systems across Japan. The centralized national agencies, such as the Ministry of Construction and the Ministry of Transport, have focused on protecting and developing their own jurisdictions. In order to sustain various urban

27 *The Congressional Record,* November 26, 1991, H11517-H11607

activities in the 21st century city, the city will be required to provide new infrastructure such as IVHS. However, the development of IVHS has fallen under governmental jurisdiction and an appropriate funding system for IVHS does not exist yet. It is time for the government to review the current funding system and to consider more flexibility in order to respond to social needs. Two solutions for IVHS are proposed to:

1) transfer highway funds to IVHS at the local government level
2) strengthen the City Planning Council to facilitate its implementation.

Advanced Public Transportation Systems (APTS) have already received national funds, so APTS is not included in this thesis, which focuses on funding systems for ATMS and ATIS. Furthermore, since in the short range, transfer of transit funds to ATMS and ATIS will cause another governmental jurisdictional issue between MC and MT, this thesis does not discuss the transfer of transit funds to ATMS and ATIS.

6.4.1 Transfer Highway Funds to IVHS

As already mentioned, under the National Highway System (NHS) in the American ISTEA program, 50 percent of NHS funds can be transferred to the Surface Transportation Program (STP), including transit and IVHS, without federal approval. This idea generates a good mechanism to develop Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) in Japanese urban areas.

In order to discuss the transfer of highway funds to IVHS, this thesis needs to understand how much money the city will need to implement and operate traffic control systems using ATMS and ATIS. Although the cost of implementing the traffic control systems depends on to what degree the city would develop IVHS, this thesis assumes that the city would develop the same level of IVHS as HEPC has achieved.

According to a report[28] by the Hanshin Expressway Public Corporation (HEPC), "The amount of investment for the traffic control system of the Hanshin Expressway including survey research from 1964 to 1981 was 7.5 billion Japanese yen. The maintenance cost of the system during the period was 1.4 billion Japanese yen, that is, a total of 8.9 billion Japanese yen. The percentage of total investment for traffic control system is calculated to be 1% of the total revenue of the expressway." Almost 1% of the annual toll revenue is estimated to have been spent on traffic control systems in HEPC.

Although 1% may seem to be insufficient for implementing and operating IVHS from the viewpoint of the US, in Japan it is a reasonable figure because the tolls paid on Japanese expressways are much higher than those on US expressways. For instance, the toll revenue on the 98.7-mile Hanshin Expressway was about 128.2 billion Japanese yen or $1.2 billion in fiscal year 1993 and the toll revenue on state toll road facilities across the entire US was $1.97 billion in fiscal year 1990.[29] Although the length of the Hanshin Expressway is less than 1% of all US state toll road facilities, its toll revenue is about 60% of state toll revenue. Therefore, an annual amount of about 1% of the toll revenue or $12 million seems to be appropriate to implement and operate ATMS and ATIS in HEPC.

The highway expenditure budget of Osaka City in fiscal year 1994 is about 276.8 billion Japanese yen. 1% of the toll revenue of HEPC is approximately equal to 0.5% of the highway expenditure in Osaka City. Therefore, the transfer of only 0.5% of Osaka's annual highway expenditure to IVHS would be sufficient to research and implement traffic control systems using ATMS and ATIS in Osaka City.

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28 Yoshino, Tsuyoshi, Sasaki, Tsuna and Hasegawa, Toshiharu, "Traffic Control System on the Hanshin Expressway"
29 U.S. Department of Transportation, *Highway Statistics 1990*

The current City Planning Law does not allow local governments to transfer highway funding. Generally, highway funding is used for acquisition of the highway right-of-way, construction of highways, and equipment for traffic safety such as traffic signs and street lights. The Ministry of Construction (MC) and the National Police Agency (NPA) have agreed that MC is responsible for traffic safety equipment and that NPA is responsible for traffic control equipment.

Since ATMS and ATIS consist of traffic surveillance systems, traffic control centers, and motorist information systems, they can be considered traffic safety and control equipment, and therefore fall under the jurisdiction of both MC and NPA. If MC and NPA regard ATMS and ATIS as part of the traffic safety equipment, city governments will be able to develop ATMS and ATIS using the highway funding.

This solution requires little change in current laws, since the City Planning Law and the Highway Law state that traffic safety equipment is built to guarantee safety for drivers and pedestrians and therefore ATMS and ATIS are regarded as part of traffic safety equipment. Table 6.4 shows a funding system proposed in this section. The funds for ATMS and ATIS will be allocated from MC.

Table 6.4 Proposed Funding System for IVHS in the Designated City

	Highway	ATMS & ATIS	Transit	APTS
National government	2/3 from MC	2/3 from MC	1/3 from MT	1/3 from MT
Designated city	1/3	1/3	1/3	1/3
Railroad company	-	-	1/3	1/3

6.4.2 Strengthen the City Planning Council

Under ISTEA, the Metropolitan Planning Organization (MPO) resolves federal level problems, but also determines the priority of each project that should be funded. MPO needs transportation experience and expertise to coordinate comprehensive transportation planning in the metropolitan area. In addition, MPO must garner funds and coordinate multi-jurisdictional efforts.

Creating a Japanese MPO is another solution in developing IVHS in Japanese urban areas. To create a Japanese MPO, some powers of MC should be vested in local governments. As already discussed, the role of the City Planning Council is currently to discuss and decide plans for the urban infrastructure through the City Planning Decision Process required by the City Planning Law. The City Planning Council is the appropriate organization to take over the powers.

If the City Planning Councils are empowered to determine the priority of each project and coordinate jurisdictional issues, those of small cities will not have sufficient transportation experience and expertise to coordinate comprehensive transportation planning or enough financial resources to implement it. In contrast to the City Planning Councils discussed above, the City Planning Councils of the designated cities, which was discussed in Section 6.2.1, have capabilities to coordinate multi-jurisdictional issues and hold funds for distribution.

The proposal in this thesis is that the City Planning Council of the designated cities should be empowered to determine the priority for urban infrastructure projects, including IVHS. The City Planning Council, instead of MC, should implement the following procedures of the City Planning Decision Process:

1) MC allocates funds to the City Planning Council on the basis of the previous year budget or on the basis of long range and financial plans.
2) The City Planning Council discusses and determines the priority of each project which should be funded, including IVHS.
3) Following the decision of the City Planning Council, the government-ordinance-designated city implements each project.

The above procedures will also help resolve problems with the current City Planning Decision Process, such as the time lag between the adoption of a plan and its implementation. Since the new procedures will guarantee that the adopted plan will be immediately implemented, the time lag will be eliminated. This proposal requires an amendment to the City Planning Law. According to the City Planning Law, a designated city must obtain the approval of MC before executing a city planning project. Therefore, the term "approval of MC" needs to be changed into "approval of the City Planning Council."

Empowering the City Planning Council of the government ordinance-designated cities will lead to a decentralization of power which is the long range aim of the Japanese cabinet—to deregulate, decentralize, and decrease the time spent by the national government on such matters.

6.5 Development of Public-Private Partnerships

The other solution to develop IVHS is the encouragement of more public-private partnerships. To the present, investment in highways has been made by the public sector. Road repair or new road construction has not required high technology and has followed highly structured procedures. IVHS requires new approaches. Retraining is necessary for preparing technicians and management staffs to use new technologies. The private sector seems to be more skilled at innovation and at responding to new technology. The development of public-private partnerships will help local governments retrain their staffs more easily as well as support new technologies IVHS requires. Examples of such partnerships are:

1) privatization of existing public services
2) public management with private sector operations
3) private sector funded by public sector.

6.5.1 Privatization of Existing Public Services

The Osaka City government has already privatized some existing departments or divisions to utilize the manpower and technology of private companies. For instance, since 1970, Osaka City has been making maps of the entire city every decade. The maps were used mainly for researching urban infrastructure and urban development plans. Some of them were sold. Osaka City began to look for a way to use mapping facilities, and found out that the digital maps for computers would become a good market in future. As a result, in 1991, the Osaka City government privatized its Urban Information Center of Planning Bureau, which became the Osaka City Foundation for Urban Technology. The purpose of this privatization was to develop digital mapping systems for computers as a means of bringing in income. Some of the digital mapping system is now used in the navigation system with which some vehicles equipped.

In establishing the Osaka City Foundation for Urban Technology, 51% of the total money invested came from Osaka City and 49% came from private companies. Private companies sent their staffs to the privatized company in order to support the startup of the business. In addition to technological cooperation, financial cooperation of private companies is essential to privatization.

If Osaka City begins operating IVHS, it will need technological expertise for operating new systems. Privatization of the Division of Road Maintenance will help the city both to utilize the technology of private companies and to operate IVHS. In order to privatize the division, Osaka City will need financial support from private companies as stockholders. The problem is how the city will attract private companies to invest in the privatized company, because providing traffic information is thought to be a free service and it is uncertain how the privatized company will get revenue, manage the company, and make a profit.

This problem has been overcome, however; when digital mapping systems were established in 1991, private companies expected that the mapping systems would provide good business opportunities and would be a worthwhile investment. Therefore, if the financial plan of the privatized company which is in charge of operating IVHS is clear, the privatization will be one way to help the city to begin operating IVHS.

6.5.2 Public Management with the Private Sector Operations

If city governments implement IVHS, overall public management with the day-to-day operations handled by the private sector can be a successful combination. This method will not require city governments to provide many experts in new traffic management technologies. Retraining staff for operating IVHS will require several months. If the public sector begins operating IVHS, it will not have the time required to retrain its staff for the new systems. Therefore, public management with private sector operation will help the public sector to begin IVHS operations. The procedure will be simple: the public sector will contract with the private sector until it can retrain its own staff to take over IVHS operations.

According to Frederick P. Salvucci,[30] who is a senior lecturer and research

30 Salvucci, P. , Frederick served as Secretary of Transportation of the Commonwealth of Massachusetts between 1975 and 1978 and again between 1983 and 1990, and prior to that as

associate at MIT, "The private companies that can help IVHS operation most effectively are telephone companies." Another feasible candidate in Osaka is the Osaka Media Port Corporation (OMP) as already discussed in Chapter 4, which was established by Osaka City, the Kansai Electronics Company, and other private companies in 1985 in order to meet the demands of highly information-oriented society. OMP is an electronic communication institute that builds optical fiber networks and provides the network to users. Osaka City holds 51% of its stocks and sends government official to supervise and support the business. The second stockholder is the Kansai Electronics Company that provides Metropolitan Osaka with electricity. To support the technology of OMP, the Kansai Electronics Company also sends their staff to OMP. Therefore, OMP is not only a private company that has technologies for operating computer and communication systems, but is also supervised by and supported by Osaka City. If Osaka City adopts public management with the day-to-day operations handled by private sectors in implementing IVHS, OMP will be the most appropriate and reliable partner to provide technologies for IVHS.

6.5.3 Private Sector Funded by Public Sector

In the partnerships of public management with the private sector operation, the public sector will be responsible for overall operations of IVHS and the private sector will be contracted to operate IVHS for the public sector. On the other hand, the private sector, funded by public sector, will be responsible for the daily operations of IVHS. This method is based on the idea that IVHS will not be a burden on the taxpayers but will be instead a new source of revenue. Therefore, the private sector must balance between its expenditure and revenues using funds from the public sector. The problem is how to make IVHS a new source of revenue that will make a

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transportation advisor to Boston Mayor Kevin White. His interest lies in infrastructure plans and institutional design in decision making.

profit for the private sector, independent of public sector funding, which is meant solely to maintain the operations of IVHS. Diebold writes, "a traffic management system might be operated by the private sector and funded by the public sector, and payment would be related to performance (for example, how well congestion is controlled at peak periods)."[31] This method is convenient for the public sector, because its dispersal of funds depend on the performance of the private sector. The private sector is responsible for its own profits, however, the private sector must devise a way to make profits using the traffic information that IVHS provides. Therefore, if the private sector can make a profit in the IVHS business, this method will be one way to help the city to begin operating IVHS.

Table 6.5 compares three methods discussed in this section. In the first method, privatization of existing public services, the willingness of the public sector is an important determinant. It provides traffic information and gets technological and financial cooperation from private companies for privatization. Since providing traffic information is thought to be a free service, the operation of IVHS is not a good investment for the private sector. In the second method, public management with private sector operation, the public sector contracts with the private sector to operate IVHS in exchange for technical expertise. In the third method, the private sector funded by the public sector, the private sector is the dominant actor. It provides daily operations for IVHS paid from public sector funds and makes its own profits by devising ways to use the traffic information provided by IVHS. The question is whether the private sector will be able to make a profit in traffic information business.

If traffic information remains a free service, the public sector must

31 Diebold, John, "Overcoming Obstacles to 21st Century Infrastructure," IVHS Review Spring 1993.

continue to provide IVHS services, because business will not invest in it. Therefore, the most feasible method of the three kinds of public-private partnerships introduced in this section is public management with private sector operation, because the private sector complements the weak points of the public sector.

Table 6.5 Comparison of the Three Public-Private Partnerships

	Role of public sector	Role of private sector	Traffic Information
1) Privatization of existing public services	provider	investment	free
2) Public management with private sector operation	provider	contractor	free
3) Private sector funded by public sector	to fund	to make profits	not free

6.6 Developer's Share in the IVHS Cost

As already discussed in Chapter 4, Osaka is promoting Technoport Osaka, an innovative urban development project on reclaimed land in the port area. The purpose of Technoport Osaka is to create a new city for the 21st century by combining the following concepts:

1) the development of advanced technology
2) international trade function
3) sophisticated information and communication function.

There is a possibility that IVHS will be implemented in this project as a model for new urban development. In approximately ten years, after the Osaka City government reclaims the new land and creates the infrastructure of the new city, it will sell the land to developers. In the new city, if IVHS is developed as part of the new infrastructure, its construction and operation cost can be included in the price of land sold to developers.

The investment for creating infrastructure in the Technoport Osaka project, including reclamation, ground improvement, highways, railroads and so on, is $8.2 billion. This estimation was conducted in 1988. In the Technoport Osaka project, about half of the newly reclaimed land will be used for public spaces. About another one-fourth will be used for Osaka City and the last one-fourth will be sold to developers.

The price of newly reclaimed land to be sold to developers is decided according to the financial policy of Osaka that states that some of the construction costs for the reclamation and implementation of the infrastructure should be covered by selling new lands to developers. The estimated average land price was $17.1 million per acre or $4,230 per square meter in 1988. If 0.5% of the investment for reclaiming land and creating infrastructure is used for implementing and operating the traffic control system, the total value of the investment for public facilities will become $8.241 billion, and the estimated average land price will become $17.2 million per acre or $4,250 per square meter.

Some of the reclaimed land has already been sold to developers. According to the interview with a government official who is working for the Port and Harbor Bureau of Osaka City, in 1993 the maximum price of land sold to developers was about $ 36.8 million per acre or $9,100 per square meter, and the minimum was about $ 18.3 million per acre or $4,500 per square meter. The average land price was about $ 27.6 million per acre or $6,800 per square meter, which showed an increase of 1.6 times compared to the land price in 1988. The change of land price by adding the IVHS cost is very small, compared to the recent increase of land prices. Since the basic land price is very high, the developer's share in the IVHS cost is minimal.

6.7 Evaluation of Each Method

This chapter introduced four methods to implement and operate ATMS and ATIS. This section compares each method. Table 6.6 shows advantages and disadvantages of each method. The difference between "Transferring Highway Funds to IVHS" and "Strengthening the City Planning Council" is that the former does not require change in the existing laws. Except for this point, both methods have the same advantages and disadvantages. Namely, both methods need to deal with jurisdictional issues between the Ministry of Construction and the National Police Agency. Once both methods are established by the two national agencies, funds for construction costs and maintenance costs will be provided by the national government.

Additionally, both methods can be applied to downtown areas as well as new urban areas such as the Technoport Osaka project. In the short term, Method I, transfer of highway funds, is the appropriate method for implementing traffic control systems in urban areas by using ATMS and ATIS. In the long range, Method II, strengthening the City Planning Council, is appropriate to achieve the Japanese cabinet's goal—to decentralize the power of allocating funds by the national government.

Method III, public management with private sector operation, will help city governments to operate and maintain ATMS and ATIS, when the city begins IVHS operations and cannot afford to spend time to retrain its staff.

Method IV, the developer's share in the IVHS cost, will significantly help city governments implement traffic control systems using ATMS and ATIS without long and complicated debate over jurisdictional issues and changing the laws. However, this method is applied exclusively to new urban development areas.

Table 6.6 Evaluation of Four Methods

	Method I	Method II	Method III	Method IV
Change in laws	a	c	a	a
Jurisdictional issues	c	c	a	b
Construction costs	a	a	c	a
Maintenance costs	a	a	c	c
Retraining staffs	b	b	a	b

Note:
1. Method I refers to transferring highway funds to IVHS.
2. Method II refers to strengthening the City Planning Council of the designated city.
3. Method III refers to public management with private sector operation. Although three kinds of public-private partnerships are proposed, this method is the most feasible of the three.
4. Method IV refers to the developer's share in the IVHS cost.
5. Figure "a" denotes "no problem."
6. Figure "b" denotes "problem."
7. Figure "c" denotes "major problem."
8. The category of Change in laws refers to whether each method needs to change related laws or not. Only Method II needs changes in related laws.
9. The category of Jurisdictional issues refers to how many problems each method needs to resolve related to jurisdictional issues.
10. The category of Construction costs refers to whether each method covers the construction cost for IVHS.
11. The category of Maintenance costs refers to whether each method covers the maintenance costs.
12. The category of Retraining staffs refers to how many problems each method needs to resolve related to the retraining of staff.

6.8 Summary

After introducing the Japanese government ordinance-designated city system, current Japanese funding systems for infrastructure, and the concept of ISTEA, this chapter discussed and compared four methods for overcoming the lack of funding for IVHS and the retraining of staff in operating IVHS:

1) transferring highway funds to IVHS
2) strengthening the City Planning Council of the designated city
3) public management with the private sector operation for the retraining of staff
4) utilizing the developer's share in the IVHS cost.

As to a means of getting monetary resources for IVHS, in the short range transferring highway funds to IVHS will be appropriate to implement IVHS in the downtown area because this method does not require changes in related laws. In the long range, if decentralization of power takes place in Japan, strengthening the City Planning Council of the designated cities will be appropriate. For a new development area, such as the Technoport Osaka project, utilizing the developer's share in the IVHS cost will help city governments develop IVHS, yet it will not be a big burden for developers, compared to the recent increase of land price.

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In terms of the maintenance and operation of IVHS, public management with private sector operation will be important to help the public sector to begin operating ATMS and ATIS, because the public sector lacks the technological expertise these systems require. One of companies that seems to be the most feasible choice is the telephone company. In order for city governments to implement and operate IVHS in urban areas, it will be essential to combine each of the four methods for complementing the weak points of each method.

In the next chapter, this thesis discusses the combinations of the four methods through a hypothetical case study.

Chapter 7 Hypothetical Case Study

7.1 Introduction

This thesis proposes applying the concept of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) to the Japanese funding systems in order to develop the kind of traffic control systems that the Hanshin Expressway Public Corporation (HEPC) has achieved. The discussion focuses on Osaka City as a model for other cities which faces similar urban problems. Chapter 4 addressed whether large cities should implement traffic control systems, Chapter 5 pointed out some of the problems faced by large cities when they try to implement these systems, and Chapter 6 proposed four methods for overcoming these problems. This chapter seeks to integrate these discussions through a hypothetical case study. First, this chapter sets up the framework of a hypothetical city (a typical, large Japanese city) and then illustrates how to approach the question of combining the four methods.

7.2 Assumption

This section deals with six features of a hypothetical city, Toru City: 1) scale of the city, 2) traffic condition, 3) institutional conditions, 4) government jurisdiction, 5) developmental policies of the city, and 6) other circumstances affecting Toru City.

7.2.1 Scale of the City

At present, there are twelve designated cities in Japan. As already discussed in Chapter 6, the designated city refers to the government ordinance-designated city that is not supervised by the prefecture government but directly by the national government. Based on the average area and the average population of the twelve designated cities, Toru City has an area of about 500 square kilometers and 1.6 million population.

7.2.2 Traffic Condition

Toru City provides urban infrastructure services for supporting social and economic activities. That is, there are extensive railway, expressway, and road network systems in the city.

Table 7.1 shows the modal split in Toru City and Osaka City. As in Osaka City, the railway service within Toru City is more important than car transportation to support the movement of people. Great public transportation systems, such as municipal subway and private railway networks, have already been achieved. In terms of automobile traffic, although urban expressway and road networks are provided, Toru City faces heavy traffic congestion. Furthermore, illegally parked cars on streets are one of the most urgent traffic problems in Toru City. They cause bottlenecks and make traffic congestion worse. In terms of bus service, although Toru City provides good bus service networks, its service cannot attract many bus passengers due to heavy traffic condition on the streets, which delays bus service. The Transportation Bureau of Toru City, which provides bus services, makes efforts to attract bus passengers by adopting bus-only lane, traffic signals for bus priority, and bus location indicators that inform bus passengers where the next bus is and when it will arrive. Toru City expects that these bus systems will be incorporated into a comprehensive traffic control system.

Table 7.1 Modal Split in Toru City and Osaka City

	Toru City	Osaka City
Railroad	30%	32.2%
Car	20%	16.8%
Bus	2%	2.0%
Bicycle	20%	19.2%
On foot	28%	29.8%

Note: Figures for Osaka City are as of 1990.
Figures for Toru City are hypothetical.

7.2.3 Institutional Conditions

(1) The government ordinance-designated city

It is assumed that Toru City is one of the designated cities and receives special powers in the areas of: 1) assignment of responsibility, 2) administrative supervision, 3) organization, and 4) finance. The designated city receives funds from the national government, not from the prefecture government, when it constructs highways, transit, and other public facilities.

(2) Funding systems for urban infrastructure

Toru City has been constructing highways based on the City Planning Law. Before Toru City constructs a highway, the law requires it to establish a highway plan. The law also requires that about two-thirds of construction costs be funded by the Ministry of Construction (MC). Toru City is responsible for the rest of the construction costs. In terms of traffic control systems, there are no national funds for Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) because the facilities for these systems are not regarded as highway facilities.

When a railroad is constructed in Toru City, its construction is required to be based on the Railway Law. The law requires that one-third of construction costs be funded by the Ministry of Transport (MT). Another one-third comes from Toru City and the last third from the railroad company. In terms of sophisticated transit systems, Advanced Public Transportation Systems (APTS) are regarded as a railroad facility. As a result, there are national funds for APTS.

(3) The City planning Council

Toru City is required to plan highways following the City Planning Law's decision process for constructing highways and accepting funds from MC. Also, when a new railroad is constructed and passes under or over roads supervised by MC, the railroad company is also required to plan its railroad following the City Planning Law's decision process. The decision process is comprised of six procedures: 1) preparation of the draft plan, 2) public announcement, 3) discussion in the City Planning Council, 4) approval of MC, 5) adoption of the plan, and 6) implementation. On the basis of the City Planning Law, Toru City has a City Planning Council, consisting of the mayor, city councilmen, professors, and representatives of MC, MT, and the National Police Agency (NPA). In the decision process, Toru City's City Planning Council plays an important role in discussing and deciding plans for its urban infrastructure.

In terms of highway construction, Toru City has a problem with this decision process: there is usually a time lag between adoption of the highway plan and its implementation. That is, adoption of the plan does not guarantee that it will be immediately implemented. In the meantime, land for highway construction is not bought by Toru City because it has received no funds from MC. At the same time, residents suffer a great loss in property value.

Railroad construction requires that the railroad company follow the City Planning Law's decision process, except for the implementation procedure because it receives funds from MT, not from MC. In order to receive funds from MT, the railroad company needs to follow the procedures required by the Railway Law.

7.2.4 Governmental Jurisdiction

Toru City is confronted with governmental jurisdiction problems. The Ministry of Construction (MC) and the National Police Agency (NPA) have agreed that MC is responsible for traffic safety equipment and that NPA is responsible for traffic control equipment. Since ATMS and ATIS can be considered both traffic safety and control equipment, the development of these systems has fallen under the jurisdiction of both MC and NPA. As a result, MC and NPA have competed with each other for traffic control and the rivalry has inspired separate development of these systems in its own jurisdiction. That is, MC developed traffic control systems on urban expressways supervised by MC and NPA also developed traffic control systems at special intersections that cause bottlenecks. Both systems are operated separately. Furthermore, MC and NPA have prevented local governments from developing ATMS and ATIS by not granting funds for IVHS.

7.2.5 Developmental Policies of the City

(1) A comprehensive transportation policy

Toru City has a comprehensive transportation policy with two main priorities: 1) improvement of convenient and comfortable public transit, and 2) road improvement and achievement of smooth traffic flow by using traffic control systems.

For improvement of attractive public transit, Toru City has not only been expanding subway and bus networks, but also promoting more convenient connections between subway and bus networks. Furthermore, Toru City has been making efforts to develop Advanced Public Transportation Systems (ATMS) in order to automatically monitor and control the subways by using investments from MT.

For road improvement and achievement of smooth traffic flow, to date, Toru City has been constructing arterial and feeder roads. Toru City now will need to work intensively on traffic control systems in order to achieve its goal of a comprehensive transportation policy. As one of the traffic control systems, Toru City started a real-time guided parking system. In

Toru City, illegally parked cars on streets have been one of the most urgent traffic problems. The social pressure to immediately resolve this problem motivated Toru City to implement this system independent of MC and its fund. Toru City expects that this guided parking system will be incorporated into its traffic control systems in the near future.

(2) Environmental impact assessments

In order to predict and assess how implementation of a project will affect the environment, Toru City must conduct environmental impact assessments before carrying out the construction of highways, railroads, and other facilities. After the assessments, necessary steps, including abandonment of the entire project, must be taken to avert damage and protect the environment. The environmental impact assessments add to the cost and time required before highway construction is allowed.

(3) New urban development

Toru City aims at promoting a new urban development for balanced growth of the city as a whole. This new urban development will be built to have three key functions: 1) the development of advanced technology, 2) international trade function, and 3) information and communication function. These are new concepts added to the conventional concept of residential and commercial area only. The traffic control system will be integrated into the information and communication function.

7.2.6 The Circumstances Affecting the City

(1) The environment (Air pollution)

Toru City is confronted with air pollution especially by nitrogen dioxide from car exhaust gas. The concentration levels of nitrogen dioxide in Toru City do not meet the air quality standards established by the national government. To meet its standards, Toru City has been working on: 1) restraining the growth of automobile traffic by promoting a comprehensive transportation policy; 2) tightening exhaust gas regulations; 3) promoting cars that meet air quality standards; and 4) educating the public about the environment.

Toru City faces a dilemma, however, since increasing highways because of heavy traffic increases traffic, which is counter to objective one. Toru City also faces the problem of how to achieve a balance between highway construction and preservation of the environment. By increasing the efficiency of the existing highway networks, ATMS and ATIS will reduce the need for additional highways, thus helping the balance.

(2) High price of land

Land cost in Toru City is extremely high. The price of land increased about 5 times between 1980 and 1991. The high price of land makes acquisition of highway rights-of-way difficult, which adds to the pressure for improving the efficiency of existing highways.

(3) The coming of an ultra-aged society

Toru City will be confronted with an ultra-aged society in the near future. As already discussed in Chapter 6, the term, "ultra-aged society" is used to refer to the phenomenon of a large elderly population. Since the percentage of elderly Japanese citizens will increase from 14% in 1993 to 25.2% in 2020 (which is a much faster rate of growth than in the US and European countries), the national and local governments, including Toru City, must prepare the infrastructure for the ultra-aged society as soon as possible.

Traffic control systems using ATMS and ATIS is one way to provide infrastructure to support its ultra-aged society. Since elderly people seem to get lost more easily and seem to be afraid of driving in urban areas, ATMS and ATIS will make travel less intimidating.

(4) Private partner

In Toru City, there are many private companies that can deal with computer and telecommunication systems. Since ATMS and ATIS are new fields for the city government, private companies will help Toru City to operate ATMS and ATIS when the city begins operating these systems.

7.3 Future Development of IVHS

This section illustrates how IVHS will work in the near future in Toru City, based on the features addressed in the previous section. With the coming of an information-intensive society, urban infrastructure including urban information systems will be established. That is, more personal and business communications will be supported by the development of nationwide satellite networks and fiber optic links to the home and office. Since people in the city will demand diverse information anytime and anywhere, the implementation of ATMS and ATIS will be a significant urban transportation policy for Toru City.

People who are about to leave home will obtain traffic information about Toru City through telephone services or a computer communication system in order to select transportation either by private vehicles or public transit. For instance, if there is heavy traffic congestion or an accident on the way to their destinations, they will select public transportation, otherwise, they will choose their own private vehicles.

Before entering an urban expressway, drivers in Toru City will be able to obtain traffic information about that expressway (as well as for alternative surface routes) from travel time information boards, variable-message sign boards, and telephone services. After comparing the travel times for that expressway and the alternative surface routes, they will be able to make an appropriate decision.

At toll booths of urban expressways, automatic vehicle identification systems will collect tolls automatically in order to reduce congestion around toll booths. Furthermore, these systems will be able to provide congestion pricing systems; in other words, tolls will be higher during rush hours than during off-peak hours. Some intersections after expressway exits cause bottlenecks due to the heavy traffic flow from the exits. In order to balance the traffic condition between the urban expressway and surface streets, these intersections will be effectively controlled by traffic signals, which will both regulate the flow of traffic and inform drivers of upcoming condition and alternative routes.

On surface streets in downtown areas of Toru City, drivers will be able to obtain traffic information on artery roads from variable-graphics sign boards in order to select a less congested route. ATMS will flexibly adjust lane usage, speed limits, traffic signals, and roadway access based on actual traffic conditions. Accident detection systems will also reduce congestion caused by accidents and will avoid the secondary accidents that result in additional delays. Furthermore, a real-time guided parking system will guide drivers directly to available parking garages. In addition to these traffic control systems, navigation devices in vehicles will help to guide elderly drivers to their destinations by avoiding congested routes, enhancing their mobility in the city.

At bus terminals and railroad stations, passengers will be able to obtain real-time transit schedules and intermodal connection information. In terms of bus location systems, bus location indicators linked to traffic control systems will accurately inform bus passengers where the next bus is and when it will arrive.

Development of traffic control systems using ATMS and ATIS will be useful not only to improve the efficiency of existing road networks, but also to divert drivers to public transportation, because traffic information about heavy traffic congestion on highways will allow drivers to choose alternative modes of transit. Since Toru City now has air quality problems, ATMS and ATIS will be part of the solution to the environmental problems. That is, smoother traffic flow resulting from improvements in congestion, improved route selection resulting from providing information to drivers, and diversions to public transportation will be able to reduce environmental impact.[32] Furthermore, the development of ATMS and ATIS will help to vitalize the electronics and telecommunication industries and stimulate the economy of Toru City. Toru City will also support R & D and human resource development to enhance the technologies for ATMS and ATIS.

7.4 Combination of the Four Methods

When Toru City tries to implement traffic control systems which will provide benefits discussed in the previous section, it will be confronted with problems: 1) the lack of national funds for ATMS and ATIS, and 2) the retraining of staff. As already discussed in Chapter 6, the four methods for overcoming these problems are: 1) transferring highway funds to IVHS, 2) strengthening the City Planning Council of the designated city, 3) establishing public management with private sector operation, and 4) using the developer's share in the IVHS cost.

Effective implementation and operation require combinations of these methods as shown in Table 7.2. Combination I is for the short-term and Combination II for the long-term. This section presents a hypothetical case to illustrate how these two combinations can be used.

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32 IVHS America, *Strategy Plan for Intelligent Vehicle-Highway Systems in the United States*, May 20, 1992.

Table 7.2 Combinations of four methods

	Method I	Method II	Method III	Method IV
Combination I	x	-	x	x
Combination II	-	x	-	x

Note: 1. Method I refers to transferring highway funds to IVHS.
2. Method II refers to strengthening the City planning Council of the designated city.
3. Method III refers to establishing public management with private sector operation.
4. Method IV refers to using the developer's share in the IVHS cost.
5. "x" refers to the application of the method.
6. "-" refers to the non-application of the method.

A scenario for achieving the combinations

It is assumed that in a decade Combination I will be achieved, and after that Combination II will be achieved. From 1994 to 1997, MC and NPA will cooperate with regard to traffic control systems and allow local governments to develop IVHS by granting them funds. In the past, MC and NPA have developed separate traffic control systems. MC dealt with traffic control systems on urban expressways, and NPA dealt with traffic control systems on special surface streets. To deal with drivers' complaints about the lack of a comprehensive traffic information, Toru City will create a comprehensive traffic control system. Complaints are that although drivers can obtain traffic information about urban expressway through its traffic control systems, such information lacks surface street information and is not comprehensive. Therefore, drivers have often faced traffic congestion on surface streets after exiting from urban expressways, and have lost whatever time they saved by using urban expressways.

In order to create a comprehensive traffic control system, Toru City will petition the national government to allocate funds for IVHS. As a result, MC and NPA will agree not only to regard IVHS facilities as part of traffic safety equipment but also to transfer highway funds to IVHS implementation (Method I). Toru City will begin implementing IVHS in the downtown area based on the transfer of highway funds from MC, while resolving the responsibility for operation and property issues.

From 1997 to 2000, IVHS will be built and made ready to operate. However, since these systems will be new fields for Toru City, it will have to obtain help from private companies that have the technological expertise for IVHS. Public management with day-to-day operations handled by the private sector will be appropriate to help Toru City to begin these systems (Method III).

From 2000 to 2004, Toru City will complete its new urban development project started in the 1980s. Due to the success of IVHS in the downtown area, Toru City will develop IVHS as part of the infrastructure in its new urban development area. In order to raise monetary resources for IVHS construction and operation costs in the new urban development, Toru City will use the developer's share in the IVHS cost (Method IV). That is, these costs will be included in the price of land sold to developers.

For the long term, after 2004, a decentralization of power will take place in the national Japanese government, which will allow the allocation of national funds to local projects. In order to determine the priorities of urban infrastructure projects and allocate national funds to such projects, the City Planning Council of Toru City will be given more power by changes in related laws (Method II). After MC allocates funds to the City Planning Council on the basis of long-range and financial plans, the council will select plans for urban infrastructure and simultaneously determine the priorities of those projects for the allocation of funds. Then, Toru City will implement each project.

For its new urban development, using the developer's share in the IVHS cost will be appropriate in both the long and the short range, because this method can achieve IVHS without using public money (Method IV). As for the retraining of staff, since in the long range Toru City will be able to afford to spend time and money to retrain its staff for operating the computer and telecommunication systems required for IVHS, Toru City will provide its own staff for daily operations.

7.5 Summary and Possible Problems

This chapter discussed how IVHS will work in the near future in the city and illustrated how to approach the question of combining the four methods through the hypothetical Toru City (a typical, large Japanese city). Two combinations are proposed: Combination I is designed for a short-term implementation, and Combination II for a long-term implementation. In Combination I, Toru City will need to convince MC and NPA to regard IVHS facilities as part of highway facilities. After MC and NPA approve the transfer of highway funds to IVHS, Toru City will also need to deal with jurisdictional issues, such as responsibilities for operation of IVHS and property issues. Furthermore, Toru City must prepare to operate IVHS. If Toru City cannot afford the time to retrain its staff, the private sector, such as the telephone company, could help the city begin operating IVHS under contract. While the private sector company begins operation of IVHS, the city can retrain its own staff, thereby saving money in the future.

In a new urban development, when Toru City adds the construction and operation costs for IVHS to the price of land sold to developers, it will need to explain to developers why they should share these costs, although their burden is minimal. In existing downtown areas, since Toru City cannot identify the beneficiaries of IVHS, Toru City will use local taxes and funds from MC for implementing and operating IVHS. In a new urban development area, however, since Toru City can identify the developers as the beneficiaries of IVHS, Toru City will use the developer's share in the IVHS costs.

In Combination II, Toru City will have the same problem with the developer's share in the IVHS cost as in Combination I. Since strengthening the City Planning Council involves a decentralization of power to allocate funds and also requires changes in laws, a lot of time will be needed to discuss these issues. In order to realize this method, the national government must prepare the vision of what the Japanese funding system should be like in the future.

Chapter 8 Conclusion

8.1 Summary of Each Chapter

Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS), developed by the Hanshin Expressway Public Corporation (HEPC), are now recognized as two of the most advanced traffic control systems in the world.[33] In Japan there are four urban expressway public corporations: 1) the Hanshin, 2) the Tokyo Metropolitan, 3) the Nagoya, and 4) the Fukuoka Expressway Public Corporations. Of the four expressways the heaviest traffic congestion was and is on the Hanshin Expressway, which pressured HEPC to develop advanced traffic control systems more intensively than any of these urban expressway public corporations.

In Chapter 2, this thesis identified the current state of traffic control systems in the Hanshin Expressway. HEPC collects traffic information by using vehicle detection devices, TV cameras, and automatic vehicle identifiers. The traffic information is transmitted to the traffic center where it is processed by computer systems. HEPC provides drivers with traffic condition report, travel time information, and information about traffic accidents and maintenance work through variable-graphics sign boards, variable-message sign boards, travel time information boards, roadside radios, traffic information terminals, and automatic telephone service. Before using the Hanshin Expressway, drivers can obtain information on the expressway's traffic conditions; or they can choose an alternative route and estimate their travel time on the basis of their daily commuting experience. After comparing the travel time on an alternative route with the travel time on the Hanshin Expressway, and calculating how much time could be saved by

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33 Hanshin Expressway Public Corporation, *Traffic Control System*, a public information brochure, 1993, Trans. Toru Takahashi

paying the five-dollar toll, they can make the decision of whether to select the Hanshin Expressway. While on the expressway, drivers can also receive current information about traffic conditions using the ATMS and ATIS services, and can then decide whether to remain on the expressway.

In Chapter 3, this thesis discussed five factors that encouraged HEPC to intensively develop such traffic control systems: 1) heavy traffic condition, 2) drivers' complaints, 3) strong financial resources, 4) competition between the Ministry of Construction (MC) and the National Police Agency (NPA), and 5) effective public-private partnerships. In terms of the competition between MC and NPA, if either agency develops traffic control systems which are more advanced than the other, the other agency would lose its jurisdiction over traffic control and the traffic control systems of that agency then would be integrated into the advanced systems. Therefore, this competition has inspired separate development of traffic control systems.

Large cities in Japan have lagged behind HEPC in creating traffic control systems. In this thesis, the discussion centers on Osaka City in hopes that it will be used as a model for other Japanese cities. In Chapter 4, this thesis discussed whether the larger cities really need the kind of advanced traffic control systems that HEPC has achieved. The following reasons will significantly motivate Osaka City to develop traffic control systems: 1) Osaka's comprehensive transportation policy; 2) difficulties in highway construction due to poor environmental conditions and the requirement for impact studies, as well as the high price of land; 3) new urban development for the 21st century; and 4) the coming of the ultra-aged society.

The concept of Osaka's comprehensive transportation policy is not to make piecemeal improvements for railroad lines, bus routes, and highways, but to establish a comprehensive traffic system to ensure various means of transportation as a part of a total integrated system. One of the main priorities is to develop traffic control systems. Osaka City government has already developed one of the traffic control systems, a real-time guided parking system, which is not funded by the national government. Illegally parked cars have been one of the most urgent traffic problems in large Japanese cities. The social pressure to immediately resolve this problem has motivated Osaka City to implement this system. Osaka City expects that this guided parking system will be incorporated into traffic control systems in the near future.

Large cities in Japan face difficulties when planning and constructing highways in downtown areas; First of all, laws to protect the environment impede construction. In order to support social and economic activities in large cities, a balance between highway construction and the preservation of the environment is essential. By increasing the efficiency of the existing highway networks, ATMS and ATIS will reduce the need for additional highways, thus helping this balance. The high price of land and the limited amount of space also make highway construction difficult, which contributes to the importance of improving the efficiency of the existing highways. Based on three key functions, Osaka City is promoting its 21st century "Technoport Osaka" project for urban development. Achievement of traffic control systems in this project is included in one of the three functions, the information and communication function. Finally, since the percentage of elderly people will increase to 25.2% in 2020 (which is a much faster rate of growth than in the US and European countries), the national and local governments in Japan must prepare the infrastructure for the ultra-aged society as soon as possible. Since elderly people seem to get lost more easily and seem to be afraid of driving on the expressways, ATMS and ATIS will make travel less intimidating.

In Chapter 5, this thesis pointed out some of the problems faced by city governments when they try to implement traffic control systems in urban areas. These problems are: 1) the lack of national funds for IVHS, 2) governmental jurisdictional issues, and 3) the retraining of staff. In order for city governments to develop traffic control systems, both social need and funding systems are essential. The need for traffic control systems in large cities will be tremendous, but appropriate funding systems do not yet exist. Traffic control systems are under the jurisdiction of two national agencies, the Ministry of Construction (MC) and the National Police Agency (NPA). MC and NPA have agreed that MC is responsible for traffic safety equipment and that NPA is responsible for traffic control equipment. Since ATMS and ATIS can be considered both traffic safety and control equipment, the development of ATMS and ATIS has fallen under the jurisdiction of both MC and NPA. As a result, MC and NPA have competed with each other for traffic control and have prevented local governments from developing these systems by not granting funds. However, their policies have currently changed from competition to cooperation. The 1990 international exhibition held in Osaka motivated HEPC supervised by MC and the Osaka Prefecture Police Agency of NPA to cooperate with regard to traffic control. Furthering their cooperation, MC and NPA started the Vehicle Information and Communication Systems (VICS) in 1991. The change from competition to cooperation will provide city governments with good opportunities to develop traffic control systems in urban areas, although they must still resolve serious problems related to jurisdictional issues, such as responsibility for operation and property issues. Since traffic control systems are a new field for city governments, staffs in city governments will need to be retrained; They will need not only expertise in traffic control, but also skills in operating computer and communication systems.

In order for city governments to implement traffic control systems in urban areas, they need to overcome the above problems. In Chapter 6, this thesis proposed and compared four methods for overcoming the lack of funding systems for IVHS and the retraining of staff: 1) transferring highway funds to IVHS, 2) strengthening city planning council of the designated city, 3) establishing public management with private sector operation, and 4) using the developer's share in the IVHS cost. In order to obtain monetary resources for IVHS, the first two methods use the concepts of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which provides local governments in the US with intermodal flexibility.

Transferring highway funds to IVHS is based on the following idea: if MC and NPA regard IVHS facilities as part of the traffic safety equipment that MC can allocate funds to, city governments would develop IVHS using highway funding. Since this method requires little change in current laws and a mutual agreement between MC and NPA, this method will be feasible in the short range.

The purpose of strengthening the City Planning Council of the designated cities, which are allowed to have the same power as the prefecture governments by the Local Autonomy Law, is to create a Japanese Metropolitan Planning Organization (MPO) of ISTEA. The City Planning Council is regulated by the City Planning Law in Japan in order to discuss and decide plans for urban infrastructure. In the US, MPO plays an important role in selecting the projects that should be invested and in allocating the federal funds. Strengthening the City Planning Council of the designated cities would empower them to determine the priority of urban infrastructure projects including IVHS. Since this method requires changes in the City Planning Law and related laws, it will take time to realize this method. If a decentralization of power, which is the long range aim of the Japanese cabinet, takes place in Japan, this method will be appropriate to implement IVHS in urban areas.

In order to address the retraining of staff, establishing public-private partnerships will be important when local governments begin operating IVHS. Because the public sector lacks the technology expertise that IVHS requires, with its specialized technology, the telephone company is one of the most feasible choice for complementing the public sector. The fourth method, using the developer's share in the IVHS cost, will be applied only to new urban developments that city governments will promote. After city governments create new land and construct the infrastructure, they will sell some of the land to developers. In the new urban development, if IVHS is developed as part of the infrastructure, its construction and operation costs can be included in the price of land sold to developers. The average land price will increase from $4,230 to $4,250 per square meter. The burden of developers is considered to be minimal.

Combinations of the four methods are necessary for short term and long term strategy. In Chapter 7, this thesis illustrated how to approach the question of combining the four methods through the hypothetical Toru City (a typical, large Japanese city). Two combinations are proposed: Combination I is designed for a short-term implementation, and Combination II for a long-term implementation.

In terms of Combination I, transferring highway funds to IVHS will be applied to the implementation of IVHS in existing downtown areas. The developer's share in the IVHS cost will be applied to a new urban development. Overall public management with day-to-day operations handled by the private sector will be significant to help city governments to begin operating IVHS.

As possible problems, city governments will need to convince MC and NPA to regard IVHS facilities as highway facilities. After MC and NPA approve the transfer of highway funds to IVHS, city governments will also need to deal with jurisdictional issues, such as responsibility for operation and property issues. In order to save money, city governments will need to retrain their staff while the private sector company begins operation of IVHS. In the new urban development, city governments will need to explain to developers why they should share the IVHS cost, although their burden is minimal.

In terms of Combination II, strengthening the City Planning Council will be applied to the whole city in the long term. For the new urban development, using the developer's share in the IVHS cost will be also appropriate in the long term, because this method can support the establishment of IVHS without using public money.

As possible problems, in the long range city governments will have the same problem with the developer's share in the IVHS cost as in the short range. Since strengthening the City Planning Council involves a decentralization of power to allocate funds and also requires changes in laws, a lot of time will be needed to discuss these issues. In order to realize this method, the national government must prepare the vision of what the Japanese funding system should be like in the future.

8.2 Fundamental Conclusion

This thesis concludes that:

1. IVHS will be needed as an important part of the infrastructure in large Japanese cities because of the following reasons:
   1) to achieve a comprehensive transportation system
   2) to deal with increased difficulties in constructing urban highways due to the environmental requirements and the high price of land
   3) to improve the efficiency of existing highway networks in urban areas
   4) to support new urban development for the 21st century

5) to guide the increasing number of elderly drivers to their destinations by avoiding congested routes
6) to meet the demands of a highly information-oriented society.

2. New relationships, a new funding system, and effective public-private partnerships will be needed to realize IVHS. Namely:
   1) new relationships between MC, NPA, and city governments will be needed to resolve existing jurisdictional issues
   2) a new funding system for IVHS will be required for IVHS implementation and operation costs
   3) effective public-private partnerships will be needed to help city governments to operate IVHS.

3. The concepts of ISTEA in the US can provide a good model for resolving jurisdictional and funding issues, specially:
   1) intermodal flexibility features can provide a framework for transferring highway funds to IVHS
   2) regional decision making features of ISTEA can provide a framework for strengthening the City Planning Council of the designated city.

4. Osaka City provides a good test bed for implementing IVHS in Japanese urban areas because of the following reasons:
   1) it is the largest designated city in Japan
   2) it has typical urban problems, such as heavy traffic congestion and air pollution
   3) it has a typical government organization.

5. The proposals in this thesis for raising money, resolving jurisdictional issues, and retraining staff will help to establish a new urban infrastructure including IVHS, although the best overall approach will

differ depending upon the circumstances of each city. They are:

1) transferring highway funds to IVHS
2) strengthening the City Planning Council of the designated city
3) establishing public management with private sector operation
4) using developer's share in the IVHS cost.

6. Combinations of the four methods are necessary for short term and long term strategy. Especially:
   1) for the short term, the combination of transferring highway funds to IVHS (Method I) and establishing public management with private sector operation (Method III) will be appropriate to implement IVHS
   2) for the long term, strengthening the City Planning Council of the designated city (Method II), will require changes in related laws and a decentralization of national power for the allocations of funds. The designated city will spend its own time and money to retrain its staff for operating IVHS in the long term, and will provide its own staff for daily operations
   3) for both short term and long term, using the developer's share in the IVHS cost (Method IV) will allow its implementation without using public money.

7. In order for IVHS to be successful in Osaka, two issues need to be addressed:
   1) the question remains of how to calculate benefits of IVHS in monetary terms. Further study should include cost and benefits analysis of IVHS in order to convince MC to transfer highway funds to IVHS
   2) who will decentralize the national government's power? In order to strengthen the City Planning Council, a decentralization of power for the allocation of funds will be needed. The Japanese political condition is now dominated by a weak coalition which seems to lack the power to effect decentralization.

If these problems are overcome, IVHS will provide many benefits to large Japanese cities. For example, with the improvement in traffic control, there will be less air pollution. In addition, the economy will be stimulated as the electronics and telecommunications industries become more involved. If IVHS is successful in Osaka City, it can provide a model for urban traffic control systems worldwide.

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