KAJIAN PELAN INDUK SISTEM PENGANGKUTAN PINTAR

Development of ITS System Architecture for Malaysia

Technical Note No. 1

July 2006

Formulation of Design Framework for the ITS System Architecture for Malaysia

TABLE OF CONTENTS

1. INTRODUCTION

The objective of this Technical Note is to develop the design framework for the ITS System Architecture for Malaysia. It will provide a rational framework for long term development and implementation of ITS projects.

The ITS system architecture for Malaysia is the framework of interconnected subsystems that together provide ITS user services through allocated functionality and defined interfaces. This architecture must be open and flexible to prevent unnecessary restriction to implementation choice and to accommodate the varied needs of the public and private sectors. At the same time the architecture definition will be sufficiently precise to ensure a transportation and communication system design that is both compatible and interoperable across the nation.

It is important to identify the existing ITS deployments in Malaysia before developing the framework for implementation of future ITS projects. Section 2 provides an overview of the existing ITS initiatives in Malaysia.

With the rapid development in the communication technologies, it is crucial for the architecture to cope with the existing and emerging communication infrastructure. Section 3 identifies the current telecommunication technologies.

Section 4 presents the list of stakeholders and the information that was gathered from stakeholders through the completion of stakeholder workbooks and the conduct of workshops.

A literature review on the global ITS initiations was conducted to provide an overview of the current status of ITS architecture development in North America, Europe, Japan, Australia and Taiwan. The findings are summarized in Section 5.

The information gathered from the stakeholders and reviews in the global ITS architecture is used to develop the framework for the Malaysian ITS System Architecture. The overall design approach for the Malaysian ITS System Architecture is presented in Section 6.

2. MALAYSIA LOCAL CONDITIONS

2.1 Background

It is important to ensure the existing ITS systems in Malaysia are put to use, where appropriate, for the future ITS implementation. The current ITS deployment in Malaysia are mainly in the traditional ITS technologies such as urban traffic control (UTC), traffic control and surveillance systems (TCSS) and electronic toll collections (ETC) on the tolled expressways. The current approach in ITS deployment is rather uncoordinated. There is an absence of a single central agency to regulate on the deployment. There is no national system architecture, nor any national technical standards to guide the respective agencies in the selections of ITS components and systems. Systems are usually installed without any provision to communicate with one another, making it very expensive to integrate into a single system at a later stage. This section provides an overview on the current and future deployments of ITS technologies in Malaysia.

2.2 Electronic Toll Collection System

Electronic Toll Collection (ETC) was introduced in Malaysia over 10 years ago and now the majority of tolled highways utilize some forms of ETC system. These range from the use of ‘Touch and Go’ smart card to the use of smart tags using microwave or infrared DSRC. In December 2003, the government directed the implementation of single ETC nationwide as a form of standardisation. The directive require toll operators to have a minimum of two Touch and Go and one smart TAG lanes per bound at every plazas. This was fully implemented by July 2004.

The 'Touch and Go' smart card technology requires driver to stop momentarily and touch the card onto the reader. The smart tag technology allows a real-time toll transaction as the vehicle passes through the toll plaza infrared zone. Refer to section 3.2 for more details on the DSRC technology.

2.3 Urban Traffic Control

Traffic signal system plays an important role in providing automatic control in major cities. In Kuala Lumpur, there are over 300 junctions that are under traffic signal control using either SCATS or ITACA (Spanish) systems. The systems are installed at the control center in Dewan Bandaraya Kuala Lumpur (DBKL). In 2003, 89 junctions were under the SCATS and the ITACA system was applied to 42 junctions. The others are isolated / vehicle actuated systems. The ITACA junctions are mostly located outside Kuala Lumpur Central Area (KLCA) in the suburban areas.

To enhance the safety at signalized intersections, the Countdown System was installed in major cities such as Kuala Lumpur, Kajang and Melaka. The Countdown system is a feature installed at signalized junctions to provide information to drivers on the remaining green time for a particular approach. The countdown of green time allows drivers to react immediately to reduce their speed when the green time is approaching to zero.

There are fifteen cameras installed at strategic locations within DBKL to provide real time traffic information to travelers. Traffic condition for DBKL is posted on the website: www.jpbdbkl.gov.my/rttis to assist travellers to pre-plan their trips.

2.4 Public Transport System

The public transport in Malaysia is largely comprised of buses, railways and taxies. The Rangkaian Pengangkutan Integrasi Deras Sdn Bhd (RAPID KL) is providing an integrated public transportation system incorporating the Light Rail Transit (LRT) and bus services in the Klang Valley.

LRT – KELANA JAYA LINE (Formerly known as PUTRA Line)

KELANA JAYA LINE covers 29 km starting from the eastern suburbs of KL (Gombak) to the western suburbs (Lembah Subang). The 24 stations are equipped with passenger information display system informing passengers of the arrival times of the next train. Feeder bus services are also available to serve passengers between stations and the surrounding areas.

The service commenced in September 1998 between Subang Depot to Pasar Seni Station. Section two between Pasar Seni to Terminal Putra was in operation in June 1999. In 2002, the system carried its 150 million the passenger, with an average of 160,000 passengers riding the system daily.

LRT – AMPANG LINE and SRI PETALING LINE (Formerly known as STAR Line)

AMPANG LINE and SRI PETALING Line have 25 stations and cover a distance of 27 km connecting the surrounding suburbs and the Klang Valley. It was constructed in two phases, the first phase covers a distance of 13 km between Ampang and Jalan Sultan Ismail. Phase 2 incorporates a 9.5-km spur line from Chan Sow Lin Station to Bukit Jalil Stadium. The stations are equipped with passenger information display unit which showing the end destination.

The AMPANG LINE runs from Sentul Timur to Ampang and the SRI PETALING Line from Sentul Timur to Sri Petaling. In 2005, these two lines carry over 130,000 to 150,000 per day on a weekday basis and an average of 120,000 per day on weekends.

Rapid Bus

RAPID KL operates 134 routes in the Klang Valley including the suburban feeder service to complement the LRT systems. It has two central workshops and 13 bus depots spread across the Klang Valley. In 2005, it has a fleet of over 1100 buses and transports over 180,000 passengers per day.

Express Rail Link (ERL)

Kuala Lumpur Monorail

The KL Monorail serves the busiest parts of the city running along elevated guildeways for a distance of 8.6 km. It has 11 stations located in the heart of KL to complement the LRT services. The KL Monorail is currently capable of handling up to a maximum of 5,000 passengers per hour per direction, operating at 3 minutes headway with 12 numbers of 2-car trains.

ERL

The ERL provides service for air travelers connecting KL Sentral to Kuala Lumpur International Airport (KLIA). There are two types of services:

KLIA Ekspres provides a non-stop service between KL Sentral to KLIA. It departs from both terminals every 15 minutes and the journey takes 28 minutes.

KLIA Transit integrates the LRT and Monorail service through three intermediate stops between KL Sentral and KLIA. KLIA Transit departs every half-an-hour from KL Sentral and KLIA terminals. Total journey time is 36 minutes.

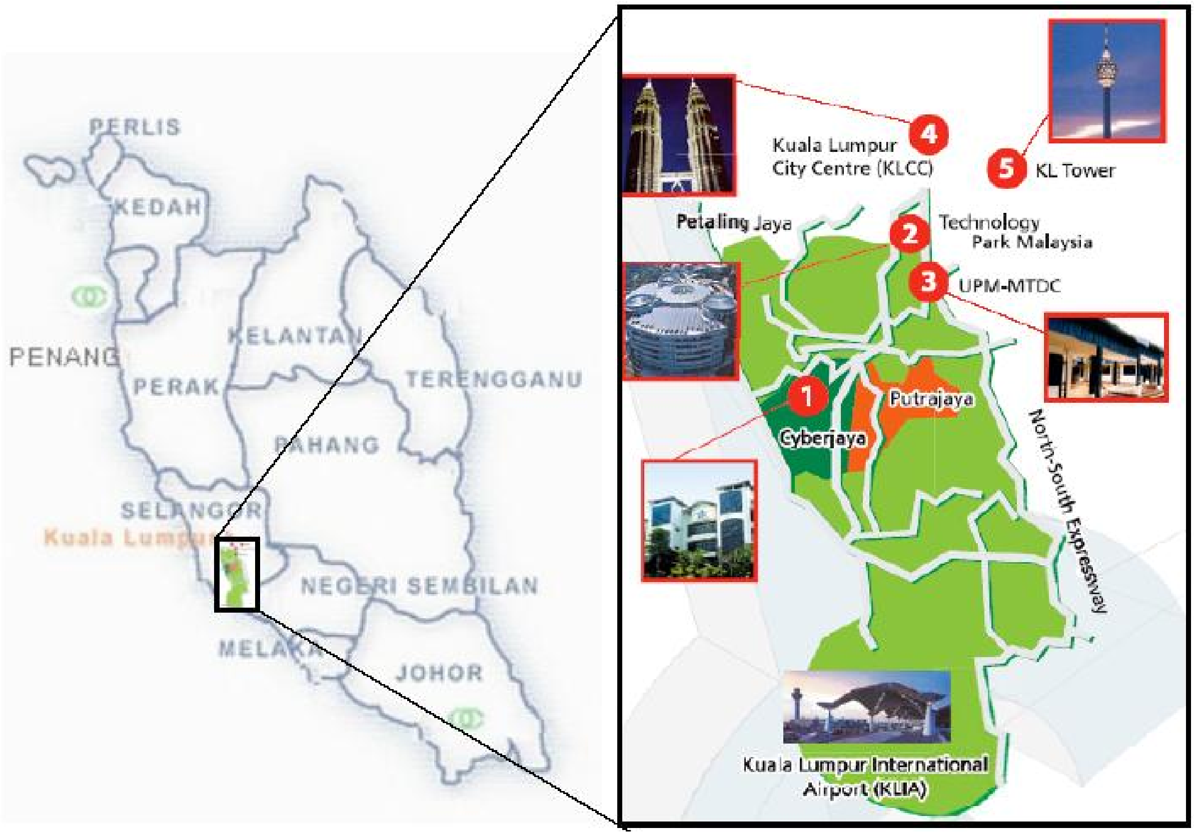
KTM Komuter

KTM Komuter provides rail services between KL and the surrounding suburban areas. It has 42 stations covering from Kuala Lumpur City Center to Seremban, Rawang, Pelabuhan Klang and Sentul.

The KTM Komuter is connected to other transit services under RAPID KL. The following figure shows the Integrated Transit Network of Kuala Lumpur.

2.5 Intelligent City Management

The Multimdeia Super Corridor (MSC) is created to embrace the development of the IT industry in Malaysia. The MSC is a length of "corridor", 15 km x 50 km area located south of the capital. The corridor stretches from Kuala Lumper City Center (KLCC) in the north to KLIA in the south with the two intelligent cities Putrajaya and Cyberjaya in the middle. These two cities are planned with sophisticated information network employing up-to-date communication technologies which offer a world class IT infrastructure within the cities.



The city of Putrajaya is located about 20 km south of KL and covers an area of 4,931 hectare. The city of Cyberjaya sits to the west of Putrajaya and spans over an area of 2,900 hectare. The management of the cities is heavily dependent on ITS technologies. Each city has its own City Command Centre (CCC) which acts as the monitoring hub of the city. It utilizes the following ITS technologies:

- Advanced Traffic Management System (ATMS) – manages traffic flow in urban and residential areas using adaptive traffic control system;
- Highway Management System (HMS) – controls traffic along highways by using loop detectors;
- Variable Message System (VMS) – displays traffic information to road users;
- Closed Circuit Surveillance System (CCSS) – uses to monitor traffic conditions and verify incidents; and
- Interactive Information System (IIS) – enhances the capabilities to detect and verify incidents and provides a better co-ordination in response to incidents.

3. COMMUNICATIONS TECHNOLOGIES REVIEW

3.1 Background

Over the past two decades, a massive worldwide telecommunication infrastructure has evolved both for wired and wireless communication. The reliability and capacity of telecommunication has increased exponentially, enabling a wide array of new services and capabilities. Over the next two decades, many new technologies will be introduced at a rapid pace to support the demands of our information age. The existence of an appropriate communications infrastructure and capacity is critical to the successful of ITS development. The ITS system architecture will identify the communication media that would support the communication needs and the standards required between subsystems. It is important that the ITS system architecture is built upon the standards which reflect the new and emerging communications technologies.

3.2 Wireless Communications

3.2.1 Dedicated Short Range Communications

DSRC consists of wireless devices that are capable of transferring data at a high rate between mobile and/or stationary devices. The most common application within ITS is to provide communication between in-vehicle transponder and roadside antenna for the Electron Toll Collection (ETC) Systems.

DSRC is a mature technology that has been widely used around the world for ITS initiatives. However, it has become apparent that there is a need to standardize DSRC to provide a common path between the vehicles and ITS devices. The specific transmission frequencies and protocols are the issues that needed to be standardized. The following table summaries the standards used for the DSRC in North America, Europe and Japan.

Region	Standard	Electromagnetic Spectrum
U.S.	ASTM 6.0 / 7.0	5.850-5.925 GHz
Canada	ASTM E-17.51	5.9 GHz
Europe	CEB-278	5.8 GHz
Japan	--	5.8 GHz

In 1999, the U.S. Federal Communications Commission (FCC) designated the spectrum from 5.850 to 5.925 GHz for transportation services while Canada is working toward the allocation of the 5.9 GHz band to ITS purposes. As there is a global acceptance on the use of DSRC media with the 5.8 GHz, it is recommended that the 5.8 GHz microwave DSRC be adopted for ITS applications for Malaysia. This will allow Malaysia to be in accordance with the international ITS community.

3.2.2 Extended Range 2-Way Communications

There are number of wireless access communication technologies that can support ITS requirements such as cellular mobile and personal communication service (PCS) mobile, trunk and ESMR mobile, fixed narrowband and broadband wireless access and point-to-point microwave.

The emerge of 3G PCS with the data capacity up to 2 Mb/s permits a high speed data access, wideband internet and video capacity which can support various ITS applications.

3.2.3 Extended Range Broadcast Communications

Highway advisory radio (HAR) systems are the primary application of extended ranges broadcast communications within ITS. A dedicated radio frequency can be allocated for extended range broadcast of traffic information.

Digital Audio Broadcast (DAB) is a wireless audio and data transmission system developed for point to multipoint broadcast applications. The DAB technology provides datacasting telecom capacity at 20-40 KB/s. However, as spell out in the spectrum policy, the use of datacasting must remain secondary to the broadcasting services. Commercial broadcasting is active in the DAB market in North America. There are over 800 digital radio stations in the U.S. while in Canada, there are 19 digital radio stations in Toronto and 9 in Montreal that are broadcasting using DAB. The application of DAB in ITS field through datacasting is still to be developed.

3.3 Fixed Wireline Communications

Dedicated and leased wireline communications wide area networks are used to integrate various ITS components. Principal network design considerations are listed as follows:

- The system must provide a high degree of reliability through a high level of redundancy in the network configuration;
- Capacity for system growth must be provided to accommodate future expansion;
- The system must be monitored for failures and loading through a central network management system; and

- Standard industry communications protocols must be employed to minimize deployment, operations and maintenance costs.

3.4 Internet

The internet has revolutionized both the computer and communications world. The internet has the world-wide broadcasting capability that can disseminate information between individuals and their computers without regard for geographic location. The use of the Internet is impacting all areas of industry, including transportation. Specific ITS examples of internet application include:

- e-business exchange of commercial carrier way-bill information;
- e-commerce toll patron account registration/settlement;
- Web-cast of raveler information services for ravelers en-route or pre-trip; and
- Centre-to-centre data exchange for ATMS/ATIS co-ordination.

Access to the Internet may be obtained through a number of technologies, including:

- Dial up access uses conventional telephone lines and provide a limited bandwidth. Practical access speeds currently are between 45 and 50 kilobits per second (kbps);
- Integrated Services Digital Network (ISDN) Access speeds are limited to a maximum of 128 kbps;
- Asymmetric digital subscriber line (ADSL) allows more data to be sent over existing copper telephone lines. Access speeds are in the range of 500 kbps to 7 megabits per second (Mbps), T1 access is generally obtained through telephone companies but is also capable through wireless technologies. Access speeds are approximately 1.5 Mbps;

- Cable Modem – Cable modems utilize the existing cable television infrastructure. The infrastructure provides a wide bandwidth with access speeds of 3 to 10 Mbps; and
- Wireless PCS providers are offering email service and introducing browser services.

4. NEEDS ASSESSMENT

4.1 Background

The objective of the "Needs Assessment" is to identify the needs of the stakeholders for the ITS System Architecture for Malaysia. Constructive involvement from the stakeholders is vital to the development of the ITS System Architecture. This "need-driven" approach ensures the ITS system architecture incorporates all aspect of the stakeholders' needs. It also provides an opportunity to identify to the stakeholders how ITS can benefit their operations.

4.2 Listing of Stakeholders

An ITS stakeholder is anyone or any organization, who has an interest or concern in ITS deployments. Various government institutions, organizations and other transportation agencies across the country have been identified. They were categorized into eight functional groups with different areas of interest, roles and responsibilities. Within each group there may be variable levels of knowledge or awareness of ITS. The identified stakeholder groups include:

Group 1: Government Agencies related to planning
Group 2: Government Agencies related to regulating and enforcement
Group 3: Highway Concessionaires
Group 4: Local Authorities

Group 5: Transport Operators
Group 6: ICT Service Providers
Group 7: Commercial Institutions
Group 8: Institutions of Higher Learning

A wide range of stakeholders was sought to attend the workshops doing the ITS Master Plan Study so that it is possible to elicit the broadest range of opinions. The complete list of the stakeholders is shown in Appendix A. They were invited to attend a series of workshops, where they were requested to fill in the stakeholder workbook containing various questions related to their current and future needs of ITS.

4.3 Stakeholders Workshops

A series of six workshops was conducted, where four were conducted in Peninsular Malaysia, and one each was held in Sabah and Sarawak. This is to expose the stakeholders with the current ITS initiatives and their benefits. The stakeholders were requested to complete a pre-designed workbook towards the end of the workshop. The workbook consists of a range of questionnaire aimed at identifying different needs, agenda, priority and policies with regards to ITS. The responses gathered from the stakeholders were then complied and analysed.

It was from the data collected during these workshops that the Malaysian ITS System Architecture was developed. Based on the ITS needs from the stakeholders, the ITS sectors and user sub-services were identified. There are nine ITS sectors, thirty-six user-services and a total of ninety-one user sub-services and they are summarized in Appendix B.

4.4 Ranking of ITS User-Services

To determine the deployment priority of the identified ITS user-services, they were ranked according to the stakeholders' needs. The desires of each stakeholder are given weighted points against each representing ITS user sub-service. The user-services are then prioritized based on the scores obtained by the associated user sub-services. The top ten user-services are recommended for short-term deployment, the next ten for medium-term deployment and the remaining user-services are for long-term deployment. The deployment priority of the user-services is listed below:

Short-Term Deployment (0 to 2 Years)

1. Pre-Trip Traveller Information
2. Incident Detection and Management
3. Urban Traffic Control
4. Improved Accident Data Collection
5. Automated Dynamic Warning and Enforcement
6. Electronic Payment Services
7. Disaster Response and Management
8. Public Transport En-Route Information
9. Emergency Vehicle Management
10. Automated Roadside Safety Inspection

Medium-Term Deployment (2 to 5 Years)

11. Operations and Maintenance
12. Public Transport Operations Management
13. Route Guidance and Navigation
14. Demand Responsive Transit
15. Public Travel Security
16. Traveller Services and Reservations
17. Archived Data Management
18. Non-Vehicular Road User Safety
19. Environmental Conditions Management
20. Commercial Freight Management

Long-Term Deployment (Beyond 5 Years)

21. Commercial Fleet Management
22. Weather and Environmental Data Management
23. Hazardous Material Incident Response
24. Multi-Modal Junction Safety and Control
25. Emergency Notification and Personal Security
26. Travel Demand Management
27. On-board Safety Monitoring
28. Commercial Vehicle Administrative Processes
29. Commercial Vehicle Electronic Clearance
30. Sensor-Based Driving Safety Enhancement
31. Ride Matching and Reservation
32. Vehicle-Based Collision Avoidance
33. Infrastructure-Based Collision Avoidance
34. Safety Readiness
35. Automated Vehicle Operation
36. Pre-Collision Restraint Deployment

5. INTERNATIONAL REVIEW OF DESIGN APPROACH FOR ITS SYSTEM ARCHITECTURE

5.1 Introduction

This section contains a detailed review of previous and current work on ITS System Architectures Development taken in North America, Europe, Japan, Australia and Taiwan.

5.2 Canada

5.2.1 Background

Canada's Intelligent Transportation Systems Plan was released in November 1999 and presents the federal government's plan to stimulate the development and deployment of intelligent transportation systems in Canada. Canada's ITS Plan incorporates the development of a national ITS architecture to ensure that products and services are seamlessly integrated. It was decided to use Version 3 of the U.S. National Architecture as the basis for the Canadian ITS architecture. This is because of the need to integrate surface transportation across the whole of North America. The U.S. Architecture has been modified for Canadian conditions, e.g. weather, the level of population dispersion and to enable the use of two languages (English and French). Other changes have led to the development of the Architecture so that it has more facilities for services related to other (non-road vehicle) modes of travel, such as walking and cycling.

5.2.2 Approach

The Canadian ITS Architecture provides a common structure for the design of ITS; it defines the functions that must be performed by components or subsystems, where these functions reside (e.g., roadside, traffic management centre, or in-vehicle), the interfaces and information flows between subsystems, and the communications requirements for the information flows (e.g., wireline or wireless) in order to address the underlying user service requirements.

Generically the Canadian ITS Architecture is structured by the following components:

- **User-Services and User-Service Requirements:** represent what the system will do from the perspective of the user (public or a system operator). These are based on the identified needs or problems that will be addressed by the Services. The high level user-services are broken down into more detailed functional statements down to a level of fundamental requirements that are the User Service Requirements.
- **Logical Architecture:** defines a set of functions (or processes) and information flows (or data flows) that respond to the user-service requirements. It presents processes in a top-down fashion beginning with general processes (e.g., "Manage Traffic") that are then decomposed into more detailed processes (Process specifications). These process specifications are as the elemental functions to be performed in order to satisfy the user-service requirements.

- **Physical Architecture:** assigns the processes identified in the logical architecture into physical entities (subsystems). Also the data flows are grouped into (physical) architecture flows. These architecture flows and their communication requirements define the interfaces required between subsystems, which form the basis for ITS standards work. Two layers describe the physical architecture: the transportation layer and the communications layer. The first one shows the relationships among the transportation-management-related elements, while the second defines the communication services necessary to connect such elements.
- **Market Packages:** identify the pieces of the Physical Architecture that are required to implement a particular transportation service. Defining the corresponding architecture flows between subsystems and terminators.

There are a total of 35 user-services proposed for the Canadian Architecture for ITS. Of these 35 user-services, 6 user-services are not presently incorporated into the U.S. National Architecture. These include:

- Operations and Maintenance;
- Automated Dynamic Warning and Enforcement;
- Non-Vehicular Road User Safety;
- Intermodal Freight Management;
- Disaster Response and Management; and
- Weather and Environmental Data Management.

Some of the changes made for Canada have in fact been included in Version 4 of the U.S. National Architecture.

5.2.3 Development and implementation

The Canadian ITS Architecture is available as a resource for any region and will continue to be maintained independently of any specific system design or region in the nation.

Regions of Canada are currently developing their regional ITS Architecture based on the Canadian ITS Architecture but adapted to specific local conditions and needs.

Transport Canada (the Canadian Ministry of Transport) has produced a plan for the use of the Canadian ITS Architecture. This is based on the notion that conformance with the Architecture is a pre-requisite of Transport Canada providing financial support for ITS deployment. There is also an education and training program that are being delivered jointly by Transport Canada and ITS Canada.

5.3 United States of America

5.3.1 Background

The U.S. National ITS Architecture is the result of TEA-21 (Transportation Efficiency Act) legislation passed by the Congress late 1992. The US DOT, through the Federal Highway Administration (FHWA) initiated in a 1993 a program to produce the U.S. National ITS architecture. In June 1996, the first version of the U.S. National ITS Architecture was released for use, and has been maintained and updated since that time. In the beginning of 2005, version 5 of the U.S. National ITS Architecture was released.

The TEA-21 legislation requires that all ITS projects funded through the Highway Trust Fund be in conformance with the National ITS Architecture and applicable standards. This is to be accomplished through the development of regional ITS architectures and using a systems engineering process for ITS project development.

The end goal is "to facilitate the integration of ITS infrastructure components, help mainstream ITS into transportation planning and programming processes and promote "good practice" during project design and implementation phases."

5.3.2 Approach

The U.S. National ITS Architecture provides a common structure for the design of intelligent transportation systems. It is not a system design, nor is it a design concept. It is the framework around which multiple design approaches can be developed, each one specifically tailored to meet the individual needs of the user, while maintaining the benefits of a common architecture.

The architecture defines the functions that must be performed to implement a given user service, the physical entities or subsystems where these functions reside, the interfaces/information flows between the physical subsystems, and the communication requirements for the information flows. In addition, it identifies and specifies the requirements for the standards needed to support national and regional interoperability, as well as product standards needed to support economy of scale considerations in deployment.

Generically the U.S. National ITS Architecture is structured by:

- User Services and User Service Requirements
- Logical Architecture
- Physical Architecture
- Market Packages

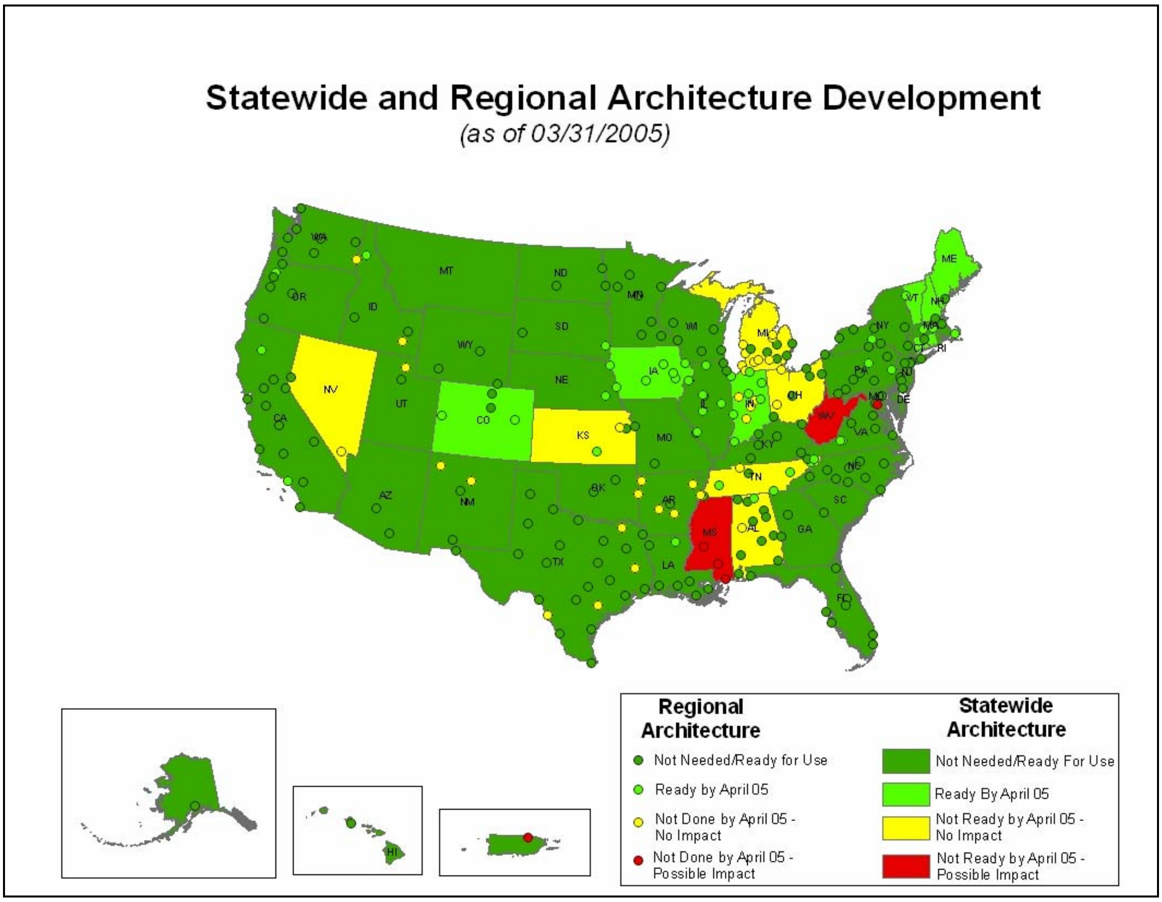
The latest release of U.S. National ITS Architecture, Version 5.1, incorporates the 33 User-Services. The latest changes are on the improvement of the coverage of transportation security in the National ITS Architecture. This is reflected by the inclusion of the New Disaster Response and Evacuation User Service.

5.3.3 Development and implementation

According to the Final Rule on ITS Architecture and Standards Conformity, Regions currently implementing ITS projects must have a regional ITS architecture in place by April 8, 2005. To facilitate this rule, the FHWA established the ITS Architecture Implementation program as part of the Facilitating Integrated ITS Deployment Program within the FHWA Office of Operations. The ITS Architecture Implementation program provides ITS practitioners with the guidance and resources necessary for develop, use and maintain a regional ITS architecture, and/or use a systems engineering process for ITS project development.

Supporting this program, the FHWA makes available to the Regions and States several guidance documentations, examples of successful cases, software tools and provides training for the different phases of implementation. The support effort included the development of the “Turbo Architecture” software tool to assist States and Regions in the development of their compliant ITS Architecture. Turbo Architecture is an interactive software application that assists transportation planners and system integrators, both in the public and private sectors, in the development of regional and project architectures using the National ITS Architecture as a starting point.

As of March 31, 2005, about 200 regional ITS architectures were in place in the U.S. Further 100 regional Architectures more were still in development. The following figure shows the regional ITS architecture development in the United States.



(source: http://www.ops.fhwa.dot.gov/its_arch_imp/regarch_map.htm)

For the past 5 years, the focus of the regional ITS architecture program has been on development. As of April 8, 2005, the Final Rule on ITS Architecture and Standards Conformity and the Final Policy on Architecture and Standards Conformity became effective and enacted by the FHWA and FTA respectively. The Final Rule / Final Policy are provided to ensure that the ITS projects carried out using funds from Highway Trust Fund and Mass Transit Fund to conform to the National ITS Architecture and applicable standards.

From that date forward, the focus of the ITS Architecture Implementation program will be on Regional Architectures use and maintenance. While tools will still be available to those that need help developing their Regional Architecture, most resources will be on using the Regional Architectures in the planning process, using the Regional Architectures in ITS project development, and an expanded systems engineering effort.

As part of the technical assistance program, FHWA ITS Deployment Team will be developing detailed content on targeted Regional Architecture topics. For instance, the topics of “Regional Architecture and Work Zones”, “Regional Architecture and Public Safety” and “Regional Architecture and Border issues”. The Architecture Implementation website will continue to be updated with the collection and share of best practices between regions and organizations involved in ITS deployment.

5.4 Europe

5.4.1 Background

Since the beginning of Europe’s unification, the European Union (EU) has been facing the challenge of mobility of people and goods through all their Members States. At the same time EU wants to ensure the reduction of transport pollution, increase safety on roads and encourage the use of sustainable modes of transport. EU recognizes that an important contribution can be made through the wide-scale deployment of Intelligent Transport Systems. To achieve the widespread deployment of ITS, it was identified the need for the establishment of a European ITS

Framework Architecture to support the various efforts in standardization, deployment plans and medium term investments.

The European Commission (European Union's policies implementer body) has been active in the field of system architecture since the very early stages of the Transport Telematics research programs in the early nineties. In 1998 the European research project KAREN (Keystone Architecture Required for European Networks) began gathering the experience available in Europe and the work accomplished by the many previous European initiatives. The first version of the European ITS Framework Architecture, released in the year 2000 by the KAREN Project, is already being used as a point of reference for work on national plans in various EU Member States, as well as the services provided by existing ITS systems deployed in Europe.

The first version of the European ITS Framework Architecture defines the underlying vision as being "the minimum stable framework necessary for the deployment of working and workable ITS within the European Union until 2010".

Following the completion of the KAREN project (1998-2000), which developed the first version of the European ITS Framework Architecture, the FRAME projects were initiated in 2000. The FRAME projects (FRamework Architecture Made for Europe) were a follow-on to the KAREN project which were funds by the European Commission. The aim of the FRAME projects was to promote the use of the Framework Architecture, provide support to users and to make any necessary updates and improvements to the Architecture. Version 3.0 of the European ITS Framework Architecture was issued in November

2004 which incorporates further improvements based on the updated requests and problem reports submitted by users of the ITS Framework Architecture.

5.4.2 Approach

The European ITS Framework Architecture has been developed, since the beginning, with the purpose of being used as a "tool-box" from which other ITS Architectures and/or systems specifications could be developed. It provides a framework for the development of ITS deployments at a national, regional or local level.

The European ITS Framework Architecture required also the inclusion of national plans (from EU Member States or other neighbor countries) and supports the various efforts in research, standardization, deployment and investment. It should also provide a migration plan, which incorporates and builds upon existing ‘legacy’ systems. This common Framework should provide specifications that enable:

- Compatibility of information delivered to end-users through different media;
- Compatibility of equipment with infrastructures, thus enabling seamless travel across Europe;
- A basis for regional, national and European authorities to produce master plans and recommendations to facilitate ITS deployment;
- An open market for services and equipment where compatible sub-systems are offered (no more ad-hoc solutions);

- Economies of scale in equipment manufacture permitting competitive prices and cheaper investments when compatibility is guaranteed; and
- A known market place into which producers can supply products with reduced financial risk.

The European ITS Framework Architecture is structured in to three main sets of information: User needs, Framework Architecture and Supporting Documents.

The "User Needs" are a structured and comprehensive list of high-level requirements of European Road transport telematics, and the interfaces with other modes until 2010 (European Policy milestone). The User Needs form the basis of the European ITS Framework Architecture.

The "Framework Architecture" expresses a System in number of ways. These are provided by the different parts of the Architecture, which are as follows:

- Functional Architecture: the functionality needed by the System to fulfill the User Needs.
- Physical Architecture: the way in which the functionality can be implemented as Applications to fulfill the User Needs. These Applications may also fulfill the User Needs in ways that cannot be expressed in functional terms, such as physical characteristics. They represent one way of creating Applications, there may of course be others, but the existence of these will depend on such things as implementation constraints for individual System.

- Communications Architecture: the links that enable data to be exchanged between the Applications in the Physical Architecture, and between the Applications and the outside World.

There is also a library of “Supporting Documents” available, including a several documents like “European ITS Cost Benefit Study”, “Deployment Approach and Scenarios, “Proposed Framework of Required Standards”, “Risk analysis for ITS architecture development”. These technical reports support the Architecture Users in different stages of development, implementation or promotion of their national and regional Architectures.

The main characteristics of European ITS Framework Architecture can be expressed as follows:

- Open - meaning that all suppliers, operators and users will be able to make use of what is in the Architecture. Put another way, the Architecture does not set out to exclude anyone;
- Multi-modal - the Architecture is designed to apply to all forms of road transport, not just the private car. There are also interfaces to other forms of transport that do not use the road. Examples are heavy rail, sea and air; and
- Technology Independent - there is no requirement or promotion of a particular technology within the Architecture. It does however promote the use of generic solutions for which several technologies are available.

5.4.3 Development and Implementation

In order to provide a continuation of activities after the release of the first version of the European ITS Framework Architecture, a Thematic Network was set-up as well as a few Supporting Measures. The Thematic Network is referred to as FRAME-NET and it is an initiative taken under the 5th Framework Programme of the DG Information Society of the European Commission. Its purpose is to continue and improve the structure adopted in the past by the KAREN project. The main activities performed within the FRAME project are as follows:

- Maintenance and specialist support to the European Architecture: the FRAME project team provides central support and a trouble-shooting function to help users with any difficulty they may encounter when using the European ITS Framework Architecture. Also several updates have been made to the European ITS Framework Architecture since its first release. The updates are based on the experience and feed back from the Architecture Users (mostly European countries), and periodical validation processes.
- Development of a Browsing Tool: this tool provides an HTML view of the European ITS Framework Architecture, enabling the Functional Viewpoint and part of the Trace Tables to be examined using a standard Internet Browser.
- Selection Tool: this tool helps users to create their own ITS architecture using the European ITS Framework Architecture as a basis.

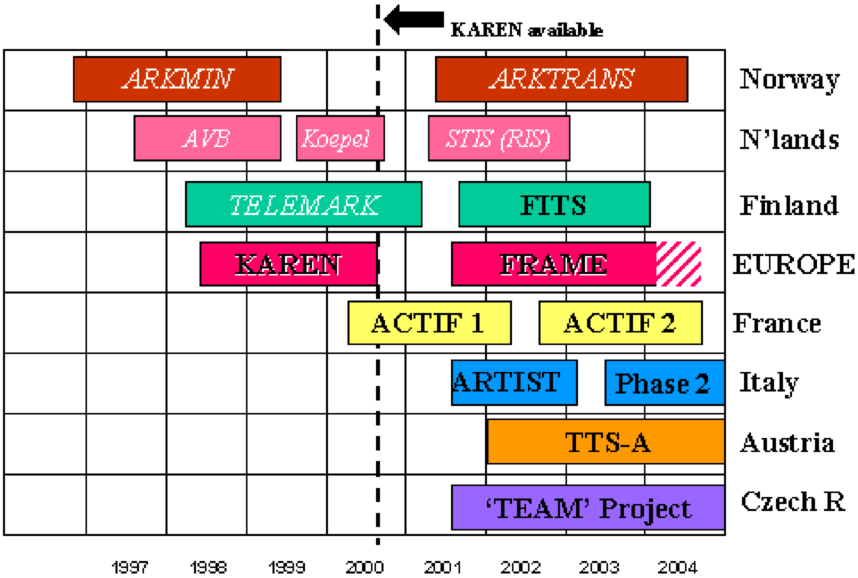
- Training and education: FRAME projects have been providing various training courses, technical seminars, etc., to raise awareness of the European ITS Framework Architecture at all levels among the organizations which are operating in the field of ITS.
- Dissemination: the goal is to promote the European ITS Framework Architecture and the results of its use. A promotional campaign was set up in order to reach the (national and regional) decision makers and communicate to them the new improvements, available results and success stories via website, brochures, papers at international conferences, workshops, etc.

Since the first version of the European ITS Framework Architecture was released in 2000, a growing number of countries in Europe have used it as a basis for the development of specific architectures at national, local or service specific levels. Currently users of the European ITS Framework Architecture include:

- Austria, TTS-A (since 2001)
- Czech Republic, TEAM project (since2001)
- Finland, TelemArk (partial compliance; since 1998)
- France, ACTIF 1 (since 2000)
- Hungary (in development stage)
- Italy, ARTIST (since 2001)
- Netherlands, AVB (partial compliance; since 1997)
- Norway, ARKTRANS (partial compliance; since 1996)
- Romania, (in development stage)

- Slovenia, (in development stage)
- Spain, (in development stage)
- Sweden, (in development stage)
- United Kingdom (no Architecture but several sectoral architectures have been developed)

The following figure shows the major national ITS architecture developments in Europe.



(source: http://www.frame-online.net/NationalArchs.htm#INVENTORY)

5.5 Japan

5.5.1 Background

Japan is one of first countries in the world to take on R&D for the Intelligent Transport Systems, inaugurated ITS work when the Ministry of International Trade and Industry started to develop CACS (Comprehensive Automobile traffic Control System) in 1973.

To promote the use of information technologies on roads, traffic and vehicles, five related government bodies (National Police Agency, Ministry of International, Trade and Industry, Ministry of Transport, Ministry of Posts and Telecommunications, and Ministry of Construction) jointly issued a "Comprehensive Plan for ITS in Japan" in July, 1996 and identified 20 main User Services. In November 1999, the five government bodies together with the VERTIS (Vehicle, Road and Traffic Intelligence Society council) formulated the “System Architecture for ITS” for Japan with 21 User Services.

5.5.2 Approach

The System Architecture for ITS in Japan represents the structure of the technology and sub-systems which composes the ITS. It plays an essential role in the process of designing and developing a system function as a whole. The System Architecture is structured by the following components:

- **User Services:** define services offered by ITS based on the users’ viewpoint, user situations and the information contents used in the services.

- **Logical Architecture:** specifies the functions provided by the systems and defines the interrelation of information with the given functions. It ensures the exchanges of information within the system share a common format.
- **Physical Architecture:** develops the optimum systems in terms of role of sharing between functions and information.
- **Standardization Candidate Areas:** defines areas of standardization for the interface between ITS elements

The National System Architecture applies the object-oriented analytical approach to ensure flexibility in response to changes in socioeconomic needs and technological advances.

5.5.3 Development and implementation

Application of ITS in Japan extends to a very wide range of functions, including ATC, ETC non-stop toll collection, expressway incident detection and management, traffic information dissemination systems by signs and radio, and the new AHS or Advanced Cruise-Assist Highway Systems.

The ITS development and deployment in Japan was categorized in to nine areas:

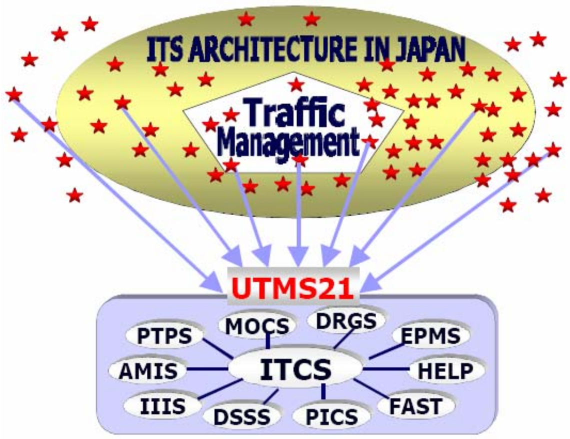
- Advances in navigation systems;
- Electronic toll collection systems;
- Assistance for safe driving;
- Optimization of traffic management;
- Increasing efficiency in road management;
- Support for public transport;
- Increasing efficiency in commercial vehicle operations;

- Support for pedestrians; and
- Support for emergency vehicle operations.

There are in total of 21 user services under the nine areas with 56 Specific User Services and 176 Specific User Sub-Services. Japan desires to implement and build upon these services by 2015.

Under the "Total Concept of Promoting Intelligent Transport System", each of the five government parties agrees to promote their own ITS programs based on the system architecture formulated and their respective administration duties. For instance, NPA (National Police Agency) is responsible for Traffic Management. They formed a committee, named UTMS (Universal Traffic Management Society) of Japan, who developed the UTMS21. The UTMS21 is a comprehensive Traffic Management system concept and structure, where the User Services and User Sub-Services categorized under Traffic Management has been further defined and constructed systematically in both logical and physical architecture levels. The UTMS21 has identified 10 projects listed as below, which are currently undergoing or has already been deployed:

- AMIS: Advanced Mobile Information Systems
- DRGS: Dynamic Route Guidance Systems
- DSSS: Driving Safety Support Systems
- EPMS: Environmental Protection Management Systems



(Sources: UTMS System Architecture by Koito Industries Co., Ltd and UTMS of Japan)

- FAST: Fast Emergency Vehicle Preemption Systems
- HELP: Help Systems for Emergency Life Saving and Public Safety
- IIIS: Intelligent Integrated ITV Systems
- ITCS: Integrated Traffic Control Systems
- MOCS: Mobile Operation Control Systems
- PTPS: Public Transportation Priority Systems

The UTMS will continue with the work and ensure that the approach and standard developed of the UTMS21 have a uniform conformity with the national system architecture.

5.6 Australia

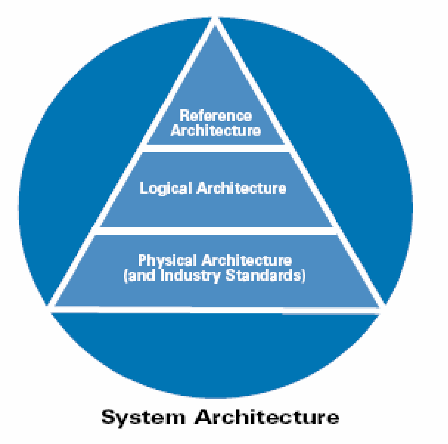
5.6.1 Background

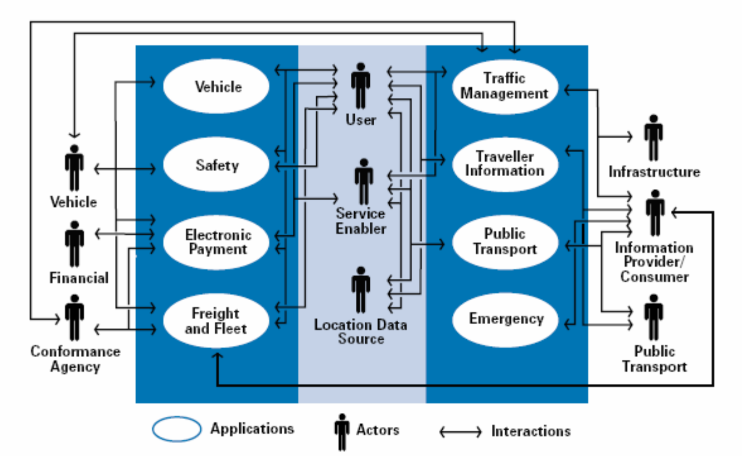
In 1999, ITS Australia initiated the process of developing a multi-modal National System Architecture for ITS based on one of key objectives recommended in the report, entitled "Intelligent Transport Solution for Australia: Technical Report" (ITSA, 1998a). The goal was to put further effort on standards and agreement for the ITS industry on a national architecture in order to facilitate the deployment of ITS applications in a more efficient and cost-effective manner in near future.

5.6.2 Approach

ITS Australia stated that the Australia System Architecture was defined based on the conceptual services of Transport Information and Control System (TICS) – Fundamental Services, ISO 1998a. The architecture considered both current and future applications. There are three steps in the architecture development process:

- **Reference Architecture:** guides the development of more tangible system architectures, an abstract, generic framework which captures the broad concepts and required inter-relationships of the specific system.
- **Logical Architecture:** elaborates upon the concepts and defines in more detail the inter-relationships between users and systems.
- **Physical Architecture:** describes in details how each module within the system interacts.





(Source: Summary Report "A National Reference Architecture for ITS in Australia, PPK Environment & Infrastructure)

The architecture employs three key concepts (i.e., APPLICATIONS, ACTORS, and INTERACTIONS) to describe the extent of the system and how it is intended to work. It also uses the UML (Unified Modelling Language) and CASE (Computer Aided Software Engineering) tools to clearly define the key concepts and effectively illustrate their inter-relationships in the architecture.

5.6.3 Development and implementation

In late 1999, a final report entitled "A National Reference Architecture for Intelligent Transport Systems (ITS)" was prepared for ITS Australia by a project team lead by PPK Environment & Infrastructure and the CSIRO. The report introduced the need of the System Architecture and documented the details of the architecture framework at the Reference Architecture level.

The Australia's System Architecture categorizes eight User Services with 32 Services. Based on this scope, the Physical Architecture maps the Logical Architecture into four physical systems (i.e., traveller, centre, roadside, and vehicle) and specifies the communication protocols and standards for supporting the exchange of information. The standards developed are based on the Logical Architecture level but they do deal with the information flows between ITS components. The System Architecture is added to the "toolbox" for national use.

5.7 Taiwan

5.7.1 Background

Following the National Science & Technology Meeting in 2001, the MOTC (Ministry of Transportation and Communications) launched the first ITS National Master Plan, identifying seven key ITS development areas.

To support the ITS National Master Plan, Taiwan developed and deployed an ITS System Architecture and a National Intelligent Transportation Infrastructure (NITI) in 2002. The ITS System Architecture is built to ensure the capability of data exchange between all national systems. The NITI is the foundation of all ITS services that allows the land transportation to be managed as a seamless, intermodal, multi-jurisdictional entity.

In mid 2002, Taiwan initiated the Six-Year National Development Plan, also known as "Challenge 2008". One of the objectives of the plan is to implement an e-Transportation program, which applies technology to improve utilization of current transportation systems and to develop advanced ITS technologies.

5.7.2 Approach

Similar to the approach of the U.S. ITS System Architecture, the Taiwan's ITS System Architecture deploys the same structure and methodology:

- User Services
- Logical Architectures
- Physical Architectures
- Communication Architectures
- Market packages

However, Taiwan's System Architecture is different from others because it was developed by using the "Structure Analysis and Design" method. Moreover, it employs Visual Basic's batch programs with Visio package program as the software development tools in considering better communication between different levels of organizations.

A common platform (in the form of software package and internet website browsing) was developed to help the ITS users to easily and effectively select the desired market package. The platform can automatically generate the minimum required ITS market packages for deployment purposes based on the users' specific needs.

5.7.3 Development and implementation

Since 2004, Taiwan has committed government funds of approximately NT$3 billion (US$91 million) to further develop the ITS System Architecture and establish the NITI. In 2004, the Institute of Transportation (IOT) under the MOTC, revised the ITS National Master Plan for 2004-2010 and increased the key development categories to nine ITS deployment areas with 35 services and 101 user sub-services:

- ATMS (Advanced Traffic Management Systems) Logical Architectures
- ATIS (Advanced Traveler Information Systems)
- APTS (Advanced Public Transportation Systems)
- AVCSS (Advanced Vehicle Control and Safety System)

- CVO (Commercial Vehicle Operations)
- EMS (Emergency Management System)
- EPS & ETC (Electronic Payment System & Electronic Toll Collection)
- IMS (Information Management System)
- VIPS (Vulnerable Individual Protection Services)

6. PROPOSED DESIGN APPROACH FOR MALAYSIA ITS SYSTEM ARCHITECTURE

6.1 Adoption of Canadian ITS Architecture

Based on the review of the international development of the ITS system architecture initiatives, it indicates that the Canadian ITS System Architecture not only closely resembles the Malaysian ITS architecture requirements and related user services, but also constitutes the latest ITS architecture development which consolidates the best results from international efforts. It will be used as the platform for the development of the Malaysian ITS System Architecture. The proposed architecture for Malaysia will be an alternative concept design to the Canadian ITS Architecture. In general, the Malaysian effort will subsume all the Canadian work and extend it to provide new services and areas of coverage.

6.2 Development Methodology

6.2.1 Approach

The Malaysian ITS System Architecture is a framework for developing and deploying ITS which consists of interconnected subsystems to the appropriate ITS functions. It has to be open and flexible to present unnecessary restriction to implementation choice and to accommodate the varied needs of the public and private sectors. At the same time, it should be sufficiently precise to ensure a transportation and communication system design that is compatible and interoperable nationwide.

The Malaysian ITS System Architecture will adopt the object-oriented analysis method which makes it easy to alternate or expand some parts of the architecture. It allows securing flexibility to meet future changes in social needs and development in technology.

Another popular method of building a System Architecture used to be the "structured analysis method" which analyzes and structures the functions necessary for realizing services. This method has been quite effective in analyzing large-scale systems, and has the advantage of requiring a relatively short time to design a System Architecture. The ITS System Architecture for Taiwan adopted this approach. However, since the structured analysis method does not systematically organize information processed in the system, it requires an enormous effort to organize new functions and to specify the information used in them when the system is changed and/or expanded. It also requires the revision of many functions, making it troublesome to correct the system.

In the meantime, the development of software engineering evolved the "object-oriented analysis method" which unifies functions and information and describes a target system with "objects" making it possible to create a unified model of information and functions within a system. Since the object-oriented analysis method organizes and structures information based on its similarities, it makes it easier to identify information in the structure by discerning information characteristics that are to be added and/or interchanged even when some services are added and/or changed. In this analysis method, functions and information processed in them are treated as a unit. The function and its related information to be added and/or changed are instantly detected. By deploying these distinctive qualities, it enables one to find the parts that need to be corrected relatively quickly as well as minimizing corrections. The object-oriented analysis method is therefore adopted for the Malaysian ITS System Architecture to make it easier to meet future changes in social needs and development in technology.

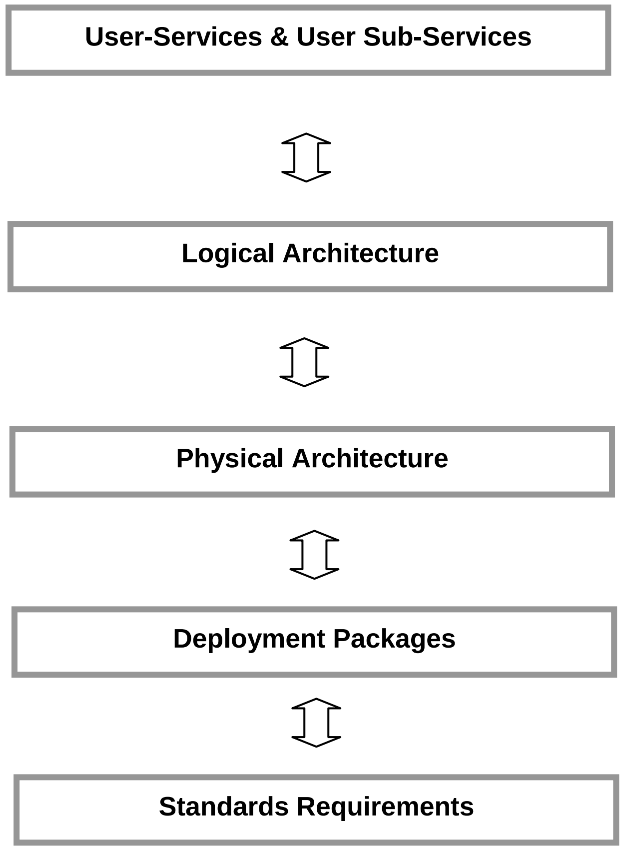
6.2.2 Language Issues

The official language in Malaysia is Bahasa Malaysia (Malay) but English is still widely used because of its importance as the language of international business. The common use of both languages can affect the format / content of the information exchange between the control centre and travellers. The need for providing multiple languages for traffic control applications may pose various issues such as: duplicate messaging requirements for center-traveller/vehicle communication, bilingual display requirement for roadside equipment and bilingual language requirements for center-to-center communication.

Road signs in Malaysia mainly use Malay, however both Malay and English languages are still in used for important direction signs such as airport and tourist places. Roadside equipment such as Dynamic Message Signs may have to be capable of displaying messages in both languages.

6.2.3 Development Procedures

The development methodology used to develop the Malaysian ITS System Architecture is illustrated in the following figure.



The procedures of constructing the Malaysian ITS System Architecture are as follows:

1. Define User-services and User Sub-services

   User-services define the ITS functions to be performed by its applications and together with the sub-services, they form the basis for the system architecture framework. They have been bundled into ITS sectors based on the areas of ITS application. Each user-service is subdivided into a set of constituent user sub-services. These sub-services are identified to allow the direct definition of the architecture support of the user-services. There are in total nine ITS sectors, thirty-six user-services and ninety-one user sub-services and they are presented in Appendix B.

2. Construct Logical Architecture

   Logical architecture represents a functional view of the user-services. It defines the functions or process specifications that are required to perform the ITS user-services and the information flows that need to be exchanged between these functions. The functional decomposition process begins by defining those elements that are inside the architecture and those that are not. For example, travelers are external to the architecture, but the equipment that is used to obtain the information is inside. The architecture defines the functions ITS must perform in support of a traveler's requirements, not the functions of the traveller.

3. Construct Physical Architecture

   Physical architecture identifies the physical subsystems, terminators and architecture flows between subsystems that will implement the processes and supports the data flows of the logical architecture. It further defines the terminator inputs and outputs for the architecture flows into and out of the system. The physical architecture takes the processes identified in the logical architecture and assigns them to subsystems. In addition, the data flows from the logical architecture are grouped into architecture flows in the physical architecture. There are twenty-three subsystems in the Malaysia ITS Architecture, which are grouped into four general subsystem classes: Centres, Roadside, Vehicles and Travellers. Terminators define the boundary of the architecture which represent the humans, environment and systems that interface to ITS.

4. Develop Deployment Packages

   Deployment packages provide an accessible deployment – oriented perspective to the ITS System Architecture. They are tailored to fit real world transportation problems and needs. They identify the pieces of physical architecture that are required to implement a particular user-service.

5. Prepare Standards Requirements

   Standard requirements are concrete specifications to ensure its objective of system interoperability, interchangeability and expandability. Applicable standards must be identified for ITS deployment.

APPENDIX A

LIST OF STAKEHOLDERS

Group 1: Government Agencies related to planning

− Department of Local Government, Malaysia
− Department of Survey and Mapping, Malaysia (JUPEM)
− Department of Town and Country Planning, Malaysia
− Economic Planning Unit, Malaysia (EPU)
− Economic Planning Unit, Sarawak
− Federal Territory Development and Klang Valley Planning Division
− Government Task Force on Integration of Public Transport in Klang Valley
− Implementation & Coordination Unit, Malaysia (ICU)
− Institut Tanah dan Ukur Negara (INSTUN)
− ITS Council
− Jabatan Perancangan Bandar dan Desa, Sabah
− Jabatan Tanah dan Ukur, Sabah
− Jabatan Tanah dan Ukur, Sarawak
− Kementerian Pembangunan Infrastruktur dan Perhubungan, Sarawak
− Kementerian Alam Sekitar dan Kesihatan Awam, Sarawak
− Malaysia Communications and Multimedia Commission (MCMC)
− Malaysian Administrative Modernisation & Management Planning Unit, Malaysia (MAMPU)
− Malaysian Administrative Modernisation & Management Planning Unit (MAMPU), Cawangan Sabah
− Malaysian Industry-Government Group for High Technology (MIGHT)
− Ministry of Finance, Malaysia (MOF)
− Ministry of Transport, Malaysia (MOT)
− National Infrastructure for Land Information System (NALIS)
− Road Safety Council, Malaysia

Group 2: Government Agencies related to regulating and enforcement

- Commercial Vehicle Licensing Board, Malaysia
- Commercial Vehicle Licensing Board, Sarawak
- Department of Railways, Malaysia
- Department of Telecommunications, Malaysia
- Jabatan Bomba dan Penyelamat Malaysia, Negeri Sabah
- Jabatan Kerja Raya Sabah
- Jabatan Kerja Raya Sarawak
- Jabatan Kerja Raya Malaysia (Cawangan Jalan)
- Lembaga Lebuhraya Malaysia (LLM)
- Ministry of Culture, Arts and Tourism
- Polis Di Raja Malaysia (IT & Technology Division)
- Pesuruhjaya Polis Negeri Sabah
- Pesuruhjaya Polis Negeri Sarawak
- Road Transport Department, Malaysia
- Road Transport Department, Sabah
- Road Transport Department, Sarawak
- SIRIM Berhad
- Malaysian Science and Technology Information Center (MASTIC)
- Multimedia Development Corporation (MDC)

Group 3: Highway Concessionaires

- Besraya (M) Sdn Bhd
- Express Lingkaran Tengah Sdn Bhd (ELITE)
- Grand Saga Sdn Bhd
- Guthrie Corridor Expressway Sdn Bhd
- Kaseh Lebuhraya Sdn Bhd
- Kesas Sdn Bhd
- KLBK Sdn Bhd (Butterworth-Kulim Highway)
- Konsortium Lapangan Kerjaya Sdn Bhd
- Konsortium Lebuhraya Utara Timur (KL) Sdn Bhd
- Lebuhraya Shahpadu Sdn Bhd
- Lingkaran Transkota Sdn Bhd (LDP)
- Linkedua (Malaysia) Berhad
- Metramac Corporation Sdn Bhd
- MTD Prime Sdn Bhd
- New Pantai Expressway Sdn Bhd (NPE)
- Penang Bridge Sdn Bhd
- Projek Lebuhraya Utara-Selatan Berhad (PLUS)
- Projek Lintasan Kota Sdn Bhd (AKLEH)
- Seremban-Port Dickson Highway Sdn Bhd
- Sistem Lingkaran Lebuhraya Kajang Sdn Bhd (SILK)
- Sistem Penyuraian Trafik KL Barat Sdn Bhd (SPRINT)

Group 4: Local Authorities

- Dewan Bandaraya Kuala Lumpur (DBKL)
- Dewan Bandaraya Kuching Utara
- Majlis Bandaraya Ipoh
- Majlis Bandaraya Johor Bahru
- Majlis Bandaraya Kota Kinabalu
- Majlis Bandaraya Kuching Selatan
- Majlis Bandaraya Shah Alam (MBSA)
- Majlis Perbandaran Ampang Jaya (MPAJ)
- Majlis Perbandaran Johor Bahru Tengah
- Majlis Perbandaran Kajang
- Majlis Perbandaran Klang
- Majlis Perbandaran Padawan
- Majlis Perbandaran Petaling Jaya (MPPJ)
- Majlis Perbandaran Pulau Pinang (MPPP)
- Majlis Perbandaran Sandakan
- Majlis Perbandaran Seberang Perai
- Majlis Perbandaran Selayang
- Majlis Perbandaran Subang Jaya (MPSJ)
- Majlis Perbandaran Tawau
- Perbadanan Labuan
- Perbadanan Putrajaya
- Putrajaya Holdings Sdn Bhd
- Setia Haruman Sdn Bhd

Group 5: Transport Operators

- Airport Limo Malaysia Sdn Bhd
- Container Hauliers Association of Malaysia
- Express Bus Operators Association (PEMBAWA)
- Express Rail Link Sdn Bhd (ERL)
- Federation of Freight Forwarders Malaysia
- Intrakota Consolidated Sdn Bhd
- Keretapi Tanah Melayu Berhad (KTMB)
- KL Monorail System Sdn Bhd
- Kenderaan Klang Banting Bhd
- Konsortium Transnasional
- Kuching Hire Lorry Association
- Malaysia Airports Berhad (MAB)
- Malaysia Taxi/Limousine & Hired Car Drivers & Operators Association
- Metrobus Nationwide Sdn Bhd
- Pan Malaysia Bus Operators Association
- Pan Malaysia Lorry Operators Association
- Park May Berhad
- Persatuan Radio Teksi Wilayah Persekutuan & Selangor
- Persatuan Teksi Bahagian Kuching
- Persatuan Teksi Bumiputera, Bahagian Kuching
- Sabah State Railway
- Sarawak Bus Transport Companies Association
- Securicor (Malaysia) Sdn Bhd
- Syarikat Pasaran Negara Berhad (PUTRA-LRT)
- Syarikat Pasaran Negara Berhad (STAR-LRT)
- The Tuaran United Transport Co Sdn Bhd
- Triton Commuter Sdn Bhd

Group 6: ICT Service Providers

- Binariang Satellite Systems Sdn Bhd
- Celcom Timur (Sarawak) Sdn Bhd
- Cellular Communications Network (M) Sdn Bhd
- DiGi Telecommunications Sdn Bhd
- Easy Call Sdn Bhd
- Electcoms Sdn Bhd
- Hutchinson Paging Sdn Bhd
- Maxis Communication Berhad
- Maxis Mobile Sdn Bhd
- Mimos Berhad
- Persatuan Industri Komputer dan Multimedia Malaysia (PIKOM)
- Telekom Malaysia Berhad (TMB)
- Time Engineering Berhad
- Time dotCom Berhad
- Time Wireless Sdn Bhd

Group 7: Commercial Institutions

- Automobile Association of Malaysia (AAM)
- Edaran Modenas Sdn Bhd
- Malaysian Motor Traders Association
- Malaysian Technology Development Corporation Sdn Bhd (MTDC)
- Perodua Manufacturing Sdn Bhd
- Proton Berhad
- Rangkaian Segar Sdn Bhd

Group 8: Institutions of Higher Learning

- Institut Kerja Raya Malaysia (IKRAM)
- Institut Sultan Iskandar Shah
- Malaysia Multimedia University (MMU)
- Malaysia University of Science and Technology (MUST)
- Malaysian Institute of Planners
- Road Engineering Association of Malaysia (REAM)
- The Institution of Engineers, Malaysia (IEM)
- Universiti Kebangsaan Malaysia (UKM)
- Universiti Malaysia Sabah
- Universiti Malaysia Sarawak
- Universiti Putra Malaysia (UPM)
- Universiti Sains Malaysia (USM)
- Universiti Teknologi Malaysia (UTM)
- Universiti Teknologi Mara (UiTM)

APPENDIX B

ITS SECTORS, USER-SERVICES AND USER SUB-SERVICES

Sector No.1: Advanced Traffic Management Systems

1.1	**Urban Traffic Control**	*1.1.1*	*Traffic Network Flow Monitoring*
		1.1.2	*Surface Street Control*
		1.1.3	*Highway Control*
		1.1.4	*Regional Traffic Control*
		1.1.5	*Traffic Information Dissemination*
		1.1.6	*Virtual TMC*
		1.1.7	*Probe-Based Flow Monitoring*
		1.1.8	*Traffic Estimation and Prediction*
1.2	**Incident Detection and Management**	*1.2.1*	*Incident Management Co-ordination*
		1.2.2	*Incident Prediction System*
1.3	**Travel Demand Management**	*1.3.1*	*High Occupancy Vehicle Lane Management*
		1.3.2	*Reversible Lane Management*
		1.3.3	*Predictive Demand Management*
1.4	**Environmental Conditions Management**	*1.4.1*	*Roadway Environmental Sensing*
		1.4.2	*Emissions Management*
		1.4.3	*Road Weather Information System*
		1.4.4	*Vehicle-Based Sensing*
1.5	**Operations and Maintenance**	*1.5.1*	*Infrastructure Maintenance Management*
		1.5.2	*Smart Work Zones*
1.6	**Non-Vehicular Road User Safety**	*1.6.1*	*Mixed Use Warning Systems*
		1.6.2	*Automated Non-Vehicular Road User Protection*
1.7	**Multi-Modal Junction Safety and Control**	*1.7.1*	*Basic At-Grade Crossing Control*
		1.7.2	*Advanced At-Grade Crossing*
		1.7.3	*Modal Operations Co-ordination*

Sector No.2: Safety Systems

2.1	**Improved Accident Data Collection**	*2.1.1*	*Accident Data Management*

2.2	**Automated Dynamic Warning and Enforcement**	*2.2.1*	*Dynamic Roadway Warning*
		2.2.2	*Variable Speed Limit and Enforcement*
		2.2.3	*Signal Enforcement*

Sector No.3: Advanced Public Transport Systems

3.1	**Public Transport Operations Management**	*3.1.1*	*Transit Vehicle Tracking*
		3.1.2	*Transit Fixed-Route Operations*
		3.1.3	*Passenger and Fare Management*
		3.1.4	*Transit Maintenance*
		3.1.5	*Multi-Modal Co-ordination*
		3.1.6	*Multi-Modal Connection Protection*
3.2	**Public Transport En-Route Transit Information**	*3.2.1*	*En-Route Transit Information*
3.3	**Demand Responsive Transit**	*3.3.1*	*Demand Responsive Transit*
3.4	**Public Travel Security**	*3.4.1*	*Public Travel Security*

Sector No.4: Advanced Traveller Information Systems

4.1	**Pre-Trip Traveller Information**	*4.1.1*	*Broadcast Traveller Information*
		4.1.2	*Interactive Traveller Information*
		4.1.3	*Real-Time Ridesharing Information*
4.2	**Route Guidance and Navigation**	*4.2.1*	*Autonomous Route Guidance*
		4.2.2	*Dynamic Route Guidance*
		4.2.3	*ISP-Based Route Guidance*
		4.2.4	*Traffic Estimation and Prediction*
		4.2.5	*In-Vehicle Signing*
4.3	**Ride Matching and Reservation**	*4.3.1*	*Ride Matching*
		4.3.2	*Real-Time Ride Matching*
4.4	**Traveller Services and Reservations**	*4.4.1*	*Traveller Yellow Pages*
		4.4.2	*Services Purchases and Reservations*
		4.4.3	*Parking Facility Management*
		4.4.4	*Regional Parking Management*

Sector No.5: Electronic Payment Systems

5.1	**Electronic Payment Services**	*5.1.1*	*Electronic Toll Collection*
		5.1.2	*Electronic Parking Payment*
		5.1.3	*Transit Services Payment*
		5.1.4	*Traveller Services Payment*

Sector No.6: Commercial Vehicle Operations Systems

6.1	**Commercial Fleet Management**	*6.1.1*	*Fleet Administration*
		6.1.2	*Freight Administration*
		6.1.3	*CVO Fleet Maintenance.*
6.2	**Commercial Freight Management**	*6.2.1*	*Freight In-Transit Monitoring*
		6.2.2	*Intermodal Interface Management*
6.3	**Commercial Vehicle Electronic Clearance**	*6.3.1*	*Electronic Clearance*
		6.3.2	*International Border Crossing Clearance*
		6.3.3	*Weigh-In-Motion (WIM)*
6.4	**Automated Roadside Safety Inspection**	*6.4.1*	*Inspection Support Systems*
		6.4.2	*Automated Vehicle Safety Read Out*
6.5	**On-board Safety Monitoring**	*6.5.1*	*On-Board Safety Monitoring*
6.6	**Commercial Vehicle Administrative Processes**	*6.6.1*	*Commercial Vehicle Administrative Processes*

Sector No.7: Advanced Vehicle Control Systems

7.1	**Vehicle-Based Collision Avoidance**	*7.1.1*	*Lateral Warning Systems*
		7.1.2	*Lateral Collision Avoidance*
		7.1.3	*Longitudinal Warning Systems*
		7.1.4	*Longitudinal Collision Avoidance*
7.2	**Infrastructure-Based Collision Avoidance**	*7.2.1*	*Intersection Collision Warning*
		7.2.2	*Intersection Collision Avoidance*
7.3	**Sensor-Based Driving Safety Enhancement**	*7.3.1*	*Sensor-Based Driving Safety Enhancement*
7.4	**Safety Readiness**	*7.4.1*	*Vehicle Safety Monitoring*
		7.4.2	*Driver Safety Monitoring*
7.5	**Pre-Collision Restraint Deployment**	*7.5.1*	*Pre-Collision Restraint Deployment*
7.6	**Automated Vehicle Operation**	*7.6.1*	*Automated Vehicle Operation*

Sector No.8: Emergency Management Systems			
8.1	**Emergency Notification and Personal Security**	*8.1.1*	*Personal Security*
		8.1.2	*MAYDAY Support*
8.2	**Hazardous Material Planning and Incident Response**	*8.2.1*	*Hazardous Material Planning and Incident Response*
8.3	**Disaster Response and Management**	*8.3.1*	*Disaster Command and Control*
		8.3.2	*Disaster Information Dissemination*
8.4	**Emergency Vehicle Management**	*8.4.1*	*Emergency Response Management*
		8.4.2	Emergency Vehicle Routing

Sector No.9: Information Warehousing Systems			
9.1	**Weather and Environmental Data Management**	*9.1.1*	*Roadway and Weather Data Fusion*
		9.1.2	*Environmental Information Dissemination*
		9.1.3	*Roadway Meso and Micro Prediction*
9.2	**Archived Data Management**	*9.2.1*	*Archived Data Mart*
		9.2.2	*Archived Data Warehouse*
		9.2.3	*Archived Data Virtual Warehouse*