Chapter IV Technological development and standardization targets geared towards realization of ITS info-communications systems

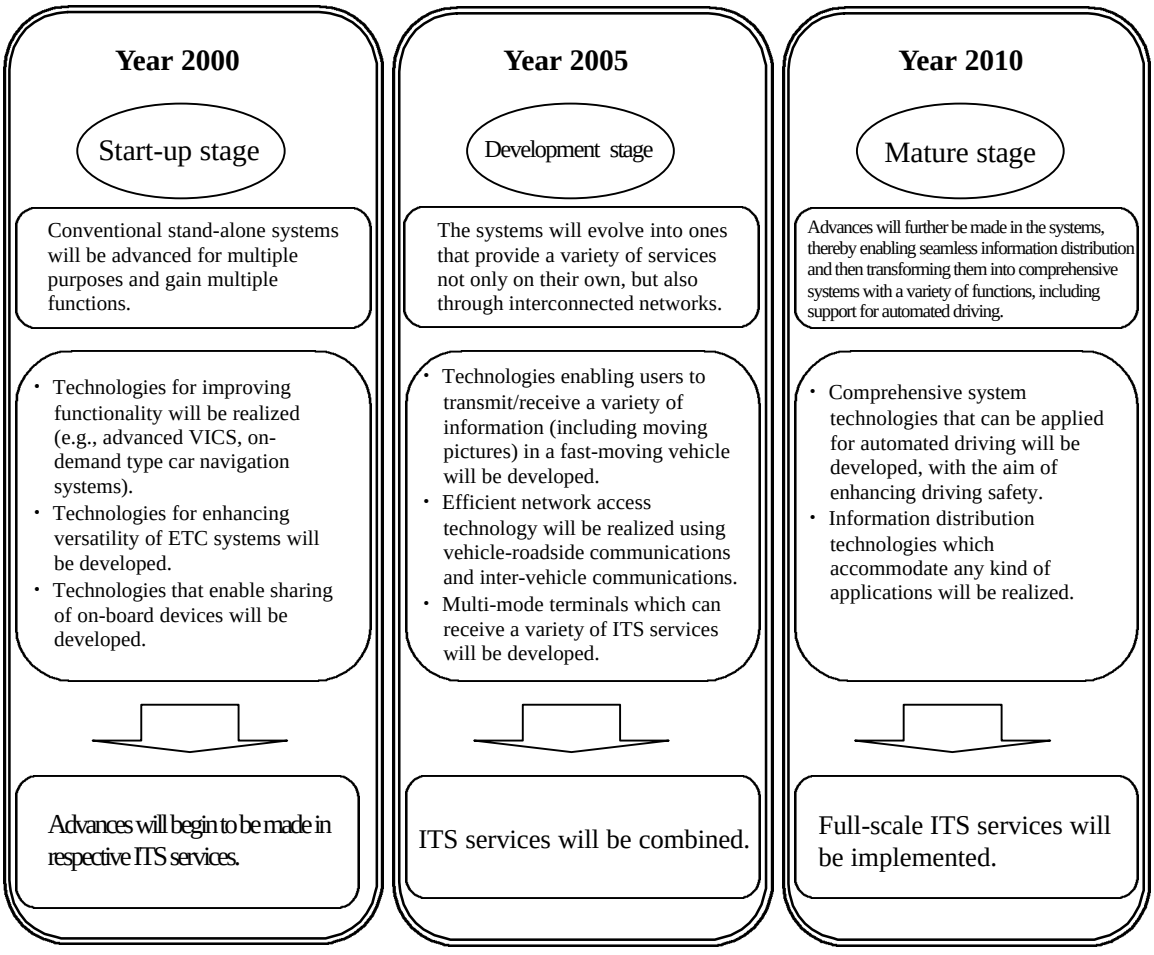
1. Technological development targets geared towards realization of ITS info-communications systems

Fig. 4-1 shows the targets for technological developments geared towards realization of ITS info-communications systems. The outline of these targets is as follows.

Technological advances are seen occurring as ITS info-communications systems progress upon following the course of developmental stages shown in Fig. 4-1. This figure also carries the results of examinations made in order to clarify the development status for ITS info-communications systems in the years 2000, 2005 and 2010, respectively.

In a nutshell, the ideal future images of ITS info-communications systems in these phases can be said as follows: the year 2000 is the "start-up stage," when "advances will begin to be made in respective ITS services"; year 2005 is the "development stage," when "ITS services will be combined"; and, year 2010 is the "mature stage," when "full-scale ITS services will be implemented."

Fig. 4-1 Images of ITS info-communications systems development



Fundamental technologies necessary for the development of ITS info-communications systems are shown in Fig. 4-2. Of these, items in bold face are the technologies crucial to the realization of ITS info-communications systems, yet have high R&D risks due to their possible impact on other extensive fields (these technologies are also listed in Table 1 in the Reference section of this TTC Report). For details of examinations on these fundamental technologies, refer to Reference Material 6.

Fig. 4-2 Fundamental technologies for ITS info-communications systems

1. Systems technologies
- **Wireless agent technology**
- **Security/authentication/encryption technologies**
- **Quality of service (QOS) control technology**
- **Advanced location detection/tracking technology**
- *Data conversion technology*

2. Information advancement technologies
- Multimedia information production technologies
  - **Optimal route information analysis technology**
  - *Digital map technology*
  - *Road traffic information projection technology*
- Information reliability enhancement technologies
  - **Reliability enhancement/distribution control technology**
  - *Network maintenance/operation management technology*

3. Network technologies
- Light-radio hybrid communications technologies
  - **Light-radio conversion device technology**
  - **Multiapplication-compatible base station component technology**
- Wireless communications technologies
  - **Roadside-vehicle/inter-vehicle communications technology**
  - **Continued cell structure technology**
  - **Advanced wireless access technology** (highly reliable transmission/connection technology)
  - **Dynamic channel allocation technology**
  - **High-speed hand-over control technology**
  - **Wireless communications zone active control technology**
  - *Dynamic range control technology*
  - *Vehicle sensor technology*
- Wired network technologies
  - **Multi-cast route technology**
  - **High-speed routing technology**
  - **Varied networks interconnection/control technology**
  - **Fast-moving objects address management technology**

4. Terminals advancement technologies
- User-oriented technologies
  - **Advanced human-machine interface technology**
  - *Voice recognition technology*
- On-board terminals technologies
  - **Multi-mode terminal technology**
  - **Terminal miniaturization device technology**
  - *Display device technology*
- Intra-vehicle network systems
  - **Advanced intra-vehicle LAN technology**

Fig. 4-3 on the following page picks seven of these fundamental technologies and indicates trends of developments in these technologies until the year 2010.

Fig. 4-3 Developments in ITS fundamental technologies until year 2010 (prominent examples)

	Year 2000	Year 2005	Year 2010
Wireless agent technology	Automated search of optimal route information will be realized on stand-alone systems	Automated search of optimal route information will be realized on interconnected systems	Automated search of optimal route information will be realized, even in response to ambiguous requests from users
Reliability enhancement/distribution control technology	Editing/modification of electronic maps and other ITS information will be realized on stand-alone systems	Editing/modification of electronic maps and other ITS information will be realized on interconnected systems	Editing/modification of ITS information will be realized, even in response to ambiguous requests from users
Light-radio conversion device technology	Light-radio conversion technology using microwave frequencies will be realized.	Various applications operating in the microwave frequency band will become available. Light-radio conversion technology using millimeter-wave frequencies will be realized.	Broadband applications operating in the millimeter-wave frequency band will become available.
Roadside-vehicle/inter-vehicle communications technology	Roadside-vehicle communications technology that enables simultaneous connection of multiple systems (vehicles and roadside devices) will be realized. Fundamental technologies for inter-vehicle communications will be developed.	On-demand systems that enable information exchanges between moving vehicles will be realized.	Uninterrupted roadside-vehicle communications technology that could result in automated driving function will be realized.
Multi-cast route technology	Routing technology enabling multi-cast of information to a selected group of receivers will be realized.	Routing technology enabling multi-cast of information (including moving pictures) to a constantly changing group of receivers will be realized.	Routing technology enabling multi-cast of information through broadcasting and communications networks will be realized.
Advanced human-machine interface technology	Human-machine interface technology that has adopted voice recognition technology handling very basic words will be developed.	Terminal technologies that can function properly despite unwanted noise and that can facilitate the needs of the elderly and disabled will be realized.	Human-machine interface technology that could be applied for automated driving will be realized.
Multi-mode terminal technology	Standardization and integration of various on-board terminals will progress.	Switching of communications systems through use of software programs will become partially possible.	Switching of communications systems through use of software programs will be fully enabled.

(1) Systems technologies

These are very fundamental technologies necessary for the development of ITS info-communications systems as a whole. Specifically, they are used to interconnect users and users, or users and information centers.

One of these systems technologies, wireless agent technology, will enable ITS systems to detect locations of an information sender and the receiver on a wireless ITS network, then to find an available communications route and to make seamless connection between the two parties. When developments are made in this technology, wireless agent technology will enable automated search of the best route information on a stand-alone basis by the year 2000. By 2005, the same function will become possible on multiple systems, due to realization of automated selection of the best communications system from among many possibilities. By 2010, this functionality will enable recognition of particular places frequented by users and then establish the most efficient connections between communications systems in the user's proximity, automatically searching out the optimal route information in response to even ambiguous queries.

Eventually, users will be able to obtain the best route information, without the need for switching networks.

[Example of systems technologies]

- Wireless agent technology
- Security/authentication/encryption technologies
- Quality of service (QOS) control technology
- Advanced location detection/tracking technology

(2) Information advancement technologies

Geographical data and other various information distributed through ITS info-communications system must be upgraded in order to meet diversified user needs. For instance, geographical data should be provided as multimedia information over ITS systems, and these information advancement technologies are aimed at producing multimedia data as well as at enhancing data accuracy.

One example, reliability enhancement/distribution control technology, is to enable distributed data processing among interconnected nodes (server and client machines), thereby also distributing loads on the nodes. This technology thus can improve network reliability while ensuring efficient use of computer resources. When progress is attained for this technology as expected, editing/modification of various ITS information including geographical data will be made possible on stand-alone systems by the year 2000. This function will also be made possible on multiple, interconnected systems by 2005. And this development will progress further to enable acceptance of ambiguous user requests for editing, alteration and addition of various ITS information by 2010.

Such progress will make the optimal geographical information available to users anytime, without the need for any action on the part of the users.

[Example of information advancement technologies]

- Optimal route information analysis technology
- Reliability enhancement/distribution control technology

(3) Network technologies

These technologies are indispensable for the construction of ITS info-communications systems, which encompass both wired and wireless communications networks. Specifically, these technologies are aimed at realizing seamless connection of optical, wired and wireless communications.

(a) Light-radio hybrid communications technologies

These technologies are aimed at the development of device and module technologies for modulation/demodulation of light with radio signals, thereby making the technologies suitable for multimedia use.

One such technology, light-radio conversion device technology, involves the development of modulation devices that convert light sent over fiber-optic cables through use of radio signals, and light-reception devices that pick up radio signals embedded in modulated light signals. In addition, light modulation technology to mount the aforementioned two technologies on systems also constitutes a portion of light-radio conversion device technology. If constant progress is attained for these technologies, light-radio conversion technologies using microwave frequencies will be realized by the year 2000. This is seen leading to the availability of various applications operating in such a frequency band by the year 2005, in addition to realization of light-radio conversion technologies using millimeter-wave frequencies. By 2010, broadband applications operating in the millimeter-wave frequency band are anticipated to become available.

[Example of light-radio hybrid communications technologies]

- Light-radio conversion device technology
- Multiapplication-compatible base station component technology

(b) Wireless communications technologies

Roadside-vehicle/inter-vehicle communications technology is one of wireless communications technologies enabling provision of ITS services, which specifically refers to communications between on-board devices and roadside systems, as well as communications between on-board devices. When progress is attained as expected for this technology, simultaneous connection of multiple systems (on-board devices and roadside devices) will be realized by the year 2000. This could be regarded as the full development of fundamental technology for inter-vehicle communications technology. By the year 2005, on-demand systems that enable information exchanges between moving vehicles will be realized. And in the year 2010, development of fundamental technologies for inter-vehicle communications will be fulfilled.

These developments, if realized as expected, will lead to the development of communications technologies that could be applied for automated driving systems.

[Example of wireless communications technologies]

- Roadside-vehicle/inter-vehicle communications technology
- Continued cell structure technology
- Advanced wireless access technology (highly reliable transmission/connection technology)
- Dynamic channel allocation technology
- High-speed hand-over control technology
- Wireless communications zone active control technology

(c) Wired network technologies

On example, multi-cast route technology, enables simultaneous transmission of the same information, for instance weather forecasts, to a group of people using the same system, while keeping the communications volume low over the entire network. This technology is a key to the realization of high-speed hand-over, tracking of fast-moving objects (vehicles as well as devices) and "broadcasting" of info-communications services over the ITS info-communications networks. If progress is attained as expected for this technology, the routing technology enabling multi-cast to a selected group of receivers will be realized by the year 2000. By2005, the technology will become advanced enough to enable the handling of moving pictures and multi-casting to a constantly changing group of receivers. And by 2010, routing technology enabling multi-cast through broadcasting and communications networks will be realized.

[Example of wired network technologies]

- Multi-cast route technology
- High-speed routing technology
- Varied networks interconnection/control technology
- Fast-moving objects address management technology

(4) Terminals advancement technologies

Terminals' functionality, size, weight and so on are important factors in promoting the development of ITS info-communications systems, as terminals are carried by users or installed in vehicles by users. Meanwhile, because advanced terminals are for use by end users in receiving information, the efforts for the development of such advanced terminals are crucial.

(a) User-oriented technologies

One example, advanced human-machine interface technology, is aimed at realizing user-friendly human-machine interfaces. Progress in this technology is anticipated to result in the development of human-machine interface technology that has adopted voice recognition technology that can handle very basic words by 2000. Then by 2005, terminals technologies that can function properly even in the presence of unwanted noise and that can facilitate the needs of the elderly and disabled will be realized. This will be followed by the realization of human-machine interface technology by 2010 that could be applied for automated driving.

These advances will enable users to obtain necessary information through the process similar to conversation and association with people, without needing to know how the terminals are used.

[Example of user-oriented technologies]

- Advanced human-machine interface technology
- Voice recognition technology

(b) On-board terminals technologies

One example, multi-mode terminal technology, is aimed at integration of all mobile communications terminals, such as devices for VICS, ETC, GPS as well as car/cellular telephones. Along with developments in ITS services, the types of terminals and devices to be installed on vehicles will be increasingly varied -- not only VICS and ETC, but also ones aimed at supporting driving safety. Development of technologies that enable integration of these terminals and cut terminal prices significantly for consumers is a must, as is the development of technology for shared-use of antennas. Developments in these technologies, if realized as expected, should advance standardization and integration of various on-board terminals by the year 2000. This will be followed by the switching of communications systems becoming a reality, through use of software programs, by 2005. And by 2010, the development of this function will be completed.

These advances will enable users to obtain necessary information without the need to change menus or switch to different terminals.

[Example of on-board terminals technologies]

- Multi-mode terminal technology
- Display device technology
- Terminal miniaturization device technology

(c) Intra-vehicle network systems

ITS info-communications technologies will enable provision of information to drivers and ensure extra-vehicular communications, by interconnecting on-board DSRC device, millimeter-wave radar and inter-vehicle communications device through intra-vehicle LAN (ITS Data Bus).

Advances in technologies will enable sharing and centralized control of various on-board devices' interfaces, thereby effectively gathering information from both inside and outside the vehicle.

[Example of technologies used for intra-vehicle network systems]

- Advanced intra-vehicle LAN technology

2. Standardization targets geared towards realization of ITS info-communications systems

Defining technologies that must be standardized is vital for the earliest possible realization of full-scale ITS info-communications systems as well as for pursuing their further diffusion and development effectively. Based upon developmental trends in the aforementioned technological development targets, items to be standardized and target years for their standardization regarding each of the fundamental technologies are shown in Fig. 4-4.

Around the year 2000, the "start-up stage" of the ITS info-communications systems development, the standardization work should greatly influence the achievements in the year 2005, the "development stage" -- that is, whether or not the development targets for the year 2005 could be attained. The shaded items indicate those falling into the "technological development standardization issues that must be dealt with immediately" (very important items in Fig. 4-4). These are to be prioritized within the standardization work. Vigorous activities are eagerly awaited upon standardization.

Fig. 4-4 Items to be standardized and target years

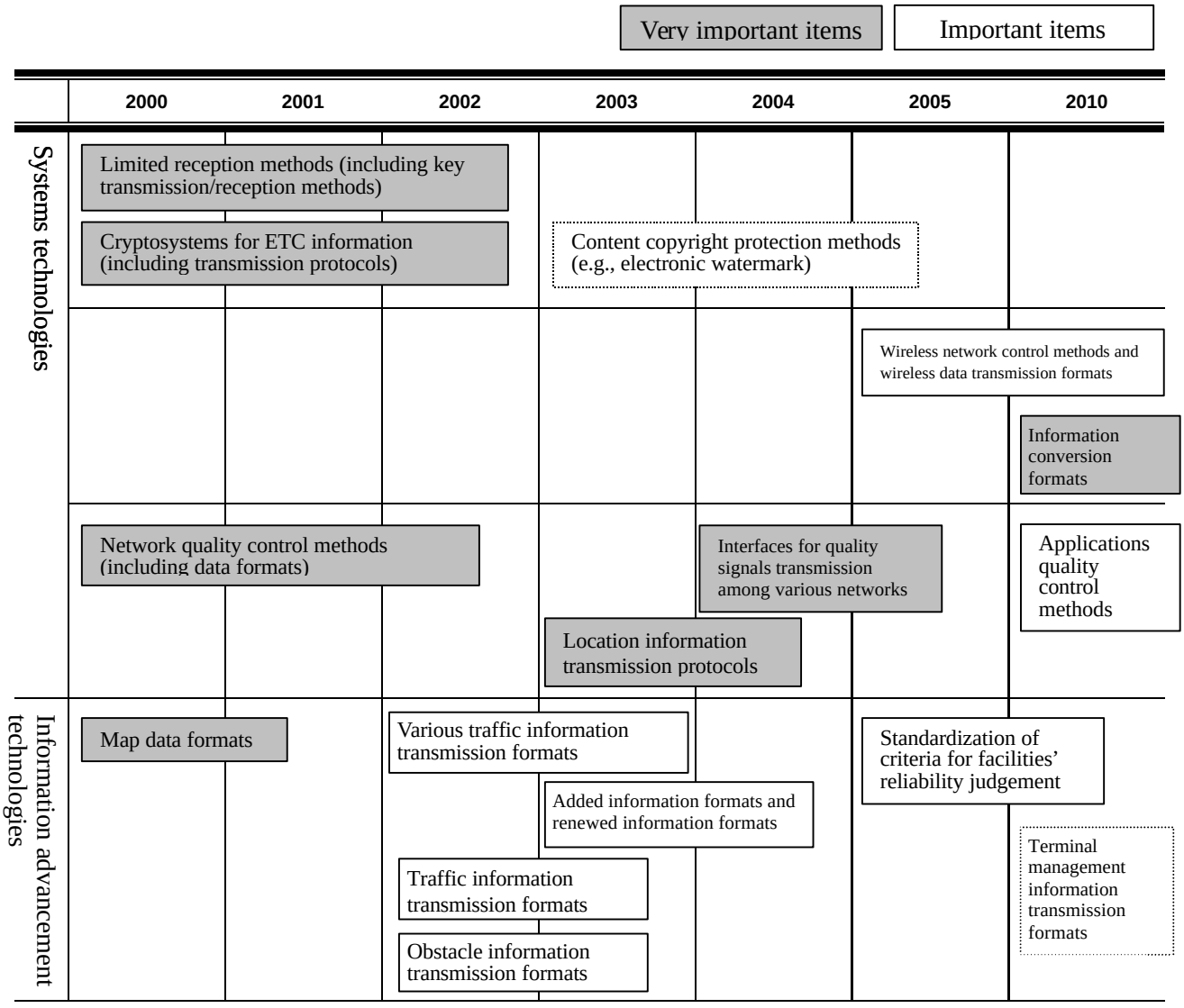
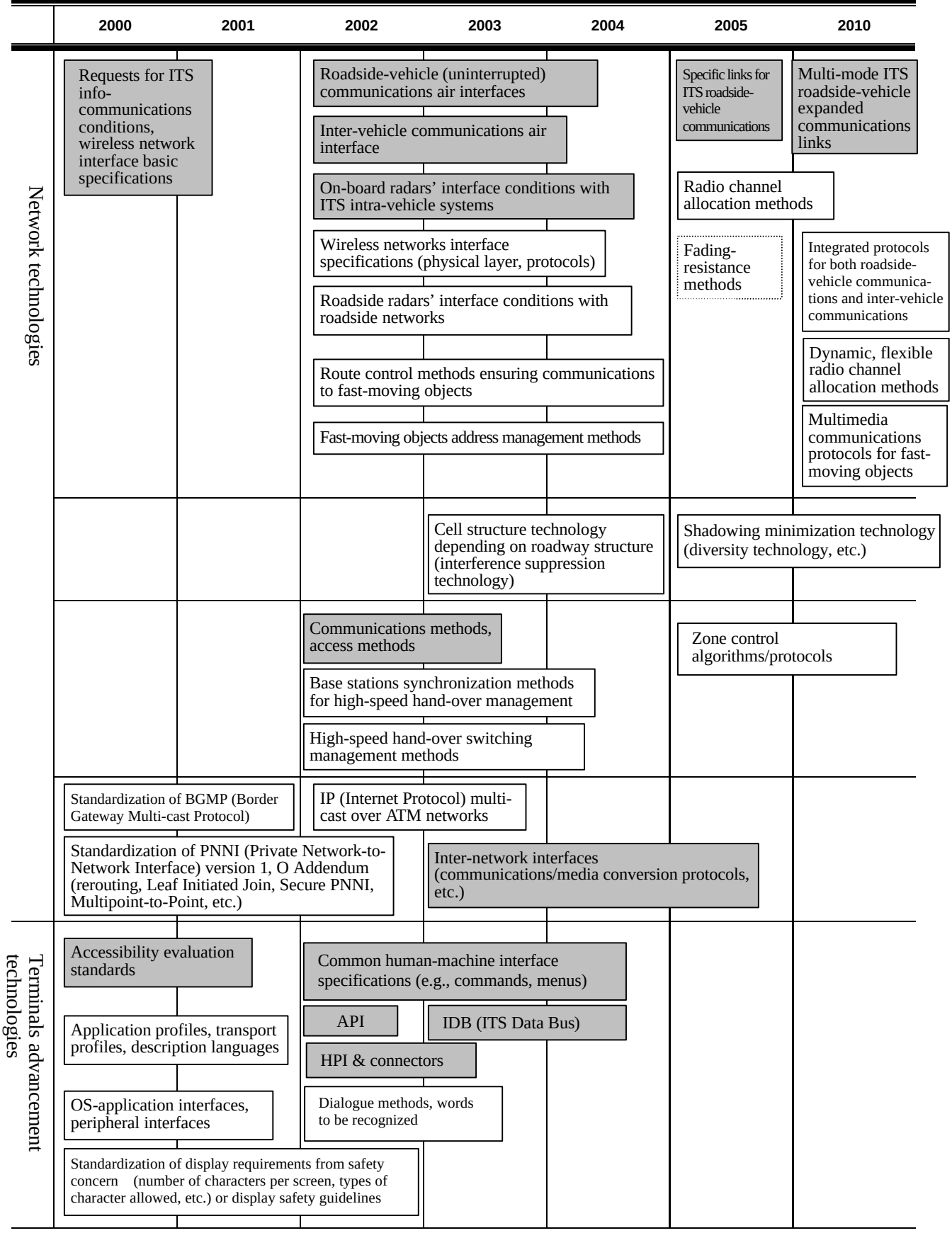


Fig. 4-4 (Continued)



Brief explanations on some of the items to be standardized by around the year 2000 are as below.

(1) Systems technologies

Security/authentication/encryption technologies are crucial for developing full-fledged ETC systems and for pursuing their multi-purpose use. To this end, efforts should be made to develop these technologies and then to standardize them. By the year 2000, limited reception methods (including key transmission/reception methods) and cryptosystems for ETC information (including transmission protocols) should be standardized. By 2003, standards for content-related copyright protection methods, such as electronic watermark, should be formulated.

For the realization of QOS control technology, standards should also be set for these items by the following target years: network quality control methods (including data formats) by the year 2000, interfaces for quality signals transmission among various networks by 2004, and applications quality control methods by 2010.

As for standardization concerning wireless agent technology, wireless network control methods and wireless data transmission formats should be standardized by 2005, and information conversion formats for sharing of varied information distributed within the same network by 2010.

Because of the nature of ITS, its users are not in fixed locations most of the time and thus their constantly changing location data are transmitted over the network. To facilitate effective transmission of location data, location information transmission protocols should be developed and standardized by the year 2003.

(2) Information advancement technologies

In order to realize digital map technology, the following items should be developed and then standardized by these target years: map data formats by the year 2000, various traffic information transmission formats in addition to formats for additional information by 2002 to 2003, and by 2005, criteria for judging facilities' attainment of the level of reliability, necessary for the development of reliability enhancement/distribution control technology.

(3) Network technologies

ITS info-communications systems are to develop networks integrating both wired and wireless communications links; therefore, the systems involve R&D and standardization items belonging both to wireless and wired communications technologies.

In the wireless communications field, requests for ITS info-communications conditions as well as wireless network interface basic specifications should be standardized by the year 2000. For various interface conditions concerning roadside-vehicle communications and inter-vehicle communications should be developed and standardized by 2002. Moreover, various communications links and integrated protocols should be developed and then standardized in the 2005 - 2010 span.

Development and standardization should be carried out for these wired communications-related items as well for these target years: BGMP (Border Gateway Multicast Protocol), which is indispensable for the realization of multi-cast route technology, by the year 2000; and IP (Internet Protocol) multi-cast over ATM networks, by 2002.

(4) Terminals advancement technologies

These are very important technologies aimed at providing information to end-users.

Standards should be set for accessibility evaluation criteria, as well as for application profiles, transport profiles and description languages by the year 2000. These are items aimed at realizing advanced human-machine interface technology. Efforts should also be made to develop and standardize various interface specifications necessary for multi-mode terminal technology by 2002, and ITS Data Bus specifications for advanced intra-vehicle LAN technology by 2003.

In the process of setting these standards, efforts should also be made to increase accessibility to much more advanced terminals by users, while evaluating objectively the level of advancements for the terminals.

3. R&D themes on ITS that should be promoted comprehensively

From now on, it is vital to take appropriate measures to promote wide-ranging R&D themes for ITS info-communications systems. The following themes, in particular, should be dealt with strategically from diverse points of view, while concentrating relevant fundamental technologies in one place, so as to enhance efficiency in R&D activities.

Realization of Smart Gateway technology

The Emergency Economic Relief Package (???), which was released in November 1999, requests that efforts shall be made to realize world's first Smartway on a model road and to succeed in test driving of Smartcar by the year 2003. Based on this description, preparation work for field trials on Smartway as well as efforts for the development of Smartcar will be invigorated. Apart from these, efforts should also be made towards the realization of Smart Gateway technology, enabling smooth communications between Smartways and Smartcars.

Realization of ITS info-communications platform (info-communications infrastructure) technology

It is anticipated that by the year 2005, the Japanese people will have systems at hand that enable them to send/receive various information (including moving pictures) smoothly in fast-moving cars. To make this a reality, it is crucial to realize the ITS info-communications platform, which will ensure a smooth flow of information between various ITS info-communications systems and various types of network interconnected.

Realization of technologies for improving versatility and advancing ITS applications

It is projected that the ITS info-communications service market will grow considerably along with advances in ITS info-communications technologies, accounting for about 65% of the entire ITS info-communications market by 2015. In order to make this a reality, it is vital to develop technologies aimed at enhancing versatility and prompting advancement of ITS applications. Such technologies include: ITS data analysis technology, which enables flexible use of geographical data necessary for ITS; technology for increasing versatility of ETC and its advancement; and security/authentication/encryption technologies, which can be applied for various other purposes.

Realization of human-friendly ITS terminal advancement technology

ITS terminal advancement technology providing excellent human-machine interfaces should be realized, in order to enable access to various ITS services from one single terminal and to ensure mobility of the elderly and disabled.