

RECOMMENDATION ITU-R M.1453-2

Intelligent transport systems – dedicated short range communications at 5.8 GHz

(Question ITU-R 205/8)

(2000-2002-2005)

Scope

This Recommendation outlines the technologies and characteristics for dedicated short range communications (DSRC) in the 5.8 GHz band. This Recommendation includes an active (transceiver) method and a backscatter (transponder) method as DSRC technologies available for intelligent transport systems (ITS). This Recommendation further includes a DSRC-application sub-layer (DSRC-ASL) which allows for multiple DSRC applications and IP-based (Internet protocol) network applications. The technical and operational characteristics of both methods and the DSRC-ASL are described.

The ITU Radiocommunication Assembly,

considering

- a) that intelligent transport systems (ITS) may significantly contribute to the improvement of public safety;
- b) that international standards would facilitate worldwide applications of ITS and provide for economies of scale in bringing ITS equipment and services to the public;
- c) that early international harmonization of ITS would have several benefits;
- d) that worldwide compatibility of ITS may be dependent on common radio spectrum allocations;
- e) that the International Organization for Standardization (ISO) has work under way on standardizing ITS (non-radio aspects) in ISO/TC204 which will contribute to the efforts in ITU-R;
- f) that administrations are operating short-range devices in the 5.8 GHz band in accordance with Recommendation ITU-R SM.1538 – Technical and operating parameters and spectrum requirements for short-range radiocommunication devices,

recognizing

- a) that the European Telecommunications Standards Institute (ETSI) has adopted the following standards on Road Transport and Traffic Telematics (RTTT):
 - ES 200 674-1 “Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Part 1: Technical characteristics and test methods for High Data Rate (HDR) data transmission equipment operating in the 5.8 GHz Industrial, Scientific and Medical (ISM) band”;
 - ES 200 674-2 “Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Part 1: Technical characteristics and test methods for Low Data Rate (LDR) data transmission equipment operating in the 5.8 GHz Industrial, Scientific and Medical (ISM) band”;

- EN 300 674 “Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Technical characteristics and test methods for Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s/250 kbit/s), operating in the 5.8 GHz Industrial, Scientific and Medical (ISM) band”;
- b) that the bands 5 795-5 805 MHz and 5 805-5 815 MHz (on a national basis) are identified for those systems listed in a) above;
- c) that other regional organizations, such as the Asia-Pacific Telecommunications Standardization Program (ASTAP), have approved a proposal on a draft standard on “Dedicated Short Range Communications (DSRC) Equipment Operating in the 5.8 GHz band”,

noting

- a) that the frequency range, 5 725-5 875 MHz, is also used by other radio systems and services operating in accordance with the RR,

recommends

- 1 that the technical and operational characteristics of DSRC described in Annex 1 and DSRC application sub-layer described in Annex 2 should be adopted for the delivery of ITS DSRC and Internet protocol-based applications in the 5.8 GHz frequency band;
- 2 that administrations should consider adoption of either active (transceiver) or backscatter (transponder) methods described in Annex 1 for DSRC implementation;
- 3 that administrations should further consider the implementation of the DSRC-ASL described in Annex 2 for ITS intended to deliver multiple DSRC and IP-based applications.

Annex 1

Technical and operational characteristics of DSRC operating in the 5.8 GHz frequency band

1 General

This Annex outlines the technologies and characteristics for DSRC in the 5.8 GHz band. This Annex includes both the active (transceiver) method and the backscatter (transponder) method as DSRC technologies available for ITS. The technical and operational characteristics of both methods are described.

1.1 Introduction

DSRC is a dedicated mobile radiocommunications system for vehicles that travel on roads. DSRC is a fundamental technology for ITS communications, helping link roads, traffic and vehicles covered by ITS with information technology.

DSRC refers to any short-range radiocommunication technology from a roadside infrastructure to a vehicle or a mobile platform. DSRC applications include electronic toll collection, parking payment, gas (fuel) payment, in-vehicle signing, traffic information, management of public

transportation and commercial vehicles, fleet management, weather information, electronic commerce, probe data collection, highway-rail intersection warning, tractor-to-trailer data transfer, other content services, border crossing, and electronic clearance of freight.

To illustrate, consider electronic toll collection (ETC). By applying two-way DSRC radiocommunication technology, ETC systems on toll roads enable drivers to pay tolls automatically on a cashless basis without the need to stop at the gates. ETC systems improve traffic flow at toll plazas, and the level of pollution by reducing fuel consumption. In addition, allowing traffic to pass through the gate without stopping can increase road capacity by three or four times and relieve traffic congestion at the tollgate. It is also expected that ETC systems will reduce the operating costs of toll roads by replacing manual toll collection.

1.2 Scope

DSRC for ITS applications is the use of non-voice radio techniques to transfer data over short distances between roadside and mobile radio units to perform operations related to the improvement of traffic flow, traffic safety and other intelligent transport service applications in a variety of public and commercial environments. DSRC systems may also transmit status and industrial messages related to the units involved.

2 Technical and operational characteristics

The types of vehicle-roadside communication are generally spot, continuous, and wide-area. DSRC concerns the radiocommunication link of the spot type. DSRC is considered effective technology for such systems as ETC and navigation. DSRC systems have the following features:

- restricted zone communications: communications possible only within restricted zones;
- short-time communications: communications possible within restricted times.

The two major components that comprise DSRC are on-board equipment and roadside equipment.

On-board equipment (OBE): OBE is attached near the dashboard or on the windshield of the vehicle, and consists of radiocommunication circuits, an application processing circuit and so on. It usually has a human-machine interface including switches, displays and buzzer.

Roadside equipment (RSE): RSE is installed above or alongside the road and communicates with passing OBE by the use of radio signals. RSE consists of radiocommunication circuits, an application processing circuit and so on. It usually has a link to the roadside system to exchange data.

DSRC systems operate by transmitting radio signals for the exchange of data between vehicle mounted OBE and RSE. This exchange of data demands high reliability and user privacy as it may involve financial and other transactions.

Both active (transceiver) method and passive (backscatter) method have been used advantageously for existing DSRC-type services.

2.1 Active (transceiver) method

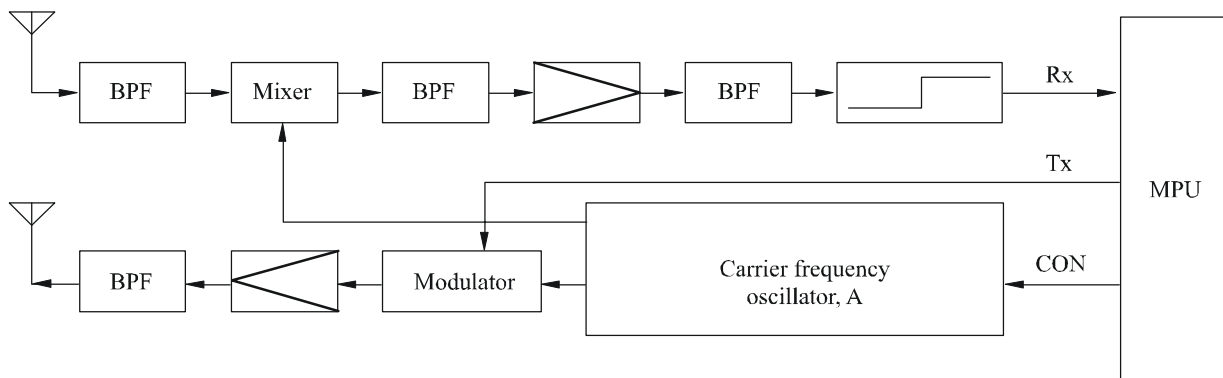
Roadside units are equipped with devices necessary for radiocommunication. For the active (transceiver) method, on-board units are equipped with the same functions as roadside units for radiocommunication. More specifically, both roadside units and OBE incorporate a 5.8 GHz band carrier frequency oscillator and have the same functionality for radio transmission.

The typical configuration of on-board units is focused on here, because an alternative scheme also exists for the configuration of OBE.

Figure 1 shows a typical block diagram for the OBE's radio circuitry.

The upper of Figure 1 half is the receiver, the lower half is the transmitter and the processing part is to the right. The transmission and reception antennas may be shared. The OBE in the active (transceiver) method receives radio signals from the roadside unit with the antenna on the upper left. Each signal received passes through each functional block and is processed by the MPU as reception data. The transmission signal from the OBE is the 5.8 GHz band carrier signal from oscillator A modulated with transmission data. The signal is sent from the antenna on the bottom left.

FIGURE 1
Typical configuration of OBE in active transceiver method



BPF: band pass filter
MPU: main processing unit

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An outline of the technical characteristics required for radiocommunication equipment is contained in Table 1:

TABLE 1
Characteristics of active (transceiver) method

Item	Technical characteristic	
Carrier frequencies	5.8 GHz band for downlink and uplink	
RF carrier spacing (channel separation)	5 MHz	10 MHz
Allowable occupied bandwidth	Less than 4.4 MHz	Less than 8 MHz
Modulation method	ASK, QPSK	ASK
Data transmission speed (bit rate)	1 024 kbit/s/ASK, 4 096 kbit/s/QPSK	1 024 kbit/s
Data coding	Manchester coding/ASK, NRZ/QPSK	Manchester coding
Duplex separation	40 MHz in case of FDD	
Communication type	Transceiver type	

TABLE 1 (end)

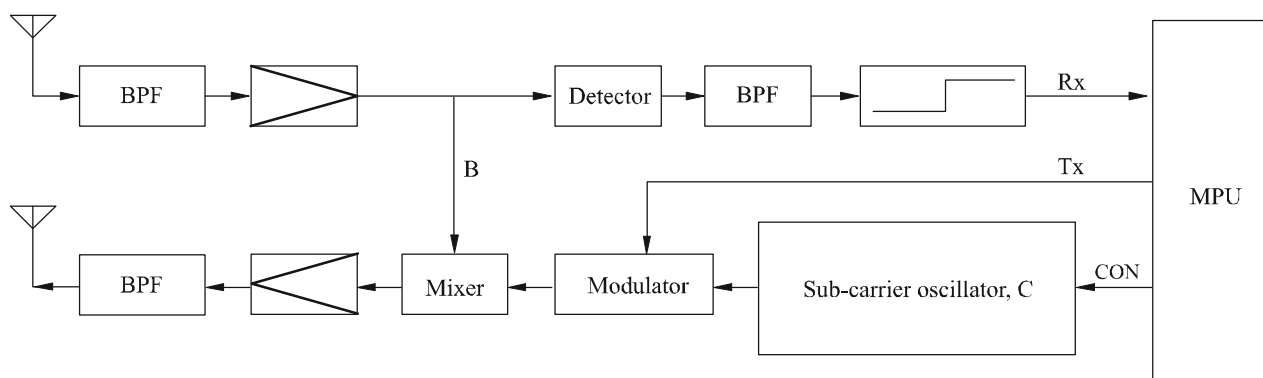
Item	Technical characteristic
Maximum e.i.r.p. ⁽¹⁾	≤ +30 dBm (downlink) (For a transmission distance of 10 m or less. Power supplied to antenna ≤ 10 dBm)
	≤ +44.7 dBm (downlink) (For a transmission distance of more than 10 m. Power supplied to antenna ≤ 24.77 dBm)
	≤ +20 dBm (uplink) (Power supplied to antenna ≤ 10 dBm)

⁽¹⁾ European Radiocommunications Committee (ERC) Recommendation 70-03 specifies values of 2 W e.i.r.p. for active and 8 W e.i.r.p. for passive systems.

2.2 Backscatter (transponder) method

In contrast to the active (transceiver) method shown in § 2.1, the OBE for the backscatter (transponder) method does not have an internal oscillator for generating a 5.8 GHz band radio carrier signal, so it relies on the 5.8 GHz oscillator of the roadside unit with which it communicates. A detailed explanation is given in Figure 2 with a typical functional block diagram.

FIGURE 2
Typical configuration of OBE in passive backscatter method



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Signals for the backscatter (transponder) method are also processed by the MPU as receiving data after passing through each functional block. The difference from the active (transceiver) system lies with transmissions from the OBE. The backscatter (transponder) system does not have a carrier signal oscillator. As a result, when transmitting from the OBE, the roadside unit has to emit an unmodulated carrier signal continuously. The OBE receives this signal, which is input in the transmission circuit after passing through circuit B, and makes it its own carrier signal. The transmission data modulates the output of the sub-carrier signal oscillator C and mixes it with the carrier signal from B. A sub-carrier signal carries this OBE's transmission data with a different frequency (carrier signal frequency plus/minus sub-carrier frequency) from the carrier signal.

An outline of the technical characteristics required for radiocommunication equipment is contained in Table 2.

TABLE 2

Characteristics of backscatter (transponder) method

Item	Technical characteristic	
	Medium data rate	High data rate
Carrier frequencies	5.8 GHz band for downlink	5.8 GHz band for downlink
Sub-carrier frequencies	1.5 MHz/2 MHz (uplink)	10.7 MHz (uplink)
RF carrier spacing (channel separation)	5 MHz	10 MHz
Allowable occupied bandwidth	Less than 5 MHz/channel	Less than 10 MHz/channel
Modulation method	ASK (downlink carrier) PSK (uplink sub-carrier)	ASK (downlink carrier) PSK (uplink sub-carrier)
Data transmission speed (bit rate)	500 kbit/s (downlink) 250 kbit/s (uplink)	1 Mbit/s (downlink) 1 Mbit/s (uplink)
Data coding	FM0 (downlink) NRZI (uplink)	
Communication type	Transponder type	Transponder type
Maximum e.i.r.p. ⁽¹⁾	≤ +33 dBm (downlink) ≤ -24 dBm (uplink: single sideband)	≤ +39 dBm (downlink) ≤ -14 dBm (uplink: single sideband)

⁽¹⁾ ERC Recommendation 70-03 specifies values of 2 W e.i.r.p. for active and 8 W e.i.r.p. for passive systems.

Annex 2**Technical and operational characteristics of DSRC application sub-layer in 5.8 GHz frequency band****1 General**

This Annex outlines the technologies and characteristics for the DSRC-ASL. The DSRC-ASL provides supplemental communication functions to DSRC upper layer protocol stacks for multiple DSRC applications, especially IP network applications, in the 5.8 GHz frequency band.

This Annex is applicable to both the active (transceiver) method and the backscatter (transponder) method as DSRC technologies available for ITS. The technical and operational characteristics of both methods are described in Annex 1.

1.1 Introduction

Recommendation ITU-R M.1453 – Transport information and control systems – Dedicated short range communications at 5.8 GHz, was approved at the Radiocommunication Assembly (RA) 2000. In August 2002, the RA approved a revision of the Recommendation as Recommendation ITU-R M.1453-1. Since then, the name of TICS has been changed to ITS.

Taking into consideration current technologies and the multiple applications of DSRC, the application sub-layer for DSRC at 5.8 GHz was developed for providing multiple protocols on DSRC.

1.2 Scope

Although this Annex is concerned with the upper layers of the DSRC protocol stacks (layer two to layer seven), the layer seven protocol has already been developed in ISO/TC204 (intelligent transport systems) with close liaison between ITU-R and ISO. This Annex provides the supplemental communication functions to the DSRC protocol stacks in order to make the current DSRC protocol stacks applicable to multiple DSRC applications.

The following are existing international or regional DSRC standards in force or in the final stage of standardization. Applicability of this Annex to these standards was carefully investigated.

- ISO FDIS 15628: Intelligent transport systems – dedicated short range communication (DSRC) – DSRC application layer (International)
- CEN EN 12253: DSRC physical layer using microwave at 5.8 GHz (Europe)
- CEN EN 12795: DSRC data link layer (Europe)
- CEN EN 12834: DSRC application layer (Europe)
- CEN EN 13372: DSRC profiles for RTTT applications (Europe)
- ARIB STD-T75: Dedicated short range communication system (Japan)
- ARIB STD-T88: DSRC application sub-layer (Japan)
- TTAS06-00625: Standard of DSRC radio communication between road-side equipment and on-board equipment in 5.8 GHz band (Korea).

2 Technical and operational characteristics

2.1 Characteristics of existing DSRC

Because of constraints specific to a DSRC link, such as limited transmission capacity, discontinuous coverage, random arrival/exit of the vehicles in the area, current DSRC operations have been limited. The use of the full OSI model was considered unsuitable to the DSRC field.

To simplify the DSRC architecture, OSI layers three to six of the DSRC protocol stacks were excluded. Especially, elimination of the network layer was vital to the network applications operating on the Internet protocol.

2.2 Concept of application sub-layer (ASL)

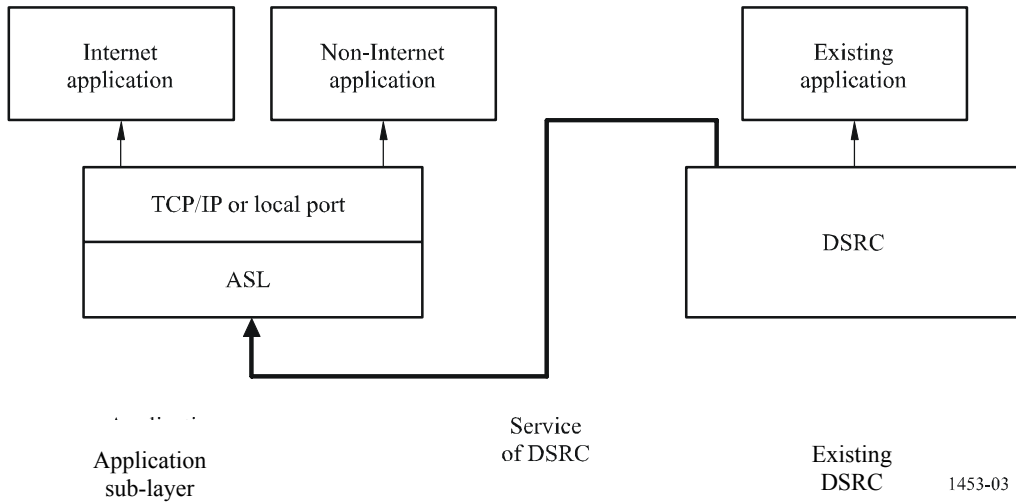
This Annex provides the network protocols and extended link control protocols as supplemental communication functions to the DSRC protocol stacks by utilizing the multi functional ACTION service that is offered by DSRC layer 7 specified in ISO FDIS 15628 “Intelligent transport systems – dedicated short range communication (DSRC) – DSRC application layer”.

The application sub-layer extends DSRC applications without modification to the existing DSRC protocol stacks, and realizes the point-to-point protocol (PPP) for wireless Internet connection, the network control protocol for LANs and the local port control protocol for non-networked applications.

The concept of the application sub-layer is shown in Fig. 3. The ASL has to be defined as the DSRC driver that interfaces to TCP/IP (transmission control protocol/Internet protocol) for use of Internet applications and to the local port for use of non-Internet applications.

FIGURE 3

Concept of application sub-layer



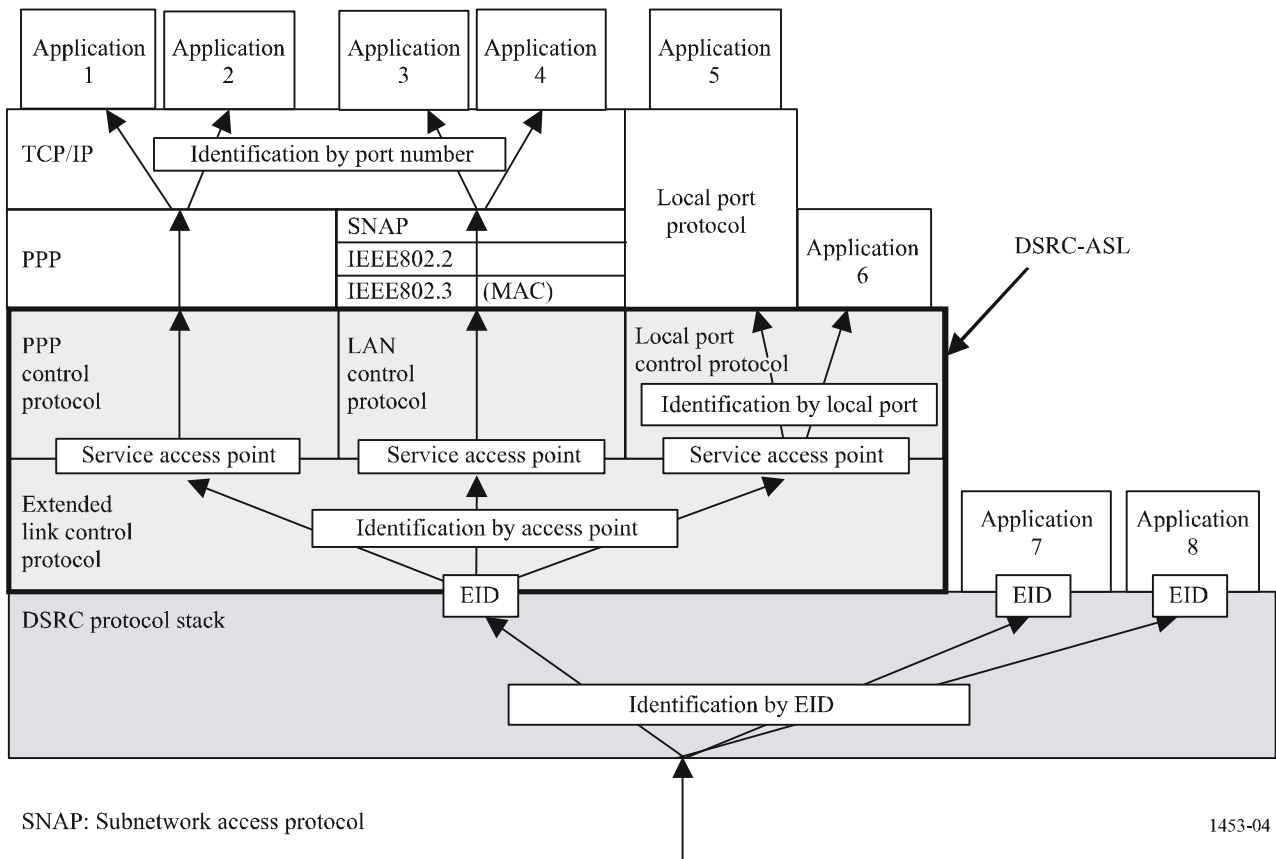
2.3 Structure of DSRC-ASL

The general structure of the DSRC-ASL is shown in Fig. 4 and the structure of the DSRC-ASL core is shown in Fig. 5.

Application 1 to Application 4 are shown as applications on TCP/IP, while Application 5 is shown as a non-Internet application operating on the local port. Application 6 is a simple, non-Internet application operating on the local control protocol (LCP). Applications 7 and 8 indicate conventional DSRC applications. Each application is identified by an EID (element ID) on the DSRC protocol and is dealt with appropriately.

FIGURE 4

General structure of DSRC-ASL and concept of connection identification



The structural features of the DSRC-ASL are as follows:

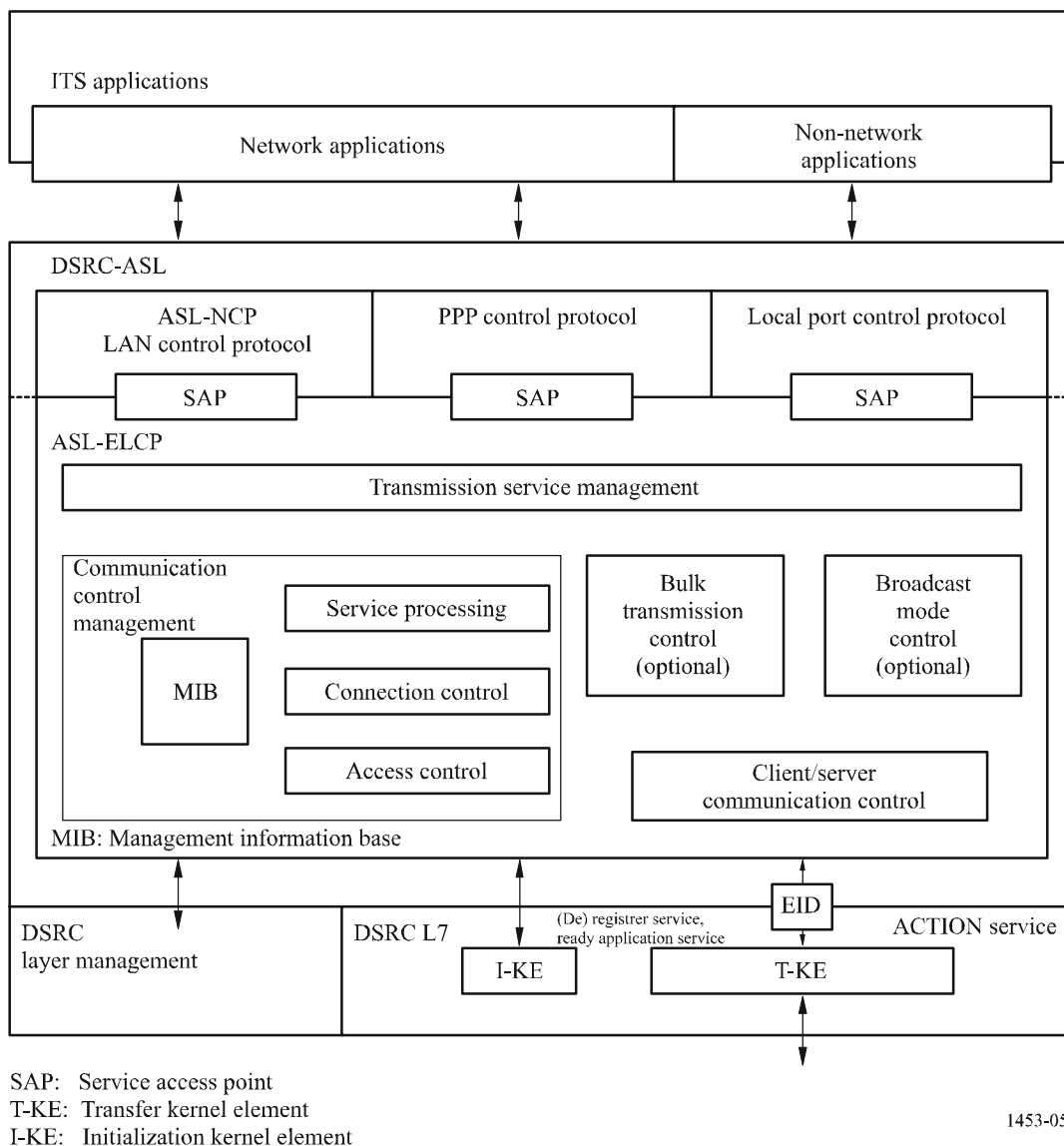
The DSRC-ASL interfaces between the DSRC protocol stacks and the network applications or non-network applications. It provides supplemental communication functions for DSRC communications. The structure of the core of the DSRC-ASL is shown in Fig. 5. It provides a platform for DSRC applications without awareness of the lower layer DSRC protocol stacks.

The DSRC-ASL, as shown in Fig. 5, consists of a network communication control protocol (ASL-NCP) and an extended link control protocol (ASL-ELCP), which interfaces with the DSRC protocol stacks and conducts fundamental application processes.

The ASL-NCP consists of plural communication control protocols such as the LAN control protocol (LANCP) which can interface various types of network protocols.

The ASL-ELCP provides plural complementary communication control protocols such as a client-server type communication control and/or a bulk transmission control. The ASL-NCP realizes the interface with plural network protocols and could treat various types of network specifications. The ASL-ELCP also provides the DSRC communication connection management functions for easy deployment of general DSRC applications.

FIGURE 5
Structure of the DSRC-ASL core



2.4 Extended link control protocols (ASL-ELCP)

The ASL-ELCP has the following functions for entities and each peer entity has a common protocol:

- services provision to the ASL-NCP;
- data transmission service (process) by identifying destination address of receiving data unit;
- client-server type communication control;
- bulk transmission control (optional);
- broadcast mode control (optional);
- communication control management.

Communication control management has the following functions:

- communication connection control management function for maintaining connection;
- access control management function to access the RSE;
- event report management function which occur in the ASL-ELCP;

- registration management function for the registration of ASL-ELCP MIB (management information base).

2.5 Network control protocol (ASL-NCP)

The ASL-NCP conducts the capsulation of plural protocols, the establishment of access points and the setting of the protocol type. The ASL-NCP also consists of plural control protocols for various types of connected network protocols.

The ASL-NCP consists of a point-to-point-protocol control protocol (PPPCP) and a LANCP for the connection to network applications, and a local port control protocol (LPCP) for the connection to non-network applications.

2.6 Network flow diagram

A network flow diagram of the DSRC-ASL is shown in Fig. 4.

The DSRC layer 7 establishes a DSRC communication link. An ASL-ELCP is activated by the notification of a DSRC communication link established from DSRC layer 7. After the activation, the ASL-ELCP, at first, compares its own ASL profile with a peer ASL profile passed through the established DSRC communication link and confirms the available functions in the ASL-ELCP. During this procedure, the ASL-ELCP does not make any changes to the ASL-NCP settings.

After confirmation of the ASL profiles, when an access management function is usable, a peer authentication is conducted. Upon successful authentication, the ASL-ELCP activates each ASL-NCP and changes its state to ASL-NCP process phase.

During the process phase, the activated ASL-NCP establishes the initial setting for the corresponding ASL-NCP. Each network protocol cannot activate until the initial setting for the corresponding ASL-NCP has been established.

After completion of the above procedure, the ASL-NCP state changes to a communication phase and starts communication using the network protocol.

As described above, network protocols, such as IP, are usable.
