System Architecture for ITS in JAPAN

November, 1999

National Police Agency
Ministry of International Trade and Industry
Ministry of Transport
Ministry of Posts and Telecommunications
Ministry of Construction

Preface

Modern society is becoming increasingly information-oriented at the global level, and the road traffic is no exception. Also in Japan, the use of information technologies on roads, traffic and vehicles are being promoted in order to solve such problems as traffic accidents, congestion and the environmental deterioration , as well as to meet the market-expansion needs of the automobile industry, the information and communication industry and other industries.

To promote the use of information technologies on roads, traffic and vehicles, the 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 finalized a "Comprehensive Plan for ITS in Japan" in July, 1996, which is based on the "Basic Guidelines for the Promotion of an Advanced Information and Telecommunications Society" (determined by the Advanced Information and Telecommunications Society Promotion Headquarters in February, 1996). They also demonstrated a long-term vision of basic ideas on ITS development, implementation and User Services in which ITS will be promoted systematically and efficiently from the users' view point, and promoted in Japan based on the Comprehensive Plan in cooperation with industrial and academic sectors.

Given this history, the practical use and R&D of each specific system of ITS have been further accelerated in recent years in Japan. At the same time, the five government bodies recognized the need to create a grand design which was more detailed than the long-term vision in order to efficiently realize an integrated, highly expandable ITS system to respond to changes in social needs and development in technology in the future. In August 1999, the five government bodies organized a draft copy entitled “System Architecture for ITS.” Subsequently, the draft was released so as to collect opinions from a broad range of the industrial and academic sectors and to actively address information overseas.

Recently “System Architecture for ITS” has been composed.

It is our hope to continue promoting ITS-related projects through extensive cooperation among the five government bodies with the industrial and academic sectors as well as other nations targeting an early and efficient realization of diverse ITS services based on the comprehensive plan and System Architecture.

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National Police Agency
Ministry of International Trade and Industry
Ministry of Transport
Ministry of Posts and Telecommunications
Ministry of Construction

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Volume I Guidelines for Constructing the System Architecture

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Chapter1　Background of Constructing the System Architecture

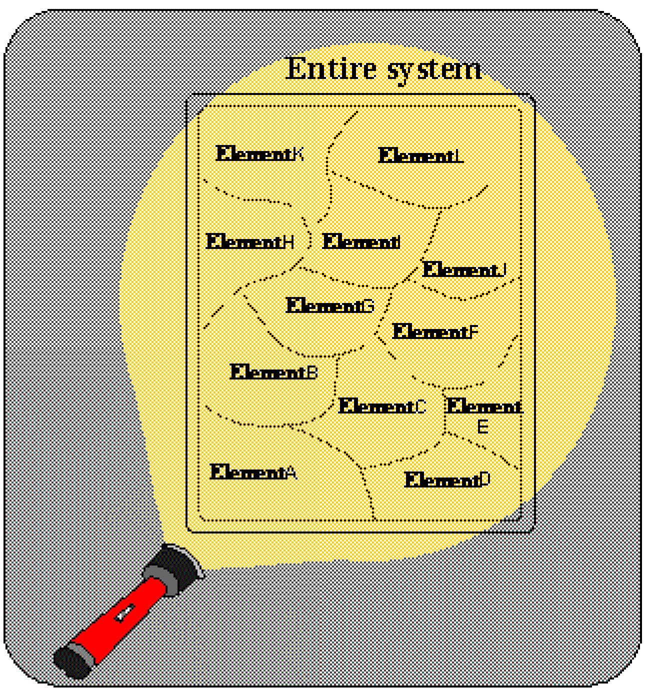
1.1 What is System Architecture?

In the late 20th century, man started to conduct large-scale projects with advanced and diverse purposes. At the same time, we saw dramatic improvements in the element technologies essential to realizing such projects. The most significant ones are information processing technologies including computers, and the information and telecommunication technologies which achieved digital communications. By combining information processing technologies and information and telecommunication technologies, man built large-scale systems with advanced and diverse purposes.

Such large-scale systems are made possible by associating diverse technologies that compose the systems in many ways. Therefore, when building a system, it is important to create a common awareness of the overall image among the parties involved, and promote the efficient realization of an integrated system. When building a large-scale system that consists of diverse technologies, we usually organize a structure for the entire system in advance, and then develop specific systems conforming to the structure.

System Architecture is a structure for the entire system that illustrates component elements (technologies and specific systems) and their relation to each other. It is essential for designing and developing a system that works as a whole.

Fig. 1. 1-1　What is system architecture? (concept)



*** System Architecture is like a picture that shows multiple elements of the system and how they relate to each other in the frame as a system, and provides an overall picture of the system.**

1.2 History and Current Situation of ITS in Japan

(1) History of Constructing the "Comprehensive Plan for ITS in Japan"

Japan, one of first countries in the world to take on R&D for the Intelligent Transport Systems (abbreviated ITS), inaugurated ITS work when the Ministry of International Trade and Industry started to develop CACS (Comprehensive Automobile traffic Control System) in 1973. Later, in the 1980s, the Ministry of Construction came out with RACS (Road/Automobile Communication System) and the National Police Agency with AMTICS (Advanced Mobile Traffic Information and Communication System), which led to VICS (Vehicle Information and Communication System) in cooperation with the Ministry of Posts and Communications which had been developing and standardizing radio wave systems. From the late 1980s to early 1990s, these government bodies promoted projects such as ARTS (Advanced Road Transportation Systems by the Ministry of Construction), SSVS (Super Smart Vehicle System by the Ministry of International Trade and Industry), ASV (Advanced Safety Vehicle by the Ministry of Transport), and UTMS (Universal Traffic Management Systems by the National Police Agency).

At the same time, the academic and industrial sectors organized the Vehicle, Road and Traffic Intelligence Society (abbreviated VERTIS), which worked closely with ITS America and ERTICO in various ITS-related activities including information exchanges with the secretariat of the World Congress on ITS and ITS-related organizations in North America and European countries. Private firms are also actively involved in forming ITS markets and launching products for the car navigation system that uses GPS based on digital road maps developed jointly by the government and the private sector.

Thus, Japan has been actively involved in the R&D of specific technologies that could become ITS core technologies. In the process, it became clear that since ITS would affect broad areas of road, traffic, vehicles and information and telecommunications, it would be necessary to work with people in various fields, promote ITS based on international exchanges, and provide User Services to meet their needs.

In February, 1995, the Advanced Information Telecommunications Society Promotion Headquarters headed by the Prime Minister determined the "Basic Guidelines for the Promotion of an Advanced Information and Telecommunications Society". And in August, 1995, the five related government bodies compiled the "Basic Government Guidelines for Advanced Information and Communications in the fields of Roads, Traffic and Vehicles," and started to apply those guidelines to development and practical issues such as selecting nine areas for ITS development as a basic ITS structure. In this climate, in July, 1996, the five government bodies compiled a "Comprehensive Plan for ITS in Japan" which is a long-term vision of ITS's goals regarding 20 User Services and development and implementation, so that the government bodies can maintain close ties with each other and promote ITS systematically and efficiently from the users' point of view.

(2) Towards the realization of ITS

While constructing the "Comprehensive Plan for ITS in Japan," Japan has seen active movement toward the practical use of specific systems such as VICS, ETC (Electronic Toll Collection System) and UTMS. The five government bodies have been involved in another ITS-related possibility focusing on local communities; to promote the ITS model regional experiment project by supporting model ITS regional experiments conducted by municipalities in cooperation with VERTIS, and sending out information on these examples to other municipalities in order to promote an ITS that is more closely tied to local communities.

At the same time, private firms launched products such as car navigation systems designed to receive information by cellular phone as well as other systems to maintain appropriate distance between cars by radar.

Thus, Japan has put some systems into practical use and accelerated other systems for practical use. However, there are difficulties in designing and developing specific systems effectively and efficiently such as a lack of the big picture of the large-scale system composed of diverse technologies, and unclear information and the necessary capacity to build a practical system based on the "Comprehensive Plan for ITS in Japan" which outlines 20 User Services.

1.3 International Trends Related to the System Architecture

(1) Trends in the U.S.A.

In America, the Department of Transportation (DOT) plays a major role. In September, 1993, DOT started a 33-month program to develop a System Architecture. In Phases I and II, several private sectors examined System Architecture designs before publishing the approximately 5000-page National System Architecture in the summer of 1996.

In the National System Architecture design, America not only promoted standardization activities, notification and PR activities based on the architecture, but also deployed actual systems and continues to maintain the National System Architecture.

As for the standardization activities, they presented 12 standardization requirements such as standardization of DSRC (Dedicated Short Range Communication) in the National System Architecture. Later in July, 1996, they published the ITS Five-Year Standardization Plan with a list of 44 priority standardization articles including communication rules between systems.

As for notification and PR activities, America not only actively publicizes its National System Architecture both in and outside of the country, but also continues to promote seminars for local governments and private firms. With the idea of making practical use of ITS within the structure of the National System Architecture in local regions, the DOT finalized "Building the ITI" in order to propose the launch of ITI (Intelligent Transportation Infrastructure) in January, 1996. Based on the MDI (Model Deployment Initiative) decided on in October, 1996, America is promoting the preparation of an ITS infrastructure based on the National System Architecture in the four metropolitan areas of Phoenix, Seattle, San Antonio, and New York/New Jersey/Connecticut.

The TEA-21 (Transportation Equity Act for the 21st Century), which controls the budget for domestic surface transportation, assigns subsidies for the deployment project of ITS on condition of preparing systems based on the National System Architecture.

Fig. 1.3-1 System Architecture-Based ITS Promotion in America

Summer 1996
National System Architecture completed.

January, 1996
Launch of Intelligent Transportation Infrastructure (ITI) proposed

Standardization

- National System Architecture presents 12 standardization requirements including DSRC.
- July, 1996, ITS Five-Year Standardization Plan publicized. (44 priority standardization articles are listed).

Notification and PR activities

- They actively notify private firms and local governments of National System Architecture achievements and application methods of ITS promotion.

ITS Deployment

- October, 1996, Model Deployment Initiative (MDI) was decided. (Four metropolitan areas including Phoenix and Seattle are established.)
- TEA-21 assigns subsidies for the deployment project on condition of preparing systems based on the National System Architecture

(2) Trends in Europe

In Europe, the European Commission (EC) is in charge. As a task force of DRIVE II (Dedicated Road Infrastructure for Vehicle Safety in Europe II), whose purpose was to increase safety and transportation efficiency and to decrease the effects on the environment by improving infrastructure, they formed SATIN (System Architecture and Traffic Control Integration) in 1994 to examine methods to build a System Architecture related to road traffic.

After completing DRIVE II, the EC started T-TAP (Transport-Telematics Application Programme). One of its activities is CONVERGE, methods to examine System Architecture. They reformed the methods examined in SATIN, and added a method of System Architecture for railways, water transport, airways and other transportation besides road traffic after study and preparation.

Thus, the EC, which conducted R&D mainly on methods of building System Architecture, applied the research results of the methods to building a Pan-European System Architecture for KAREN (Keystone Architecture Required for European Networks).

Fig. 1.3-2 Flowchart of System Architecture examination in Europe

1.SATIN (1994 - 1996)
The Task Force SATIN was formed to examine methods for road traffic-related system architecture to be constructed in Europe

⇩

2.CONVERGE (1996 - 1997)
The methods of the SATIN projects were revised to add and apply architecture methods to railway, water transportation and airway systems.

⇩

3.KAREN (1998 -)
Building a Pan-European system architecture was started based on methods developed in SATIN and CONVREGE.

1.4 Necessities for Constructing the System Architecture

After formulated "The Comprehensive Plan for ITS in Japan," specific ITS, which is comprised of diverse specific systems, has been actively put into practical use or under preparation. Therefore, in order to build concrete systems based on "The Comprehensive Plan for ITS in Japan" which conformed to 20 User Services, it is necessary to clarify the position of each specific system in the entire ITS and to develop designs considering the necessities for each specific system in relation to the entire ITS as well as common areas shared among other specific systems and the timing of putting those systems into practical use. To achieve this, it will be necessary to promote an understanding of the entire ITS by ITS-related people in industry and academic sectors and all users, and to show them the systematic development of ITS.

At the same time, other countries, such as America, are strategically promoting ITS considering the future development of overall ITS by formulating System Architecture and applying it to ITS standardization activities, notification/PR activities, deployment and so forth.

Japan should also make ITS an integrated system, build it efficiently, and develop it as a highly expandable system that corresponds to future changes in social needs and development in technology.

Also, Japan’s original system architecture (framework) has to be constructed in order to realize, in the global expansion of ITS environment, the original User Services which respond to Japan’s own natural and social environment. Japan’s original System Architecture needs to be based on the clear recognition and distinction between parts that should be standardized to foreign System Architecture and parts that is peculiar to Japan.

Therefore, in order to secure system integration and systems-building efficiency in integration and building of the system during the process of promoting its actual building, it is necessary to consider the role of the specific systems in ITS when designing specific systems, share information and functions in the systems, and utilize such information and functions as a platform for developing systems. In order to secure system expandability, it is necessary to systematically organize information and functions in the systems, and make the interface and other elements in the systems interchangeable. Furthermore, it is also necessary to signify the system information and functions to be shared as Standardization Candidate Areas so as to effectively and efficiently participate in national and international standardization activities.

Now that Japan is striving to implement the service contents and basic concepts of the system presented in "The Comprehensive Plan for ITS in Japan" and acknowledges the necessity of System Architecture this commitment has been published in order to efficiently build integrated systems, secure expandability of systems, and assure promotion of national and international standardization activities.

Chapter2　Concept for Constructing the System Architecture

2.1　Purpose of Constructing the System Architecture

The purpose of constructing theSystem Architecture for ITS is: 1) to build an integrated system efficiently, 2) to secure expandability of the system, and 3) to promote national and international standardization.

By building an integrated system which makes the system compact, users will have diverse applications such as carrying the system wherever they go, and they will be less burdened by a system that can replace the operations and the judgment users used to make. Another advantage is that building an efficient ITS and sharing common information and functions can avoid duplicate investment. Thus, fair costs will be offered because a common infrastructure enables manufacturers to easily participate and to become multiple vendors of device supply.

At the same time, by securing expandability of the systems, it will be easier to alternate and add information and functions due to changes in social needs and development in technology, as well as toadd systems due to the increase of User Services and the expansion of user service areas.

Furthermore, by comparing currently promoted standardization tests to candidate areas of standardization, and by clarifying duplicates and areas not yet examined for standardization, it will help decide priorities in standardization work in standardization-related institutions. And it will be more realistic to efficiently build an integrated system in Japan and to secure expandability of the system in the process of global ITS development.

Thus, by constructing System Architecture to achieve the requirements of 1) to 3) and building a system based on it, it will be possible to promote ITS more efficiently and effectively. Another advantage is that building an efficient ITS and sharing common information and functions can avoid duplicate invest. Also, making a common infrastructure enables to secure the opportunities for the creation of new markets and participation of various size of businesses, and to offer fair costs involved in multiple vendors in instrument procurement.

2.2 Concept for Constructing the System Architecture

(1) Procedure of constructing the System Architecture

The procedure of constructing the System Architecture is: 1) to define the details of User Services, 2) to construct the Logical Architecture, 3) to construct the Physical Architecture, and 4) to prepare Standardization Candidate Areas.

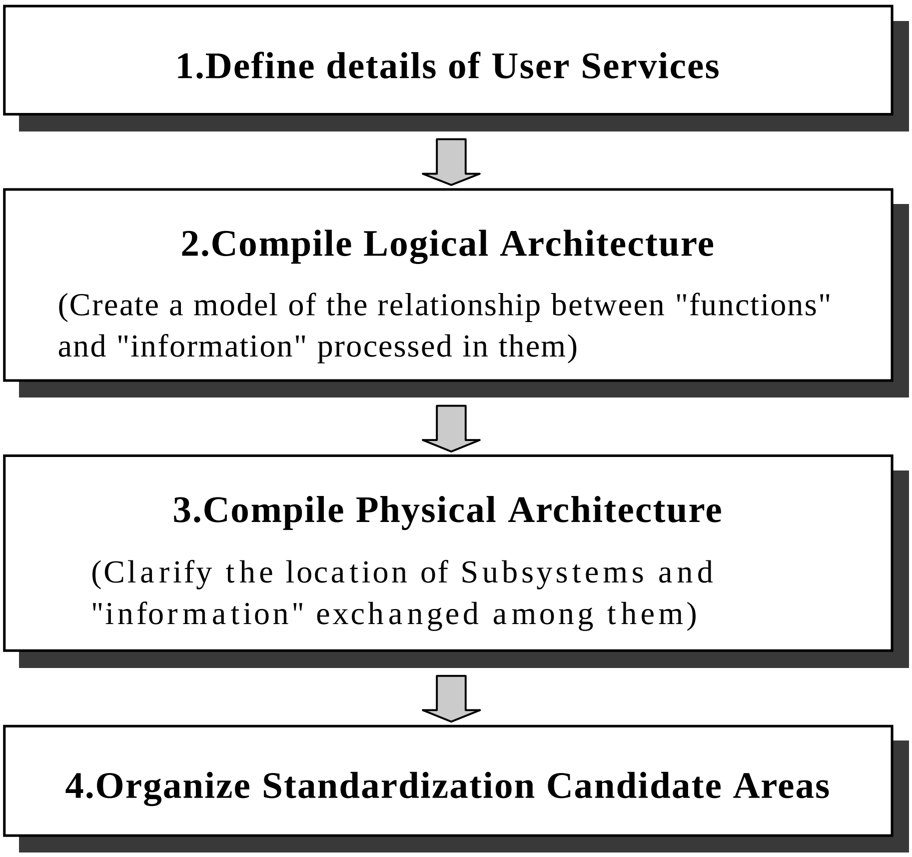
The first to be implemented, "1) to define the details of User Services" means to define detail contents of User Services to be analyzed in constructing Logical Architecture. To be more concrete, we defined "purpose" and "contents" of Specific User Sub-services. In this definition, User Services were subdivided into 172 detailed Specific User Sub-services. Also, Specific User Services were established as median organizing units between User Services and Specific User Sub-services and ITS services are systemized into four ITS service levels including development. The System Architecture for ITS should be constructed based on defined detail Specific User Sub-services. That way, the System Architecture constructing Logical and Physical Architecture, which are prepared after examining the entire sub-services will not be in the user service category that is a structure of subsidizing services into sub-services.

The second to be implemented, "2) to construct the Logical Architecture", means to clarify information sent and received between users and systems and processed in the systems in order to offer each Specific User Sub-service; to take out "information" and "functions" while processing to systematize the "information," and to create a model of the relationship between the "functions" necessary to offer services and "information" processed in the function by using a common form.

"3) To construct the Physical Architecture" is to make a common combination of "functions" taken out in the Logical Architecture and "information" processed in the functions among Specific User Sub-services in order to integrate the entire system; to distribute those combinations to cars, roadside and centers in order to create a model of the entire system to realize ITS.

"4) To prepare Standardization Candidate Areas" is to place all of the 24 subsystems, one of the achievements of the Physical Architecture, and four communication systems in the areas (Standardization Candidate Areas) to be standardized. This process is shown in the subsystems interconnect diagram. The subsystems evaluated based on the "degree of sharing Specific User Sub-services" and the communication points used in the subsystems is summarized. Its goal is to support the priority decision-making of standardization activities by standardization-related institutions.

Fig. 2.2-1 Procedure of constructing the System Architecture for ITS

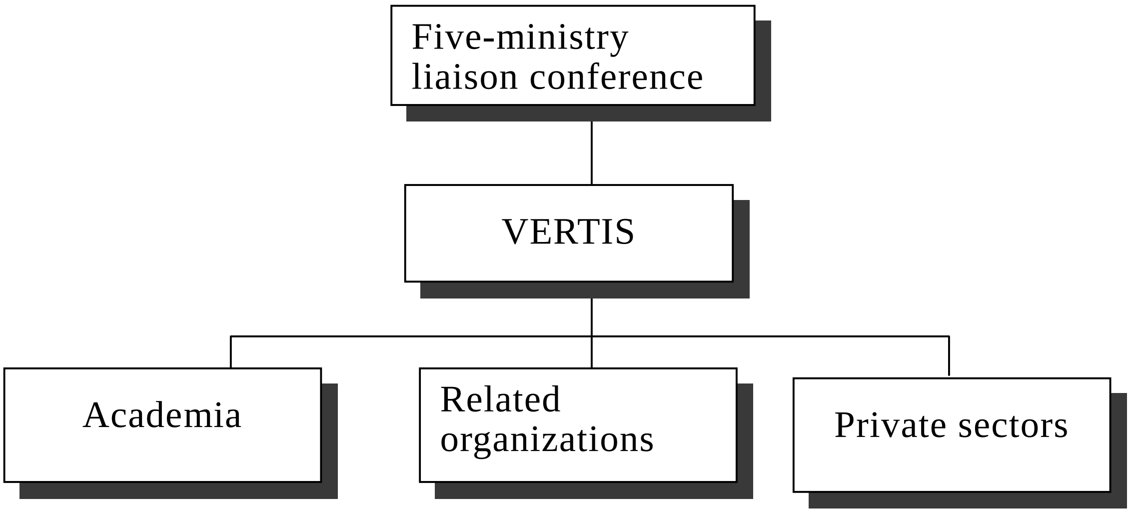


(2) Structure to compile system architecture

It was decided that the five government bodies would compile the System Architecture for ITS in cooperation with VERTIS. In the process, the construction work was inaugurated in January 1998 and the draft was organized in August 1999. Subsequently, the draft was released so as to collect opinions from a broad range of the industrial and academic sectors and to actively address information overseas, In November 1999, the process was completed as “System Architecture for ITS.”

The System Architecture for ITS will be revised occasionally in case the upper plans such as “Comprehensive Plan for ITS in Japan” is revised and conditions of ITS promotion changes, such as rapid progress in element technology related to ITS.

Fig. 2.2-2   Structure for constructing the System Architecture



Volume II Achievements of Constructing the System Architecture

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Chapter1 Achievements of Constructing the System Architecture

1.1 Varieties of Achievements of Constructing the System Architecture

The achievements of constructing the System Architecture are composed of four sections: to define detailed User Services, to construct a Logical Architecture, to construct a Physical Architecture, and to organize Standardization Candidate Areas.

The three major achievements from the definition of detailed User Services are as follows: a "user service structure chart" which systematically describe Specific User Services and Specific User Sub-services under nine areas for development and 21 User Services; a "sub-service definition" which describes the "purpose" and "contents" of Specific User Sub-services, and a "definition sheet of sub-service details" which describes the capabilities necessary for realizing each Specific User Sub-service as well as target areas besides "sub-service definition."

The two major achievements of constructing a Logical Architecture are as follows: an "information model" which represents all the information processed in ITS as a layer-structure system, and a "control model" described in a common form, which represents the relationship between the "functions" necessary to offer services and the "information" processed in the functions.

The three major achievements of constructing a Physical Architecture are as follows: a "Physical Model for Each Specific User Sub-servicess" which clarifies the structure of systems offering Specific User Sub-services; a "Physical Model for the Entire System" which clarifies the entire system for realizing ITS; a "sub-systems diagram" which is prepared for the purpose of an overview of the structure of the entire system.

The major achievements of organizing Standardization Candidate Areas are: 24 subsystems and 4 communication points, shown in the Sub-Systems Interconnect Diagram, which is placed in the area to be standardized. The selected 11 sub-systems and one communication point that determine the priority of standardization activities in institutions related to standardization.

1.2 Characteristics of the System Architecture

In constructing a System Architecture, the following two points were emphasized: 1) securing flexibility to meet changes in social needs and development in technology; 2) securing compatibility and interconnectibility with an advanced information and telecommunication society.

(1) Securing flexibility to meet Changes in Social Needs and Technological Development

Since ITS is a project which targets a wide range of roads, traffic, vehicles, information and telecommunication and others, it is possible only when the five government bodies cooperate as well as the industrial-academic sectors. It is expected that technological development in information and telecommunications and computer-related fields will be further accelerated. In the process of realizing ITS, it is also expected that technological development will bring out new needs and that current user needs will change due to fundamental changes in society, environment and economy.

To secure flexibility to meet changes in social needs and technological development, efforts were made by programming System Architecture to maintain its original functions and also by partially changing/expanding System Architecture in the cace of future changes in social needs and development in technology.

(2) Secure compatibility and interconnectibility with an advanced information and telecommunication society

"The Comprehensive Plan for ITS in Japan" presented the following two points: The Advanced Information and Telecommunication Society is an information-oriented society in many fields including ITS; and it is important to link ITS and many other information-oriented fields. Specifically, in order to realize an advanced information and telecommunication society, it is essential to prepare an information telecommunication infrastructure such as optical fibers, to make intelligent roads and vehicles which are terminals for receiving and transmitting information, and to improve information contents. We made it clear that, in promoting ITS, it is important to look over a wide range of areas which and the areas that need to integrate with ITS into the Advanced Information and Telecommunication Society, and to secure compatibility and interconnectibility in infrastructures not only within ITS areas but other areas to harmonize with ITS, terminals to receive and to transmit information and its contents.

In recent years in Japan, private firms offer users information in fields other than roads, traffic and vehicles through ITS-related services belonging to an area which needs to harmonize with ITS. Therefore, it is becoming increasingly necessary to secure compatibility and interconnectibility among different areas for the Advanced Information and Telecommunication Society and areas that need to harmonize with ITS. Given this background, we made efforts to secure compatibility and interconnectibility with an advanced information and telecommunication society in constructing System Architecture for ITS.

1.3 Ideas for Achieving Characteristics

(1) Ideas for securing flexibility to meet Changes in Social Needs and Technological Development

The System Architecture for ITS adopted the object-oriented analysis method which makes it easy to alternate/expand some parts of the System Architecture. It allows to secure flexibility to meet future changes in social needs and development in technology and to occasionally revise the architecture to meet changes in ITS promotion situations.

A 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. 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 and so forth 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 minimizng corrections.

In constructing the System Architecture for ITS, we adopted the object-oriented analysis method to make it easier to meet future changes in social needs and development in technology.

As for the object-oriented analysis method, worldwide software engineering specialists have been developing different languages, and are now gradually standardizing them to a UML (Unified Modeling Language). Given this situation, we decided to use the UML for the ITS System Architecture. Incidentally, when discussing the standardization propositions given by member nations, the ISO/TC204 WG1 (System Architecture sub-committee) has been examining System Architecture as a common basis of discussion in order to clarify where the plan for the entire ITS system stands. In this examination, UML from the object-oriented analysis method, and real time structuring from the structured analysis method are proposed as different languages.

Fig. 1.3-1 Characteristics of the structured analysis method and the object-oriented analysis method

	Characteristics
Structured Analysis Method	-It has long use history and has much satisfactory result -It analyzes and organizes "functions" in the definition of User Services. -It is bothersome to alternate the functions.
Object-oriented Analysis Method	-Method improved and evolved from the structured analysis method -It describes a target system with "objects" that unify "functions" and "information" processed in the functions. -It excels in interchangeability and expansion

By adopting the construction method used here, compared to other methods, it becomes possible to smoothly proceed the evaluation of coordination among systems, upon evaluating in details the particular infrastructure related to road traffic and communications, specific system which composes ITS, and specific instruments related to the System Architecture.

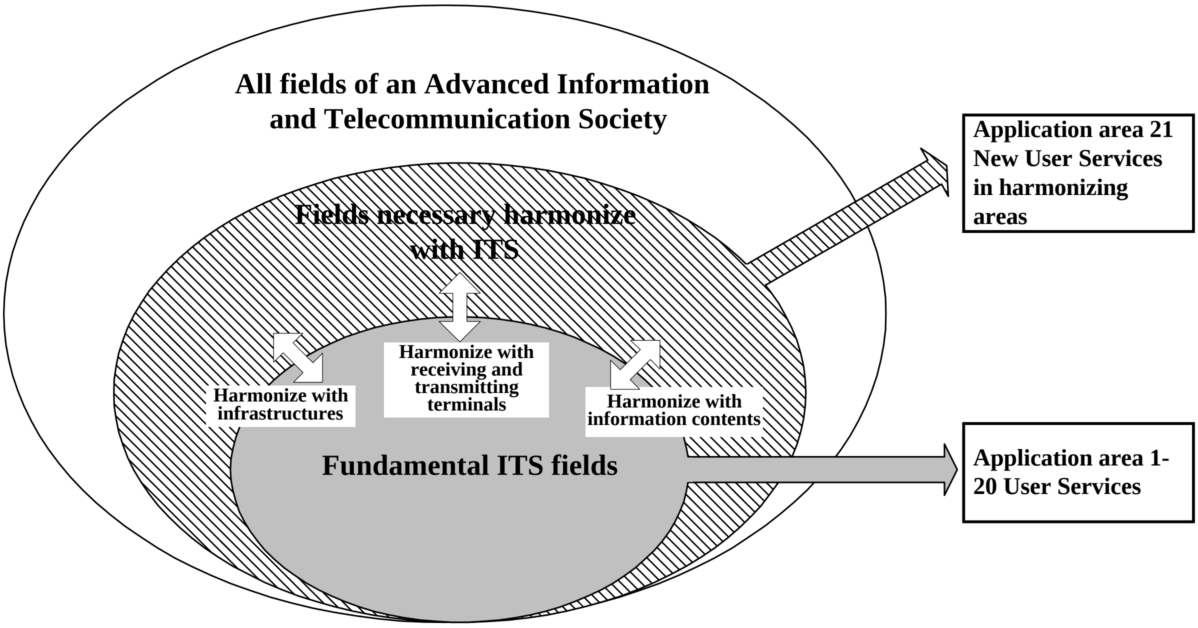
(2) Ideas for securing compatibility and interconnectibility with an advanced information and telecommunication society

"The Comprehensive Plan for ITS in Japan" signifies 20 User Services which clearly show a society realized in the fundamental fields of roads, traffic, and vehicles. And it also declares the important principle of securing compatibility and interconnectibility with all the fields of an advanced information and telecommunication society.

In constructing the System Architecture for ITS, it is necessary to clarify the overall system structure to build the system, while keeping these 20 User Services and the principle in mind. When building the system, it is necessary to include a mechanism within it in order to secure compatibility and interconnectibility with all the fields of the Advanced Information and Telecommunication Society.

Therefore, in order to secure the second characteristic, which is the compatibility and the interconnectibility with the Advanced Information and Telecommunication Society, we established a 21st user service which defines a society to be realized in the fields necessary to ITS. Then, after defining the detailed Specific User Sub-services, just as the 20 User Services were defined, we designed the System Architecture. This will achieve the system's compatibility and interconnectibility with the Advanced Information and Telecommunication Society.

Fig. 1.3-2 User service application areas in all the fields of an Advanced Information and Telecommunication Society



Chapter2 Detailed Definition of User Services

2.1 What is a Detailed Definition of User Services?

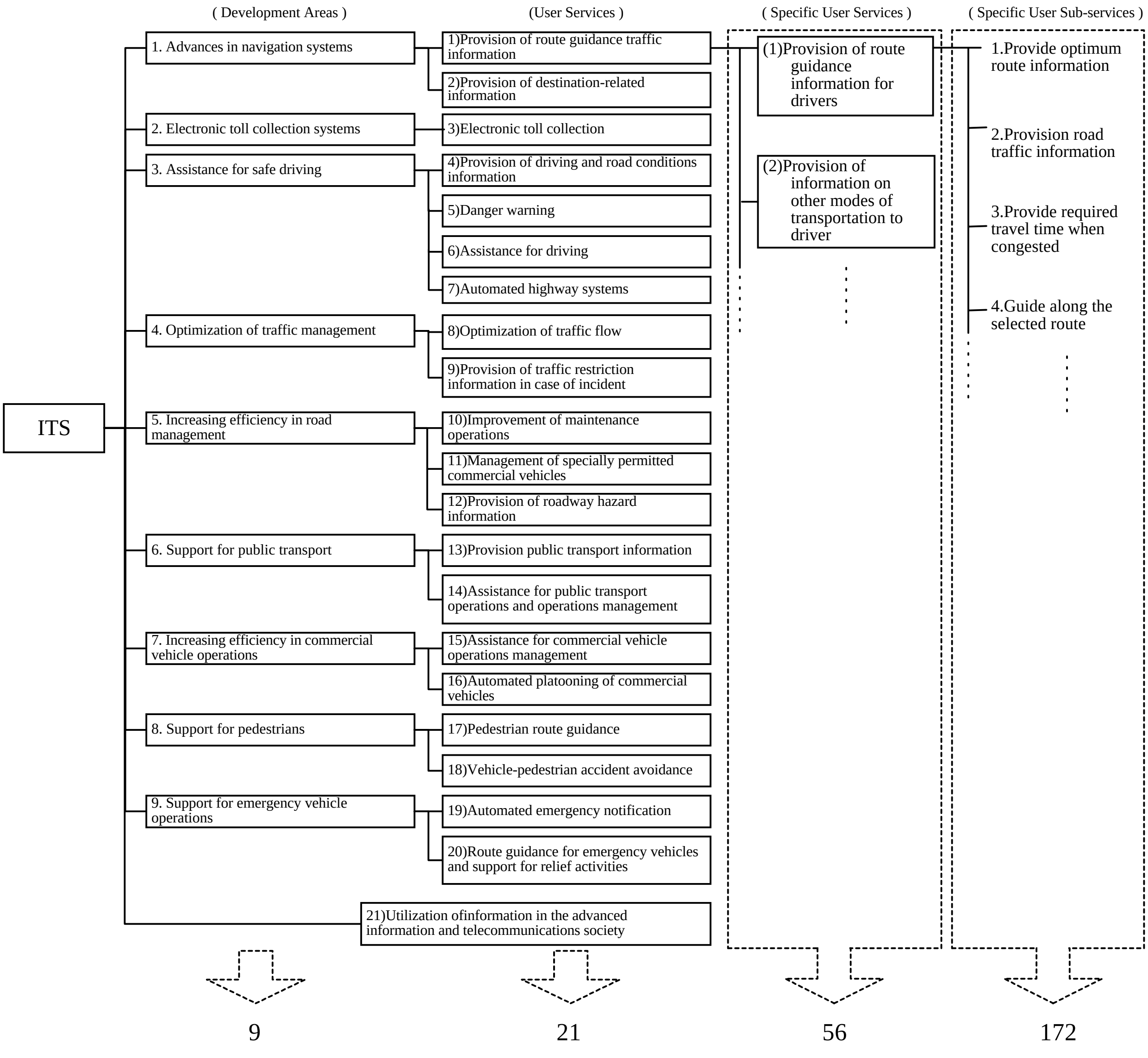
A detailed definition of User Services means subdividing the 20 User Services specified in "The Comprehensive Plan for ITS in Japan" and the newly added 21st user service from users' viewpoint, user situations, and the information contents used in the services in order to illustrate the flow for each situation of service provision from collecting to processing the information which is required by users. These subdivided User Services are called Specific User Sub-services. When constructing a logical System Architecture, a detailed definition of Specific User Sub-services means describing the "purpose" and functions of the sub-services and "contents" which summarize the information used for the sub-services in order to extract information received and transmitted between users and the system as well as processes in the system.

We established Specific User Services as a median unit which makes it possible to include sub-services between User Services and Specific User Sub-services.

2.2 Structure of ITS User Services

Based on a detailed definition of User Services, 56 Specific User Services and 172 Specific User Sub-services are systematically organized under the nine developmental areas and 21 User Services.

Fig. 2.2-1 Overall structure of User Services that influenced constructing a System Architecture



The following shows the structure of Specific User Sub-Services in each of the nine development areas.

Fig. 2.2-2 User service scheme for constructing System Architecture (Advances in navigation systems)

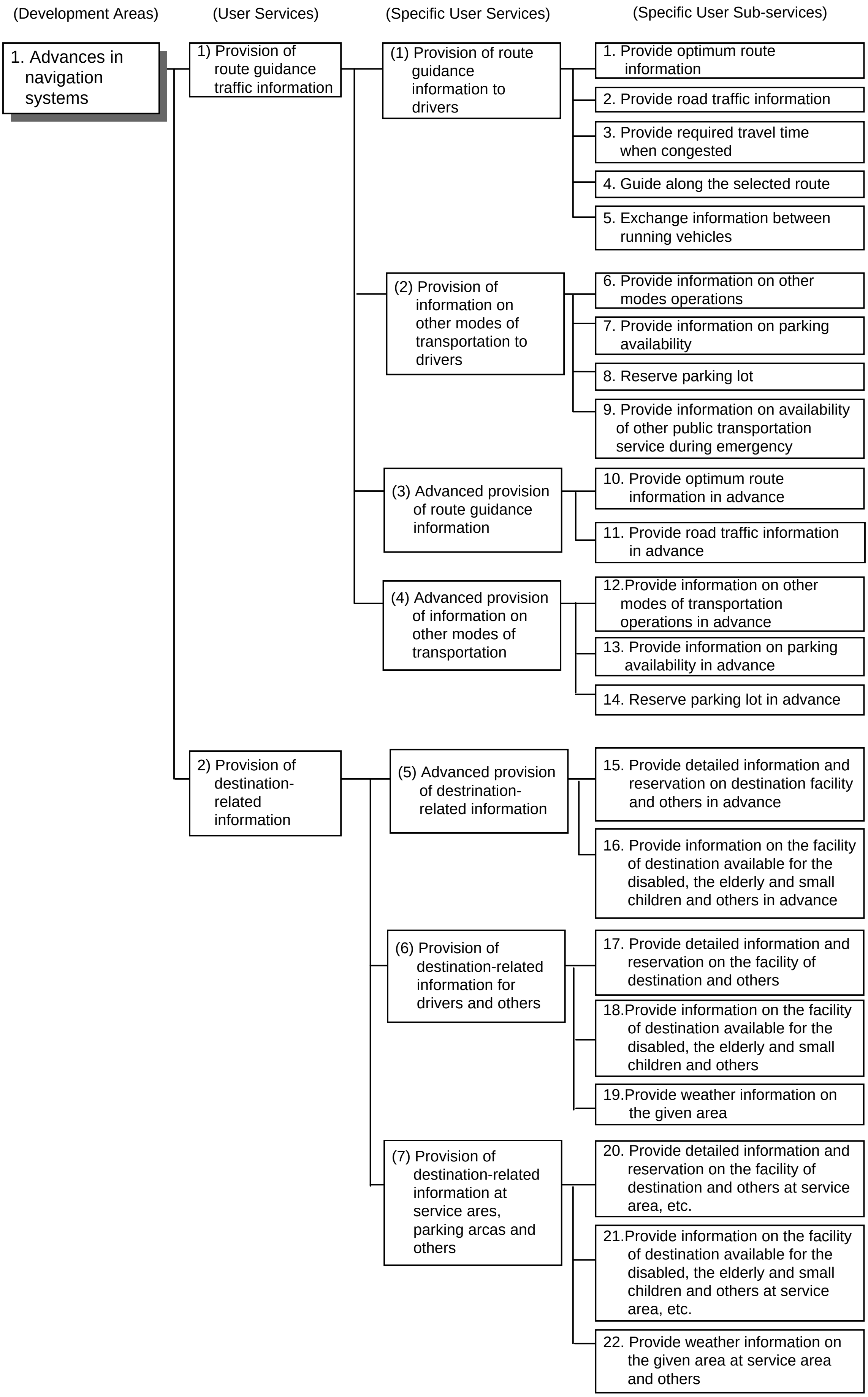


Fig. 2.2-3 User service scheme for constructing System Architecture (Electronic toll collection systems)

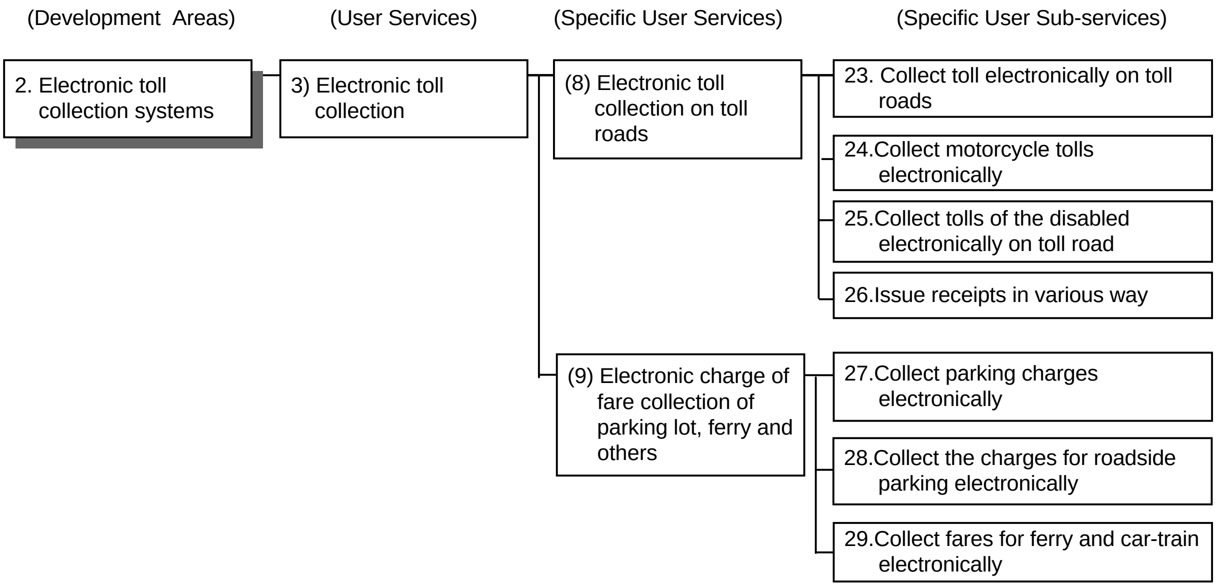


Fig. 2.2-4 User service scheme for constructing System Architecture (Assistance for safe driving)

(Development Areas) — (User Services) — (Specific User Services) — (Specific User Sub-services)

- 3. Assistance for safe driving
  - 4) Provision of driving and road conditions information
    - (10) Provision of information on road conditions
      - 30.Provide weather information
      - 31.Provide information on road surface condition
      - 32.Provide information on road alignment
    - (11) Provision of information on vehicles in the vicinity and others
      - 33.Provide information on obstacles ahead and behind
      - 34.Provide information on vehicles passing in another lane
      - 35. Provide information on intersection in city
      - 36.Provide information on vehicles in the vicinity on expressway
      - 37. Provide information on railroad-crossing
      - 38. Provide information on traffic signals and others
  - 5) Danger warning
    - (12) Danger warning of vehicles ahead and others
      - 39. Warn of danger due to road alignment and others
      - 40. Warn of danger due to vehicles ahead and following
      - 41. Warn of danger due to obstacles or pedestrians
    - (13) Danger warning of vehicles in neighboring area and others
      - 42. Warn of danger due to changing lanes
      - 43.Warn of vehicles lane departure
    - (14) Danger warning of vehicles crossing ahead and others
      - 44.Warn of danger at intersection
      - 45. Warn of danger at merging or demerging section
    - (15) Danger warning of condition of drivers or vehicles
      - 46.Warn a driver of danger
      - 47.Warn vehicles in the vicinity of danger
  - 6) Assistance for driving
    - (16) Asistance for driving against danger due to vehicles ahead and others
      - 48.Assist driving against danger due to road alignment and others
      - 49.Assist driving against danger due to vehicles ahead and following
      - 50.Assist driving against danger due to obstacles or pedestrians
      - 51.Assist driving to maintain space with a leading vehicles and to maintain specified speed
      - 52.Assist stopping vehicles during emergency stops
    - (17) Assistance for driving against danger due to vehicles in neighboring area and others
      - 53.Assist driving when changing lanes
      - 54.Assist driving when changing lanes
    - (18) Assistance for driving against danger due to vehicles crossing ahead and others
      - 55.Assist driving at intersection
      - 56.Assist driving when merging or demerging
    - (19) Assistance for driving against in driver's unusual situations
      - 57.Assist drivers when driving in abnormal conditions
  - 7) Automated highway systems
    - (20) Automated cruise of general vehicles
      - 58.Cruise automatically in dedicated lane
      - 59.Cruise automatically when congested
      - 60.Cruise automatically through a long tunnel
      - 61.Cruise automatically in harsh weather
      - 62.Park automatically in parking lot
    - (21) Automated cruize of service vehicles
      - 63.Cruise service vehicles automatically
      - 64.Cruise snowplow automatically

Fig. 2.2-5 User service scheme for constructing System Architecture (Optimization of traffic management)

(Development Areas) → (User Services) → (Specific User Services) → (Specific User Sub-services)

- 4. Optimization of traffic management
  - 8) Optimization of traffic flow
    - (22) Assistance for traffic management planning
      - 65.Assist traffic management planning for wide-area
      - 66.Assist traffic management planning for local area
      - 67.Assist decision-making process on traffic management
      - 68.Collect and provide basic information on traffic demand management
    - (23)Assistance for traffic management and traffic management facility operations
      - 69.Analyze and evaluate traffic restriction plans
      - 70.Assist operation and maintenance of traffic control facility
      - 71.Assist design and installation of traffic control facility
      - 72.Assist advancement for road usage approval operation
    - (24) Assistance for parking policy and others
      - 73.Provide guidance to parking lots
      - 74.Conduct traffic control suitable for residential zone
      - 75.Assist efficiency of illegal parking enforcement
      - 76.Assist parking control plan
      - 77.Control traffic to maintain environment along roads
    - (25) Advancement of driver assistance
      - 78.Advance driver assistance
      - 79.Assist in planning and recording of vehicles operations
    - (26)Assistance for police activities
      - 80.Discover and retrieve the theft vehicles
      - 81.Improve management of police vehicles
      - 82.Assist police activities
    - (27) Maintenance of traffic order
      - 83.Improve conducting after accident procedure
      - 84.Advance analyzation of accident results
      - 85.Make operational recording automatically
      - 86.Detect, warn and prevent dangerous driving control
    - (28) Optimization of traffic signal control
      - 87.Control traffic signal at an intersection
      - 88.Control traffic signal at arterial roads
      - 89.Control wide-area traffic
      - 90.Control traffic signals at railroad crossing
      - 91.Control corresponding to a lane
    - (29)Route guidance
      - 92.Guide a route corresponding to the needs to traffic management
      - 93.Guide to a lane corresponding to a vehicle type
    - (30) Dynamic lane control
      - 94.Reversible lane control
      - 95.Control bus lane dynamically
      - 96.Control bicycle lane dynamically
      - 97.Control lanes allowed for parking
      - 98.Control one-way driving dynamically
  - 9) Provision of traffic restriction information in case of incident
    - (31) Assistance for traffic management under usual conditions
      - 99.Manage traffic when disaster occurs
      - 100.Manage traffic under atypical traffic conditions
      - 101.Manage traffic under unusual weather
      - 102.Manage traffic under atypicall traffic conditions

Fig. 2.2-6 User service scheme for constructing System Architecture (Increasing efficiency in road management)

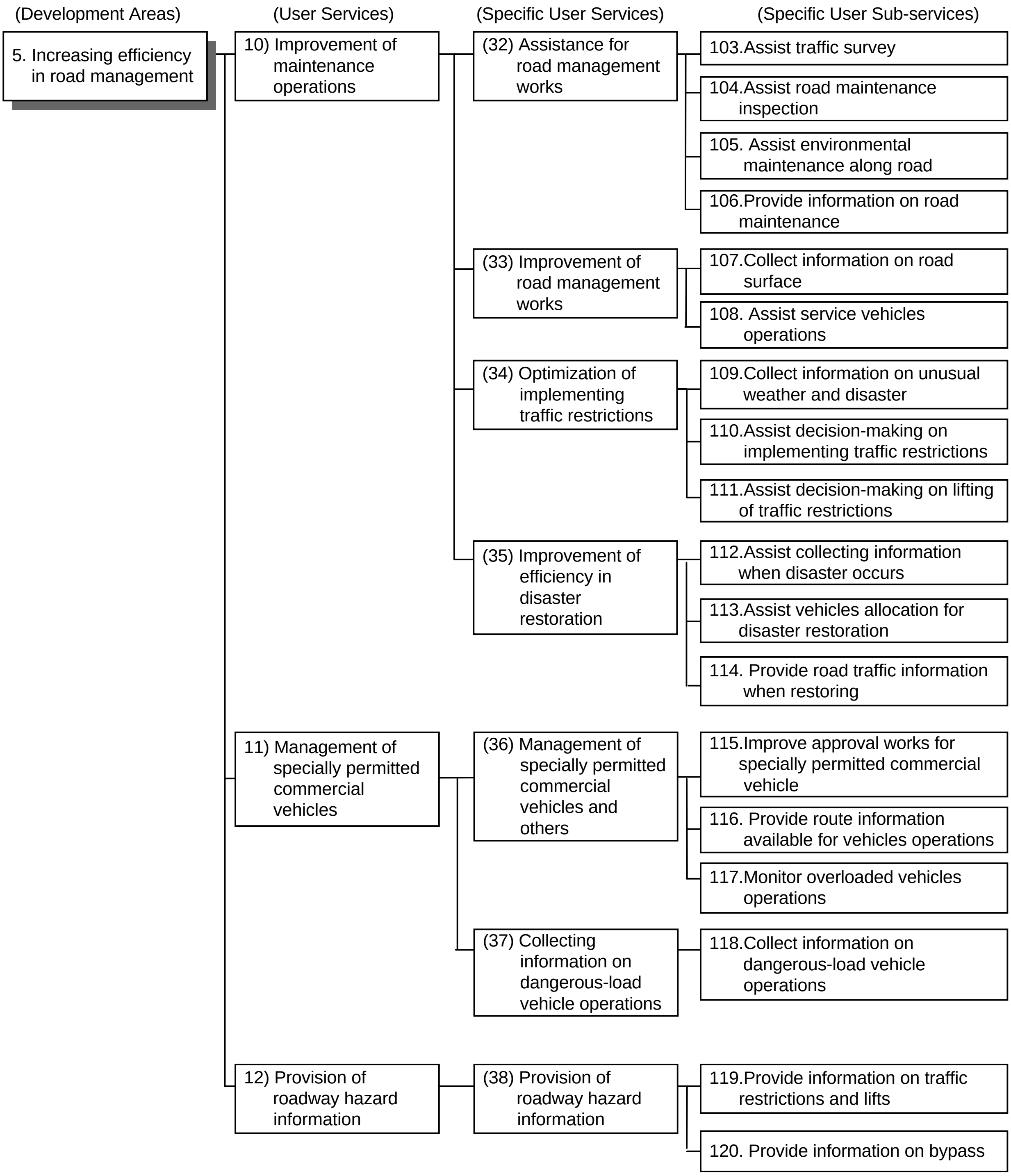


Fig. 2.2-7 User service scheme for constructing System Architecture (Support for public transport)

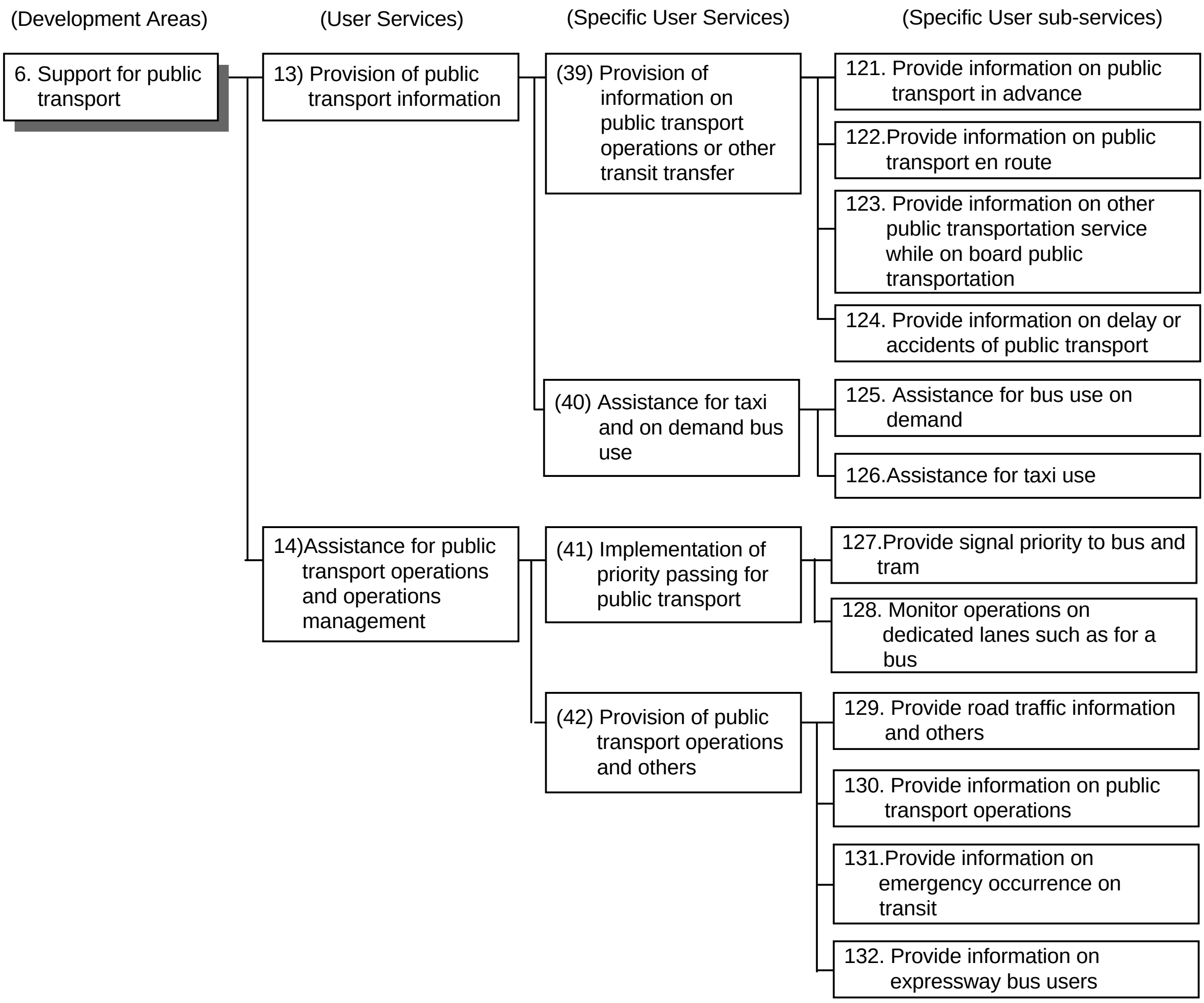


Fig. 2.2-8 User service scheme for constructing System Architecture (Increasing efficiency in commercial vehicle operations)

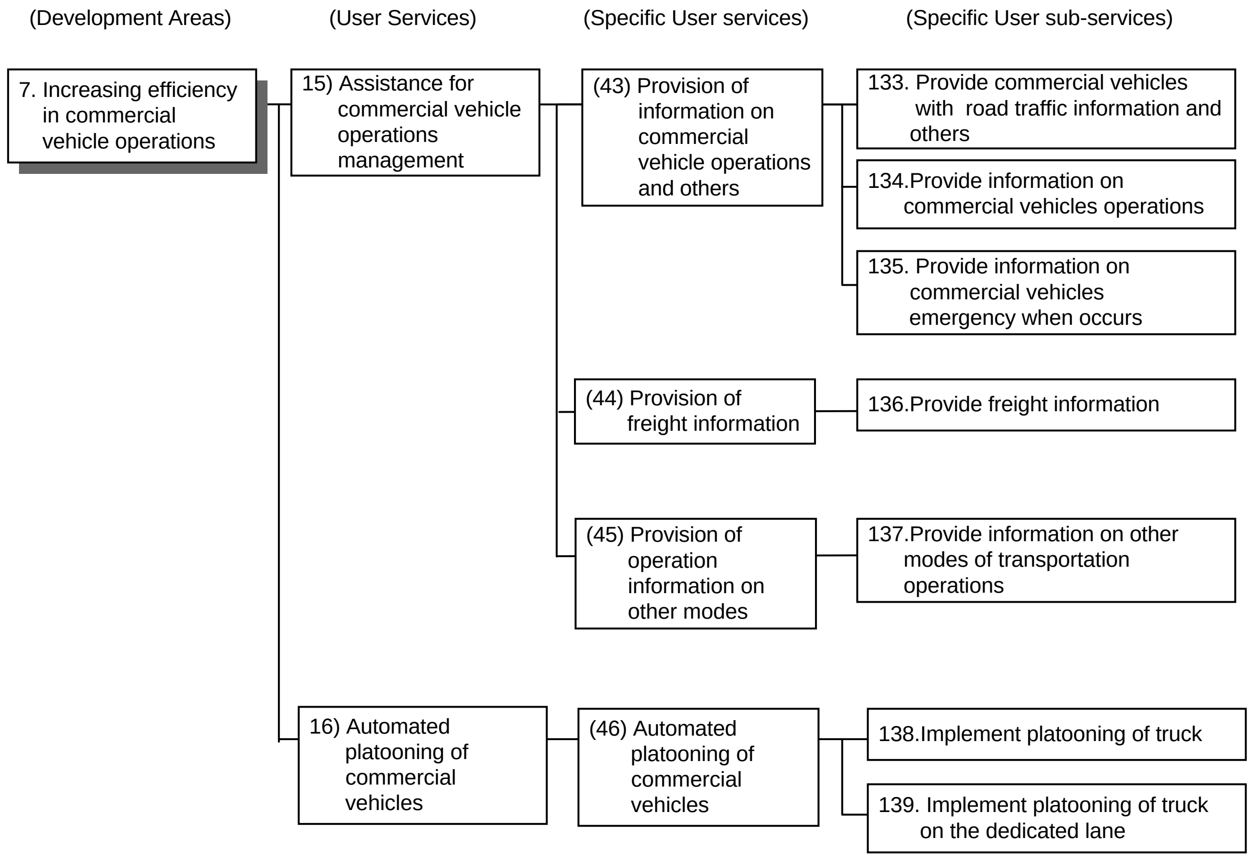


Fig. 2.2-9 User service scheme for constructing System Architecture (Support for pedestrians)

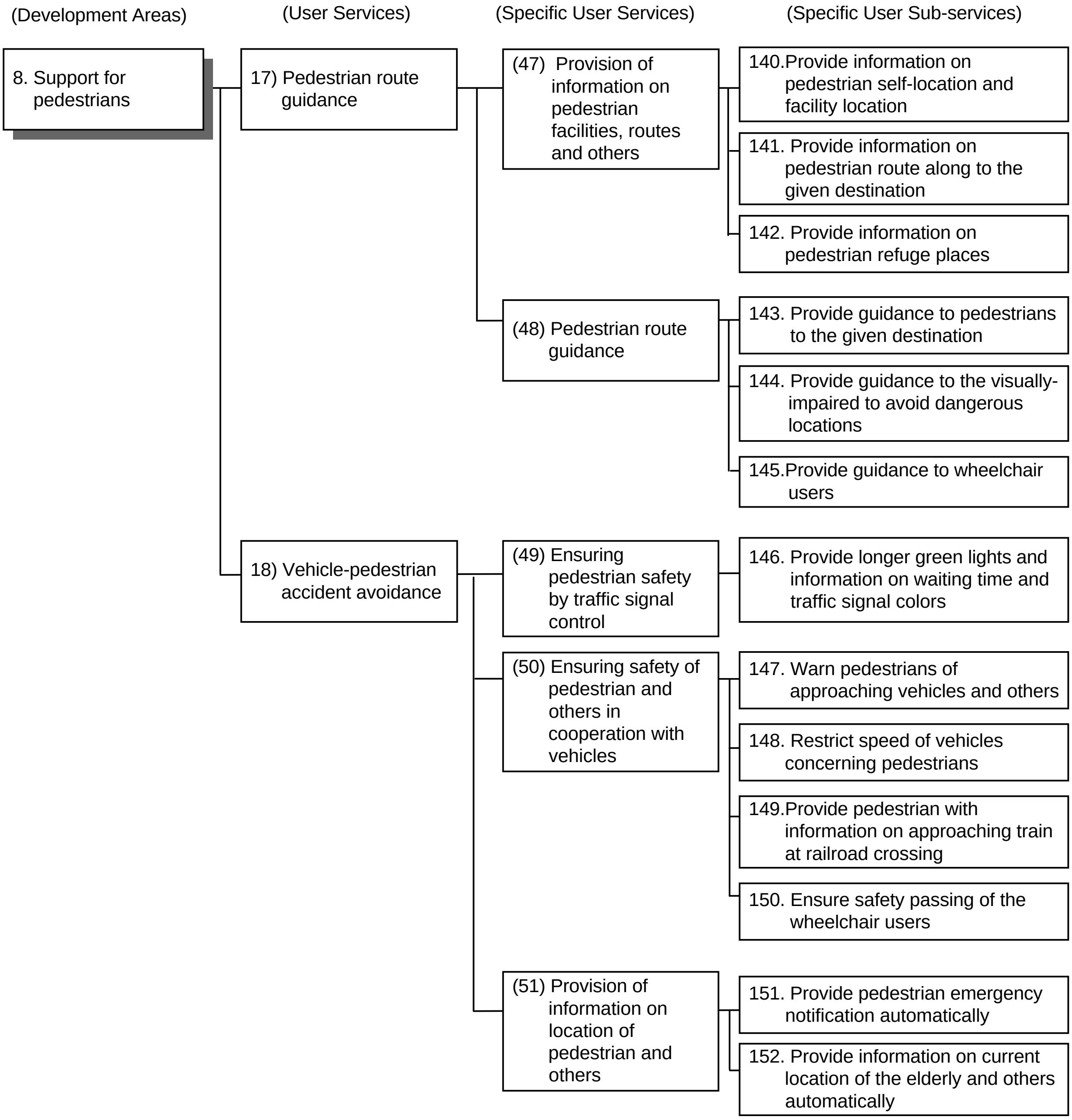


Fig. 2.2-10 User service scheme for constructing System Architecture (Support for emergency vehicle operations)

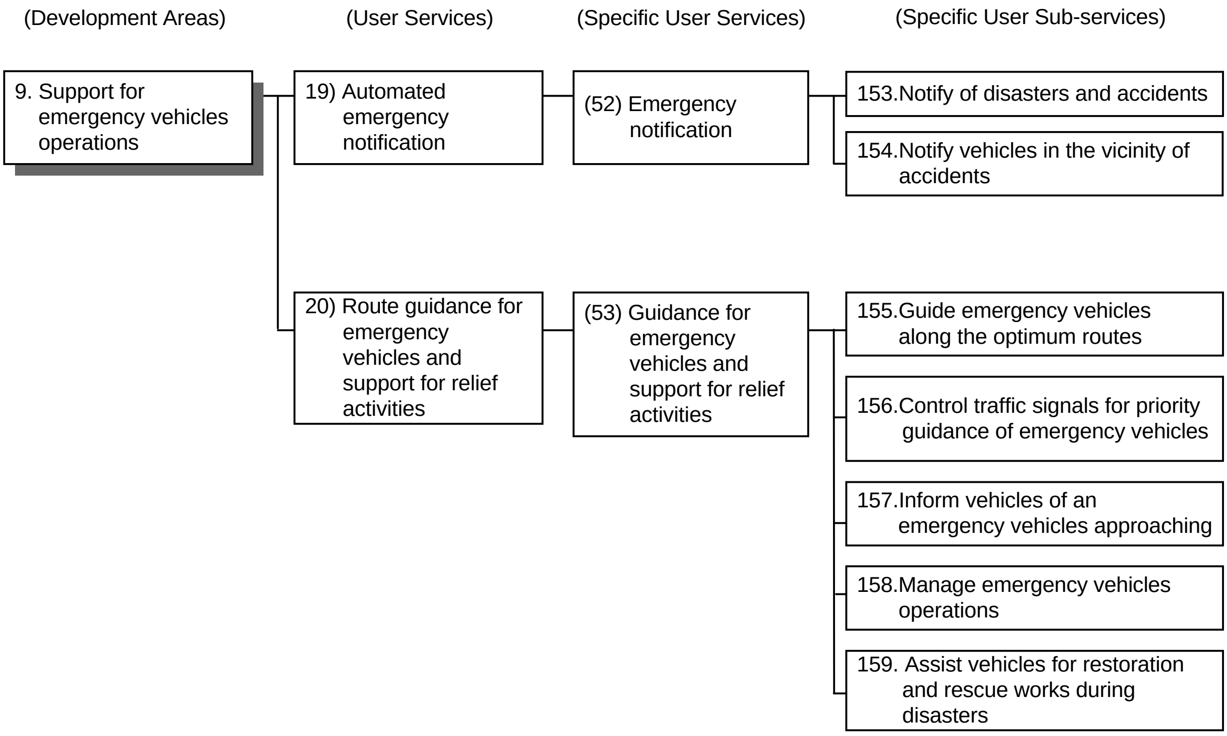
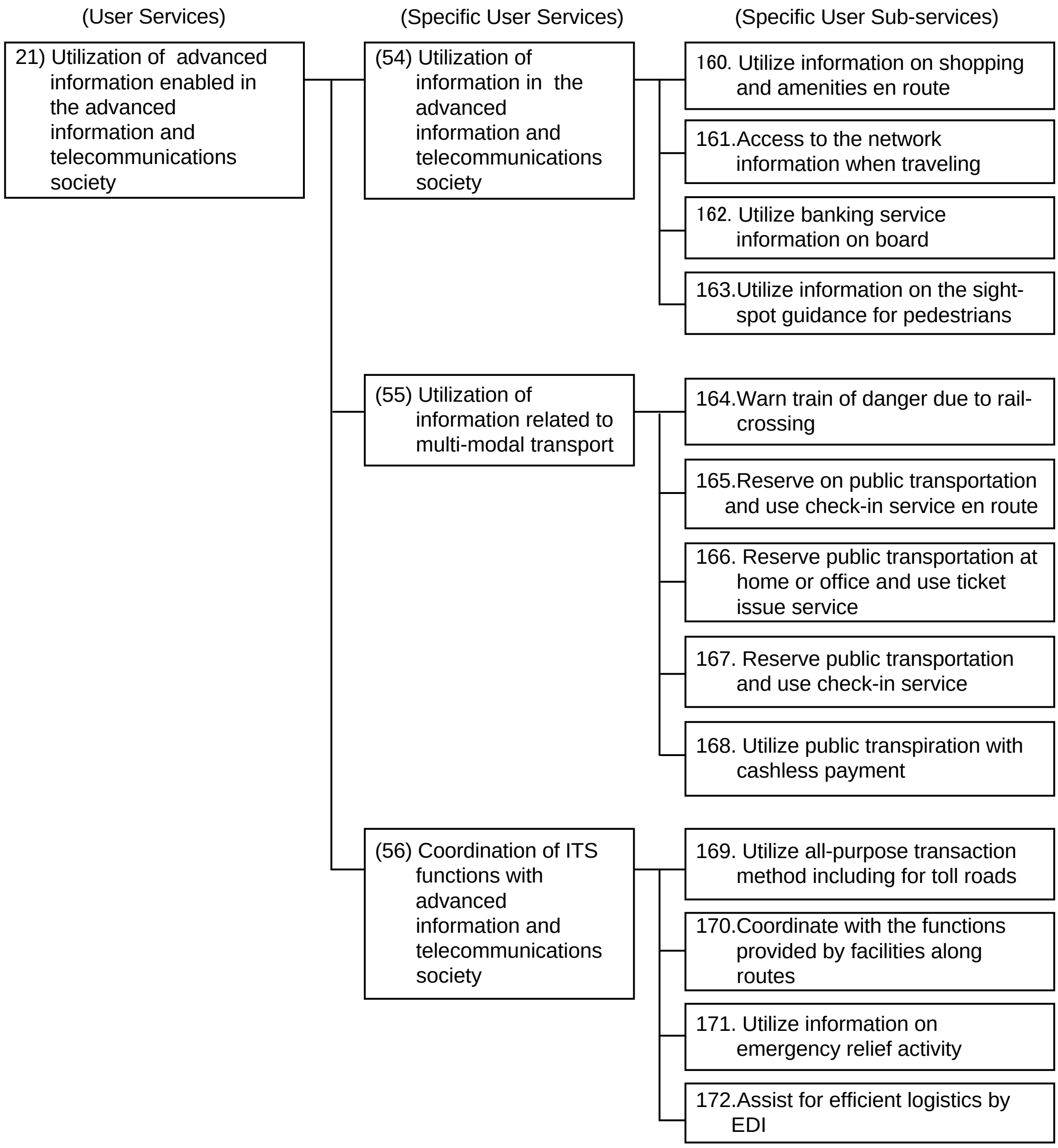


Fig. 2.2-11 User service scheme for constructing System Architecture (Utilization of advanced information enabled in the advanced information and telecommunication society)



Chapter3　Constructing the Logical Architecture

3.1　What is Logical Architecture?

In the Logical Architecture, upon clarification of the transmission and reception of information that occurs between the users and the systems for the realization of sub-services and the processing performed within the system (called "procedures" below). The information and functions handled in those procedures are determined; the information is systematized; and the relationships between the functions which is needed for the realization of services. The information handled by those functions are shown as a model using a common format. Here, "information" refers to the elements collected on the basis of a phenomena outside the system, and the elements obtained by processing and condensing them. "Functions" are the portions which perform the collecting, the supplying, processing of information as well as related control, and the other exchange of information within the system.

The functions, which are to be arranged under the Physical Architecture construction work, and also the information to be handled, have been clarified through these kinds of modeling. To make it easier to find the information and functions which can be shared among multiple sub-services in the construction of Physical Architecture, we have uniformly established the relevant terms and their content to prevent the use of different terms to describe the same phenomenon.

3.2　Achievements of Constructing the Logical Architecture

(1)Steps in Constructing Logical Architecture

The Logical Architecture has been constructed through the following steps, [1] to [5].

[1]　After making assumption on the process for realization of services from the content of Specific User Sub-service definitions, and making distinction between the users and the system, which is a portion without user interposition, we listed the transmission and reception of information which will occur between users and the system, such as user requests and the supply of information from the system side, and processing which will be performed within the system (procedures). In listing these procedures, deliberate attention was paid in order to avoid any limitations on the specific realization technologies and devices.

[2]　Next, we determined the information and functions which are to appear in each of the listed procedures.

[3]　Concerning all of the information and functions which had been determined, we uniformly defined the terms and their content in order to prevent the use of different terms when describing the same phenomenon.

[4]　With regard to the information which had been determined, we first established the basic elements related to ITS, such as the operational body, drivers, and public transport vehicles, then arranged them into groups according to the correlations among elements, and took these groups as sets of information expressed by the names

of basic correlated elements. Based on the subset relationships among these information sets, we indicated the structure of the grouped information by strata. This system, having a stratified structure, is called an "information model."

[5] Concerning the functions which had been determined, we used a common format to model the functions needed for realization of each Specific User Sub-service, along with the information to be handled by those functions. This model is called a "control model."

(2) Achievements of Logical Architecture

[1] Information Model

An information model is a model of the relationships between the “functions” and the “information” to be handled by those “functions”. It clarifies the correlations among all of the “information” handled in ITS, and it relates all of the “information” as a system having a stratified structure in order to facilitate expansion and changes to the System Architecture in case any additions or changes have to be made in the “information” handled by ITS due to future changes in social needs or technological process. The “information” placed under this system is uniformly defined by this systematization, thus avoiding the existence of redundant information expressing the same content in the system.

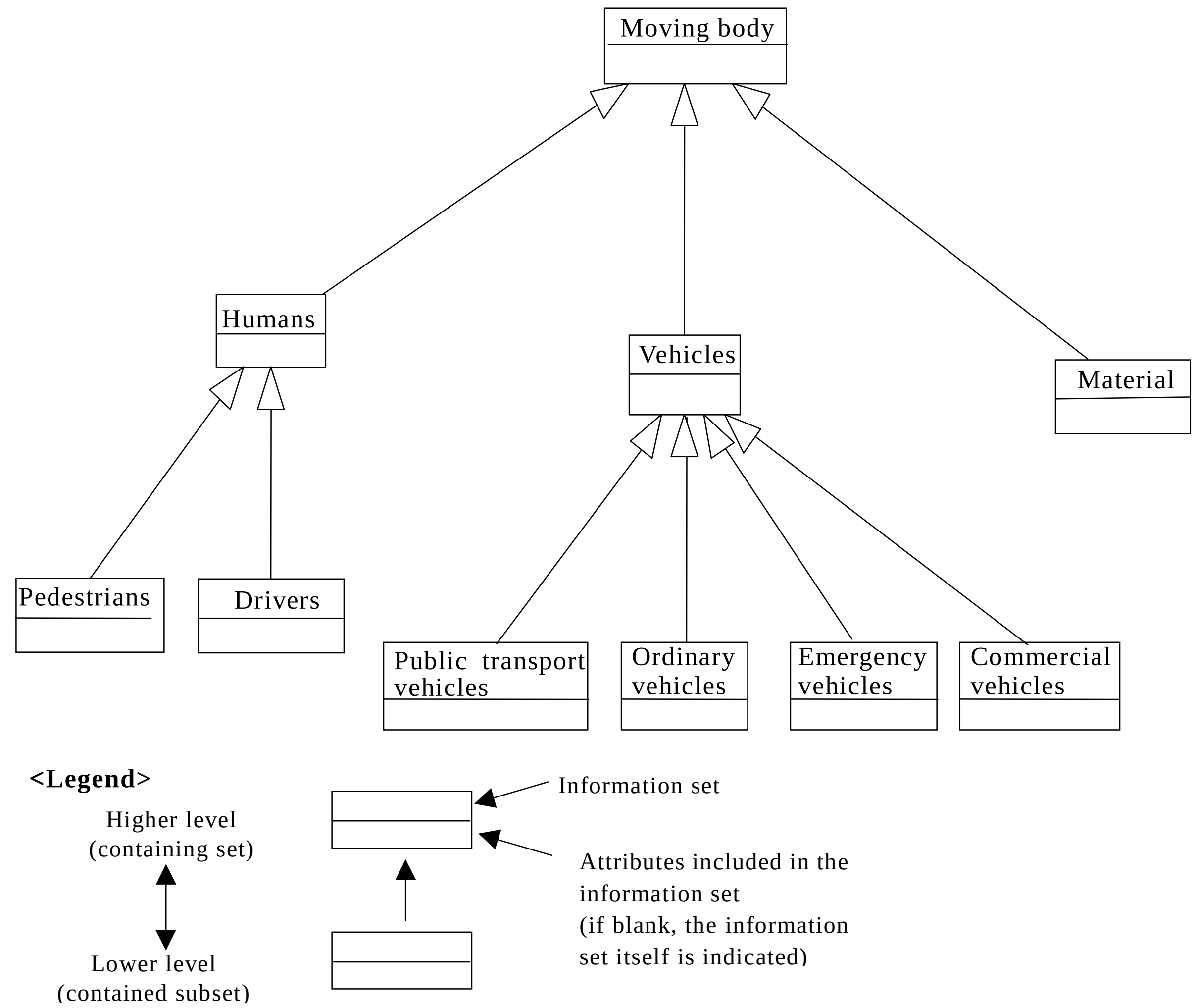
The “information” handled by ITS has been arranged into a stratified structure with seven basic information sets (spot, routes, roadway, moving body, schedule, operational body, and external institute) all at the highest level. (No other information sets can be placed at a higher level than these sets.)

We also organized the vertical relationships among information sets to ensure that the nature of higher level information sets is carried down to all lower levels. Focusing on only the stratified structure of this model, we refer to this structural portion as the "detailed model" with regards to the “information” model.

We have organized all of the information handled by ITS into such strata by applying the relevant “information” to the various information sets. This information sets were arranged this way.

Here, of the detailed model which has moving body as its highest information set, we will indicate the information sets which will be used in common among the nine ITS development areas.

Fig. 3.2-1 Detailed Model of the Information Set System for Moving Body



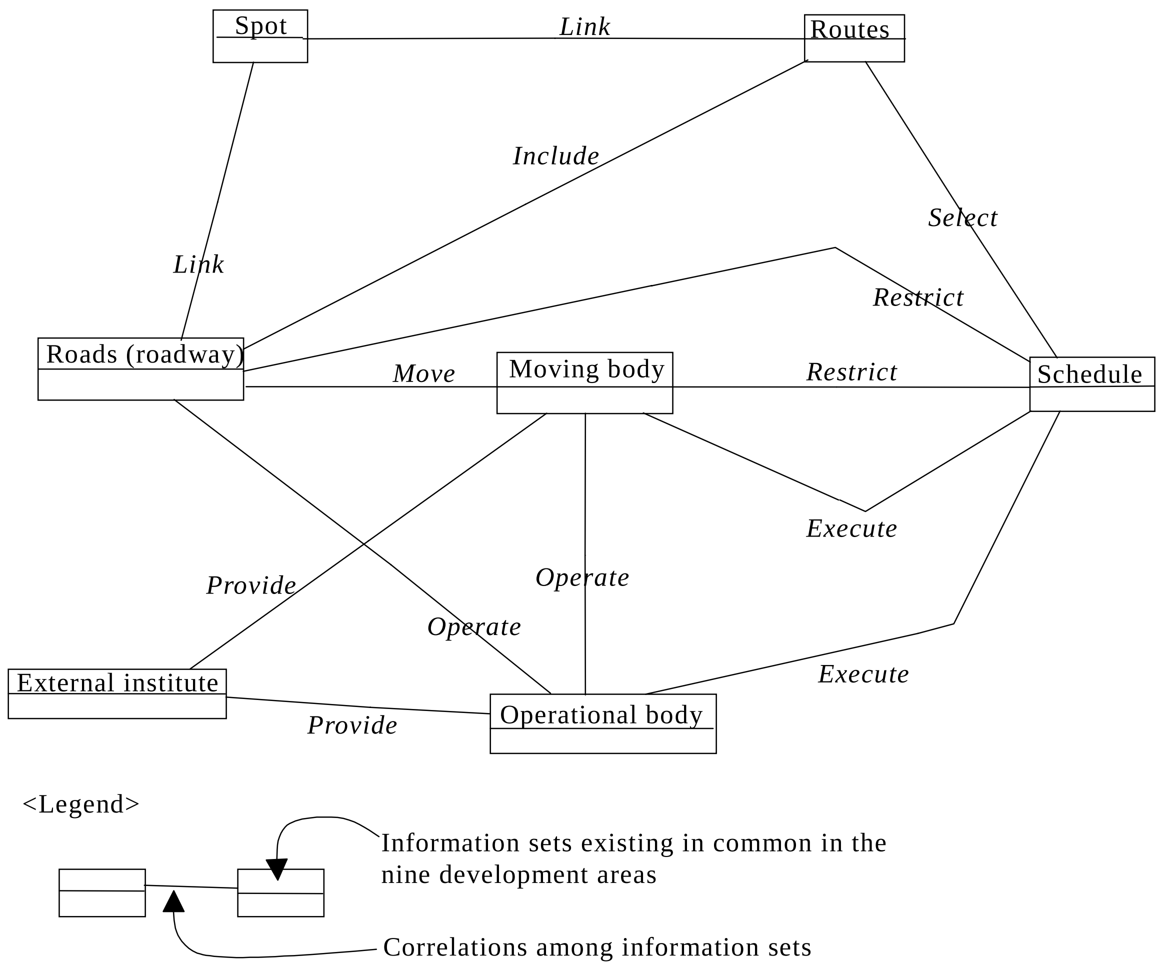
Explanatory Notes:

- The information handled in ITS is organized into a stratified structure with seven basic information sets (spot, route, roadway, moving body, schedule, operational body, and external institute) at the highest level. Here, the information set of moving body is shown as an example.
- The vertical relationships among information sets have also been organized to ensure that the nature of higher level information sets is carried down to all lower levels. Therefore, lower level information sets are arranged according to more limited conditions than the higher information sets above them.
- In this example, we have established "humans" as an information set containing the nature of both "pedestrians" and "drivers," and "vehicles" as an information set containing the nature of "public transport vehicles," "ordinary vehicles," and so on. Further, we have established "moving body" as an information set which contains the nature of "humans," "vehicles," and "materials."
- This systematic arrangement of information will facilitate additions and revisions to the System Architecture, with regard to changes such as System Architecture modifications, additions to specific systems, and so on.

In systematizing the information with regard to the relationships among information sets, we have indicated not only the stratified relationships of inclusiveness, but also the interrelationships among them. In this manner, we have been able to prepare a single overall system which clarifies all of the correlations among information as stratified relationships of inclusiveness or as other relationships.

Case there is a necessity for any addition/change to “information”, it has become easy to clarify the “information” which is related to the “information” which is added/changed, after the completion of this system. Thus, it has become possible to facilitate changing and expanding of the System Architecture. As a result of the systematization of information, we have been able to produce a diagram showing an overview of the entire information system (by indicating only the relationships among the highest level information sets which exist in common in the nine ITS development areas). This is called the "core model" of the information model.

Fig. 3.2-2 Core Model: Relationships Among Highest level Information Sets



Explanatory Notes:

- This diagram focuses only on the seven highest level information sets of the information model providing a systematic arrangement of information, along with their interrelationships. This allows an overview of the information handled by ITS.
- In the case of changes or additions to the specific systems which constitute ITS, such as the addition of a new system, it is possible to find candidates for the information which is to be modified, or etc.
- Since the relationships among the information sets are indicated, it is possible to find candidates for information to be confirmed, besides the information to be modified.
- If, for example, new information related to routes is added in conjunction with the addition of a new system, then confirmation is only needed with regard to these four information sets and the information sets located under them since the information sets related to routes are spot, roadways, and schedules.

[2] Control Model

Using a common format, the control model is the result of modeling the relationships among the "procedures" and "functions" needed for the realization of sub-services and the "information" they handle. The first objective of determining the control model is to clarify the functions, which are to be arranged in the subsystems such as centers, roads, and vehicles, in construction of the Physical Architecture.

The second objective is to facilitate the finding of information and functions which should be shared in construction of the Physical Architecture, through the use of uniformly defined functions and the information they handle, as well as modeling by a common format.

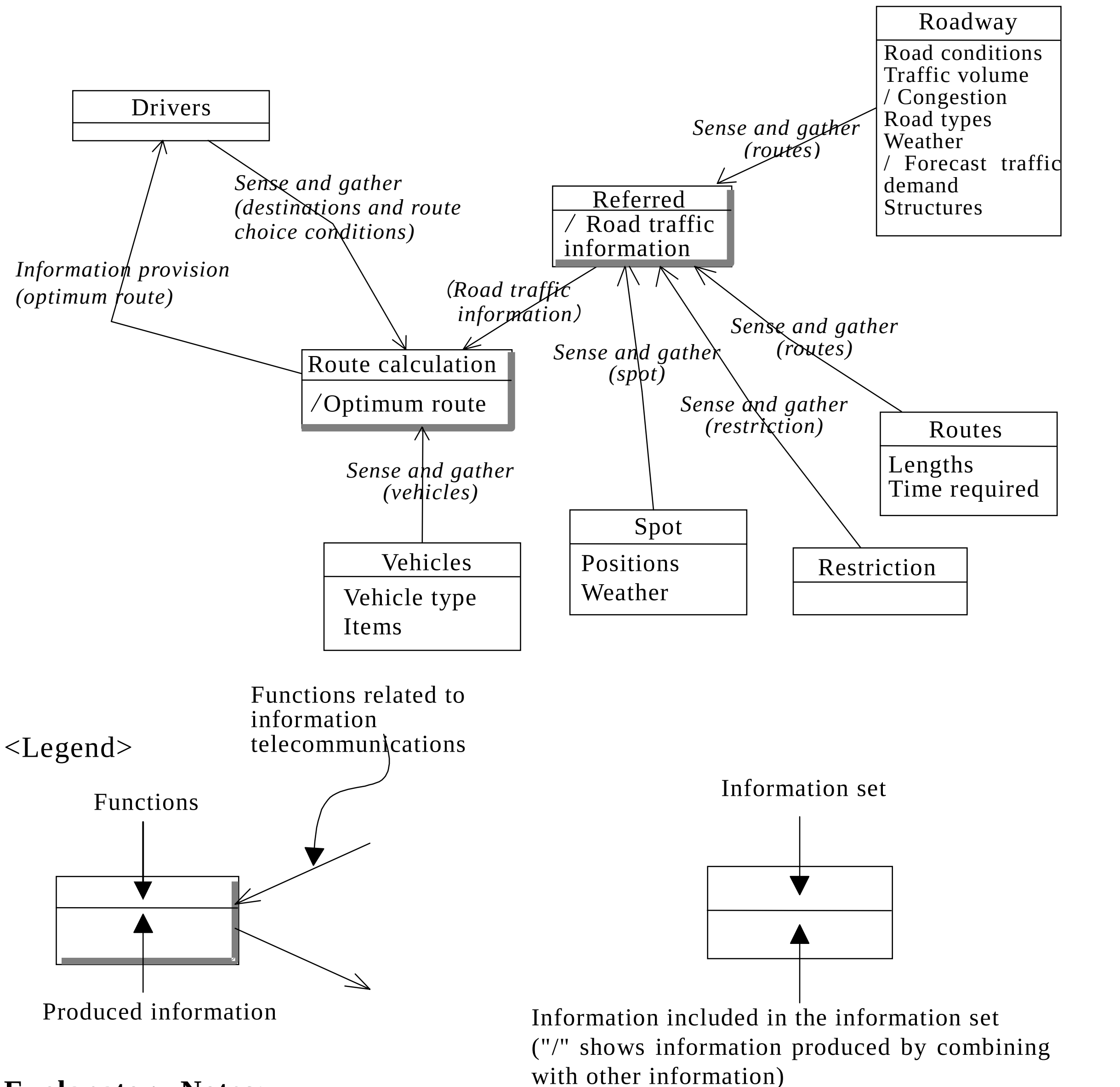
In Japan's ITS in the past, service content and so on has been expressed in writing for nine separate development areas, in documents such as “The Comprehensive Plan for Intelligent Transport Systems (ITS) in Japan”. This expresses the content of services to be enjoyed by users at the time when ITS is realized; it does not define the "information" and "functions" handled by the services from the viewpoint of system construction for finding common attributes.

In preparing the control model, we first stated the specific "procedures" needed for realization of the sub-services as flows of "information" and "functions", with information sets or functions as the starting and ending points, using the uniformly defined functions and the information they handle. Next, through interconnection of the points where the same functions or information sets of each statement exist as starting and ending points, we integrated all of the "procedures" prepared from one sub-service into a single unit, and prepared a diagram stating the flows of the "functions" and "information" stating the procedures.

In the control model, “functions” and “information” that they handle are treated together. Therefore, it becomes possible to make overall change in the system without any affect to other “functions” which is treated together with “information” absorb the content of additions or changes in the “information.”

Here, the control model for a representative sub-service is given as an example. Moreover, it becomes easy to detect “functions” related to “information” in which additions or changes are made.

Fig. 3.2-3 Example of a Control Model for the Area of Navigation System Sophistication: Providing Optimum Route Information



Explanatory Notes:

- Following the definition of clear descriptions of the information and functions based on the content of sub-services, the functions and the information they handle are organized in an integrated manner, and this is shown in the model
- For instance, the service of "providing optimum route information" is realized through the following flow.
- The system calculates the routes and provides information on the optimum routes, based on the drivers' demands concerning the provision of information, the destinations detected and collected from the drivers, and the route selection conditions.
- Following calculation of the optimum routes, the system detects and collects the necessary vehicle information (vehicle types and specifications) and road information.
- The road traffic information is composed by detection and collection of roadway information including road conditions and traffic volume, the route information of length and time required, information on restrictions, and spot information such as position and weather.
- The information and functions to be shared in the Physical Architecture can be found easily through such organization.

Chapter4 Constructing the Physical Architecture

4.1 What is Physical Architecture?

The Physical Architecture is a model of the overall image of the system to realize ITS and arrange the vehicles, roads, centers, etc. with sharing among the sub-services to promote integration of the entire system with regard to the combination of the functions determined by the Logical Architecture and the information handled by those functions.

Construction of the Physical Architecture clarifies the positions of all of the subsystems constituting ITS and the information exchanged among the subsystems, and indicates the overall system structure (framework). The subsystems are a combination or aggregation of the functions determined by the Logical Architecture and the information handled by those functions.

4.2 Achievements of Constructing the Physical Architecture

(1) Steps in Constructing the Physical Architecture

The Physical Architecture has been constructed according to the following steps: [1] Establishing the Highest Level Subsystems, [2] Establishing the Lowest Level Subsystems, [3] Constructing specific Physical Model for Each Specific User Sub-services, and [4] Constructing Physical Model for the Entire System.

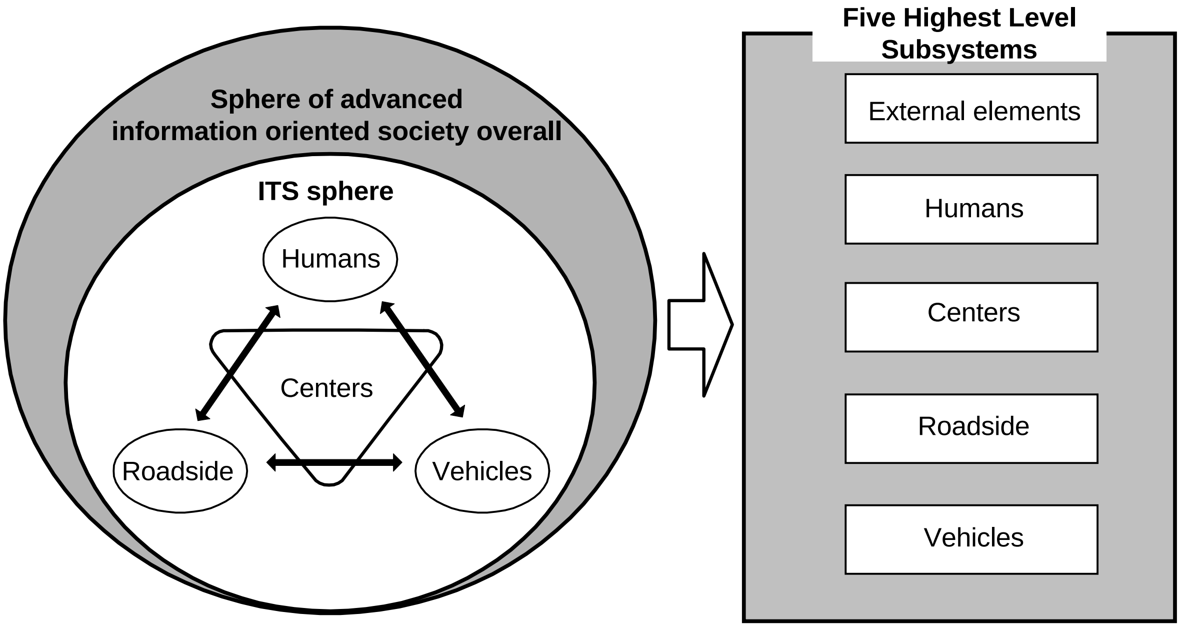
[1] Establishing the Highest level Subsystems

“The Comprehensive Plan for ITS in Japan” describes the concept of integrating humans, roads, and vehicles through the use of state-of-the-art communications technology and so on, toward the realization of ITS. In terms of the elements making up the system to realize ITS, in addition to humans, roadside, and vehicles, there is also a need for centers as elements for efficient operation.

An advanced information oriented society encompasses a variety of areas including ITS. In the construction of a system for the realization of ITS, a wide range of other elements making up systems in other areas must be kept in mind as well, and it is necessary to ensure mutual operability and mutual connectivity with these.

Based on the above considerations, we have positioned the specific subsystems making up the system as functions requiring vehicles, roads, centers, humans, and external elements. The term "humans" does not indicate human beings in general, but subsystems to be arranged for home and office users, and pedestrians in motion. By establishing external subsystems in constructing the Physical Architecture, mutual operability and mutual connectivity with an advanced information oriented society have been ensured. This is one of the characteristics of Japan's System Architecture.

Fig. 4.2-1 Relationship of ITS Sphere to Highest level Subsystems



[2] Establishing the Lowest Level Subsystems

Next, we established the combination of the functions determined by the Logical Architecture and the information handled by those functions as the elements of the smallest units which make up the system (Lowest Level Subsystems). Since the relationships of functions and the information handled by those functions have already been organized in the Logical Architecture, establishment of the Lowest Level Subsystems means that the information exchanged among Lowest Level Subsystems will also necessarily be organized.

[3] Constructing Physical Model for Each Specific User Sub-services

Based on the nine factors of technological maturity, reliability, security, user cost, infrastructure cost, processing time, information renewal interval, user safety, and disaster resistance; we performed a comprehensive evaluation concerning several formats which could be considered in the realization of the Lowest Level Subsystems. Concerning the formats which were found to be the most appropriate as a result of this evaluation, we arranged the Lowest Level Subsystems among the Highest Level Subsystems, taking feasibility into consideration. The models of these achievements are called “the specific physical models for each Specific User Sub-service”. To avoid having the same phenomenon expressed by different terms in the course of this modeling, we established unified terms along with their content. We ensured mutual operability and mutual connectivity with an advanced information oriented society through the establishment of a function to collect and supply information with external subsystems as one of the Lowest Level Subsystems. However, the configuration within external subsystems has not been clearly defined, since the construction of System Architecture relating to ITS mainly concerns the ITS sphere alone.

Considering feasibility based on the communications infrastructure which already exists or is expected to be built in the future, the formats for communications among the Highest Level Subsystems have been chosen from wired communications, wide-area wireless communications, dedicated short-range communications (between road and vehicles), and short-range communications (among vehicles). The same considerations were also applied concerning the formats for communications among the Lowest Level Subsystems.

[4] Constructing Physical Model for the Entire System

All of the" physical models for each specific users sub-service" were integrated through the sharing of Lowest Level Subsystems which exist commonly in multiple "physical models for each specific users sub-service". The resulting model is called "Physical Model for the Entire System". In this" Physical Model for the Entire System", in order to facilitate the determination of the overall system structure (framework), we combined the expression of those Lowest Level Subsystems located at the same arrangement position which are basically similar in action. This kind of combination was repeated to express the grouping of Lowest Level Subsystems as a stratified structure.

(2) Achievements of Constructing Physical Architecture

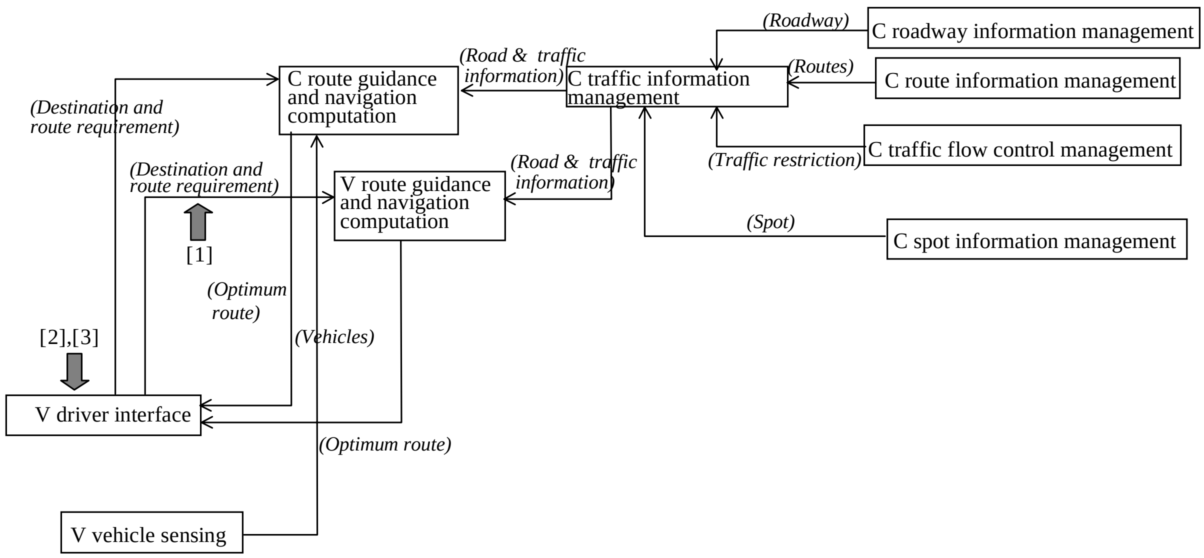
[1] Physical Model for Each Specific User Sub-services

"Physical models for each Specific User Sub-service" are formed by organizing the information exchanged among the Lowest Level Subsystems and the communications formats, and by arranging the Lowest Level Subsystems within the Highest Level Subsystems. Construction of the "physical models for each Specific User Sub-service" has clarified the structure of the system for realization of the subsystems.

We basically decided to construct an" Physical Model for Each Specific User Sub-services". However, since sub-services which are expressible by the same subsystem composition can be realized by the same system, these were expressed by the same model, in view of the integration of "physical models for each user sub-service". When positioning Lowest Level Subsystems within Highest Level Subsystems, as a general principle, we did not place them in multiple highest level systems. They were placed in multiple Highest Level Subsystems when judging from technical feasibility, the functions could not be fully realized through placement in a single highest level system alone; and also when it was judged that there was no need to limit their placement to a single position, based on a comprehensive evaluation in terms of nine factors.

Here, the example is given of a "physical model for each user sub-service" of providing optimum route information, for which a control model has also been indicated.

Fig. 4.2-2 Example of Physical Model for Each User Subservice for the Area of Navigation System Sophistication: Providing Optimum Route Information



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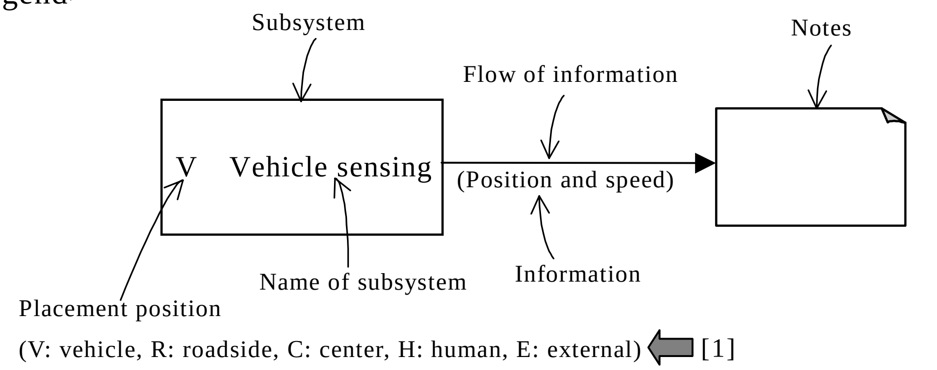


Explanatory Notes:

[1] The five placement positions (highest level subsystems) of the lowest level subsystems are set as vehicles, roadside, centers, humans, and external elements, and these are abbreviated as V, R, C, H, and E respectively.

[2] The combination of the functions determined by the logical architecture, and the information handled by those functions, is set as the lowest level of subsystems.

[3] For example, the subsystem of driver interface was evaluated on nine factors including technological maturity and processing time, and placed under "vehicles." The information exchanged among lowest level subsystems is expressed according to the relationships of the functions already arranged by the architecture and the information handled by those functions.

[4] It can be seen from the constructed “Physical Model for Each Specific User Sub-services” that the subsystems of road traffic information management, roadway information management, route information management, traffic flow control management, and spot information management are placed under "centers," while the subsystems of driver interface and vehicle sensing are placed under "vehicles," and the subsystem of route guidance and navigation computation is placed under "centers" or "vehicles."

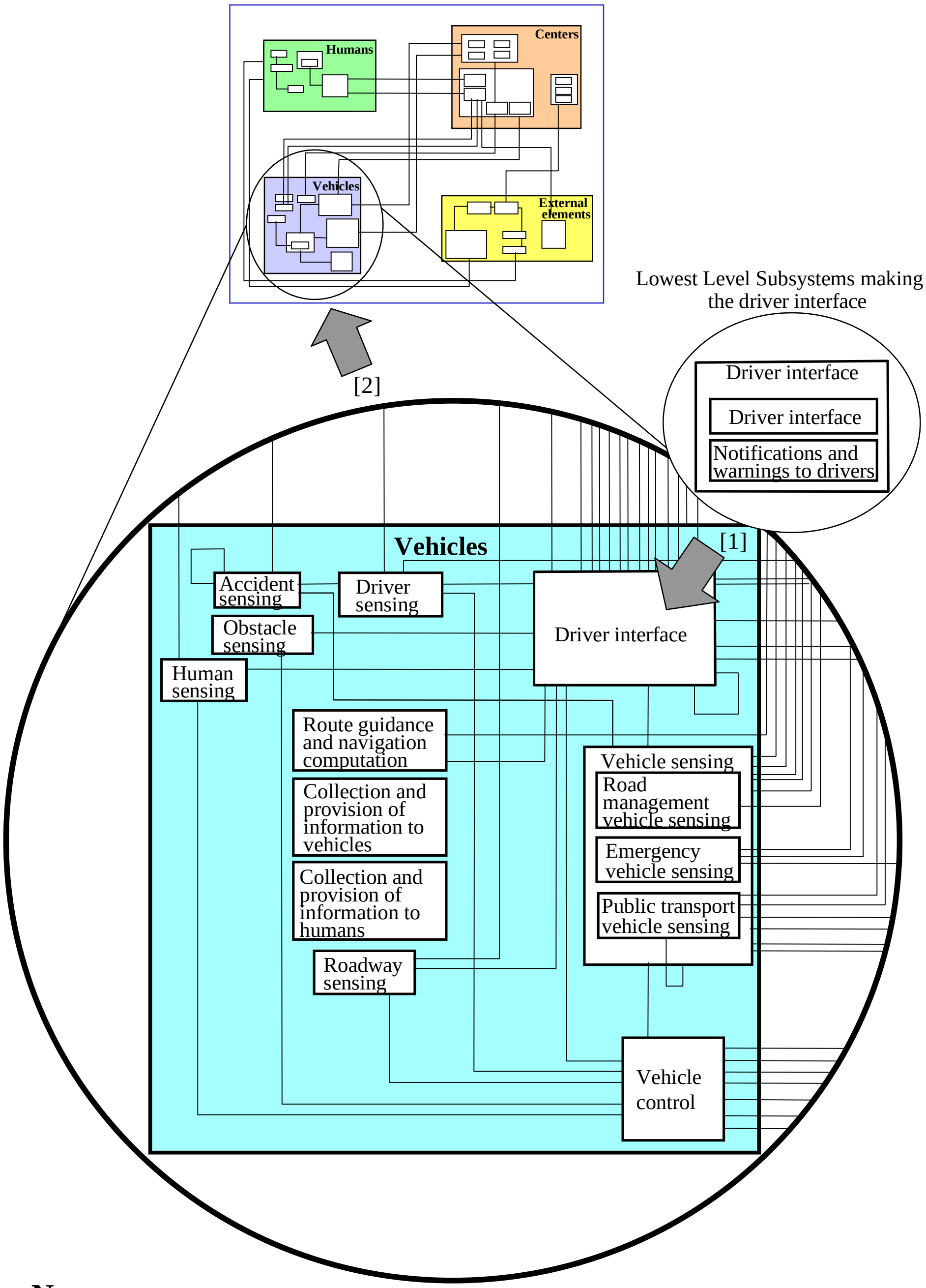
[2] Physical Model for the Entire System

The “Physical Model for the Entire System” clarifies the overall system structure (framework) for realization of ITS, by arranging the Lowest Level Subsystems making up the overall system within the Highest Level Subsystems, and by modeling the information exchanged among subsystems and the used communications formats. In the “Physical Model for the Entire System”, the Lowest Level Subsystems have been expressed collectively in order to facilitate determination of the overall system structure (framework). The details of the information exchanged among subsystems and the used communications formats , can be referred in the Detailed Materials. Use of the “Physical Model for the Entire System” along with the “Physical Model for Each Specific User Sub-services” makes it possible to determine the positions of the Lowest Level Subsystems within the system overall.

We have drawn up a subsystems interconnect diagram in order to provide an overview of the structure (framework) of the overall system. The subsystems interconnect diagram shows the composition of the Highest Level Subsystems by means of the collectively expressed Lowest Level Subsystems, and also indicates the information collection and provision among subsystems shown on the chart which is shared among Highest Level Subsystems, along with the communications formats thereof. In preparing the subsystems interconnect diagram, external subsystems have been identified in order to express more clearly that mutual operability and mutual connectivity with an advanced information oriented society have been ensured.

Following are the “Physical Model for the Entire System” (conceptual diagram), the subsystems interconnect diagram, and a list of the subsystems which composed them.

Fig. 4.2-3 Physical Model for the Entire System (Conceptual Diagram)



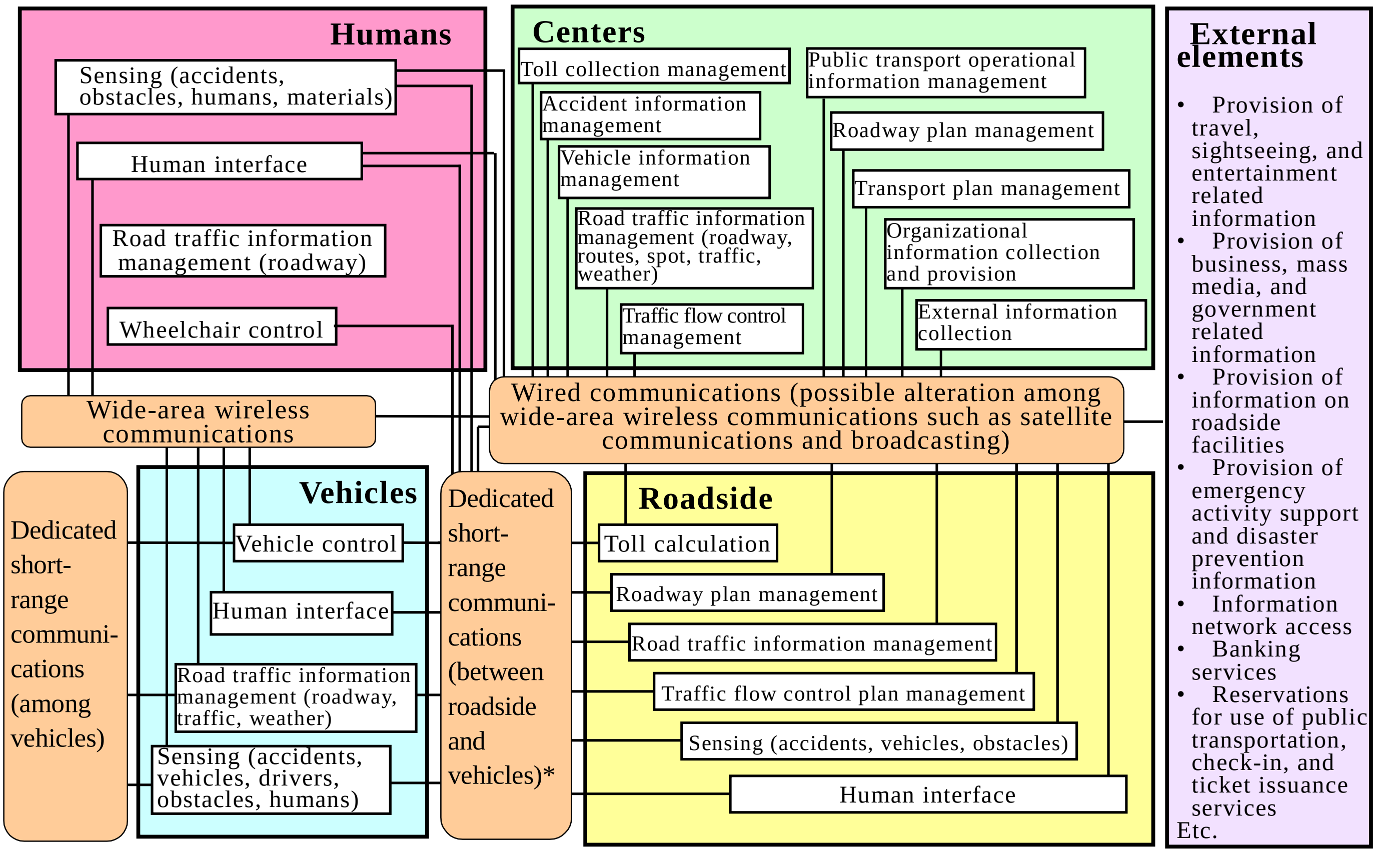
Explanatory Notes:

For example, when determining the position within the overall system of the subsystem for driver interface (a Lowest Level Subsystem) in the sub-service for providing optimum route information:

[1] In the list of subsystems (see the Detailed Materials), one confirms which subsystem under the overall physical model contains the subsystem in question.

[2] This makes it possible to confirm the position of the subsystem in question on the "Physical Model for the Entire System", and also makes it possible to confirm that on the "Physical Model for the Entire System", this is expressed in the same grouping as the subsystem for notifications and warnings to drivers (a Lowest Level Subsystem).

Fig. 4.2-4 Subsystems Interconnect Diagram



* Dedicated short-range communications (between roadside and vehicles) means narrow-area communications which are conducted among roadsides, vehicles, and humans.

The following are definitions of the subsystems shown in the subsystems interconnect diagram.

Vehicles: Subsystems installed on vehicles. They function primarily to control vehicular action, collect data concerning vehicles, and collect and provide information from and to the vehicle passengers.

- Vehicle control

  A subsystem for controlling vehicular movement.

- Human interface

  A subsystem for collecting and providing information from and to the vehicle passengers, including the driver.

- Road traffic information management (roadway, traffic, weather)

  A subsystem for managing information on road structures and incidental facilities, traffic congestion and restrictions, weather, and so on.

- Sensing (accidents, vehicles, drivers, obstacles, humans)

  A subsystem for detecting information on the locations of accident occurrences, information on the situation of vehicular action and so on, driver related information such as driving characteristics, obstacle information including the locations and sizes of obstacles, locations of pedestrians and persons in homes and offices, and payment information.

Roadside: Subsystems which need to be installed on roads or at places adjoining roads. They function to collect and provide information from and to vehicles and humans, and to collect and process information concerning roads.

- Toll calculation
  A subsystem for calculating the fees for use of toll roads and so on.
- Roadway plan management
  A subsystem for managing transport route utilization schedule, including road construction schedule.
- Road traffic information management
  A subsystem for detecting and managing information on road structures, incidental facilities, traffic volume, and so on.
- Traffic flow control management
  A subsystem for managing plans concerning the control of traffic flow, such as regulation of transit and signal control.
- Sensing (accidents, vehicles, obstacles)
  A subsystem for detecting information on the locations of accident occurrences, vehicle information, and obstacle information including the locations and sizes of obstacles.
- Human interface
  A subsystem for collecting and providing information from and to vehicles and humans.

Centers: These function to gather and process information, and to collect and provide information for persons and businesses who manage and use that information. There are no specific stipulations concerning the places where center subsystems are to be established.

- Toll collection management
  A subsystem for obtaining and managing information on the payment of fees for toll roads and so on.
- Accident information management
  A subsystem for obtaining and managing information concerning the locations of accident occurrences, etc.
- Vehicle information management
  A subsystem for obtaining and managing information concerning vehicles, including their positions and actions.
- Road traffic information management (roadway, routes, spot, traffic, weather)
  A subsystem for obtaining and managing information on road structures and incidental facilities, information on travel routes and so on by destination, information on facilities such as parking lots and bus stops, information on the locations of railway crossings, information on traffic congestion and restrictions, weather information, and so on.
- Traffic flow control plan management
  A subsystem for managing plans concerning the control of traffic flow, such as regulation of transit and signal control.

- Public transport operational information management
  A subsystem for obtaining and gathering information on the scheduled departure and arrival times, transit situation, etc. of public transport, and to manage this information so that it can be provided to users.
- Roadway management
  A subsystem for managing plans for the utilization of roadways, including road construction plans.
- Transport plan management
  A subsystem for managing transport plans.
- Organizational information collection and provision
  A subsystem for collecting and providing information from and to public transport operators, commercial vehicle operators, and other businesses; transportation managers, road managers, and other managers; emergency organizations, and other organizations.
- External information collection and provision
  A subsystem for collecting and providing of information from and to systems external to ITS, including travel, financial, and media systems.

Humans: Portable subsystems which are carried by people, subsystems installed in homes, offices, etc., and subsystems which control wheelchairs.

- Sensing (accidents, obstacles, humans, materials)
  A subsystem for obtaining information on the locations of accident occurrences, etc., obstacle information including the locations and sizes of obstacles, locations of pedestrians and persons in homes and offices and payment information, information on the locations of materials to be transported, and so on.
- Human interface
  A subsystem for collecting and providing information from and to pedestrians and people in homes and offices.
- Road traffic information management (roadway)
  A subsystem for managing information on road structures and incidental facilities, etc.
- Wheelchair control
  A subsystem for controlling wheelchair movement.

External elements: Subsystems which function for purposes outside the basic sphere of ITS, as expressed by the 20 User Services. These include the functions of general information providers, hospitals, and financial institutions.

Chapter5　Standardization Candidate Areas

5.1　What are the Standardization Candidate Areas?

In the course of building systems in accordance with the System Architecture, it is necessary to ensure that the information and functions included in ITS have general applicability, so that they can be used by all of the systems which share them. In this generalization of the applicability of information and functions, in the case that standards have already been set in advance to ensure general applicability in the information and functions which are to be shared, it is possible to carry out the necessary work related to information and function design in an efficient manner, without repeating any special studies.

Because many of the subsystems and communications points included in ITS are shared by various sub-services, the ITS System Architecture considers all of the four communications formats and 24 subsystems indicated in the subsystems interconnect diagram as areas requiring future standardization (Standardization Candidate Areas).

For the promotion of standardization, by constructing the System Architecture, it becomes possible to refer to the results of evaluations on the areas included in ITS from various viewpoint. Here, as an example of the evaluation, we made evaluation on all of the communications formats and subsystems indicated in the subsystems interconnect diagram from the standpoint of ensuring general applicability, according to factors such as the degree of sub-service sharing and the frequency of subsystem usage.

By making such evaluation, it becomes possible to smoothly promote our contribution to the study of standardization strategies at related organizations, along with its importance in terms of policy and the progress situation of standardization work in foreign countries.

5.2 Evaluation of the Areas from the Viewpoint of Securing Compatibility

(1)Evaluation of Areas Related to Subsystems

[1] Procedures for Evaluation of Areas Related to Subsystems

As an examples of evaluation based to System Architecture after separate scoring of evaluation points based on the factors listed as i) to v) below, we evaluated all of the subsystems indicated in the subsystems interconnect diagram according to the total score of evaluation points from each factor.

i) Frequency of subsystem sharing

The number of sub-services which have this particular subsystem in common.

ii) Degree of sub-service sharing

The number of users of sub-services which include this particular subsystem.

iii) Connectivity with advanced information oriented society

Whether or not this particular subsystem includes the exchange of information with the advanced information oriented society external to ITS.

iv) Range of actual subsystem availability

The size of the area in which sub-services including this particular subsystem are available for use.

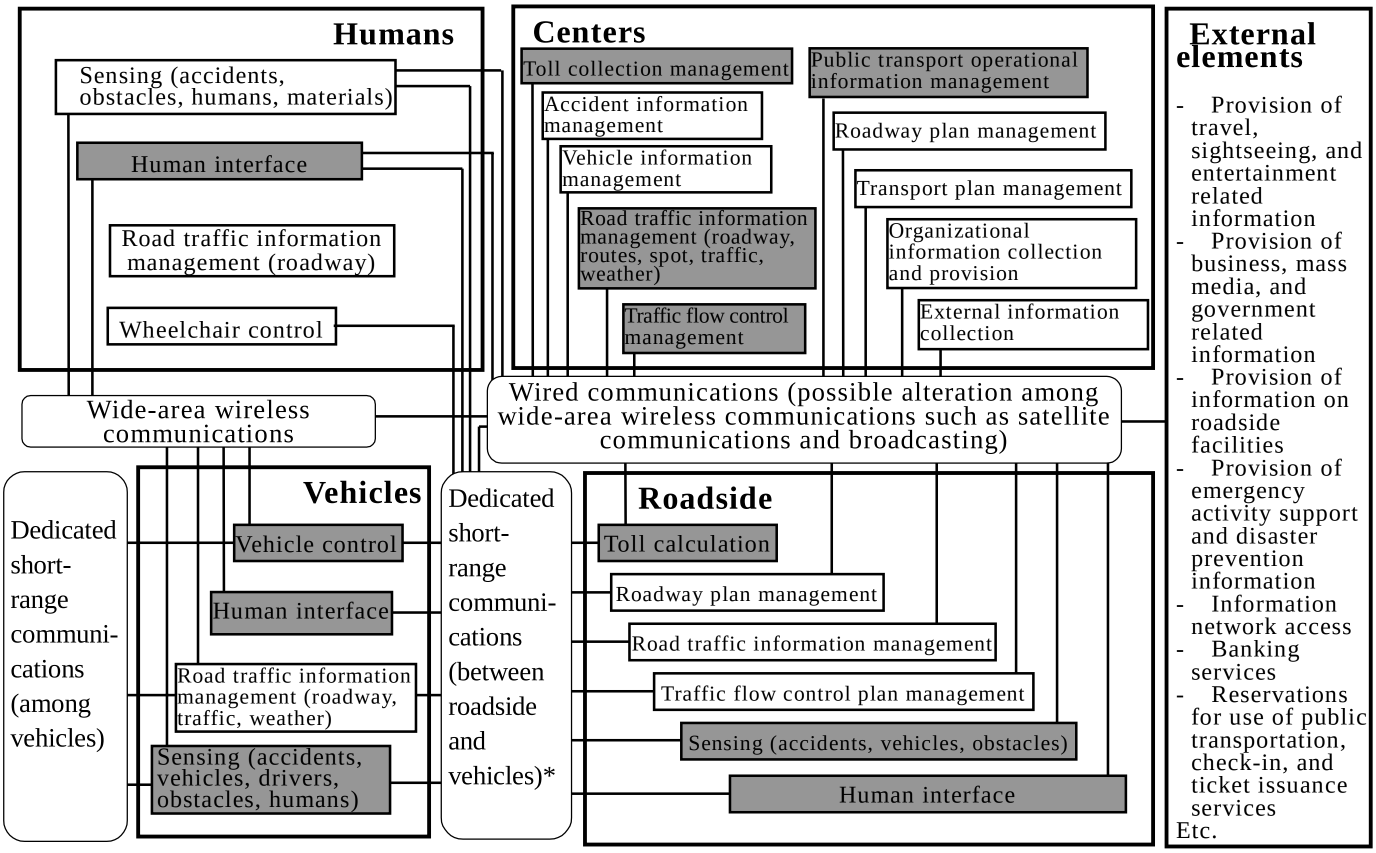
v) Progress of study on subsystem standardization

The progress situation of domestic and international standardization activities in the functions and interfaces included in this particular subsystem.

[2] Examples of the Achievements of Evaluation of Areas Related to Subsystems

As an example of evaluation based on the System Architecture, the following 11 subsystems received high scores, from the viewpoint of securing compatibility, in the evaluation of area related to subsystem. These subsystems include some which form a common basis for the system, such as vehicle and road based detection, road traffic information management in centers, and traffic flow control plan management; and some with a high frequency of usage, such as toll collection management in centers and toll calculation at roads.

Fig. 5.2-1 example of the Achievements of Evaluation of Areas Related to Subsystems



* Dedicated short-range communications (between roadside and vehicles) means narrow-area communications which are conducted among roadsides, vehicles, and humans.

Note: See p. 42 for the definitions of these subsystems.

[shaded box] :Subsystems receiving high scores in the evaluation from the viewpoint of securing compatibility

(2) Evaluation of Areas Related to Communications

[1] Procedures for Evaluation of Areas Related to Communications

As an example of evaluation based on the System Architecture, the four communications formats indicated on the systems interconnect diagram are evaluated, from the viewpoint of securing compatibility, in the following procedure.

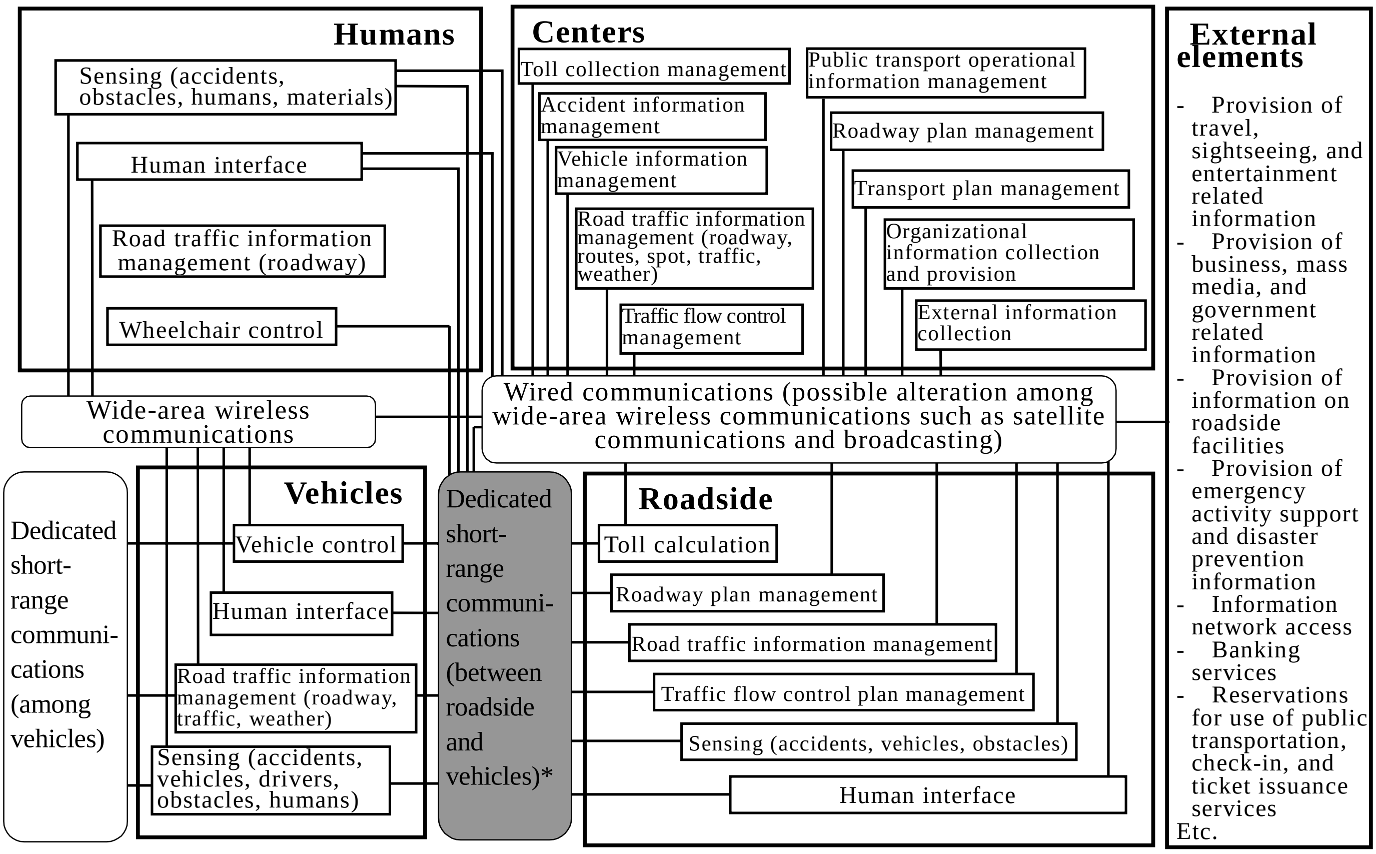
i) Of all of the combinations of Lowest Level Subsystems conducting communications across multiple Highest Level Subsystems, we listed those combinations in which one or both of the Lowest Level Subsystems received high scores for the five factors given in part (1) above.

ii) We gathered the Lowest Level Subsystems, listed in part i) above, under the four communications formats, and took the numbers of Lowest Level Subsystem combinations using each format as evaluation points.

[2] Example of the Achievements of Evaluation of Areas Related to Communications

As an example of evaluation based on the System Architecture, the short –range communications (between roadside and vehicles) received a high score, from the viewpoint of securing compatibility, in the evaluation of areas related to communications.

Fig. 5.2-2 Example of the Achievements of Evaluation of Areas Related to communications



* Dedicated short-range communications (between roadside and vehicles) means narrow-area communications which are conducted among roadsides, vehicles, and humans.

[grey box] :Areas receiving high scores in the evaluation from the viewpoint of securing compatibility

Volume III　Guidelines on Applying the System Architecture

Contents

Chapter1　Concept for Applying the System Architecture

1.1　Stages of Applying the System Architecture

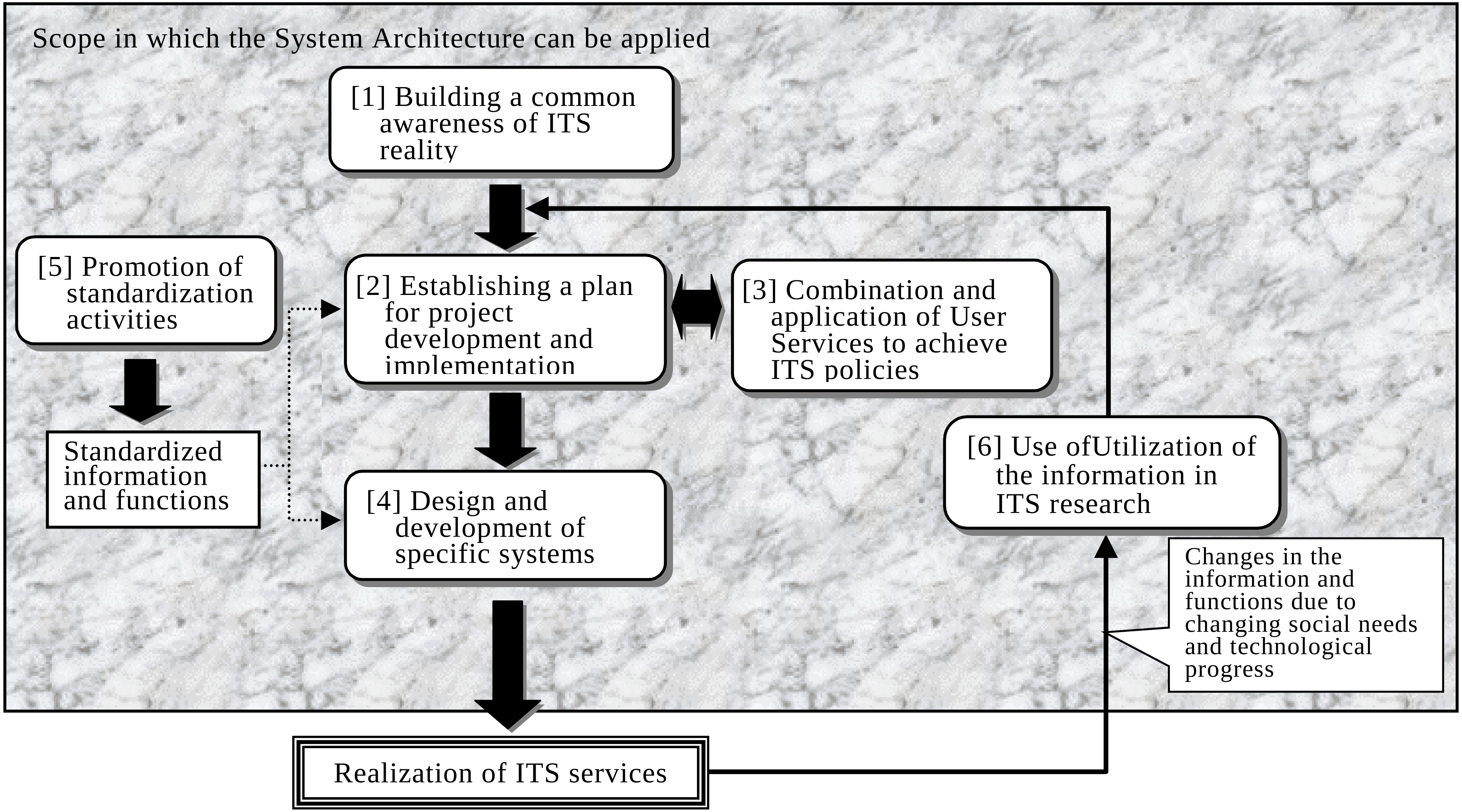
The application of System Architecture is a description of the achievements for reference in each application situation and the application methods, based on the establishment of application situations to achieve the three objectives of System Architecture construction.

The process of realization of ITS services includes the following stages: "[1] building a common awareness of ITS reality", "[2] establishing a plan for project development and implementation", "[3] combination and application of User Services to achieve ITS policies", and "[4] design and development of specific systems".

In order to allow efficient promotion through the standardization of information and functions which are to be shared with regard to the stages of specific system planning and development, which are "[2] establishing a plan for project development and implementation" and "[4] design and development of specific systems", an important stage for the realization of ITS services is "[5] promotion of standardization activities", which will allow efficient promotion through the standardization of information and functions which are to be shared.

In the stage of realization of ITS services, "[6] utilization of the information in ITS research" is another important stage, because this will implement full-scale ITS research and transportation phenomena analysis and provide feedback to stages [2] and [4] on suggestions for changes in the information and functions due to change in social needs and development in thechnology.

Fig. 1.1-1 Process of Realization of ITS Services, and Application Situations



[1] Building a common awareness of ITS reality

In the process of the realization of ITS, the various interested parties in industry, academia, and government are separately involved toward the realization of ITS, and it is essential for all of these interested parties to fulfill their respective roles appropriately.

Therefore, it is necessary to build a common awareness of ITS reality among the various interested parties in order to clarify the directions for their respective involvement based on a view of the future image of ITS.

Since the System Architecture which has now been constructed indicates the important points concerning the concept of ITS, the services to be realized through ITS, ITS as a system, and so on, the application of this System Architecture will make it possible to build a common awareness of ITS reality among the various interested parties.

[2] Establishing a plan for project development and implementation

When clear directions have been determined for the involvement of the various interested parties in industry, academia, and government, and the further steps are to be made toward the stage of concrete project and business development and implementation, it will be necessary to clarify the objectives and important points for consideration in establishing a plan for project development and implementation.

However, although the various interested parties grasp the content of services of the project and the areas of the functions which systems carry, there may be some cases in which they lack a full understanding of the specific conditions for the decision of hardware and software specifications, including the technological formats needed for project realization, standards, and systems.

The application of the System Architecture which has now been constructed will contribute to an understanding of the specific conditions for decision of the hardware and software specifications after defining the content of services of specific projects and the areas of the functions which systems carry.

[3] Combination and application of User Services to achieve ITS policies

The systematic application of various related specific measures is necessary for the radical resolution of traffic congestion, environmental de,erioration and other problems arising from many causes, and for the improvement in the efficacy of policies for wide-ranging areas such as AMD(Transportation Demand Management) and environmental countermeasures.

In implementing these measures, therefore, it is important to execute appropriately the specific measures with consideration for linkage among those, based on the discernment of wide-ranging areas by the persons responsible for those measures.

By referring to the system of User Services, detailed definition sheet of sub-services, “Physical Model for Each Specific User Sub-services”, and other items indicated in the System Architecture which has now been constructed, it will be possible to combine appropriately and apply the related sub-services in the implementation of measures for TDM and so on.

[4] Design and development of specific systems

In the design and development of specific systems, it is necessary to determine all of the structures and development situations of other systems and so on in order to ascertain the information and functions to be shared with other systems and to design and develop those specific systems with general applicability, and this requires a great deal of time and effort.

Since the System Architecture which has now been constructed is based on the sharing of information and functions related to ITS, it is possible to build ITS overall as an integrated system by performing design and development in accordance with this System Architecture.

When performing design and development, it is easy to determine whether the necessary information and functions have already been realized in another system, and this makes it possible to perform the work of design and development in a more efficient manner.

[5] Promotion of standardization activities

In two of the four stages of the realization of ITS, "[2] establishing a plan for project development and implementation" and "[4] design and development of specific systems", standardizing the information and functions, and so forth to be shared within the system will make it possible to proceed efficiently with the necessary work. Therefore, it is desirable to promote the relevant standardization activities and to standardize the information and functions which have a high degree of sharing at an early time.

The points with an especially high need for standardization including the important standardization areas for system building indicated in the System Architecture which has now been constructed are identified. That will allow the statement of basic direction for standardization related to ITS in Japan.

In identifying the specific items for standardization, it is necessary to first refer to the ITS System Architecture. This will clarify a development scenario based on long term future trends in technology and market development, define the information and communications paths in detail, and to develop Physical Architecture corresponding to specific objectives (such as AHS System Architecture, traffic management System Architecture, and on-board System Architecture). This will make it possible to determine the process of standardization work and proceed efficiently with standardization activities.

[6] Use of information in ITS research

When ITS services are realized and various types of data are being collected and stored in a planned manner, it will be important to perform full-scale ITS research and traffic phenomena analysis at universities, research institutions, and so on, and to provide feedback to stages [2] and [4] on suggestions for changes in the information and functions due to changing social needs and technological progress.

In ITS research and traffic phenomena analysis, it is necessary to know what usable data exists and how such data can be obtained. But at present, there may be some cases in which the existing data managed by interested parties is not being fully utilized.

Under the System Architecture which has now been constructed, the flows and locations of ITS information are organized by means of the physical model for the entire sytem, the systems interconnect diagram, and so on; and their determination makes it possible to realize appropriate access to the necessary data.

Thus, through the implementation of "[2] establishing a plan for project development and implementation" and "[4] design and development of specific systems", in accordance with the System Architecture which has now been constructed and based on "[1] building a common awareness of ITS reality", it will be possible to construct efficiently an integrated system and to ensure system expandability.

Also, contributions to the progress of domestic and international standardization will be provided by indicating areas for priority standardization in relation to [5] promotion of standardization activities, and identifying points for emphasis in standardization studies, including those areas.

In implementing measures for wide-ranging areas, it will be possible to achieve enhanced efficacy through "[3] combination and application of User Services to achieve ITS policies".

ITS research and transportation phenomenon analysis will be facilitated through "[6] use of information in ITS research", allowing the provision of feedback on social needs to the stages of "[2] establishing a plan for project development and implementation" and "[4] design and development of specific systems"; and this will allow further augmentation of the effects of ITS.

1.2 How to Apply the System Architecture and Who it Applies to

The System Architecture which has now been constructed consists of a summary section, the main text in two volumes, and Detailed Materials prepared by practical organizations.

The summary section presents the main points in the content of the ITS System Architecture, and should be referred to by ITS-related interested parties in government, the private sector, and academia, for building a common awareness of ITS reality.

Specifically, the first volume of the summary section deals with the background and conception for the construction of this System Architecture; the second volume of the summary section gives an overview of the achievements of System Architecture; and the third volume of the summary section describes specific ways of applying the System Architecture.

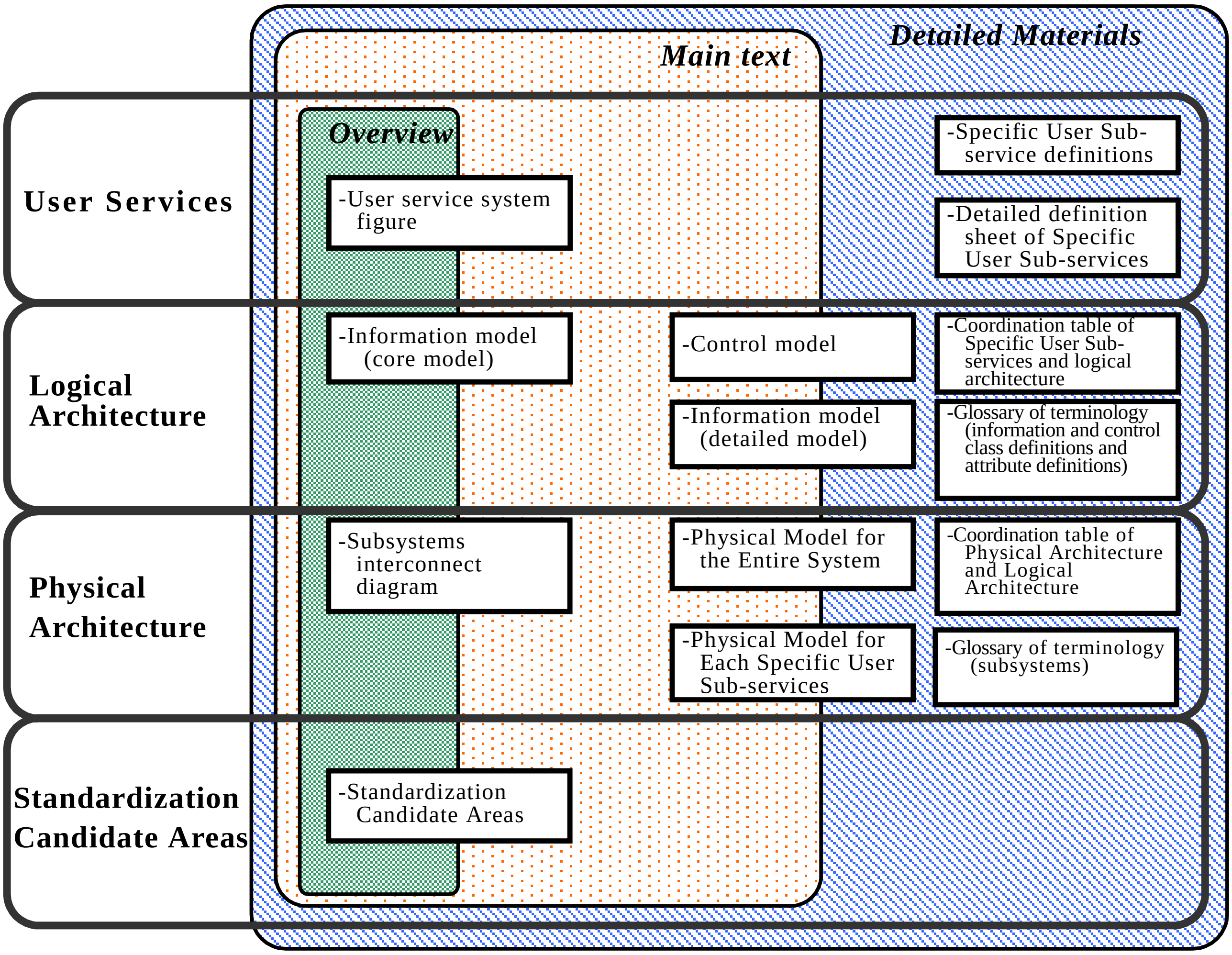
The main text is a presentation and a summary of the concepts and so forth concerning the construction objectives, achievements, and application objectives of ITS System Architecture. It gives an overview of some of the achievements of User Services, Logical and Physical Architecture, Standardization Candidate Areas, and explains the ways of applying the Logical Architecture and Physical Architecture indicated in the Detailed Materials. Therefore, the main text should be referred to by ITS-related interested parties in government and industry for deciding application methods and combining User Services for the establishment of plans for project development and implementation and the realization of ITS measures.

Specifically, section 2.2 under Chapter 2 of Volume II presents a user service system figure which is the result of User Services; section 3.2 under Chapter 3 of Volume II gives an information model and control model which are the achievements of Logical Architecture; section 4.2 of Chapter 4 under Volume II presents the subsystems interconnect diagram, “Physical Model for the Entire System”, and “Physical Model for Each Specific User Sub-services” which are the achievements of Physical Architecture; and sections 5.1 and 5.2 of Chapter 5 under Volume II of this main text describe the Standardization Candidate Areas and evaluation of the various areas from the viewpoint of ensuring general applicability.

The volume of Detailed Materials consists of descriptions of detailed documentation concerning the User Services provided under ITS, the Logical Architecture, and the Physical Architecture; and should be referred to by ITS-related interested parties in government, the private sector, and academia for specific system design and development, promotion of standardization activities, and the use of information for ITS research.

Specifically, Chapter 2 of the volume of Detailed Materials covers documentation such as detailed definitions of the sub-services and the user service system, which are achievements of User Services; Chapter 3 covers documentation such as the information model, control model, and list of information functions, which are achievements of the Logical Architecture; Chapter 4 covers documentation such as the “Physical Model for Each Specific User Sub-services”, “Physical Model for the Entire System”, and list of subsystems, which are the achievements of the Physical Architecture; and Chapter 5 covers documentation such as the achievements of evaluating the various areas from the viewpoint of ensuring general applicability, which is a result related to the Standardization Candidate Areas.

Fig. 1.2-1 Document Composition of the Summary Section, Main Text, and Detailed Reference Materials



Chapter2 Actual Application of the System Architecture

2.1 Building a Common Awareness of ITS Reality

Since the System Architecture which has now been constructed presents the main points concerning [1] the concept of ITS, [2] the services to be realized through ITS, and [3] ITS as a system, the application thereof will make it possible to build a common awareness of ITS reality among the various interested parties in industry, academia, and the government.

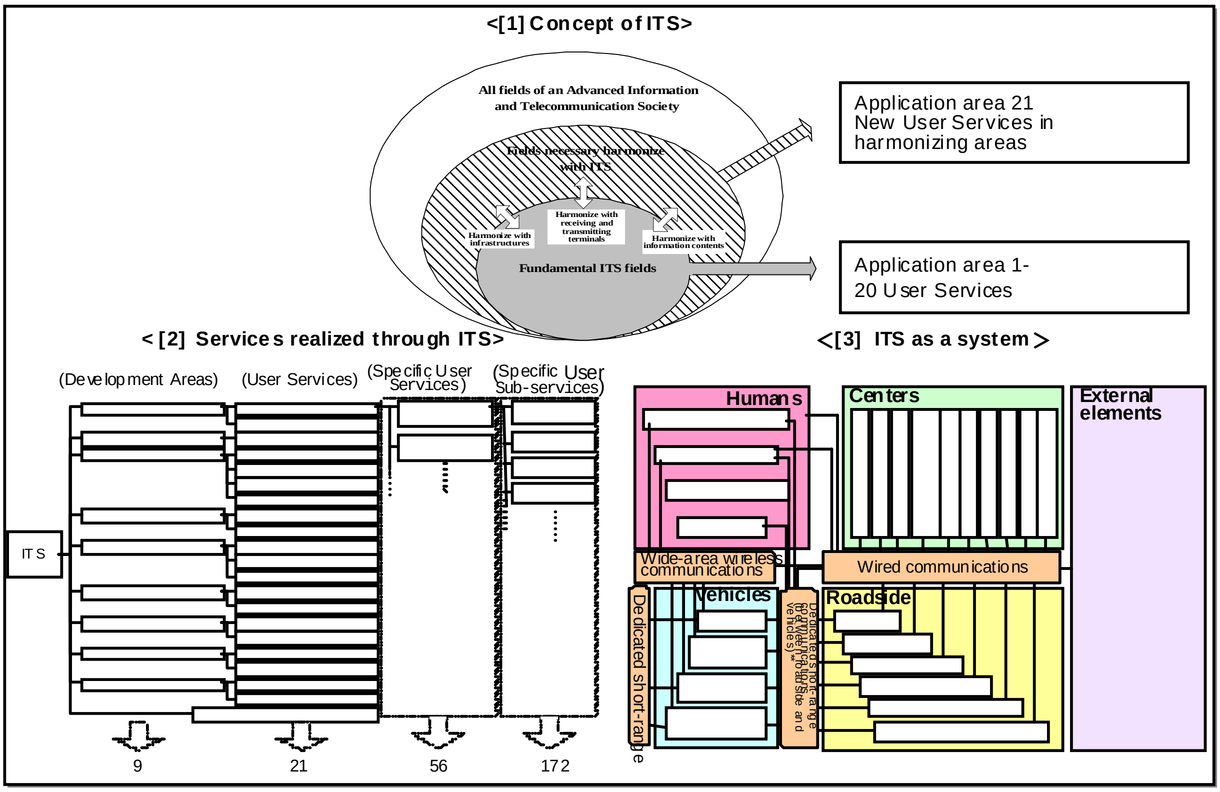
Concerning the concept of ITS, we have presented the relationships of the basic sphere of ITS within the sphere of an advanced information oriented society as a whole, and the areas which need to be coordinated with ITS, in order to promote the building of a common awareness concerning the role of ITS in an advanced information oriented society.

Next, concerning the services to be realized through ITS, under the System Architecture which has now been constructed, we took the nine development areas indicated under the basic government guidelines of advanced information and communications in the field of roads, traffic, and vehicles, and the 20 User Services stated under "The Comprehensive Plan for Intelligent Transport Systems (ITS) in Japan" as an overall framework for ITS. Based on this system, we then arranged a user service system composed of 56 specific User Services and 172 sub-services. We have used this system to indicate the potentials of ITS from the viewpoint of the User Services to be realized through ITS, in order to promote the building of a common awareness of the future image of User Services to be provided by ITS.

And concerning ITS as a system, we have prepared the subsystems interconnect diagram and other documents to promote the building of a common awareness of the specific subsystems making up ITS and the interfaces connecting those subsystems.

This will allow the realization of involvement by ITS-related interested parties in industry, academia, and the government on the basis of alliances and appropriate division of roles.

Fig. 2.1-1 Three Points on ITS Indicated in the System Architecture

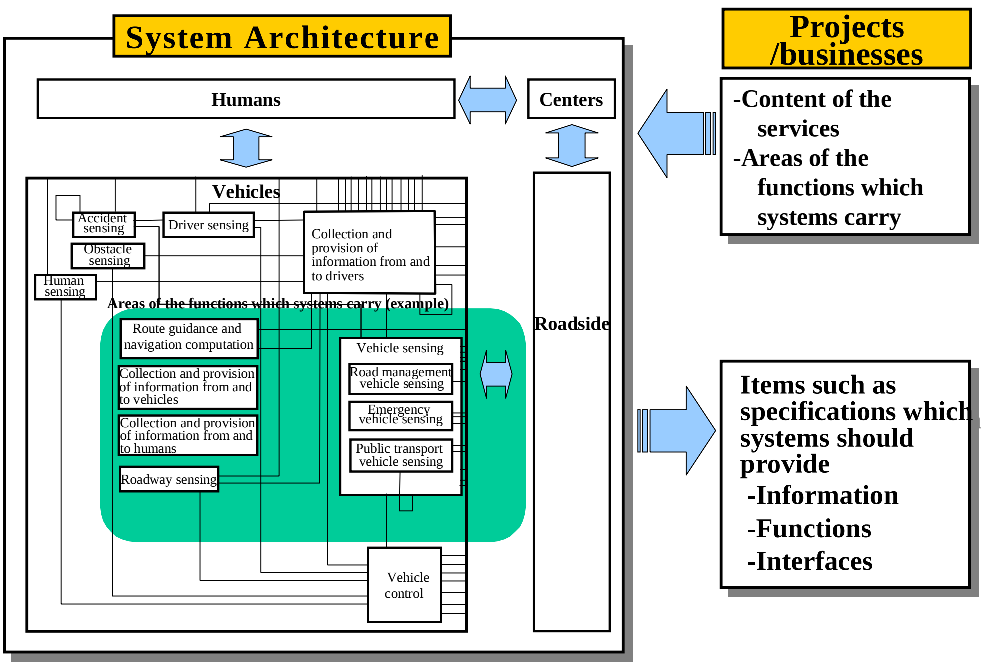


2.2 Establishing a Plan for Project Development and Implementation

For the efficient development and implementation of ITS-related projects and businesses, it is necessary to clarify the objectives and points to consider in project plan establishment and to determine the specific conditions for decision of the hardware and software specifications, in order to improve planning effectiveness. Overall physical model is a clarified view of the overall system of ITS made by properly arranging "information" and "functions" in order to make ITS functionable as a system.

In the future, clarification should be made on the Physical Architecture, the service contents that infrastructure provides and the areas of subsystems included in it. This process makes it possible to coordinate the area which is evaluated into the whole system of ITS, and also to easily grasp the relation between "functions" and "information". When a new business such as a plan for goods and services related to ITS is being discussed and when new policy and/or infrastructure are being evaluated. In this manner, it becomes possible to evaluate efficiently the technical method, standards and various systems needed for the realization of new business, policy and/or infrastructure, and also to easily move on from the work of evaluating the content of the services and the areas of the functions which systems carry to the work of extracting items such as specifications which systems should provide.

Fig. 2.2-1 Relationship of Project Plan Establishment to System Architecture



2.3 Combination and Application of User Services to Achieve ITS Policies

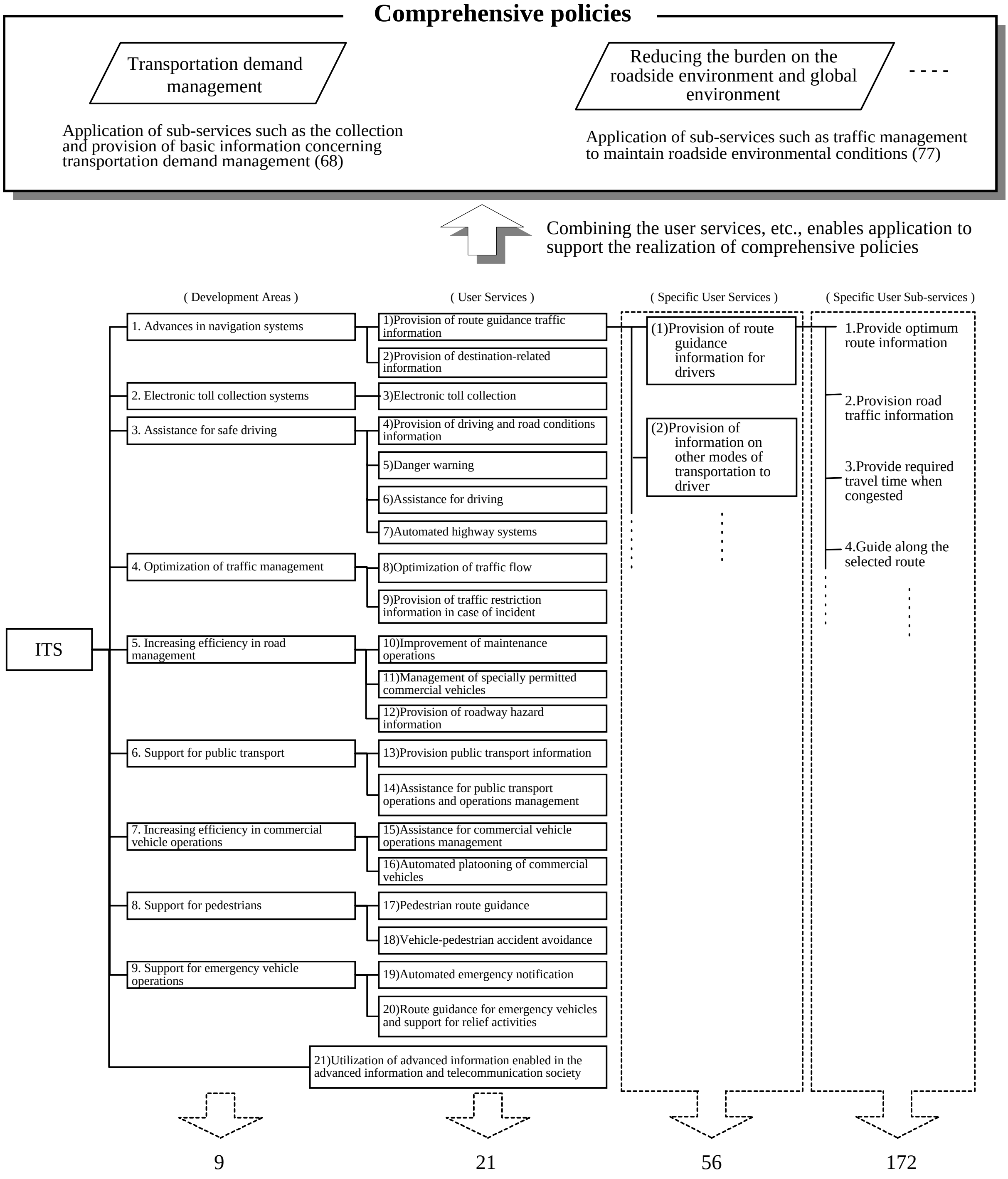
A variety of factors lead to problems such as traffic congestion and environmental deterioration. The comprehensive policies on wide-ranging areas, such as TDM and environmental countermeasures, can only show maximum effectiveness through the effective linkage of multiple specific policies.

The System Architecture presented here provides a systematic overview of ITS-related services, organized into 56 Specific User Services and 172 Specific User Sub-services, under 9 areas for development and 21 User Services. By combining these User Services, they can be applied to the achievement of an integrated TDM system.

Moreover, when constructing specific systems, it will be possible to use groups of sub-services efficiently through the recognition of information and functions that can be used in common.

This will make it possible to improve the efficacy of comprehensive policies on wide-ranging areas, contributing to the resolution of problems such as traffic congestion and environmental damage. In order to ensure the continuous and effective use of the System Architecture which has now been constructed, it will be essential to keep changing and revising it to reflect future international trends and technological development trends in industry.

Fig. 2.3-1 Combination and Application of User Services to Achieve Comprehensive Policies



2.4 Design and Development of the Systems Concerning ITS

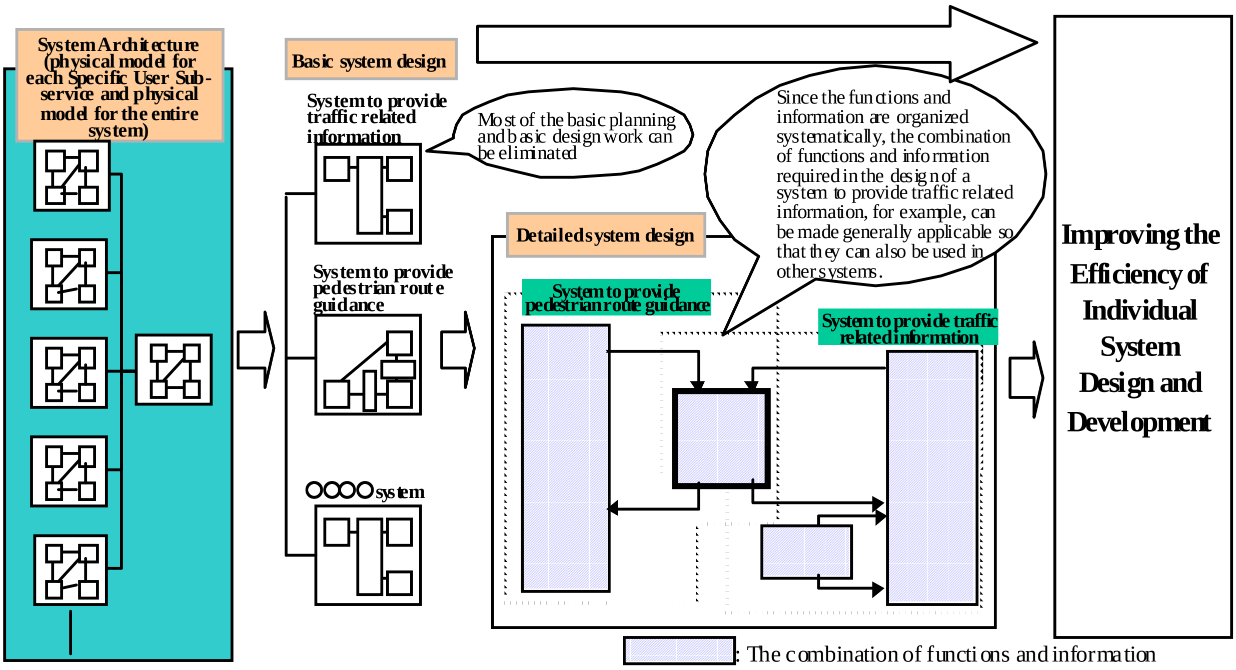
The design and development of specific systems can be classified mainly into two categories: Basic design which assembles the outlines of specific systems, and detailed design which includes detailed study of the structures of programs included in the system. In basic design, it becomes possible to use the information and functions, which are already organized according to their mutual relationships in the System Architecture, as a framework for system design and development when the information and functions required for realization of the specific systems are drawn out using the System Architecture which has now been constructed. This eliminates much of the work needed for basic design, such as collecting the necessary peripheral information.

In some cases, the functions realized in other systems are also contained in the system to be designed or developed. In detailed design, the System Architecture which has now been constructed is used to allow discovery of identical functions existing in separate specific systems. Therefore, the detailed design concerning overlapping functions can be unified, and the functions contained in the system to be designed or developed can be made generally applicable so they can be used by other specific systems as well.

For example, it can be seen that the driver interface, which is the main function of vehicles in the area of navigation system sophistication, is also needed in using information related to the advanced information oriented society. So when this is followed, the functions can be unified and improved in a planned fashion.

Also, if necessary functions or information are already realized in another system, this can be determined easily; and therefore, redundance can be eliminated in design and development, so that the work of design and development can be performed in an efficient manner.

Fig. 2.4-1 Improving the Efficiency of Design and Development Using System Architecture



2.5 Promotion of Standardization Activities

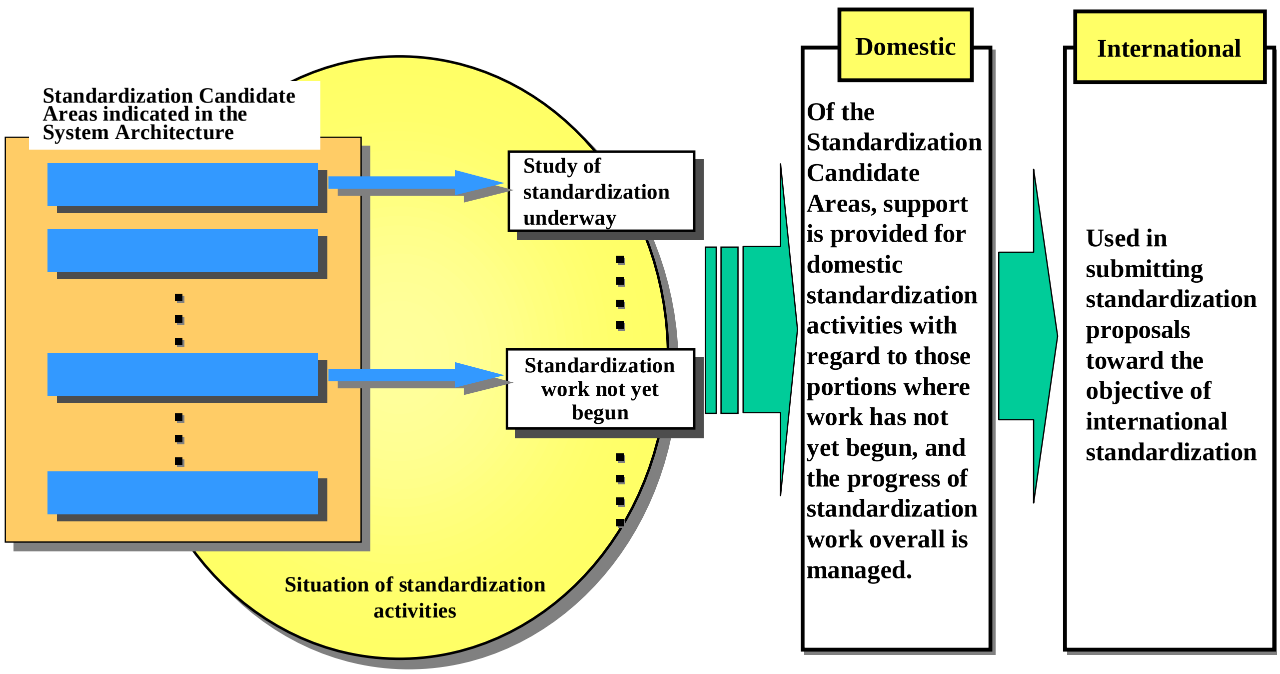
With regard to standardization activities related to ITS, the functions and interfaces to be handled in a shared manner are being studied individually. However, under the current efforts, it is not necessarily the case that their degrees of priority are determined on the basis of an overall image of the system.

In the System Architecture which has now been constructed, after organizing the Standardization Candidate Areas in view of ITS overall, the subsystems and communications formats which are important in system construction are drawn out, as components that have an especially high need for standardization in future standardization activities.

Since these have been gathered with the goal of contributing to the decision of degrees of priority for standardization activities at the organizations involved in standardization, keeping in mind an evaluation of the various areas from the viewpoint of ensuring general applicability, the use of the System Architecture supports the promotion of effective standardization activities by the private sector with reference to this.

By drawing out the information and functions related to Standardization Candidate Areas for reference, using the “Physical Model for the Entire System” and “Physical Model for Each Specific User Sub-services”, it is possible to contribute to the concrete study work for standardization.

Fig. 2.5-1 Standardization Activities Based on the Standardization Candidate Areas



2.6 Utilization of the Information in ITS Research

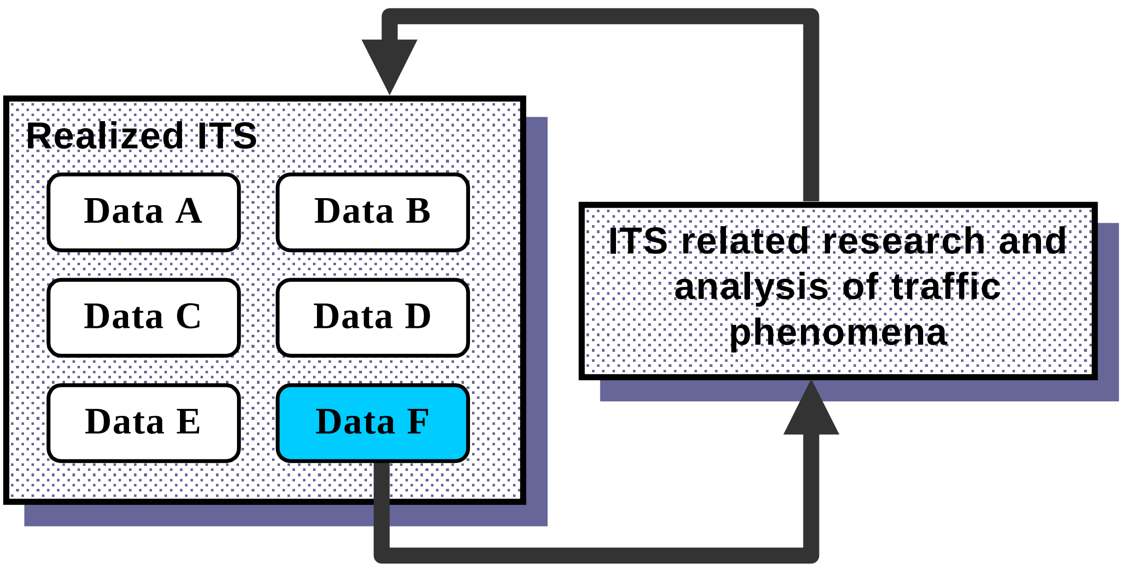
For the realization of ITS to meet social expectations, it is important to perform the following: a detailed analysis on the causes of traffic accidents, the situation of traffic congestion, the traffic behavior of drivers and so on, and to continue efforts to improve the content of ITS services in terms of both "hardware" and "software."

In the analysis of traffic phenomena overall, independently of ITS, various types of detailed data handled by ITS will contribute to establishing a new theory of transportaion planning and verification in terms of human engineering if they are used in appropriate way.

When the specific systems for realization of ITS services begin to be developed in accordance with the “Physical Model for the Entire System”, subsystems interconnect diagram, and other elements which have now been constructed, it will become possible to determine the locations of specific systems which handle the detailed data that is needed for ITS-related research and the analysis of traffic phenomena.

Universities and research institutes will be able to easily and appropriately obtain the data they need through information networks, by referring to these and determining their locations. This will allow the use of information in full-scale ITS research and the analysis of traffic phenomena. The effects produced by ITS will be further enhanced. This will make it possible to provide a feedback on social demands to the stages of establishing plans related to development and implementation of projects and the design and development of specific systems.

Fig. 2.6-1 Usage and Feedback of ITS Related Information



Appendix

- Glossary of Terminology -

21st user service:

The world of realization in areas requiring harmonization with ITS to ensure mutual operability and mutual connectivity with an advanced information oriented society has been established as a new user service. In the "Comprehensive Plan for Intelligent Transport Systems (ITS) in Japan", issued in July 1996, 20 services to be offered by ITS in the future were specified. This 21st user service has now been added as a new service.

Specific User Sub-services:

In the Specific User Sub-services, the User Services are subdivided in such a way that a series of flows, from collecting information needed by the user or system to usage, is unique in terms of the usage situation of the user, the content of information handled, etc.

Specific User Services:

These are an intermediate unit between User Services and Specific User Sub-services established by the inclusive handling of sub-services.

Logical Architecture:

In the Logical Architecture, upon clarification of the transmission and reception of information that occurs between users and systems for the realization of Specific User Sub-services and the processing performed within the system (called "procedures" below), the information and functions handled in those procedures are determined. The information is systematized and the relationships between the functions needed for the realization of services and the information handled by those functions are modeled using a common format. The resulting Logical Architecture is composed of information models and control models.

Information models:

These clarify the relationships among all of the information handled under ITS, and relate them as systems having a stratified structure. They are composed of core models and detailed models.

Core models:

These express the relationships among spot, route, roadway, moving body, schedule, operational body, and external institutes, which are positioned as the highest level elements in the system of information handled by ITS.

Detailed models:

For each basic element indicated by a core model, the information making up that basic element is systematized in a stratified manner, based on the respective inclusive relationships, to form a detailed model.

Control models:

The procedures needed for the realization of sub-services are modeled, using a common format, as the relationships between functions and the information handled by those functions.

Object oriented analysis method:

This is the technique of viewing the information and functions handled in the system in a unified manner as "objects," and using these to express the system in question. The use of this technique makes it possible to produce a unified model of the information and functions handled under ITS overall, and in the case of additions or changes to the services, it is possible to instantly determine the information and related functions which are to be added or changed.

Structured analysis method:

This is the technique of analyzing and systematizing the functions needed for the realization of services. It has often been used in the analysis of large-scale systems, and has the advantage of allowing construction in a relatively short period of time.

Physical Architecture:

The combinations of the functions determined by the Logical Architecture and the information they handle are arranged among vehicles, roads, centers, etc., and an overall image of the systems for the realization of ITS is modeled to form the Physical Architecture.

Subsystems:

The subsystems are a combination or aggregation of the functions determined by the Logical Architecture and the information handled by those functions. They are composed of the five highest level systems of vehicles, roadside, centers, humans, and external elements, the Lowest Level Subsystems, which are combinations of the functions determined by the Logical Architecture and the information they handle and collections of these.

Physical Model for Each Specific User Sub-services:

This models the results of arranging the Lowest Level Subsystems within the Highest Level Subsystems with Specific User Sub-services as the unit, the information exchanged among the Lowest Level Subsystems, and the communications formats.

Physical Model for the Entire System:

This models the results of arranging the Lowest Level Subsystems within the Highest Level Subsystems, and the information exchanged among subsystems along with the communications formats, with regard to the overall system for the realization of ITS.

Subsystems interconnect diagram:

This diagram was prepared in order to give an overview of the structure (framework) of the overall system for the realization of ITS. It expresses the composition of Highest Level Subsystems by means of the Lowest Level Subsystems expressed collectively, and indicates the interfaces among subsystems shown in the diagram which bridge across Highest Level Subsystems, along with their communications formats.

Standardization Candidate Areas:

These are the areas which are to be standardized. In the System Architecture related to ITS, all of the subsystems and communications points included in ITS are shared by various sub-services, so all of the subsystems and communications formats shown on the subsystems interconnect diagram are treated as Standardization Candidate Areas.