THE INTELLIGENT TRANSPORTATION SYSTEMS (ITS) AS A TOOL TO SOLVE CONGESTION PROBLEMS: THE CASE OF SEOUL

By

Andrea Milena Ramirez Peñaloza

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

MASTER OF PUBLIC POLICY

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ABSTRACT

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Increases in the demand for transportation and the impossibility to indefinitely enlarge road infrastructures motivates one to look for alternative transportation solutions in order to mitigate congestion problems and improve vehicle flow. In East Asia, the congestion problems are getting worse day by day; the traffic situation is becoming chronic in major cities and around large towns. In this thesis we are concerned about the Korean case, specifically Seoul. Seoul is one of the highest populated cities in both the Asian Region and in the world, and of course, the traffic problem in the city is one of the main issues of this metropolis. At this point, the Intelligent Transportation Systems (ITS) appear as excellent tools to help improve the situation. This thesis will study first the congestion theories; next the general theory of the ITS and its elements that could be useful to solve congestion problems; and finally, the specific case of Seoul and how the ITS tools have been used by the local government to improve the congestion situation.

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Dedicated to my family

I. INTRODUCTION

A. Why the ITS are important tools for solving congestion problems

Increases in the demand for transportation and the impossibility to indefinitely increase the road infrastructures motivates one to look for alternative transportation solutions in order to mitigate the congestion problems and improve vehicle flow. Traffic management policies should be an instrument to overcome traffic congestion by optimizing traffic flow. At this point, the Intelligent Transportation Systems (ITS) appear as excellent tools to help improve the situation.

In East Asia, the congestion problems are getting worse day by day. The traffic situation is becoming chronic in major cities and adjacent to large towns. For instance, the average speed during rush hours in Bangkok city is 5.0 ~ 10.0 km/hour and 18.0 km/hr in the case of Seoul[1].

There are also problems related with the traffic issue, for instance the high accidents rates have become an increasing problem in the Asian countries. The number of traffic accidents in Korea are 340 thousand a year including about 10 thousand fatalities[2]. But unfortunately, this is not all there are also long term issues as the increase in the air pollution, caused by the increase in car use. This becomes severe as the size of the city grows, like most cities in the East Asian countries, with both

[1] Young, Keung-Whan, *Policy & Institutional Issues of ITS in Korea & Asia-Pacific Regional cooperation*, Seoul : 5th Asia Pacific ITS Forum, 2002.
[2] Ibidem

high population and density growth. In major cities and towns of these countries, the deteriorating traffic environment and automobiles cause over 60 percent of the air pollution

B. Why the Seoul case is relevant for this study

We are very concern about the Korean case and specifically about Seoul, because it is one of the most highly densed cities in the Asian Region and in the world. Consequently, the traffic problem in the city is one of the main issues of this metropolis. Some data summarize the large problem at hand; "the occupancy ratio of bus and subway in Seoul has already marked 150% and 210% respectively which means the shortage of public transportation is one of the most urgent problems to be solved in Korea"[3].

Another cause of the crowded streets is the rapid growth of motor industries plunging into motorization era with high growth rates in Asian countries such as China, Thailand and Korea as shown on Table I.1 where we can find the annual growth rate from 1992 to 1996 of some Asiatic nations. This increase of the number of vehicles results in traffic congestion, accidents, and environmental problems.

[3] Ibidem

"The socio-economic loss due to traffic congestion in 1997 was estimated at US$ 16.7 billion per year which is 4.4% of GDP in Korea"[4]. This displays the great problem the country is facing.

Table I-1 Plunge into motorization era from 1992 to 1996[5]

China	12.5 % per year
Indonesia / Philippines	9% per year
Thailand	25% per year
Korea	25% per year

C. General description of the research

Firstly to address the issues of congestion we will show how the Intelligent Transportation Systems are very useful tools in solving those problems. In the second part we will look at the congestion theories, including some important definitions, describing some mitigation strategies, and situating the ITS as one of the approaches to help to solve traffic problems. To understand how useful these systems can be in the traffic solving, the third part will describe the general theory of the ITS, its basic concepts and the major ITS subsystems. We will also discuss the ITS implementation, the possible architecture and how the international community is leading to a standardization so that little by little, the net of the ITS becomes world wide. Finally, in the fourth part, the specific case of Seoul City will be discussed, explaining how it is an interesting case, which process of implementation on ITS has followed, which programs have been executed, the actual situation of the ITS in Seoul and finally an evaluation of those policies.

4 Ibidem
5 Ibidem

II. CONGESTION THEORIES

A. GENERAL CONCEPTS

1. Definition

Congestion is one of the major problems to be confronted by transportation professionals; it is defined as the situation when demand exceeds the capacity of the transportation system. Some congestion types are highway congestion, terminal congestion, airspace congestion, and mass transit system congestion. This thesis is interested in urban road congestion. A more specific definition for *congestion*, is a travel time or delay in excess of an agreed-upon norm, which may vary by time of transportation facility, travel mode, geographic location, etc. This is why we should describe some of the components of congestion and the standards to consider that a traffic flow is congested.

2. Congestion Components and Standards

The congestion components are more easily understood by looking at Table II.1

Table II-1 Congestion Component[6]

Congestion Aspect	System Type		
	Single Roadway	**Corridor**	**Area Wide**
Duration	*Hours facility operates below acceptable speed*	*Hours facility operates below acceptable speed*	*Travel time contour maps, "bandwidth" maps showing amount of congested time*
Extent	*% or amount of congested VMT[7] of PMT[8], % or lane-miles of congested road*	*% of VMT or PMT in congestion, % or miles of congested roads*	*% of trips in congestion, person-miles or person-hours of congestion, % or lane-miles of congested road*
Intensity	*Travel rate, delay rate, relative delay rate, minute-miles, lane mile hours*	*Average speed or travel rate, delay per PMT, delay ratio*	*Accessibility, total delay in person-hours, delay per person, delay per PMT*
Reliability	*Average travel rate or speed ± δ, delay ± δ*	*Average travel rate or speed ± δ, delay ± δ*	*Travel time contour maps with variation lines, average travel/time ± δ, delay ± δ*

In order to evaluate a road and understand if it is congested or not, there are some standards to determine, as we can see in Table II.2.

Table II-2 Congestion Standards[9]

Functional Classification	Tolerable Congestion Levels (min per km)		
	None to low	**Moderate**	**High**
Freeways / Expressways	*0.62-0.75 min/km (80-97kph)*	*0.81-0.93 min/km (64-72kph)*	*1.06-1.24 min/km (48-56kph)*
Class I Arterials	*1.06-1.24 min/km (48-56kph)*	*1.49-1.86 min/km (32-40kph)*	*1.86-2.49 min/km (24-32kph)*
Class II/III Arterials	*1.49-1.86 min/km (32-40kph)*	*1.86-2.49 min/km (24-32kph)*	*2.49-3.73 min/km (16-24kph)*

[6] Lee, Seung-Hwan, *Introduction to Transportation*, in "Transportation Policy", Program sponsored by Korea International Cooperation Agency, 2003, page I-14.
[7] Vehicle Miles of Travel
[8] Passenger Miles Traveled
[9] Lee, Seung-Hwang, Op. Cit., page I-17.

3. Causes and Effects of Traffic Congestion

a) Causes

The classical factor that we point out when talking about congestion, is the lack of transportation space; the fact that the demand (volume of vehicles) is higher than the supply (capacity of the roads). But the traffic problem is more complex, as many factors contribute to the congestion problems, which are not directly related to the transportation field. Some of the causes that might be helpful in this study are as follows:

- <u>The Lack of Affordable Housing:</u> "The lack of affordable and mixed-income housing near employment centers, and the imbalance between jobs and housing, creates the notorious two-hour commutes"[10] between the work places and the homes. This produces the dormitory towns, because the reduced space or the high prices of the job places are prohibitive for the workers.

- <u>Sprawling Patterns of New Growth:</u> "Poorly planned sprawling development and land use patterns and zoning codes that separate uses further and further apart require people to travel longer distances. Many short trips that until recently had been made by walking from home to school, between commercial

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[10] Corless, James, *Beyond Gridlock: Meeting California's Transportation Needs in the Twenty First Century*, Chapter 3, May 2002.

establishments, from work to lunch, are now made by vehicle trips that often occur at similar times and lead to peak hour congestion around intersections and along freeways. Indeed, recent research by the U.S. Department of Transportation found that only 13 percent of the increase in driving is attributable to population growth. The remainder has been a result of a steady growth in the number of trips taken and the length of trips, both primarily products of low-density suburban development that requires ever greater levels of dependency on driving"[11].

- Homogenization of activities: In many cities the activities of the town begin at the same time, school entrance, work times, banking hours, etc. This produces a massive simultaneous mobilization of the population, that will result in congestion of the entire transportation system in the peak hours, and underutilization of them the rest of the day.

- Non-recurring Congestion: There is also a big percentage of congestion caused by temporary disruptions, for example, incidents (crashes, disable vehicles, etc), weather conditions (rain, snow, fog), etc.

[11] Ibidem

b) Effects

The effects of the traffic congestion are multiple and affect each individual in different ways. The principal effects are: decreases in productivity, increases in fuel consumption, increases in pollutants, decrease in vehicle life, an increase accidents, delays in delivery services, emotional bad effects due to delays, etc.

From these consequences, one could quote some data about congestion from the U.S. Department of Transportation. Congestion results in 5.7 billion person hours of delay annually in the United States; the individual cost of congestion exceeded $900 per driver in 1997, resulting in over $72 billion in lost wages and wasted fuel.

B. MITIGATION STRATEGIES

1. Generated traffic

The infrastructure approach which considered that the solution for traffic congestion was to construct more roads and highways has been refuted by what is called *generated traffic*. This means that "road improvements that reduce users' travel costs tend to attract traffic from other routes, times and modes, and encourage longer and more frequent vehicle trips"[12]. This does not mean that constructing roads is useless per se, but the *generated traffic* alert us of the dangers of not combining this strategy with other ones, as the ITS, for instance.

The *generated traffic* has three negative impacts concerning transportation planning[13]:

- It reduces the congestion-reduction benefit that can result from increased road capacity.

- It often increases external costs, such as parking demand, environmental damages, etc.

- Since it consists of marginal value trips (vehicle travel that consumers are most willing to shift or forego if their costs increase), consumer benefits tend to be modest.

The *generated traffic* alert us of the necessity of taking in account its impacts in the planning measures to reduce urban traffic congestion. Without this alert, the actions undertaken by the local governments may not match the necessities of the roads. The congestion problem might be resolved just in the short term, as a result of negligent decisions made by the public servants. This is why the infrastructure approach should be considered in combination with other measures, in order to choose the best alternative to solve the problem of overcrowded streets. We will show some other

[12] Litman, Todd, *Generated Traffic: Implications for Transport Planning*, in "ITE Journal", Volume 71, # 4, April 2001, page 38.
[13] Ibidem

strategies to attack the traffic problem that could be combined with the infrastructure approach to make this last one really efficient.

2. Pricing strategy

Congestion pricing and other forms of road pricing are potentially effective means of improving traffic flow and reducing congestion. Such strategies use pricing (e.g.: during peak driving periods) to create incentives to change travel behavior. "The Metropolitan Transportation Commission in the San Francisco Bay Area estimates that raising the Bay Bridge toll from US$1 to US$3 (excluding low-income drivers) during the morning rush hour would reduce traffic by 7%"[14].

Some pricing strategies are, congestion tolls, parking fees, subsidies to mass transit, license fees, fuel taxes, etc. All of this strategies attempt to attack, in an alternative way, the congestion problem, especially during the peak periods, giving a great help to the infrastructure approach.

Congestion tolls, for instance, charge a premium to road users who want to drive during peak periods, such as rush hours, holidays and weekends. Drivers pay a toll to enter congested areas; the toll varies according to the level of congestion with higher tolls during peak hours or in peak directions. Experience in countries like France,

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[14] Marshall, Johnathan, *Reducing Traffic Through Economics,* "San Francisco Chronicle", December 12, 1994, p B1.

demonstrates that congestion pricing does significantly reduce gridlock during peak traffic periods. America's top scientific organizations, including the prestigious National Academy of Sciences, also give high marks to congestion pricing, praising it as a potentially powerful tool to persuade people to carpool, use transit, telecommute, vary the times they travel, alter their routes, choose other destinations, or avoid or combine some trips[15].

3. Management and Policy

Management and policy strategies work in the same way as the pricing strategies, which try to help the reduction of traffic through effective measures that come from the government level. Some of these actions are ramp metering, travel and parking restrictions, flexible work hours, special mass transit operation, high occupancy vehicles (HOV) - carpool priority, traffic adaptive control (TAC), etc.

Ramp Metering "refers to the modified traffic signals on certain egress ramps to freeways; their purpose is to control the rate of traffic merging onto the freeways. When designed properly, these devices can keep vehicle density below saturation, thus improving traffic flow on the freeway"[16]. Another example is High Occupancy Vehicles. HOV lanes require vehicles to carry more than one person; during HOV restricted periods, HOV-2 lanes require a minimum of two people per passenger vehicle and HOV-3 lanes have a minimum of three. Some vehicles also qualify as exemptions, and during all other times, HOV lanes are open to all passenger vehicles.

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[15] National Research Council, *Curbing Gridlock: Peak-Period Fees to Relieve Traffic Congestion*, Vol. 1 & 2, , Washington, D.C., May 1993.

[16] Lee, Seung-Hwan, Op. Cit., page VI-25.

4. Advanced Technology

Finally there are technological tools, which this study is interested in, and are usually called Intelligent Transportation Systems, ITS. All of the necessary explanations and descriptions for this topic, as it is the matter of this thesis, will be deeply described in the next chapter.

III. GENERAL THEORY OF THE ITS

A. BASIC CONCEPTS

1. *General Information*

a) Brief History

Before referring to a small history of ITS, it is important to state their definition. "ITS are transport systems that apply information, communications, and control technologies to improve the operation of transport networks. ITS tools are based on three core features – information, communications, and integration – that help operators and travelers make better and coordinated decisions. ... ITS tools are used to save time and lives, to enhance the quality of life and the environment, and to improve the productivity of commercial activities"[17].

Since the 1970's major efforts had been undertaken to develop ITS, especially in Japan and Germany, and focused on showing new technologies in integrated systems. In the next decade, the 80's, the technological frontier was open and so too was ITS development; thanks to computer advances, infra-red sensors, cellular telephones, etc., it was possible to materialize a large number of ideas. The leaders in those programs were in Europe, Japan and the United States.

[17] Lee, Seung-Hwa, *ITS Part I*, in "Transportation Policy", Program sponsored by Korea International Cooperation Agency, 2003, page VI-5.

Formal ITS projects and programs were launched: PROMETHEUS[18] and DRIVE in Europe. The first one was started in 1986 and was initiated as part of the EUREKA program[19]; the project is lead by 18 European automobile companies, state authorities, and over 40 research institutions. EUREKA is a pre-competitive research project, with the output being a common technological platform to be used by the participating companies once the product development phase begins. DRIVER was started in 1989 under the control of the Commission of European Communities. Its intention is to move Europe towards an Integrated Road Transport Environment (IRTE) by improving traffic efficiency and safety and reducing the adverse environmental effects of the motor vehicle.

In Japan, in 1991, the "VICS [20] Promotion Council" was established by 203 corporations and organizations to try to improve road safety and environment protection by providing accurate information of road and traffic information. Also the UTMS[21], established in 1996, focused on research and development on ITS as well as standardization projects.

Finally the United States, which started with two national programs: Mobility 2000 and ADVANCE/AHS. Regionally many programs and projects were launched, as *TravTek*, *Advance, Pathfinder, Travelpilot, Driver Guide*, etc[22]. The United States, realized the importance of a national plan for nation-wide ITS implementation, while

18 Program for a European Traffic with Highest Efficiency and Unprecedent Safety
19 EUREKA is a pan-European network for market-oriented, industrial R&D.
20 Vehicle Information and Communication System Center
21 Universal Traffic Management Society of Japan
22 For more information, refer to the U.S. Department of Transportation: Federal Highway Administrator

its fellow Europeans and Japanese focused on developing technology. The United States developed its first National Strategic Plan in 1992 and then its National ITS Architecture in 1993-1996[23].

Table III-1 explain the ITS services and architecture development process followed by the different regions, and compared with the Republic of Korea.

Table III-1 Comparison of ITS Service and Architecture Development[24]

	Study Period	Architecture Methodology
U.S.A.	1993 - 1996	• Top-down • Process oriented
ISO	1997	• Button-up • Object oriented
Korea	1997 - 1999	• Top-down • Process oriented
Japan	1998 - 1999	• Object oriented
Europe	1998 - 2000	• Process oriented

b) ITS Services

The Technical Committee 204 (TC-204) of the International Organization for Standardization is working on the "Transport Information and Control Systems – Reference Model. Architecture(s) for the TICS Sector – Part 1: TICS Fundamental Services", to establish the first classification of ITS, in order to standardize the different national classifications. They divided the services into eight categories and subdivided the categories into thirty two, as follows:

[23] Ibidem
[24] Lee, Seung-Hwa, Op. Cit., page VI-4.

Table III-2 Division of ITS Services[25]

Service Category	Service Name
I. Traveler Information	1. Pre-trip Information
	2. On-trip Driver Information
	3. On-trip Public Transport Information
	4. Personal Information Services
	5. Route Guidance & Navigation
II. Traffic Management	6. Transportation Planning Support
	7. Traffic Control
	8. Incident Management
	9. Demand management
	10. Policing/Enforcing Traffic Regulations
	11. Infrastructure Maintenance Management
III. Vehicle	12. Vision Enhancement
	13. Automated Vehicle Operation
	14. Longitudinal Collision Avoidance
	15. Lateral Collision Avoidance
	16. Safety Readiness
	17. Pre-Crash Restraint Deployment
IV. Commercial Vehicle	18. Commercial Vehicle Pre-clearance
	19. Commercial Vehicle Administrative Processes
	20. Automated Roadside Safety Inspection
	21. Commercial Vehicle On-board Safety Monitoring
	22. Commercial Vehicle Fleet Management
V. Public Transport	23. Public Transport Management
	24. Demand Responsive Public Transport
	25. Shared Transport Management
VI. Emergency	26. Emergency Notification and Personal Security
	27. Emergency Vehicle Management
	28. Hazardous Materials & Incident Notification
VII. Electronic Payment	29. Electronic Financial Transactions
VIII. Safety	30. Public Travel Security
	31. Safety Enhancement for Vulnerable Road Users
	32. Intelligent Junctions and Links

[25] International Organization of Standardization, *Transport Information and Control Systems – Reference Model. Architecture(s) for the TICS Sector – Part 1: TICS Fundamental Services*, ISO/TR 14813 : 1999.

2. MAJOR ITS SUBSYSTEMS

a) ATMS

We will develop the major ITS subsystems, beginning with Advanced Traffic Management Systems (ATMS). ATMS ensure that the road network capacity is used to its maximum; this is achieved trough the control of traffic flow by presenting real-time road conditions to commuters and by adjusting signal times to suit changing traffic. This is performed with the help of Variable Message Signs (VMS), signal coordination and CCTVs[26].

ATMS can be achieved through three control systems: Urban Traffic Control (UTC), Freeway Traffic Management Systems (FTMS) and Demand Management (DM)

- UTC: This has been the principal focus of ITS, to reduce traffic congestion and pollution, to reduce traffic accidents, to save energy and to preserve the environment; and these are the objectives of UTC. Its basic functions are the collection of traffic information using various sensors, control of traffic signals based on the previous information, provision of those informations, such as traffic congestion status via information boards and other devices, and relaying instructions from the traffic control centers to the local traffic police.

[26] Close Circuit Television

- FTMS: “Freeway traffic management systems monitor traffic conditions and then automatically advise motorist of alternative routes and whether or not to reduce speed”[27]. The intention is to improve safety, optimize the real capacity of the highway and provide a better level of service to motorists, without the addition of more traffic lanes. These improvements are accomplished by faster detection and response to incidents on the highways, and through balancing of traffic volumes between the highways and other viable alternate routes.

- DM : In order to mitigate congestion, one method is to manage the demand for transportation. Electronic tolling systems are an application of incentive demand management through ITS, designed to reduce road congestion; incentive measures can be applied directly on the basis of economic incentives (through toll charges) or indirectly, as in connection with parking charges[28].

b) ATIS

The goal of Advanced Traveler Information Systems (ATIS) is to provide information to the travelers, so they can make smart choices on their route, mode, etc. The basic principle of ATIS is that the more information the users have, the better alternative they will take.

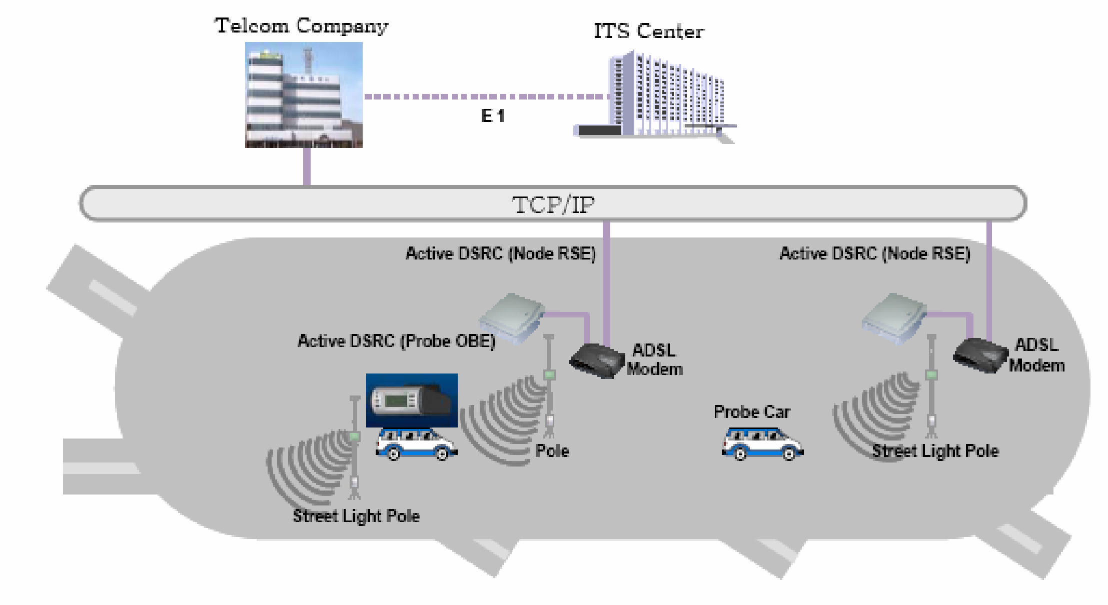
Some types of ATIS are radio traffic reports; traffic congestion maps; information about transit over the internet; in-vehicle navigation systems; traffic conditions

[27] Lee, Seung-Hwan, Op. Cit, page VI-25.
[28] Ibidem

through personal communication, such as pagers, smart watches, cellular phones, etc. The information provided must be gathered from a traffic center, which may be generated from ATMS. Thus, ATMS are normally developed before ATIS, and are mostly controlled by the public sector, while ATIS work in a partnership between the public and the private sectors.

Figure III-1 show us how ATIS work, in this case using Active Dedicated Short Range Communications[29] (DSRC).

Figure III-1 Schematic Structure of ATIS using DSRC[30]



c) APTS

[29] *Dedicated Short Range Communications* is a communications approach to allow short range communications between vehicles and the roadside for a variety of purposes, such as intersection collision avoidance, transit or emergency vehicle signal priority, electronic parking payments, and commercial vehicle clearance and safety inspections.

[30] Nam, Doohee, *Intelligent Transportation Systems Model Deployment Initiatives in Korea*, Seoul: 2002, 5th Asia-Pacific ITS Forum.

Advanced Public Transportation Systems (APTS) are advanced navigation and communication technologies applied to all aspects of public transportation system operations. APTS provide the technology for transportation agencies to make timely transit information available to the passenger and to improve the convenience, reliability and safety of public transportation services.

"They include, improved information systems to disseminate timetable, fare, and ride sharing information to users through the Internet and other media; automated fare collection systems, vehicle locator systems (AVL: Automatic Vehicle Location), increased security, communication to passengers the exact arrival time of the next bus"[31].

d) AVCS

Advanced Vehicle Control Systems (AVCS) include any vehicle or road-based systems that provide increased safety and/or control to the driver, either by means of improving the information about the driving environment or by actively aiding the driver in the driving task. In the case of the in-vehicle automation, this field has been developed by the vehicle manufacturers and by governments that encourage the use of those systems to increase safety.

e) CVO

[31] Choi, Keechoo, *ITS Part II,* in "Transportation Policy", Program sponsored by Korea International Cooperation Agency, 2003, page 1

ITS applications for Commercial Vehicle Operations (CVO) are designed to enhance communication between motor carriers and regulatory agencies. Examples include electronic registration and permitting programs, electronic exchange of inspection data between regulating agencies for better inspection targeting, electronic screening systems, and several applications to assist operators with fleet operations and security. All of these aim to minimize unnecessary stops, and achieve and improve logistics.

The activities related to CVO are: freight movement, carrier operations, vehicle operations, safety assurance, credentials administration and electronic screening[32]. With the aim to make CVO work, it is also necessary to develop CV Information Systems and Networks (CVISN) which collect and communicate information. The principal objectives of the CVISN are to support new capabilities in the safety information exchange, the credential administration and the electronic screening.

B. OPTIMAL INTRODUCTION OF ITS

1. ITS Architecture, necessaries public policies

ITS architecture is the framework defining key elements of various ITS functions and data; it also describes how the different components of the system interact and work together for all ITS subsystems to be operated and managed to their full potential. With a well defined architecture, it is possible to accommodate different levels of

[32] The *Electronic Screening* is a selection of mechanism to target high-risk operators and make efficient use of weigh station and inspection resources.

implementation, different system designs, and flexibility to allow the system evolution over time.

The architecture defines the functions that are required for ITS (e.g., gathering traffic information or requesting a route); the physical entities or subsystems where these functions reside (e.g., field or vehicle) and the information and data flows that connect these functions and the physical subsystems together into an integrated system.

"To fully maximize the potential of ITS technologies, system design solution must be compatible at the system interface level to share data, provide coordinated area-wide integrated operations and support interoperable equipment and services where appropriate"[33].

From this organization, nations can obtain specific benefits in the short and long-term. In the short-term the benefits are related to saving time and money. In order to attain this, the system must correlate needs and problems to services; illustrate efficiencies; provide a view into the future to identify services and functionality; define the kind of information one should consider sharing among the agencies; provide a departure point for developing functional requirements and system specifications and identify the interfaces and data exchanges.

In the long-run, the system should work with interoperability; in increased competition; with future expandability, at low costs and with increased transportation system integration.

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[33] Young, Keung Whan, Op. Cit.

The system architecture requires an institutional framework, which means that the ITS architecture must fit within the existing organizational infrastructure, becoming an extension of the existing frame and respecting the local autonomy. Secondly, the system architecture must be flexible to be able to integrate the existing ITS technology into the proposed future system, and open to future incorporation of the evolving technology, at the same time.

2. Possible Architecture Formats

The three basic types of architectures that exist in traffic management systems and their advantages and disadvantages are[34]:

a) Centralized System Architecture

This concept treats the region as a single agency; there is a central Traffic Operations Center (TOC) that collects data, analyzes it and controls all aspects, including signs, ramp meters, and surface street signals.

The advantages of the Centralized Architecture are: Straight-forward design; this means that the system isolates the majority of the software and with dedicated communications links hardware requirements to the central computer. The

[34] Lai, Peter, *Planning Process For Integrated Transportation Management Strategies (ITMS) Master Plan – The New Jersey Experience*, Seoul: 2002, 5th Asia-Pacific ITS Forum.

disadvantages include: Heavy inter-dependency; big processing requirements; high life cycle costs; single points of failure (i.e. if the central system or communication fails all or most functionality is lost); less responsive to local needs; smaller compatibility with organizational structures and difficulty of transitions.

b) Decentralized or Distributed System Architecture

This concept contains multiple agencies or city Traffic Management Centers (TMCs), monitor and control ITS features along roadways under their jurisdiction, with a Traffic Operations Center (TOC) handling freeways. These centers are independently operated.

The advantages of the decentralized architecture include: Interaction between subsystems; minimal communications requirements between agencies (TMC); enables jurisdictions to have independent or coordinated control options, responsiveness to local needs and compatibility with organization structures.

The disadvantages are: Requires more complex communication systems, possible challenges in affecting economies of scale and potential avoidance of delays or miscommunications due to lack of centralized coordination.

c) Hybrid Architecture

The hybrid architecture format is an assembly of selected features of the centralized and distributed architectures. This model has more than one local Traffic Management Centers (TMC) for local monitoring and control, a freeway Traffic Operations Center (TOC) and an area-wide multi-agency Traveler Information Center (TIC). These structures enable fusion of status data, major incident management, and control at an area-wide level, as appropriate. The information is tied together using automated data sharing, and the communication requirements are more flexible.

We could say that this structure takes what is best from the other two to better adjust the needs of the nation, region and local authorities. In general, we could say that it is important to find a structure that permits the best introduction of ITS tools. As experience has shown, the most difficult part in an ITS introduction is not the technology, but the architecture and the implementation into the old system. ITS as we know are not systems to replace the already existing structures, but tools to enhance improvements of the transportation systems. This is why the architecture is one of the primary focuses, in order to attain the desired objectives.

C. STANDARDIZATION

A basic point in the deployment of technological solutions, as with ITS, is standardization. ITS standardization is essential for achieving the interoperability and compatibility which is necessary to allow ITS systems to function. The new system should be compatible with existing, planned and future systems in the nation, the region, and world-wide. Without these measures, the national or local systems could not produce interchangeable projects and products/services internationally, and would be isolated without the opportunity of feed backs. Consequences of a non-standardized ITS could be a waste of national resources and/or duplicated investments.

In the international scene, there are multiple work groups focused on the standardization of ITS in its different fields, as communications, architecture, etc.

1. The ISO TC-204

The ISO has a technical committee in charge of ITS, the TC-204. This committee works in the "standardization of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveler information, traffic management, public transport, commercial transport, emergency services and commercial services in the intelligent transport systems field. ISO/TC 204 is responsible for the overall system aspects and infrastructure aspects of ITS, as well as the coordination of the overall ISO work program in this field including the schedule for standards development, taking into account the work of existing international standardization bodies"[35]. It excluded the in-vehicle transport information and control systems on which the Technical Committee TC-22 focuses.

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[35] International Organization for Standardization, http://www.iso.ch

To attain those objectives, the TC-204 is divided in Working Groups[36] (WG), as follows:

Table III-3 Working Groups of the TC-204

Committee	Title	Sub-working groups	Scope
TC 204/WG 1	Architecture	SWG 1.1 Architecture Documentation SWG 1.2 Glossary SWG 1.4 Data Dictionaries and Data Modeling SWG 1.5 Fundamental Services SWG 1.6 Reference Model Architecture	Provide ISO TC204 with a reference model of Conceptual Reference Architecture(s), provide definitions of terminologies used by the TC-204
TC 204/WG 3	TICS database technology	SWG 3.1 Geographic Data File SWG 3.2 Physical Storage Format SWG 3.3 Update Publishing and Location Referencing SWG 3.4 API	* Geographic Data File (Physical storage for TICS Database) * Location Referencing Procedure * Publishing Updates for Geographic Databases
TC 204/WG 4	Automatic vehicle and equipment identification		
TC 204/WG 5	Fee and toll collection		Standardization of information, communication, and control systems in the field of fee and toll collection systems for urban and interurban surface transportation, including intermodal and multimodal aspects
TC 204/WG 7	General fleet management and commercial/freight		Definition of standards in these areas to improve the management and safety and facilitate the interaction between the vehicles/freight operators and the local and international authorities within the intermodal and multimodal environments
TC 204/WG 8	Public transport/emergency		
TC 204/WG 9	Integrated transport information, management and control	SWG 9.1 Data Dictionary	Define the systems that will operate to provide end-users with integrated transport information, management, and control
TC 204/WG 10	Traveller information systems	SWG 10.1 TTI messages via Traffic Message Coding SWG 10.2 TTI messages via DSRC Beacons SWG 10.3 TTI messages via Cellular Networks	Timely delivery of accurate, relevant information to travelers, in a form suitable for them to use

[36] Society of Automotive Engineers, http://www.sae.org

		SWG 10.5 TTI Messages via Stationary Dissemination Systems SWG 10.6 TTI User Services Integration	
TC 204/WG 11	Route guidance and navigation systems	SWG 11.1 Locally Determined Route Guidance SWG 11.3 Centrally Determined Route Guidance	Provides to the driver orientation and gives route recommendations on how to reach a destination
TC 204/WG 14	Vehicle/roadway warning and control systems		Standardization devices of systems that contribute to: • avoiding crashes • increasing roadway efficiency • adding to driver convenience • reducing driver workload • monitor the driving situation • warn of impending danger • advise of corrective actions • partially or fully automate driving tasks
TC 204/WG 15	Dedicated short range communications for TICS applications		Propose a common air interface standard for DSRC-Link
TC 204/WG 16	Wide area communications/ protocols and interfaces	SWG 16.0 Architecture and Liaisons SWG 16.1 CALM SWG 16.2 Internet in Support of ITS SWG 16.3 Probe Data from Vehicles	Message structure and protocol specifications, but will not define application data elements

The TC-204 also developed a standardized division of ITS services as we saw in Table III.2, in order to uniform the divisions made by each nation. As many of the programs and activities of the TC-204 are in the working draft stage, (i.e. the *Road transport and traffic telematics - Automatic vehicle and equipment identification - System specifications*, which in November 2003 was just in the inquiry stage); the governments have time to adapt their domestic technologies during the development of international standards.

2. Asia-Pacific Telecommunity Standardization Program

Asia-Pacific Telecommunity Standardization Program (ASTAP) is a standardization organization in the Asia-Pacific Telecommunity (APT) which was established in

February 1998. In the 21st APT Management Committee meeting in 1997, held in Bangkok; it was decided to establish an organization to promote standardization activities. ASTAP's main objectives are[37]:

- To establish regional cooperation on standardization
- To harmonize standardization activities in the region
- To enhance the level of expertise on standardization among the membership
- To expand contribution to global standardization activities, through cooperation activities on standardization such as exchange of views and information on standardization
- To foster appropriate institutional arrangements for promotion of telecommunications standardization in the Asia-Pacific region

Currently there are 13 Expert Groups who report directly to the Chairman. These are[38]:

1. ATM/xDSL (ATM)
2. Digital Multimedia Broadcasting (DMB)
3. Fixed Wireless Access (FWA)
4. High Altitude Platform Stations (HAPS)
5. Interoperability/APII Backbone Network (IA)
6. IMT-2000 and Beyond (IMT)

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37 Asia-Pacific Telecommunity Standardization Program (ASTAP), http://www.aptsec.org/astap/APT-ASTAP.htm.

38 Ibidem

7. Internet-related Topics (IRT)

8. Information Security (IS)

9. Intelligent Transport Systems (ITS)

10. Metadata (MD)

11. Next Generation Network and Network Management (NGNNM)

12. Next Generation Web (NGW)

13. Public Safety and Disaster Relief Communications (PSDRC)

The ITS Expert Group (EG) has been organized in ASTAP as one of several expert groups. There are 39 radio communications experts from 11 Asia-Pacific countries in ITS-EG. The goal of the group is to create standards on ITS generally useful to Asia-Pacific countries.

"ASTAP/ITS Expert Group has created some draft recommendations, and successfully submitted these draft recommendations to ITU-R/SG8/WP8A[39] with APT members and associates with their approvals. Some important draft recommendations for ITS such as "Dedicated Short Range Communication (DSRC) at 5.8GHz" have been approved as ITU-R recommendations"[40].

[39] International Telecommunication Union / Radio Communication Sector / Study Group 8 / Working Party 8A – Land mobile service excluding IMT 2000; amateur and amateur-satellite service.
[40] Oyama, Satoshi, *ITS Radio Communications International Standardization Activities in ASTAP , ITU and ISO,* Seoul: 2002, 5th Asia-Pacific ITS Forum.

IV. THE CASE OF SEOUL

Before going into the specific ITS issues in Seoul, it is important to understand the situation of the city in terms of transportation, population and congestion. Regarding the physical boundary of the Seoul Metropolitan Area (SMA), three areas have been delineated for administrative purposes: Seoul City, Seoul Metropolitan Region and Capital Region. The first, the narrowest one, coincides with the jurisdiction of the Seoul Metropolitan Government; it as a single urban entity covering 605.33 km^2. The second one covers 2,999.48 km^2 including Seoul City, its adjacent jurisdictions and the Incheon City. The third one covers the entire Kyungggi Province in addition to Seoul and Incheon, totaling 11,686 km^2[41].

Seoul Metropolitan Region (SMR) is the one we are interested in, for this study. It has a population of 10.6 million within an area of 605 km^2; of this, an area of 374.5 km^2 is for human activities and the remainder is for the Restricted Development Zone (RDZ, or the green-belt). To understand the great concentration of the region, we can see the share that the Seoul Capital Region (SCR) has in the nation's population. In 2000, the SCR was home to 21.3 million people, which is 46.3% of the total national population within 11.8% of national land[42].

This situation of concentration, not only of human settlements but of socio-economic activities in the SMR, has resulted in many problems with housing shortages,

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[41] Park, S. W, cited by AHN, Kun-Hyunck and Ohn, Yeong-Te, *Metropolitan Growth Management Policies in Seoul: A critical View*

[42] Kim, Moon-Hyun and Jung Hee-Yun, *Spatial Patterns and Policy Issues of the Seoul Metropolitan Region*, in "Urban Management in Seoul: Policy Issues and Responses", Seoul Development Institute, 2001.

overcrowding, high land prices, speculation, environmental pollution and of course, traffic congestion. All of these, degrade the quality of life of the regions' inhabitants and demand solutions from the administration. Compared with other major metropolis, the density level of Seoul is higher than the largest city in the world, Tokyo; in 1999 the density of Seoul was 1.3 times that of Tokyo (23 districts[43]), with 170 persons/ha, and twice that of New York[44].

Even if, from the 1980's, the concentration of the population in the Seoul City has decreased, the socio-economic activities have increased. Seoul CBD (Central Business District) and southeastern parts of Seoul seem to have sustainable job bases; in these areas, the employment share of population in 1997 was more than 50% of the whole SCR with high employment density[45]. In the many cities of the SCR, there is a phenomenon of bed-towns; situations that bring an increasing demand of interregional transportation, among other things.

"Traffic volume of the SMR in 1997 was concentrated on the major transportation corridors. These roads play major roles in connecting Seoul and the suburban areas, mainly characterized as bed-towns. This traffic congestion in the SMR has mainly been caused by much leapfrog type housing developments along arterial roads to Seoul without proper investment of region-wide public transit system. Road-oriented investment system of the central government also seems to exacerbate congestion of the SMR[46]".

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43 There are 23 special wards (Tokubetsuku), special districts in Tokyo.
44 Ibidem
45 Ibidem
46 Ibidem

At this point ITS arrive as a good alternative to attack those problems, for the impossibility of continuing the construction of roads, which is restrained by the shortage of land, and also because of its cost-benefit advantages.

A. HISTORICAL IMPLEMENTATION PROCESS

The SMR actions were inserted in a national plan that coordinated the link of different cities in the Republic of Korea and that had a long run approach. This implementation followed the desirable guidelines of the architecture implementation of the ITS. So we will look first into the processes that the country has followed and how Seoul follows that approach.

Historically, Korea followed a transportation policy to combat congestion, that focused on increasing infrastructure, but forgot the operational efficiencies over the transportation systems and network. This hole in the policy lead to an increase of congested sections in the road network, measuring approximately 16 times over a 10 year period. The country went from having 262km of congested roads, to having 4,323 km in 1997, totaling 30% of the national highway network at that time[47].

The problem did not result from the idea of increasing the provision of roads, but from the lack of coordination with the very useful tools of ITS and its application technologies, which not only are effective in resolving the congestion, but can save up to 35% of costs, compared with the infrastructure-only approach.

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[47] YOUNG, Keung-Whan, Op.cit.

1. Foundations for the deployment of ITS in Korea

In order to improve the traffic system, the Korean government established the necessary foundations to deploy in an appropriated way the ITS in the Nation. This was organized through five stages: in 1997 the (1) ITS Master Plan was launched and revised in 2000, the establishment of (2) Research and Development Programs in the same year, (3) Transportation Efficiency Act in 1999 and revised in 2000, (4) Standardization in 2000 and the (5) National Architecture also in 2000.

a) ITS MasterPlan

The National administration realized the importance of the implementation of a general plan that would fight against the congestion problem in a coordinated way. This is why in 1997 a strategic plan was launched from the government level but with the active participation of the private sector involved in the ITS business. However this plan was not designed for the user level, and a revision to re-orient the goals of the plan was initiated in 1999, in order to have more realistic purposes.

Therefore, in March 2001, a new national ITS master plan was established and approved by the government, which modified the existing plan toward the challenges of the 21st century in ITS. The new plan contained the detailed descriptions of each user service area, and subdivided user services further into 63 sub services (See Appendix A.1: Table IV-1).

This plan would be adjusted to the defies of each generation, so it is to be modified and upgraded to 20 years (from year 2001 to year 2020) with three stages of implementation. The two plans, the initial one and the new one, were organized as follows:

Table IV-2 Comparison of Time Table and Budget[48]

Unit: Million U.S. Dollar

Plan	Period	Time Table	Budget	Budget Total	Goal
Plan for 1997	*Short Term*	*1996 to 2000*	*695*	*3,015*	*Initiating ITS Infrastructure Development*
	Mid Term	*2001 to 2005*	*1,020*		*Expanding ITS Infrastructure*
	Long Term	*2006 to 2010*	*1,300*		*Enhancing System Performance*
Revised Plan for the 21st Century	*Short Term*	*2001 to 2005*	*1,200*	*8,700*	*Establishing ITS Infrastructure*
	Mid Term	*2006 to 2010*	*3,700*		*Expanding ITS Infrastructure*
	Long Term	*2011 to 2020*	*3,800*		*Providing Full System Benefit*

The total investment amount for the 20 year long-term plan (2001-2020) is estimated at US$ 8.7 billion. As we can see, the investment established in the revised plan is almost 3 times that of the first one. Also, the orientation of the plan changed to a more user service one, as well as the total function of the system.

This new national plan has several targets to cover in the 20 year vision[49]:

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48 BAE, Sanghoon and Chon, Kyung Soo, *The National ITS Strategic Plan in Korea for the 21st Century*, Seoul: ITS World Congress, 1998.

• Reduction of construction costs of transportation infrastructure by parallel implementation with ITS. This would save 35% of costs, compared with the case of road construction only.

• Improvement of traffic conditions by decreasing 30% of traffic congestion.

• Improvement of traffic safety by decreasing 60% of traffic accidents.

• Improvement of the daily environment by decreasing travel time with the improvement of travel conditions and of the environment.

• Improvement of traffic environmental conditions by decreasing air pollution and noise and strengthening national competitiveness.

b) Research and Development[50]

The division of roles and coordination organization is basic for the success of the projects undertaken. Since the ITS projects have been handled by ITS related ministries and organizations, proper division of roles and coordination efforts are very important.

Specifically, Prime Ministry, Ministry of Construction and Transportation (MOCT) are responsible for standards in system interface and integration, (e.g. data dictionary, message protocol etc.) as well as the responsibility of the R&D on express highways and arterial roads. Ministry of Information & Communication (MOIC) is responsible for standards in information and communication (e.g. communication protocol, R&D

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[49] YOUNG, Keung-Whan, Op.cit.

[50] Ministry of Construction and Transportation, *ITS Model City Development in Korea*, 2001, Informative Brochure.

for communication standardization). Ministry of Commerce, Industry & Energy (MCIE) are responsible for motor industry standards (e.g. vehicle & equipment, R&D for manufacturing standardization). National Policy Agency (NPA) puts its efforts in the adaptive signal control, and the Ministry of Sciences and Technology (MOST) in the basic technology.

This is more clear in Table IV-3 below:

Table IV-3 Research and Development Areas by Ministry[51]

Objectives	Area	Ministry
Efficiency Maximization of Transportation Facility	*(1) Traffic Flow Management* *(2) Traffic Information* *(3) Transportation Facility Management* *(4) Electronic Toll/Fare Collection* *(5) Traffic Management and Control*	*MOCT* *MOCT* *MOCT* *MOCT* *NPA*
Improvement of Traffic Safety	*(6) Vehicle Safety Evaluation* *(7) Vehicle Safety* *(8) Automated Enforcement* *(9) Traffic Safety Facility*	*MOCT* *MOCIE* *NPA* *NPA*
Development of ITS Information and Communication Technologies	*(10) ITS Information and Communication*	*MOIC*
Development of Basic Technologies for ITS	*ITS Basic Technology*	*MOST*

On the other hand, the private sector focuses on traveler information and commercial vehicle related issues. Some of the big roles to be played by the private sector are the provisioning of value-added information and the giving of information to the users

[51] Ministry of Construction and Transportation, Op. Cit.

through effective media in a timely manner. The private sector is a vital player for the government to attain its goals and to approach the user level, so we cannot forget its importance. Thus, we will here focus on the public sector's tasks.

c) Transportation Systems Efficiency Act[52]

The *Transportation System Efficiency Act* is a basic law of ITS, established in 1999 and revised in 2000, which stipulates the establishment of ITS plans, research and development, standardization, implementation and organization. Its major contents are:

1. Article 12: Establishment of ITS Master Plan
2. Article 13: Establishment of ITS Implementation Plan
3. Article 14: Implementation of ITS Projects
4. Article 15: Establishment and Approval of Execution Plan
5. Article 16: Permission/Approval Accredited by Different Laws
6. Article 17: Inspection for Completion of Project
7. Article 18: ITS Standardization and Safety Management
8. Article 23: Establishment and Functions of National Transportation Committee

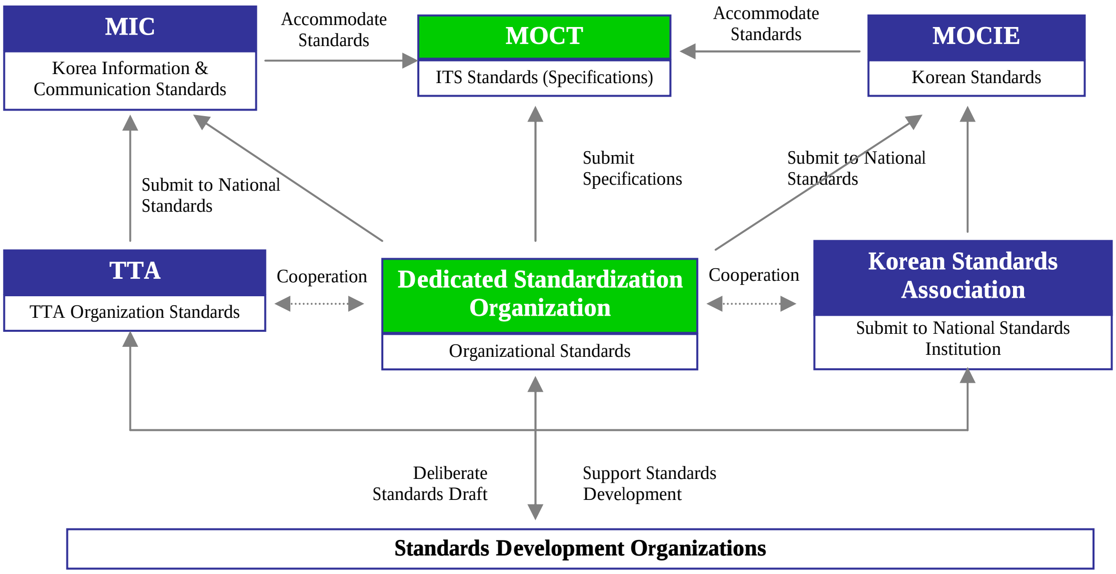
d) Standardization

[52] YOUNG, Keung-Whan, Op.cit

This field is one of the most important because on it depends the operability of the system. In this order, the Korean government established a working strategy among the ministries to have an integrated working system to attain the goal of standardization. This strategy consists of the coordination of the ministries and also, of the support of private standardization activities.

Figure IV-1 illustrates the roles of each ministry involved in ITS that are focused on standardization:

Figure IV-1 Standardization Activities[53]



"Thereupon, since 1998, the Korean Research Institute for Human Settlements (KRIHS) has conducted *The Yearly Program of National ITS Standardization*. Among the 61 work items in the first yearly program, 14 work items including ITS

[53] Ministry of Construction and Transportation, Op. Cit.

terminology, Data Dictionary, etc., were developed and proposed as national standards"[54]. This process of decision making of standardization strategies is based upon the status of international standardization proposed by the TC-204 of the ISO. The goal of the first stage of the Standardization work plan (2002-2006) is the settlement of ITS standardization, and the objective of the second stage (2007-2011) is the completion of the work plan, taking an international lead in the standardization activity.

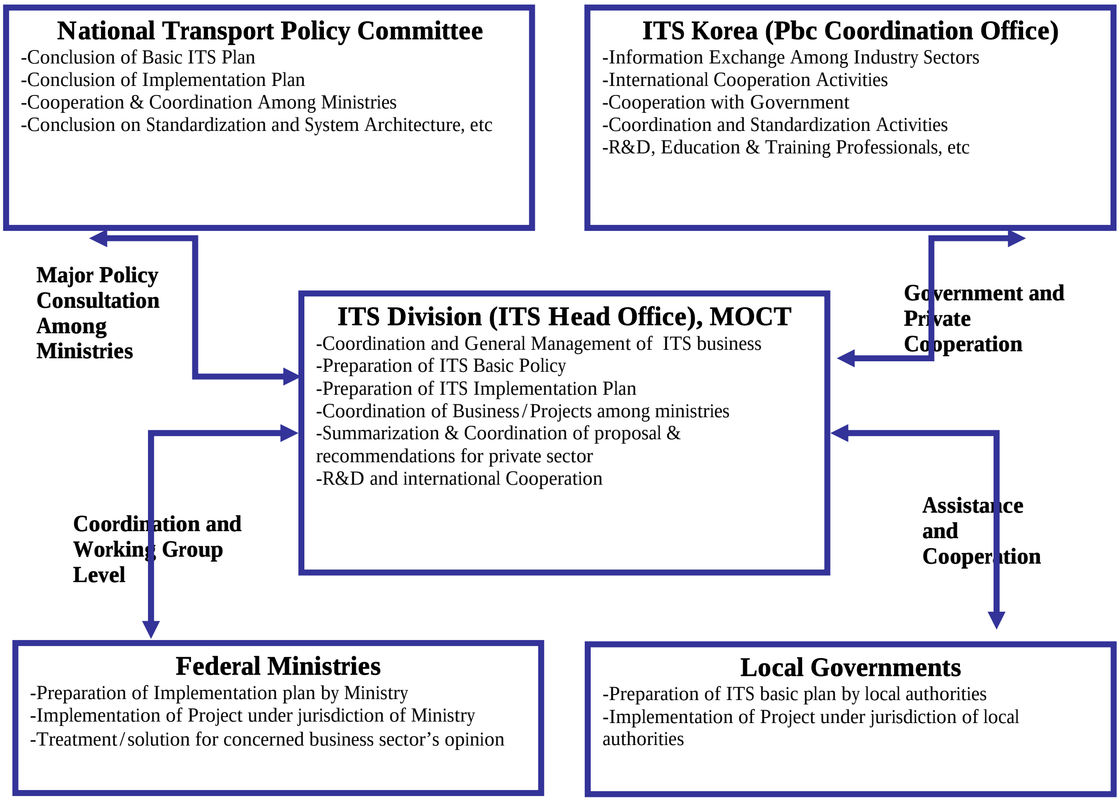
e) National Architecture

ITS working committee and subcommittees were established under the national transportation committee in accordance with the transportation system efficiency act. The Ministries are coordinated with the committees as well as the local government.

In Figure VI-2 we can understand the division of labor among the different Ministries and committees and their responsibilities in the ITS architecture.

Figure IV-2 ITS Organizations & Their Roles[55]

[54] Lee, Sang-Keon, *National ITS standardization Program Phase III*, Seoul: 2002, 5th Asia-Pacific ITS Forum.
[55] YOUNG, Keung-Whan, Op.cit



As we can see, the Seoul Metropolitan Government (SMG) enters in this entire national scheme, which has a wide spectrum and non-isolated measures. The appropriated administrative architecture has been planned to introduce the ITS tools as a whole to obtain more effective results.

2. *The role of the Seoul Metropolitan Government*

Going to the specific area we are interested in, the SMR, we will see the various measures that have been taken to improve the transportation planning and management of the metropolitan region.

The metropolitan government focused on the legal and institutional arrangements including the enactment of a metropolitan transportation planning special law and the establishment of a planning group for metropolitan transportation, headed by the Assistant Minister of Ministry of Construction & Transportation (MOCT)[56]. All form a part of the national broad plan that was displayed in Figure IV-2.

The planning group currently undertakes the activities on transportation planning not only for the SMR, but for all of the SCR, which covers the Special City of Seoul and its surrounding area, Inchon major city and Kyunggi province. The wider project is directed to have a real impact in the extensive area, as the problems are related to the whole region and cannot be treated separately.

Related with the principal problem of the SMR, the concentration of socio-economic activities, there are also plans implemented to spread their scopes. From 1999 the local governments of Seoul, Inchon and Kyonggi province (SCR), in coordination with the central government worked out the Seoul Metropolitan Strategic Plan, with eight major policy issues. These issues try to attack the roots of the problems of the region; the eight policies were[57]:

- Seoul-oriented and mono-centric spatial structures
- Saturation of Seoul and over-population of suburban areas
- Urban sprawl along major arterial roads
- Urban consumption of agricultural land and environmentally sensitive areas

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56 Ibidem
57 Kim, Moon-Hyun, Op. Cit.

- Job-housing mismatches
- Lack of interregional functional mixes
- Automobile dependent traffic systems and congestion
- Lack of inter-regional cooperative systems

B. ACTUAL SITUATION OF THE ITS

Before going to the ITS plans that the SMG has implemented, it is important to have a general overview of Seoul's transportation system:

1. The Current Status of the Transportation System in Seoul[58]

- General information

Commuting Population (2001) : average 28 million people/day

Population of Seoul : 10.37 million

Registered Vehicles (as of April 2002) : 2.6 million

- Major Means of Public Transportation[59]

City Bus : 60 companies, 368 routes, 8,189 buses

Community Bus : 150 companies, 253 routes, 1,527 buses

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[58] KIM, Hyonsik, *Public Transportation Payment System of the Transportation Card in Seoul*, Seoul : 5th Asia Pacific ITS Forum, 2002.

[59] Information to May 2002

Airport Bus : 7 companies, 28 routes, 372 buses

Subway : 8 lines operated by two subway corporations under the control of Seoul's Metropolitan Government

Taxi : 70,000 cars

Table IV-4 Percentage of Each Type of Public Transportation (2001)[60]:

Mean	Percentage
Bus	27.6%
Subway	36.5%
Taxi	8.4%
Private Car	18.7%,
Others	8.8%

2. Status of some of the ITS used in Seoul to solve congestion problems

Traveler Information Systems are the main subject areas leading ITS industry in Korea. Although the Korean government wanted to reach a high development of all the ITS branches, the budget restricted this desire to focus more on ATIS than on another one. The government part is more focused on the infrastructure provisions and encourages the private sector to commercialize the real-time traffic information.

The SMG makes various efforts in the deployment of real-time traffic information system. A unique system is the dedicated FM radio broadcasting system for real time traffic information, and it was feasible by opening the Transportation Broadcasting

[60] KIM, Hyonsik, Op. Cit.

Station (TBS) from 1990. The TBS has played a key role in congestion mitigation in the capital region. TBS works 22 hours a day to provide travel speed, travel time, accident, and work zone information for 21 traffic corridors in Seoul, via the FM broadcasting network. Additionally, it provides ARS and Internet services with real time traffic information[61].

Concerning the system, TBS operates 89 image detectors, 6 local and regional posts, and invites more than 3,500 volunteers as traffic information messengers. It provides also Trunked Radio System (TRS) to volunteered messengers for instantaneous transmission of information. It is also interconnected with 113 CCTV's from NPA to monitor the traffic scenes in strategic locations in Seoul.

Table IV-5 give us all the details about the system.

Table IV-5 Information Sources for TBS[62]

System	Quantity	Data Frequency
Image Detector	*89*	*10 Min.*
CCTV	*113*	*10 Min.*
Local and Regional Posts	*6*	*30 Min.*
Volunteered Messengers	*3,500*	*On demand*

3. Participation of the Private sector, the leading company

61 Bae, Sanghoon and Lee, Bong Gyou, *A Real-time Traffic Information Service by Dedicated FM Broadcasting System in Seoul Korea*, Torino: 7th ITS World Congress, 2000.
62 Ibidem

In 1999, 4 private companies within SMA provided traffic information services, but in addition to those companies, about 20 more were trying to get into the business. The private sector is concentrated on traveler information and commercial vehicles. In commercial vehicle operation, two firms were exclusively designated by the Korean government, Korea Telecom and KL Net (Korea Logistic Network)[63]. KL Net was designated by the MOCT as the exclusive provider of the Integrated Logistics Information Network, in 1996.

Today one of the leading private companies in Korea in the ITS business is ROTIS[64] (Road Traffic Information Systems). Its traffic information collection system, consists of beacons installed on the roads which collect and transmit sectional speed and location data, and 12 regional centers and a main information center that produce traffic information based on raw data from the location beacons mentioned before. From this information, ROTIS provides multiple services, as shown in the Appendix A.2: Table IV-6.

C. PRACTICAL APPROACH AND EVALUATION OF ITS IMPLEMENTATION

1. *The case study of the Phase I NATIS in Seoul*[65]

63 BAE, Sanghoon, Op. cit.
64 ROTIS Web Page
65 LEE, Chungwon, Kwon Byungchul and Yoon Hyuk Ryul, *Evaluation of the Phase I NATIS in Seoul,* in "Journal of the Eastern Asia Society for Transportation Studies", Vol. 5, October, 2003.

We will see the specific case of the operational impact of the Phase I NATIS (Namsan hillside Traffic Information System), which provides real time queue length and incident information inside of the Namsan 1st Tunnel, measuring 1600 meters long in the Seoul Metropolitan Region. The Phase I NATIS contains 5 variable message signs and 122 loop detectors and is the first ATIS in the arterial network of Seoul. We are going to evaluate Phase I, which has been in service since December 21st, 2000; Phase II just began in December 2003.

The importance of this ITS tool is the necessity of it to solve the big congestion problem of the tunnel. The Namsan 1st tunnel, 1600 meters long in the Seoul Metropolitan, carries more than 40 thousand vehicles a day and frequently suffers from severe congestion. The tunnel connects the CBD to the southern part of the city, and drivers need to pay a toll to use it. The tunnel has a non-tolled bypass. Thus, drivers need to make the decision of which path to use without any real time traffic information. Sometimes drivers who pay the toll experience a large jam inside the tunnel and feel uncomfortable. Observations show that the non-tolled bypass is faster than the tunnel from time to time. A real time traffic information system has been installed, called NATIS to relieve this unfavorable situation. The Phase I of NATIS covers only the tunnel path and the phase II project will cover the surrounding area including the bypass. We will see the usefulness of the NATIS Phase I as a friendly traffic management tool. (See Appendix A.3: Figure VI.3 to see the location)

Before beginning the analysis of the NATIS function, we should look at a general description of the place we are studying and its conditions.

The Namsan 1st Tunnel connects the CBD and the southern part of the Seoul Metropolitan Region. Although a Toll of US$2[66] is collected the tunnel is often overloaded on week days as well as on weekends. An advanced system was needed to mitigate that problem, which is why the NATIS was implemented.

It is important to see a brief description of the components of the NATIS Phase I, so that we can understand the functioning of this ITS tool:

The system hardware consists of two subsystems, as shown in Appendix A.4: Figure VI.4, field and center subsystems. The field subsystem includes VMS (Variable Message Sign), CCTV, detectors and communication lines. The center subsystem consists of operation room, servers, etc.

The two subsystems are described as follows:

VMS: one for north bound, four for south bound (total five);

- Detector: 122 inductance loop detectors;
- CCTV: ten pre-installed CCTV and one new CCTV (total eleven);
- CCTV operating equipment: fiber-optic communication equipments, fiber-optic transmitter/receiver, video split units, control keyboards and monitors;
- Operating Computer: network (communication) server, database server, operator pc;
- Detector and VMS operating equipment: CSU DSU, wiring concentrator and hub.

[66] Toll as December 2003

The following information is provided 24 hours per day, using traffic data through the VMS:

- Tunnel congestion (queue length status of the Namsan 1st tunnel);
- Travel time and speed;
- Incident, special event and weather information.

To evaluate the impact of the introduction of the NATIS, monthly traffic volumes were studied in the tunnel for the 5 years before the introduction of the NATIS and were compared with the year 2001, when the system was in full operation. The principal idea of the NATIS, is to give an option to the drivers that have to cross the Namsan Mountain: through the tunnel or through the bypass.

Figure VI.5 in Appendix A.5, shows the change in the traffic flow since the introduction of the NATIS Phase I, to be a decrease of 13.8%.

Before the inclusion of the system in the tunnel, the tendency of the traffic flow was to increase, but thanks to the NATIS Phase I, traffic volumes decreased greatly. These results comes from the fact that drivers, influenced by the VMS when it shows a “Congestion” sign, take the bypass. In normal conditions the time spent taking the bypass compared with the tunnel, was larger, but during the congestion periods, even the longer route is faster than the toll pass.

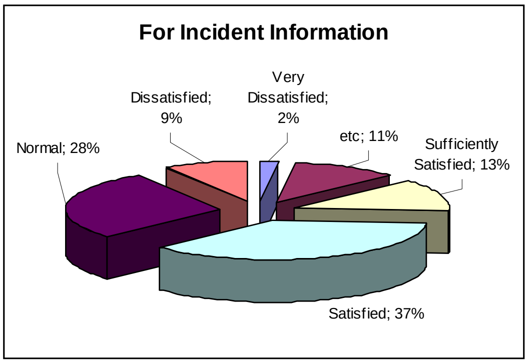
We can see Appendix A.6: Figure VI.6 so that we understand the length difference between the Namsan 1st Tunnel and its bypass (Sowol Street).

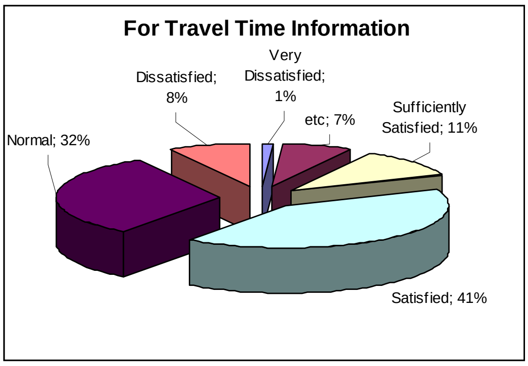
The study concluded that the NATIS made the difference in travel time between the Namsan 1st Tunnel and its bypass decrease, and the travel time transparency for drivers was improved by real time traffic information. Although bypass traffic information was not provided, the tunnel traffic information stimulated drivers to choose the bypass when the tunnel congestion was severe and the state of traffic flow became more stable.

The major achievement of this system is not the decrease in the congestion, but its psychological impact; drivers feel the system is valuable, especially during peak time because the system relaxes their hasty minds. This ITS tool gives the control to the driver as he/she decides which road to take with trustful information and feels that he/she controls the situation (congestion for instance) not the inverse.

This was seen in the surveys conducted by the study, as we can see in the next figures, where in all the cases, more than the 50% of the drivers felt satisfied or sufficiently satisfied.

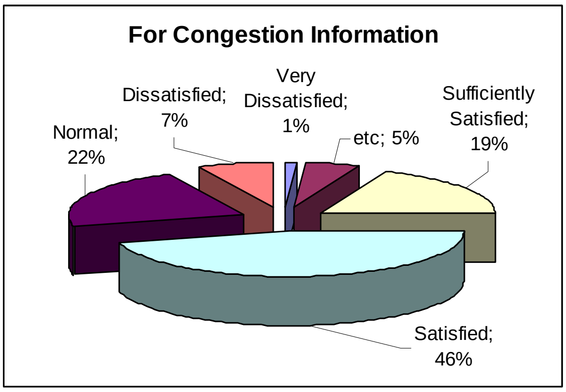
Figure IV-7 Incidents and Travel Information Satisfaction[67]





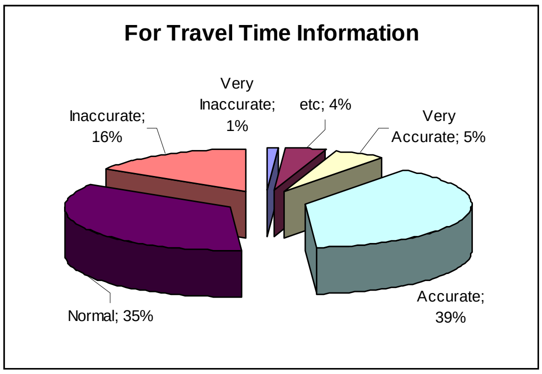
[67] Ibidem

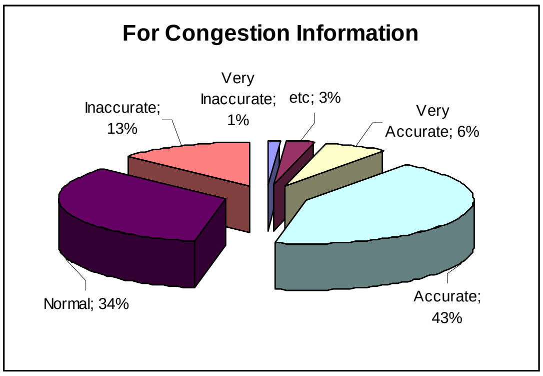
Figure IV-8 Congestion Information Satisfaction



We can also see how the people surveyed perceived the accuracy of the VMS information in the tunnel.

Figure IV-9 The Accuracy of VMS Information[68]





Other measures to evaluate the NATIS from the users point of view, are how understandable the system is, if it helps them to develop a sense of stability and how it influences the travel choice of the route. The answers from the drivers were also very positive as the great majority found the VMS understandable, and the information useful in deciding which route they took, as the next figures show.

Figure IV-10 The comprehension of VMS Information

68 Ibidem

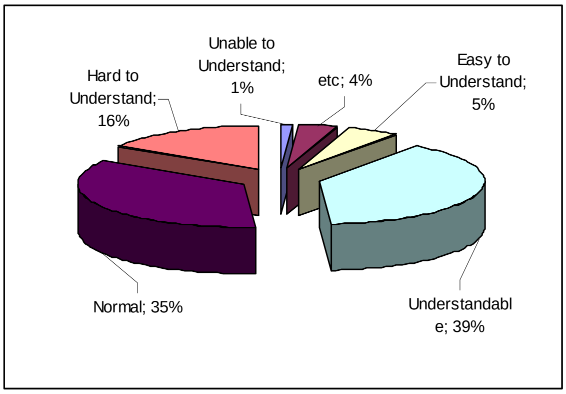
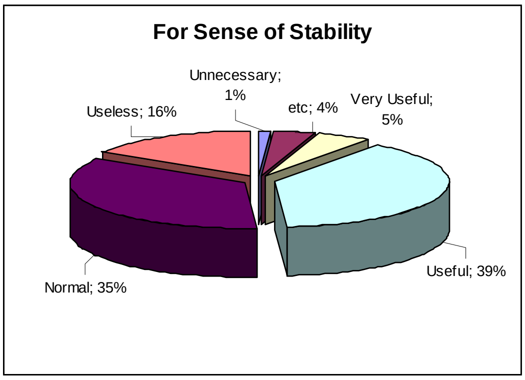
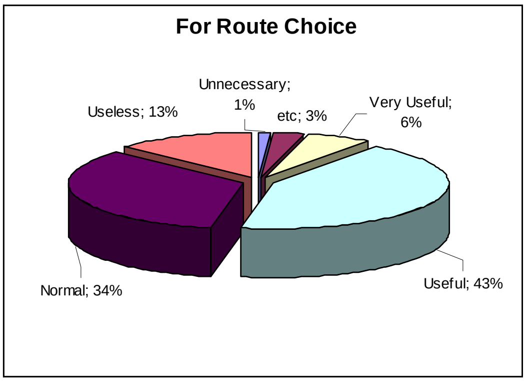


Figure IV-11 The Usefulness of VMS Information[69]





The conclusions of the study are that the NATIS helps the reduction of congestion and travel time variation on the tunnel path and its bypass, in spite of no traffic information on the bypass. This result is due to the route diversion caused by the traffic information. Additionally, the NATIS Phase I, even during peak time, helps drivers to relax, which is a non-quantifiable impact, but is one that make a difference in the drivers' behaviors. "Conclusively, the VMS information system, such as the Phase I NATIS provided in urban streets, can make a positive impact on the network

69 Ibidem

performance as well as help the drivers' dynamic route switching without any major adverse impact”[70].

2. Evaluation of the ITS systems

a) A general overview

It is said that the ITS approach compared with an infrastructure one, saves up to 35% of the costs, even though, we could not find a study of Seoul city, that shows a comparative approach between both of them that could confirm this affirmation. Anyway, as we understand, the ITS implementation is not possible to replace the infrastructure needs, but a tool to improve the service that the roads constructed could have.

In cases such as Seoul City, where the spatial space is largely reduced, urges innovative solutions. All of this is done to improve the efficiencies of the measures taken by the local governments and to mitigate the increasing problem of congestion. The ITS tools surge as instruments to sustain the infrastructure approach, to uphold it where there are not other measures to take, and to support an existing system, while other collateral measures are taken, such as public transportation reinforcement.

In the case of Korea, and especially Seoul, the system has not proved to be an economic or quantitative advantage over the traditional congestion measures, such as

[70] Ibidem

infrastructure, congestion toll charges, the 10 *buje*[71] etc. Although, there are some studies that set out to prove this thesis, they conclude that the advantage of ITS over other transportation measures, is not a general truth, that we should study each specific case to affirm that. (For more specific information, read Inwon Lee and Eunmi Park, *The Win-Win Solution of Seoul for Mobility and Environmental Quality,* in the 5th World Congress on ITS, Seoul, 1998)

In any case, the reduction of stress in the drivers, the sensation of control over the situation when they have accurate information from the road, the sense of stability, etc, are non-quantifiable measures that give credence to the ITS. The responses from the users that we saw in the NATIS case, give us an idea of the positive reception of this system, among the users. This is more evident when the drivers feel that they are the ones that make the choices, as in the route selection, the travel time, the incident avoidance, etc.

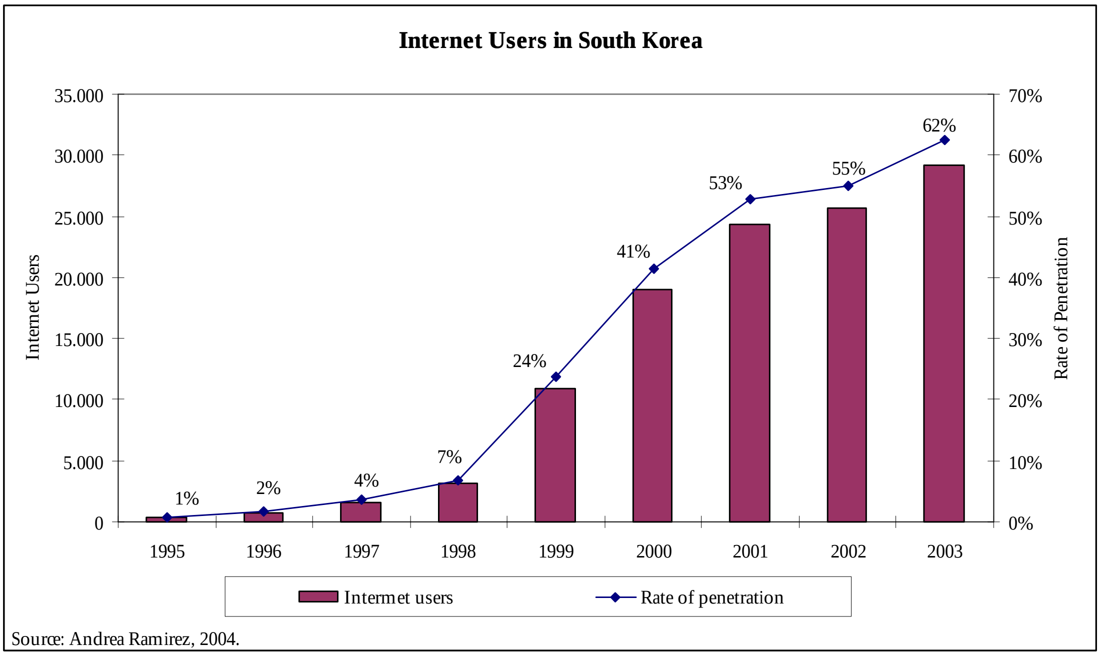
b) Necessary elements

ITS succeeded in Seoul because there are some requirements that are fulfilled by the citizens; without this it would be impossible to achieve any advance in the traffic control. Here we are talking about internet access in Korea, the incredible scope of technological devices among the Seoul citizens, like cellular phones, PDA's, etc, that give them the possibility to use all of the tools given by the government and the private companies.

[71] A 10% demand control measure of registered vehicle i.e. each vehicle can not operate when its plate's last digit matches the last digit of the date.

In Figure VI.8 we can see the development of Internet in the country over the last decade, and we can understand how the ITS implementation in Seoul correlates with the penetration of Internet. Without this sharp growth of internet users, how would it be possible to use some of the tools of the ATIS? For instance there are some of the services accessible through the Internet and the wireless Internet, like the real-time traffic information, the optimal route guidance, the location services, etc.

Figure IV-12 Number of Internet Users in South Korea



The same can be seen if we take in account that "the mobile market in Korea is one of the most advanced in the world and boasts nearly 100 per cent coverage across the peninsula. Korea's mobile penetration rate in 2002 was 67.9 … subscribers per 100 inhabitants"[72]. Equally, in the cases of PDA's and GPS services, the devices are not

[72] Taylor Reynolds and Jeong Jin-Kyu, Shaping The Future Mobile Information Society: The Case Of The Republic Of Korea, in ITU 2004.

inexpensive, and only high-income populations, as those of South Korea, can have access to them.

V. CONCLUSIONS

We have many conclusions to make regarding the generalities of ITS and their functionality as tools to solve congestion problems, but also as a useful means for the Seoul case. As we have seen, the ITS are very helpful in solving traffic problems, but transportation problems have many alternative solutions that should be considered for each case.

We cannot forget that there are many causes for congestion problems and most of them come not from transportation measures, but from life-styles, urban planning, etc. A smart transportation system will be realized by achieving the following:

A. New urbanization and Lifestyle

In order to change transportation patterns and have a long-term solution to congestion problems, encouragement is needed for the uses of car sharing and public transportation. Also, a shift is needed, towards a human-oriented city where green parks prevail instead of car parks, and there is a better traffic environment by reducing pollution, energy consumption, noises and traffic accidents. Urbanization should move in the direction of lower housing costs by building more houses, more space for gardens, play grounds and in general more high quality housing at low costs.

B. Advanced ITS Technology Application

These tools should provide a peaceful living environment, smooth operation and proper coordination and standardization, which include most of the elements described in chapter 3. These implementation processes are important to establish and execute National ITS master plans, and define proper architectures that optimally combine elements from a central and a decentralized approach.

As we saw, for instance in the Korean and Seoul implementation processes, it is important to establish public organizations that coordinate, research and organize the introduction of the ITS and that have a continuity during the life-time of the local and national ITS network. Finally, the consolidation of the system should be the partnership between the public and private sectors, promoted by the government, as the Korean government has successfully done.

C. Parallel Implementation

Parallel implementation of ITS projects and transportation infrastructure approaches are fundamental in order to make policy decisions that give solutions to traffic congestion problems in the long-run. ITS technologies should be linked to the latest developments but should also be combined with the different theories to solve congestion problems. Most of the solutions come from creativity and specific case measures that require more, an imaginative policy maker than sophisticated measures.

D. Additional Necessary Elements

An additional point that we did not develop in this thesis but is very important as well, is the training and education for the new systems. Training programs should cover potential experts groups, such as student, private sector, and government officers. This is a key process for ITS to be successful. Otherwise the systems can be very useful, but people will either not be able to use them, or will not use them because of unawareness of their existence or usefulness.

Also the power of penetration of ITS and their successes depend on some conditions that not all of the Nations have; like access to the internet, cell phones use, PDA's, etc. In the case of Seoul those conditions are fulfilled, but in most developing countries this is not the case. In the countries where those elements are not existent, ITS should be oriented more to public transportation than to the private vehicle users.

E. International Link

Finally, a very evident point for a foreigner, is the construction of an English version of the system. Especially for a case like Korea, where the language is a barrier as Korean is not a very known tongue. To develop cooperation amongst the nations in this subject, it is imperative to open an English version of ITS in each country; thus, for the situation concerning this paper, a Korea ITS English chapter. This element will help the development of ITS systems in Korea, as a result of the international cooperation, but it will also help export local ideas and enable communication with other nations.

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GLOSSARY

GLOSSARY

APT: Asia-Pacific Telecommunity
APTS : Advanced Public Transportation Systems
ARS: Auto Response System
ASTAP: Asia-Pacific Telecommunity Standardization Program
ATIS : Advanced Traveler Information Systems
ATMS: Advanced Traffic Management Systems
AVCS: Advanced Vehicle Control Systems
AVL: Automatic Vehicle Location
CBD: Central Business District
CCTV: Close Circuit Television
CVISN: Commercial Vehicle Information Systems and Networks
CVO: Commercial Vehicle Operations
DM: Demand Management
DSRC: Dedicated Short Range Communications
EG: Expert Group
FTMS: Freeway Traffic Management Systems
HOV: High Occupancy Vehicles
IRTE: Integrated Road Transport Environment
ISO: International Organization for Standardization
ITS: Intelligent Transportation Systems
KRIHS: Korean Research Institute for Human Settlements
MCIE: Ministry of Commerce, Industry & Energy
MOCT: Ministry of Construction & Transportation
MOIC: Ministry of Information & Communication
MOST: Ministry of Sciences and Technology
NATIS: Namsan hillside Traffic Information System
NPA: National Policy Agency
R&D: Research and Development
RDZ: Restricted Development Zone
ROTIS: Road Traffic Information Systems
SCR: Seoul Capital Region
SMA: Seoul Metropolitan Area
SMG: Seoul Metropolitan Government
SMR: Seoul Metropolitan Region
TAC: Traffic Adaptive Control
TBS: Transportation Broadcasting Station
TC: Technical Committee
TICS: Transport Information and Control Systems
TMC: Traffic Management Centers
TOC: Traffic Operations Center
TRS: Trunked Radio System
UTC: Urban Traffic Control
VMS: Variable Message Sign
WG: Working Groups

APPENDICES

APPENDIX A

APPENDIX A.1

Table VI-1 User Services for the National ITS Strategic Plan for the 21st Century[73]

Service Areas	Services	Subservices
1. Transportation Management Optimization	*1. Traffic Flow Management*	*1) Real Time Traffic Control 2) Freeway Traffic Control 3) Wide Area Traffic Control 4) Traffic Control Information*
	2. Incident Management	*5) Incident Detection 6) Incident Reaction Management 7) Emergency Vehicle Management*
	3. Traffic Enforcement	*8) Speed Enforcement 9) Exclusive Bus Lane Enforcement 10) Lane Enforcement 11) Traffic Signal Enforcement 12) Overload Vehicle Enforcement*
	4. Transportation Pollution Management	*13) Transportation Pollution Management*
	5. Transportation Facility Management	*14) Transportation Facility Maintenance and Operation Support*
2. Electronic Toll/Fare Collection	*6. Electronic Toll Collection*	*15) Electronic Toll Payment 16) Electronic Congestion Pricing*
	7. Electronic Fare Collection	*17) Public Transportation Fare Collection 18) Electronic Parking Payment*
3. Traffic Information Service Area	*8. Basic Information Broadcasting*	*19) Basic Information Broadcasting*
	9.Traffic Information Coordination	*20) Traffic Information Coordination*
4. Value Added Traveler Information	*10. Driver Information*	*21) Traveler Information 22) Pre Trip Traveler Information 23) En Route Traveler Information 24)Dynamic Route Guidance 25) Parking Information*
	11. Non-Driver Information	*26) Pedestrian Path Information 27) Bicycle Path Information 28)Path Information for Handicapped 29) Other Information*
5. Public Transportation Service Area	*12. Public Transportation Information*	*30) City Bus Information 31) Express Bus Information 32) Inter City Bus Information*
	13. Public Transportation Management	*33) City Bus Operation Management 34) Express Bus Operation Management 35) Inter City Bus Operation Management 36) Seat Reservation 37) Integrated Public Transportation Fare Collection 38) Public Transportation Safety Management 39) Public Transportation Facility Management*
6. Freight Transportation	*14. Freight Information Management*	*40) Freight Management 41) Commercial Vehicle Operation Management 42) Commercial Vehicle Safety Management 43) Commercial Vehicle*

[73] Ministry of Construction and Transportation, "ITS Model City Development in Korea", 2001

Service Area		*Route Guidance*
	15. Hazardous Material Vehicle Management	*44) Hazardous Material Incident Management 45) Hazardous Material Management 46) Hazardous Material Vehicle Route Guidance Management*
	16. Commercial Vehicle Administration	*47) Commercial Vehicle Electronic Clearance 48) Commercial Vehicle Administration*
7. Advanced Vehicle and Highway Service Area	*17. Safe Driving Support*	*49) Automated Accident Alarm 50) Longitudinal Collision Prevention 51) Lateral Collision Prevention 52) Intersection Collision Prevention 53) Railway Crossing Safety Management 54) Speed Zone Safety Management 55) Automated Safety Checking 56) Pedestrian Safety Support 57) Safety Support for the Handicapped 58) Driver Vision Enhancement 59) Reckless Driving Prevention*
	18. Automated Driving Support	*60) Automated Vehicle Headway Control 61) Automated Cruise Control 62)Vehicle Platoon Cruising*

APPENDIX A.2

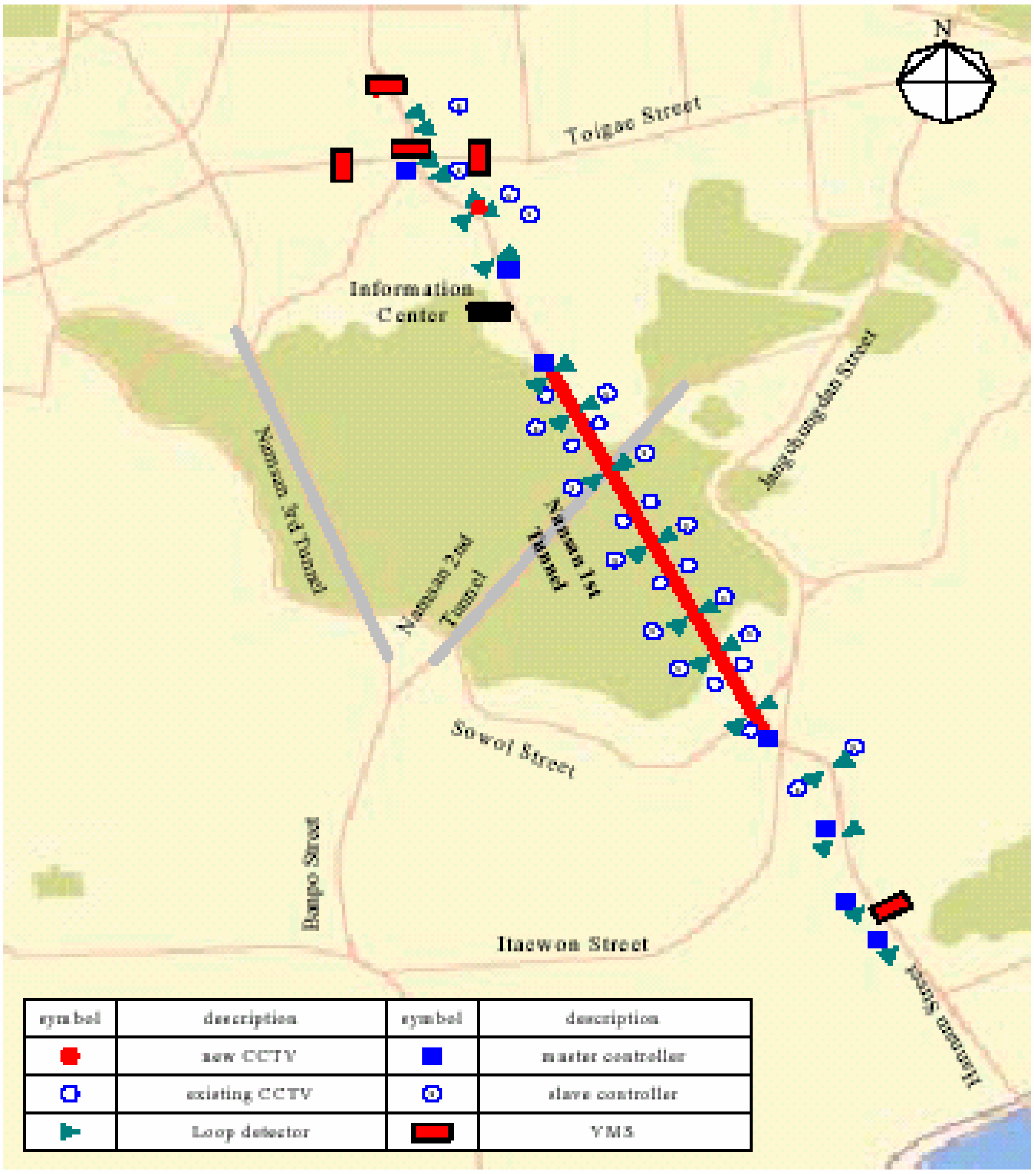
Table IV-6 ROTIS Systems and Services

Business Domain	Business Models	Characteristics
I. Systems	*(1) Bus Information System – BIS*	*1. Check & display, present location of all the buses with detailed information on operating condition*
		2. Efficient management for bus dispatching & operation by statistical analysis
		3. Maximizing bus operators' benefit and passengers' convenience
	(2) Taxi Call System	*1. Prompt dispatching the nearest taxis to customers: by real-time location recognition system*
		2. Efficient management through providing detailed operation data
		3. Statistical data analysis for saving operating costs
	(3) Real-time Traffic Data Collecting Systems	*1. ROTIS is the 1st traffic information provider in urban area*
		2. Service area includes Seoul and 7 satellite cities around Seoul
		3. The system is updated every 5 minutes
II. Information Services	*(1) Real Time Traffic Information*	*1. Customers can easily access through various applications : (wireless) internet, ARS, PDA, CNS, mobile phone, radio broadcast*
		2. In-vehicle terminal for information services (Telematics)
	(2) Optimal Route Guidance	*1. Show the optimal path to destinations with the expected travel time, average speed, driving mileage, and also expected taxi fare*
		2. Show each sectional speed through ROTIS' real-time traffic information system
	(3) Traffic Information at Crossroad / Bridge / Tunnel	*1. Traffic information through ARS, for all the roads in Seoul metropolitan area*
		2. Traffic information for the Han River and main tunnels
	(4) Location	*1. Location information service at its homepage,*

		'www.ROADi.com'
	Information Services	*2. In-vehicle Terminal for Information Services considering present traffic condition for easier and safer driving.*

APPENDIX A.3

Figure VI-3 Phase I NATIS – Location[74]



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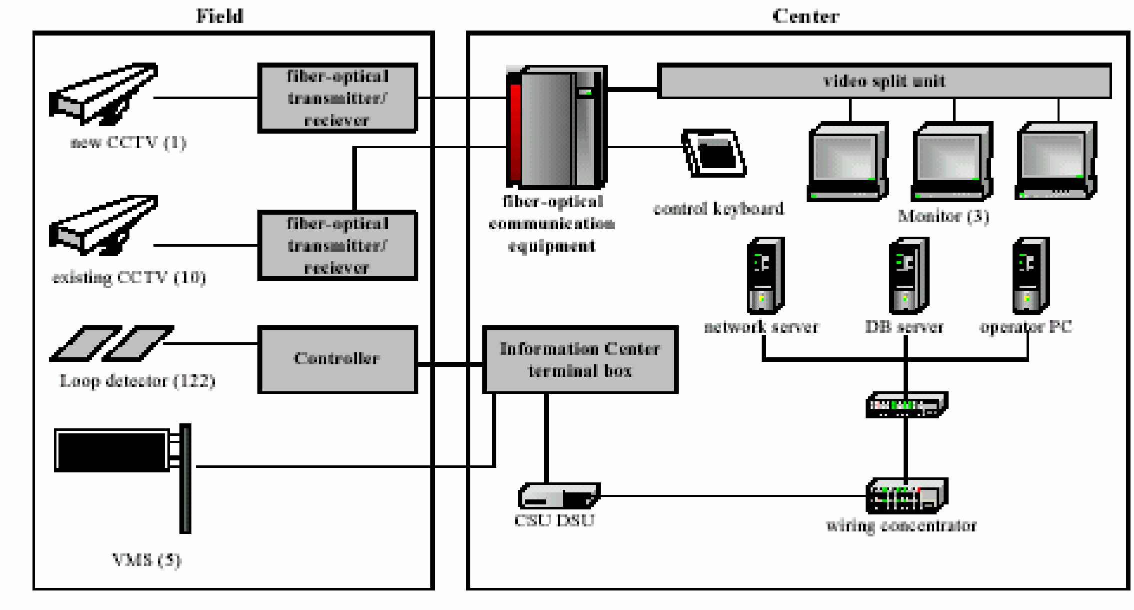
74 Lee, Chungwon, Op. Cit.

APPENDIX A.4

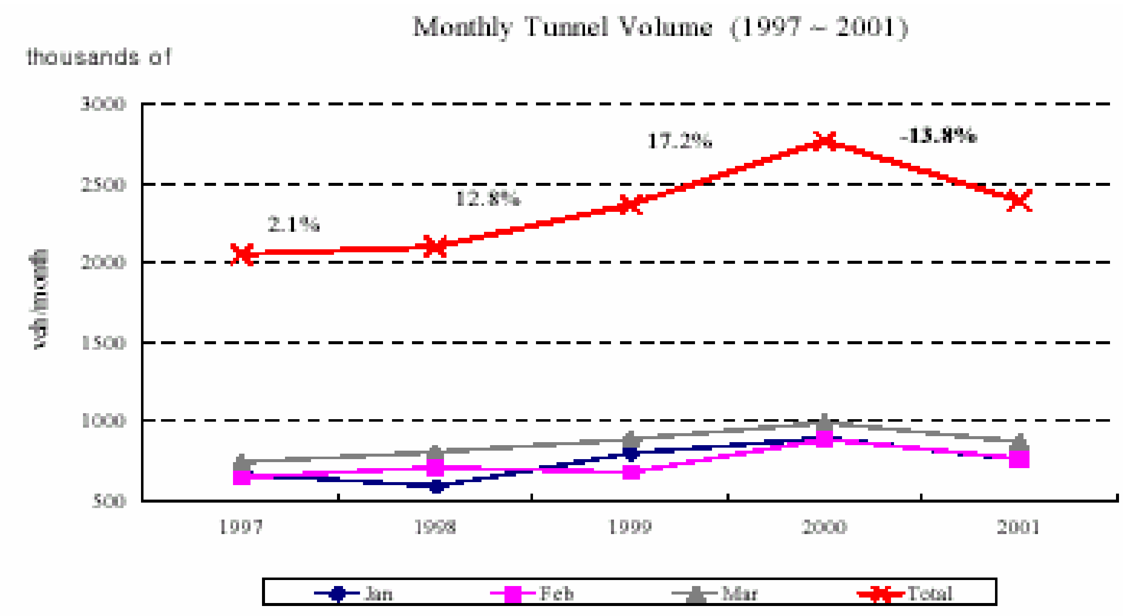
Figure IV-4 NATIS Phase I - System Hardware Diagram[75]



75 Ibidem.

APPENDIX A.5

Figure VI-5 Namsan 1st Tunnel Monthly Volume[76]



[76] Ibidem.

APPENDIX A.6

Figure VI-6 The Tunnel and it bypass[77]

[77] Ibidem