DSRC Multiple applications in Japan

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2. Development of DSRC applications
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4. Development of Application Sub Layer (ASL)
5. Development for Next generation ITS radio communication

ARIB, Japan

GSC-9/GRSC-2, Seoul, Korea
May 9 - 13, 2004

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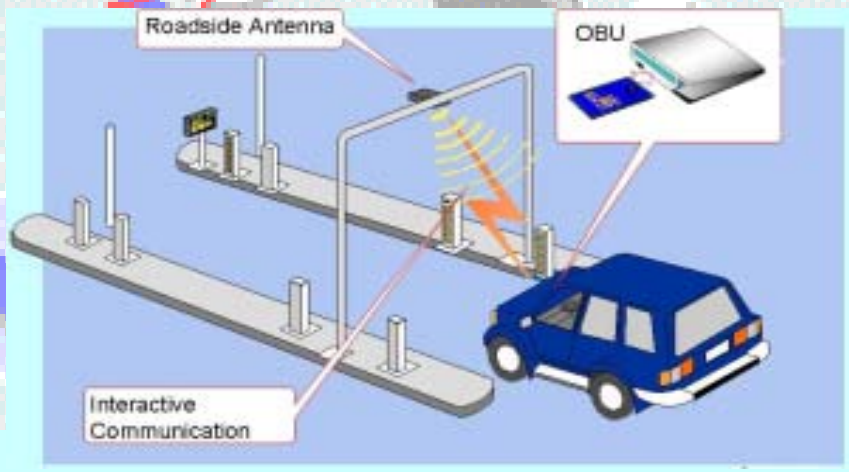
1.1 ETC in Japan

- **Nationwide Interoperable System**
  Service Providers: Japan Highways, Metropolitan Express Ways, Hanshin Express Ways, Honshu-Shikoku Bridges, etc.
- **Number of toll gates: 1,300 as of the end of March 2004.**
- **Number of OBU (On Board Unit): 2,699,372 as of the end of March 2004**
- **Target: 10 million OBUs by 2007, 50% of total transactions**



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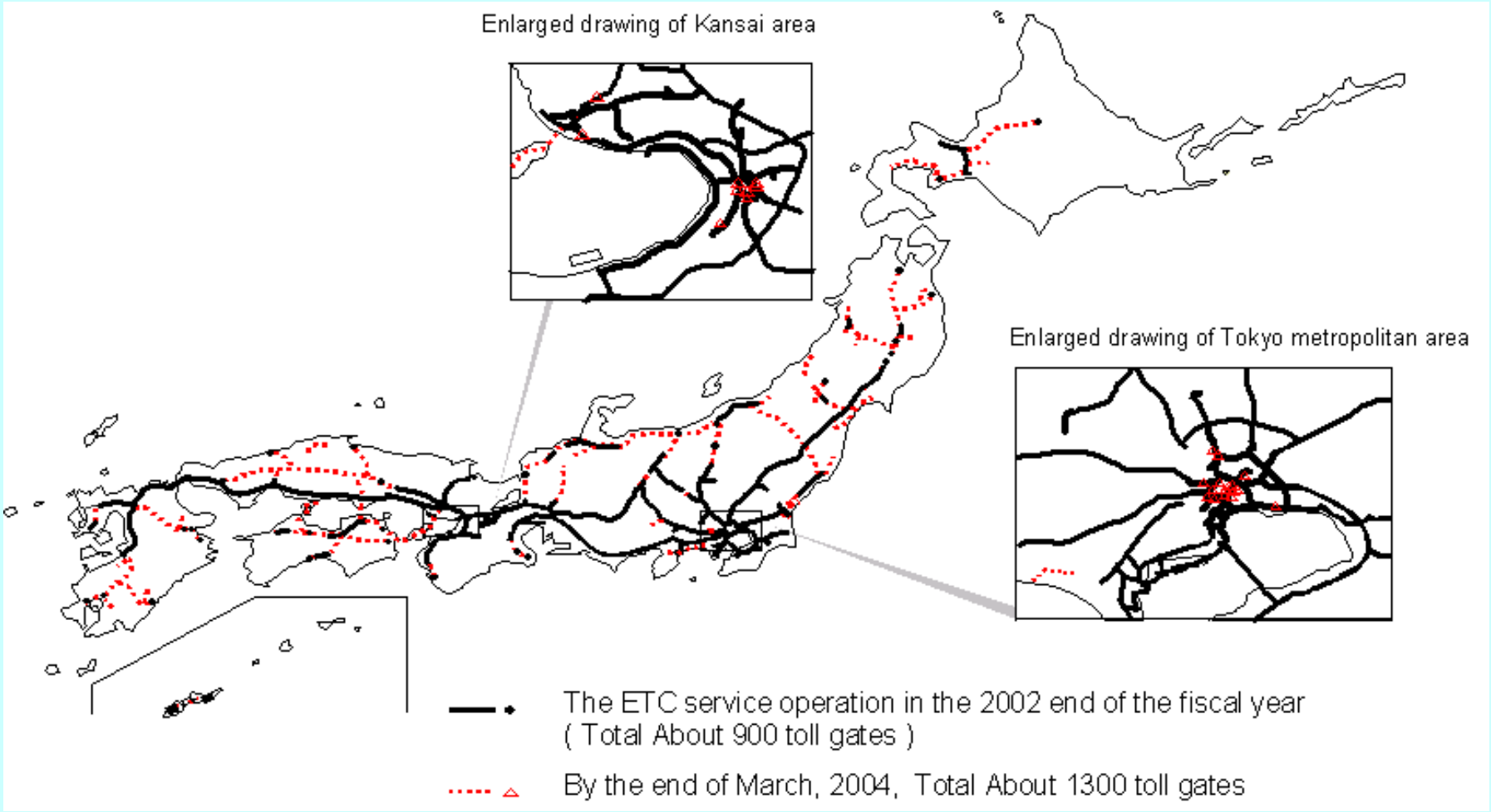
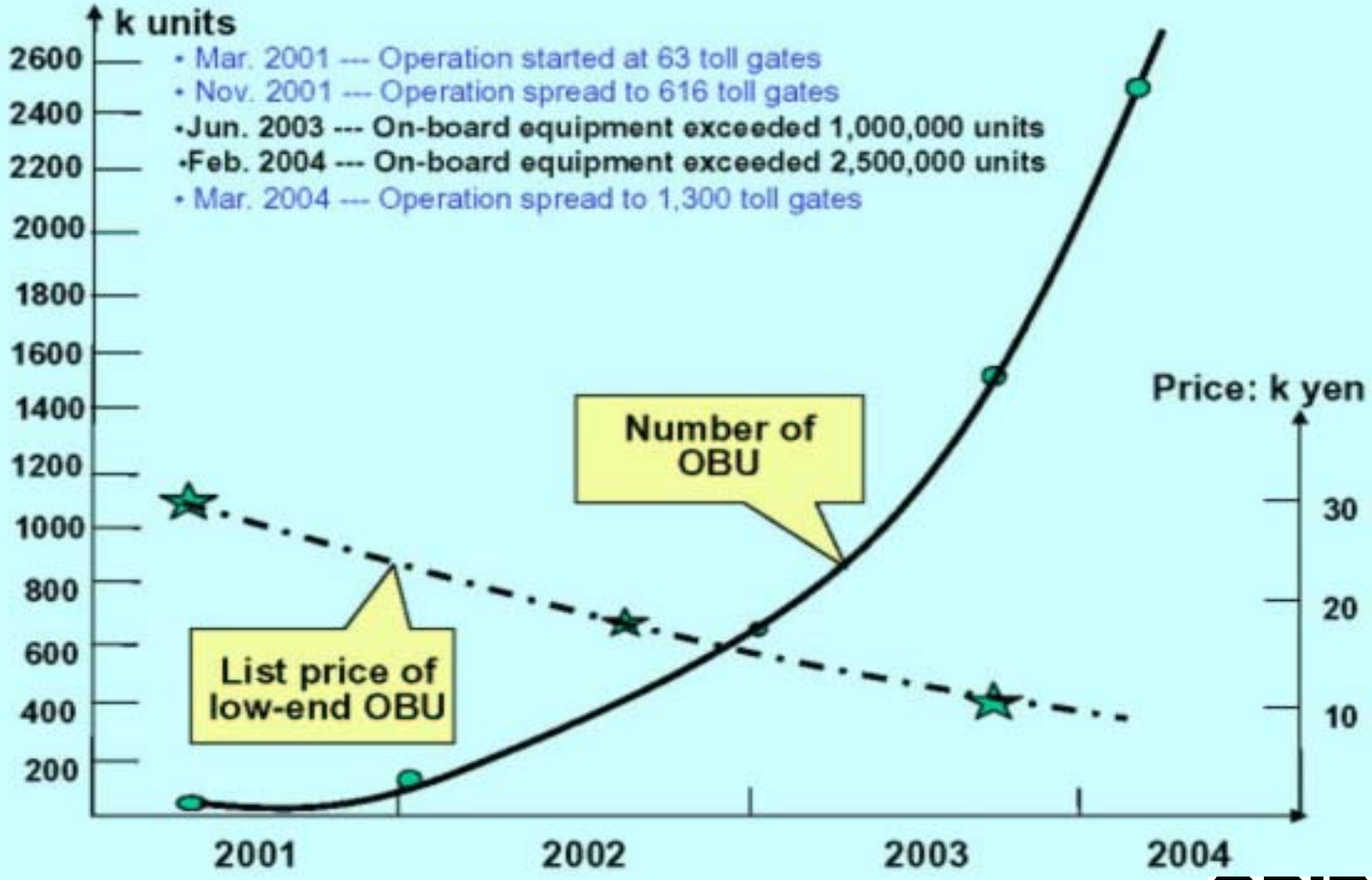
1.2 Nationwide ETC Deployment



http://www.orse.or.jp/

1.3 Diffusion of ETC On Board Units



2.1 Development of DSRC applications

Some examples

- **Smart Gateway** by TAO (Telecommunications Advancement Organizations): Development of a radio hand-over technology and a network hand-over technology over consecutive or discrete communication zones.
- **Smart Communications** by the Ministry of Land, Infrastructure and Transport: ITS Communication Services Platform Using 5.8GHz DSRC.
- **Multiple DSRC Applications Systems at Gas Station** by ITS Laboratory, Inc.: Trial of multi-application DSRC system at Gas station.
- **Parking Garage Management Systems** by TOYOTA TSUSHO and TOWA Real Estate: Use of DSRC in underground parking garage.

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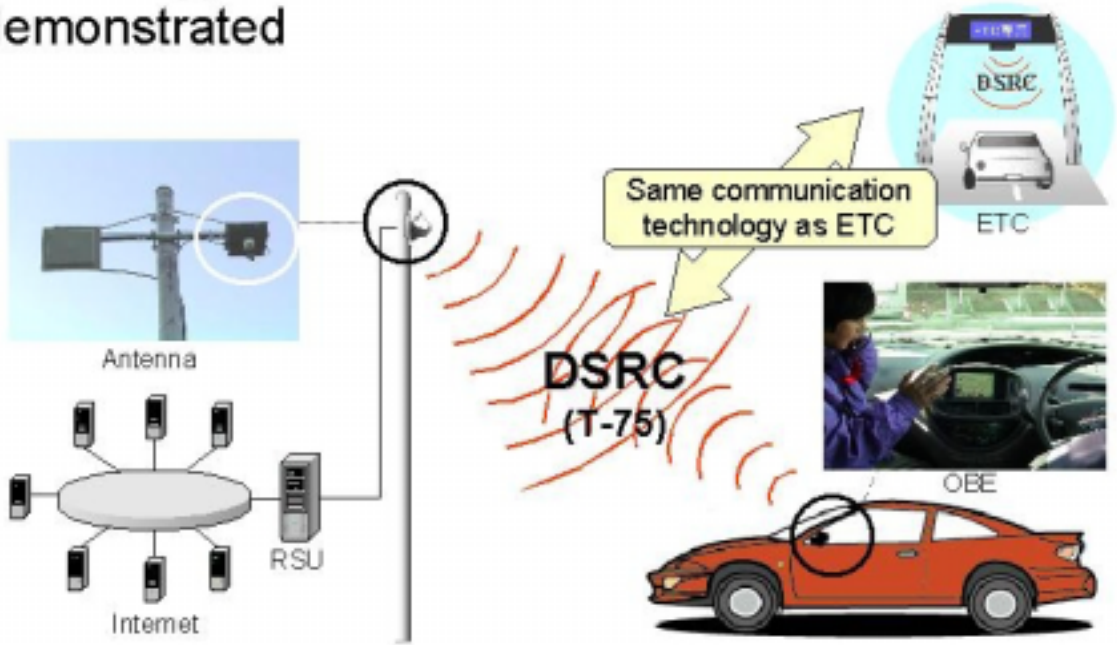
2.2 Smart Communications

- IP connection experiment using ETC communication technology
  - ETC dedicated communication become multipurpose communication through the use of ASL (Application Sub Layer)
- Various types of Smart Communication services are demonstrated



Calsonic Kansei Corporation

KDDI Corporation

Sumitomo Electric Industries, Ltd.

DENSO Corporation

TOYOTA MOTOR Corporation

Nissan Motor Co., Ltd.

NEC Corporation

Hitachi, Ltd.

Fujitsu Limited

Matsushita Electric Industrial Co., Ltd.

Mitsubishi Heavy Industries, Ltd.

Mitsubishi Electric Corporation

Yazaki Corporation

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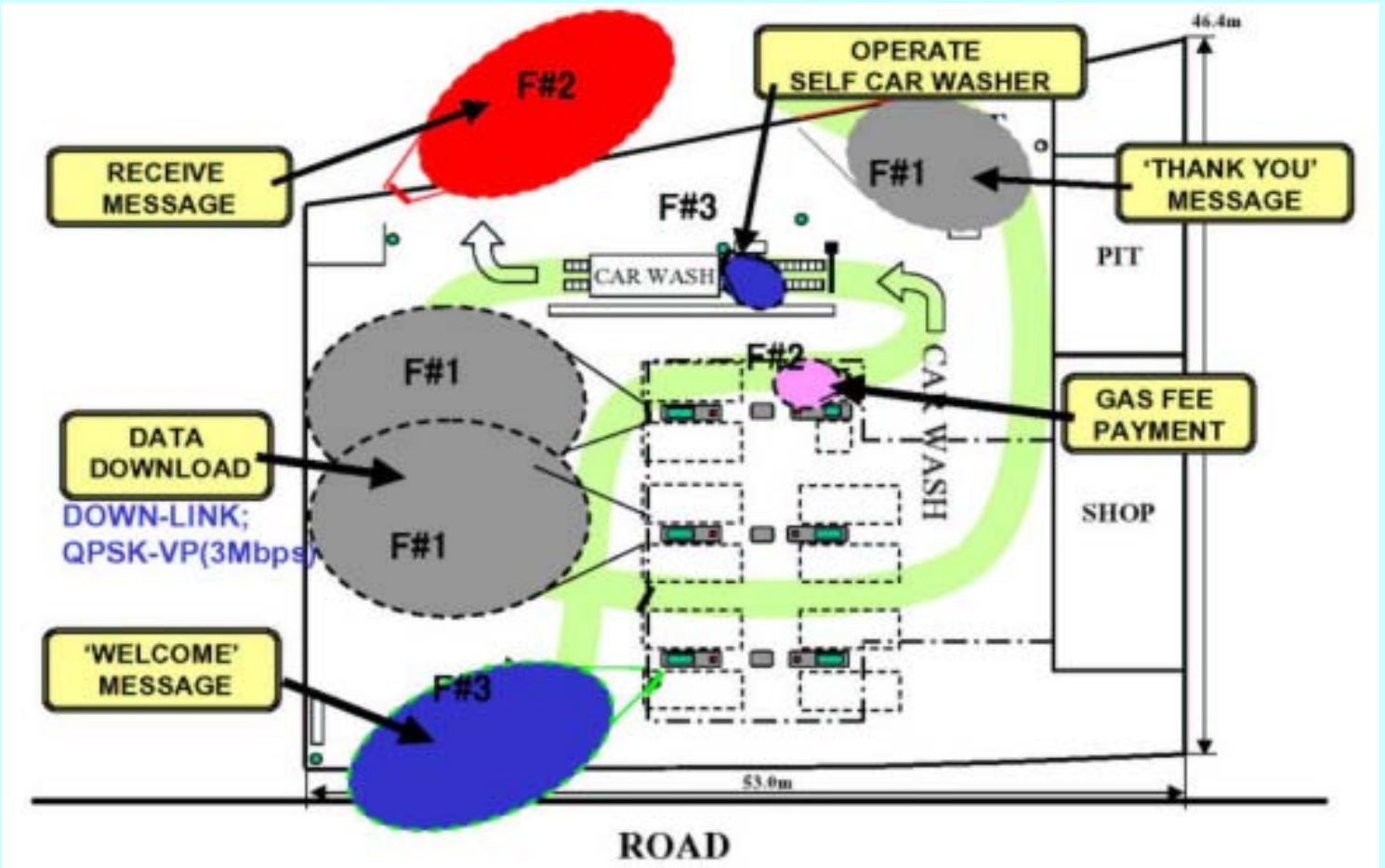
2.3 Multiple DSRC Applications Systems at Gas Station

DSRC multiple application at Gas Station using ASL and QPSK-VP

PSK-VP (Phase Shift Keying with Varied Phase):

Refer to **GSC-8-086**, GRSC-1, Ottawa



AUTOBACS SEVEN, Tsubasa Sytems, OMRON, Panasonic….

3.1 Regional standards for ITS radio communication

Item	DSRC in Japan (ARIB)	DSRC in Europe (CEN)	"WAVE" in North America (ASTM)
Duplex	OBU: Half-duplex RSU: Full-duplex	Half-duplex	Half-duplex
Communication system	Active	Passive	Active
Radio frequency band	5.8GHz band 80MHz bandwidth	5.8GHz band 20MHz bandwidth	5.9GHz band 75MHz bandwidth
Channels	Down-link: 7 Up-link: 7	4	7
Channel separation	5MHz	5MHz	10MHz
Data transmission rate	Down / Uplink: 1 or 4 Mbps	Down-link: 500kbps Up-link: 250kbps	Down / Up-link: 3 - 27Mbps
Coverage	30m	15 - 20m	1,000m (Max)
Modulation	2-ASK (1Mbps) 4-PSK (4Mbps)	RSU: 2-ASK OBU: 2-PSK (Sub-carrier modulation)	OFDM

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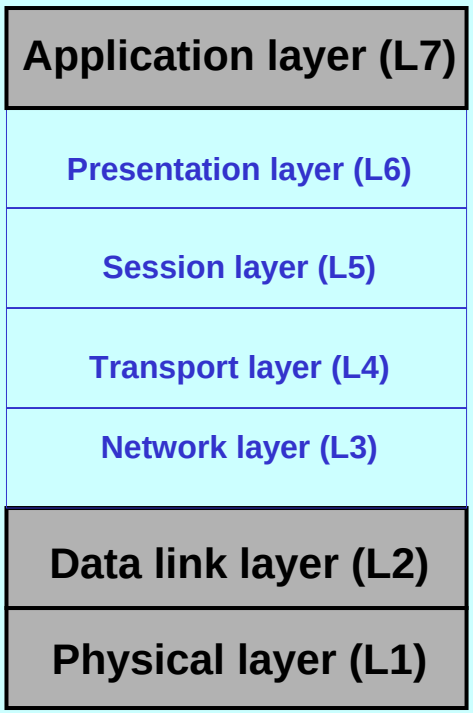
3.2 Characteristic of existing DSRC

DSRC protocol stack



Communication Architecture of existing DSRC*

(*Existing DSRC: In 1992, standardization for the DSRC started in European Committee for Standardization)

Because of constraints specific to a DSRC link, i.e., "Limited Transmission Capacity," "Discontinuous Coverage," "Random Arrival / Exit of the Vehicles in the Area" etc. using the full OSI model was considered unsuitable to the DSRC field.

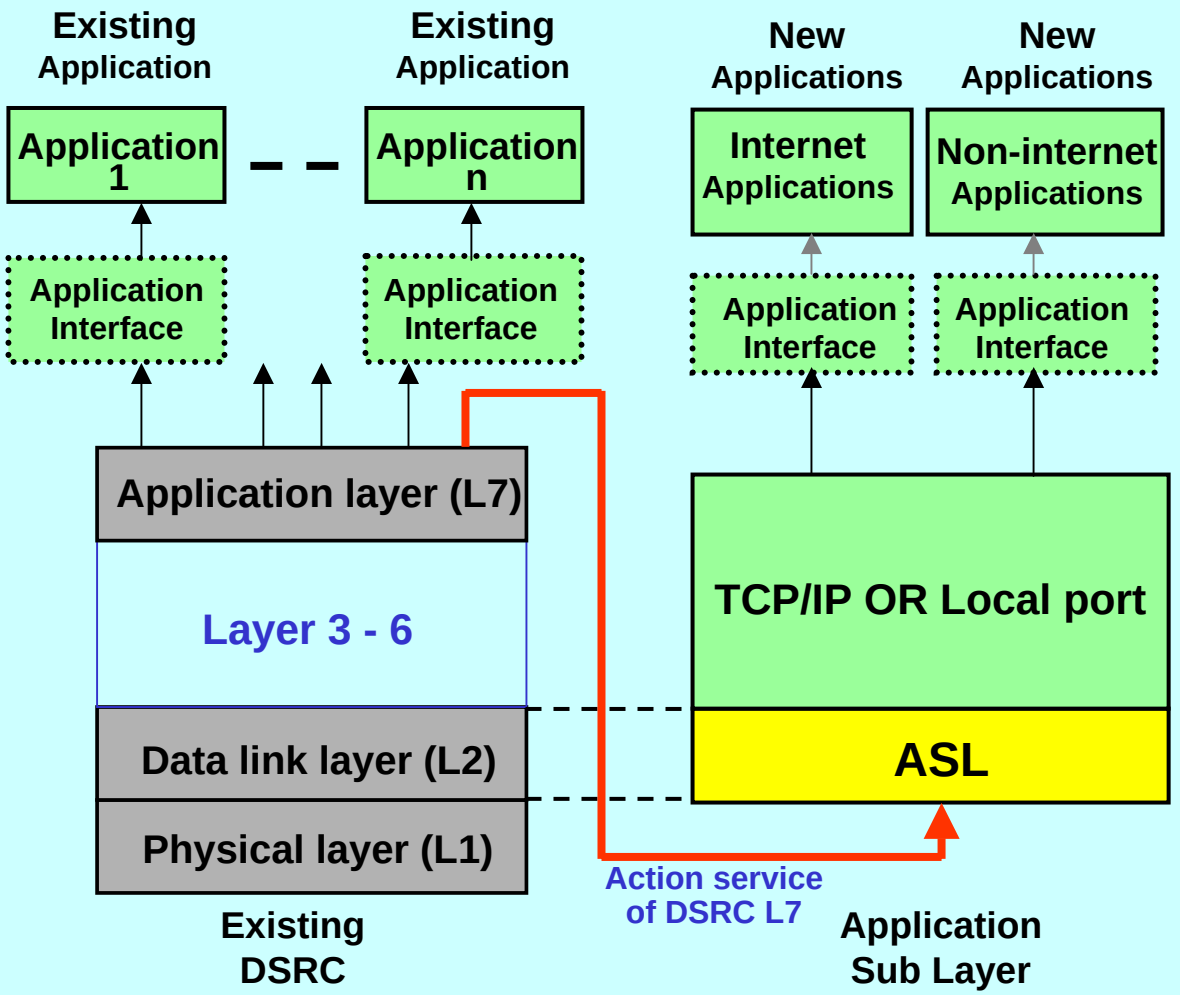
- Network layer is eliminated:
Real-time End-to-end Routing is difficult.

- Transport layer is eliminated:
As real-time routing is eliminated, real-time end-to-end communication is also eliminated.

- Session layer is eliminated:
As tasks sharing by various vehicles or distant hosts are not considered, sessions between them need not be established.

- Presentation layer is eliminated:
Implicit or pre-set data formats are used. Data encryption, data certification, terminal authentication etc. can be performed in layer 7.

3.3 Concept of application Sub Layer (ASL) which extends existing DSRC applications



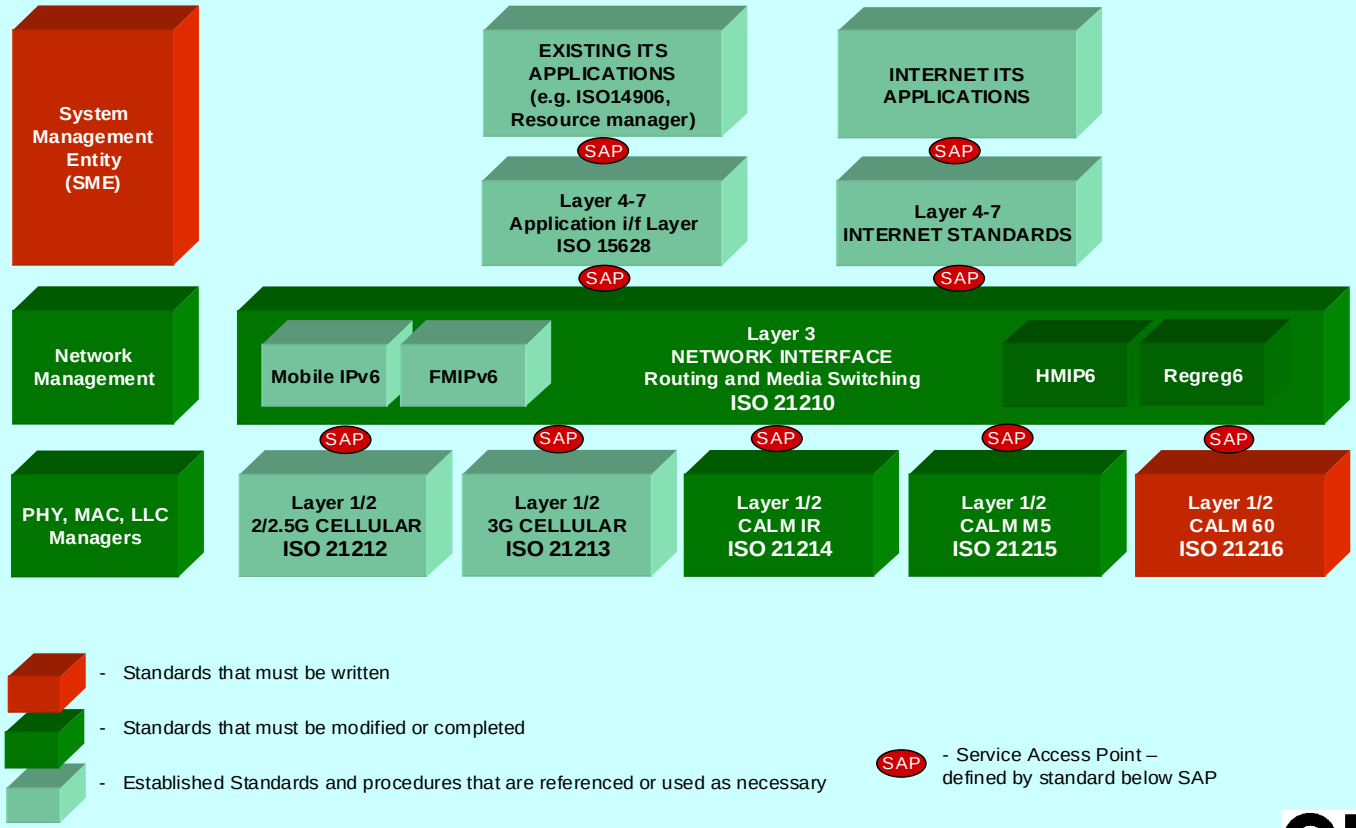
Application Sub Layer (DSRC-ASL)

is developed in ARIB, Japan (ARIB TR-T17) for easy deployment of multi application for the existing DSRC.

ASL includes
PPP control protocol
LAN control protocol
for IP applications
and
Local Port control protocol for non-IP applications

3.4 Reference: ISO TC204 WG16 CALM Architecture

In the CALM Architecture, **Network interface is originally supported**.
(CALM: Communication Air interface for Long and Medium range)

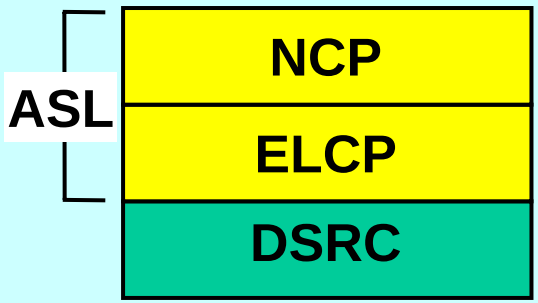


4.1 Features of Application Sub Layer (ASL)

Application Sub Layer (ASL)

- Extends DSRC applications *without modification to the existing DSRC protocol stack*
- Realizes PPP (Point-to-Point Protocol) for *Internet connection*
- Realizes network control protocol for *Local Area Network (LAN)*
- Realizes local port control protocol for *non - networks applications*

4.2 Structure of Application Sub Layer (ASL)



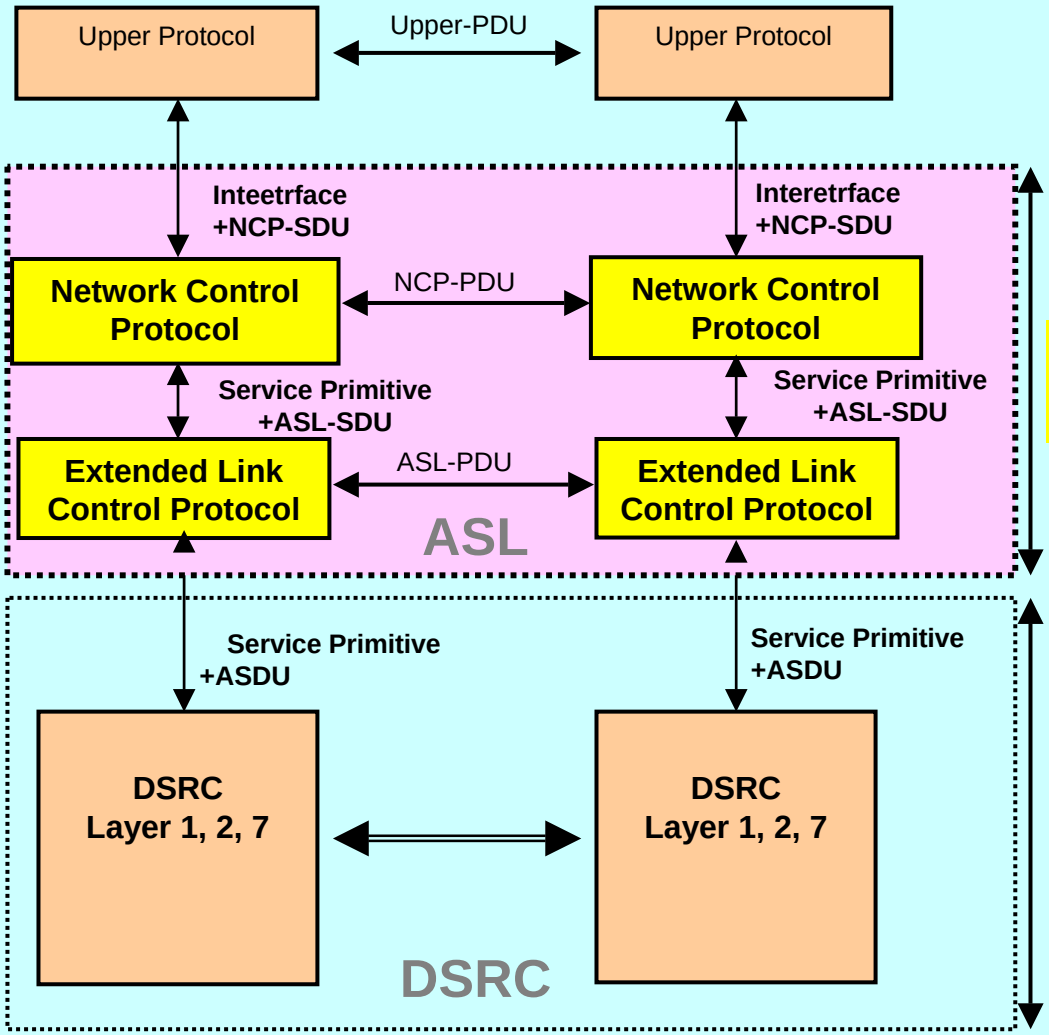
ASL-NCP: ASL Network Control Protocol

ASL-ELCP: ASL Extended Link Control Protocol

- ASL (Application Sub Layer) consists of
  - Network control protocol (ASL-NCP) and
  - Extended link control protocols (ASL-ELCP).
- ASL-NCP is composed of
  - PPP control protocol (PPPCP),
  - LAN control protocol (LANCP) and
  - Local Port control protocol (LPCP).

  PPPCP and LANCP provide the communication link for the network applications such as IP.
  Non-network applications are connected by LPCP.
- ASL-ELCP is composed of
  - Transmission control,
  - Client/server communication control,
  - Broadband communication control and
  - Communication control management for providing the service access point for ASL-NCP.

4.3 Function of Application Sub Layer (ASL)



Though DSRC-ASL is inserted between upper protocol and DSRC layer7, it works as the DATA LINK layer

DSRC-ASL
Standard
ARIB TR-T17

DSRC
Standard
ARIB STD-T75

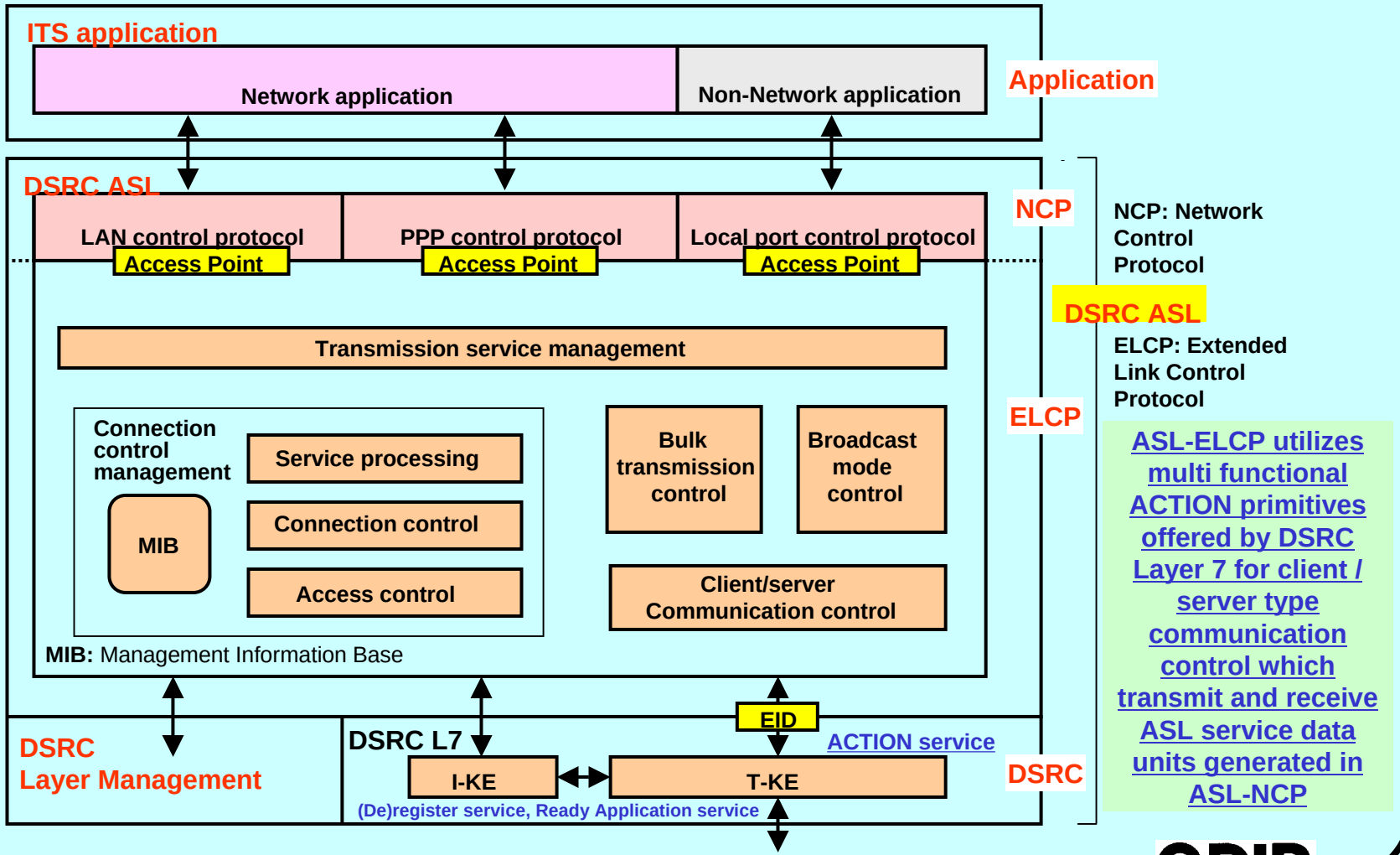
PDU:
Protocol Data Unit

SDU:
Service Data Unit

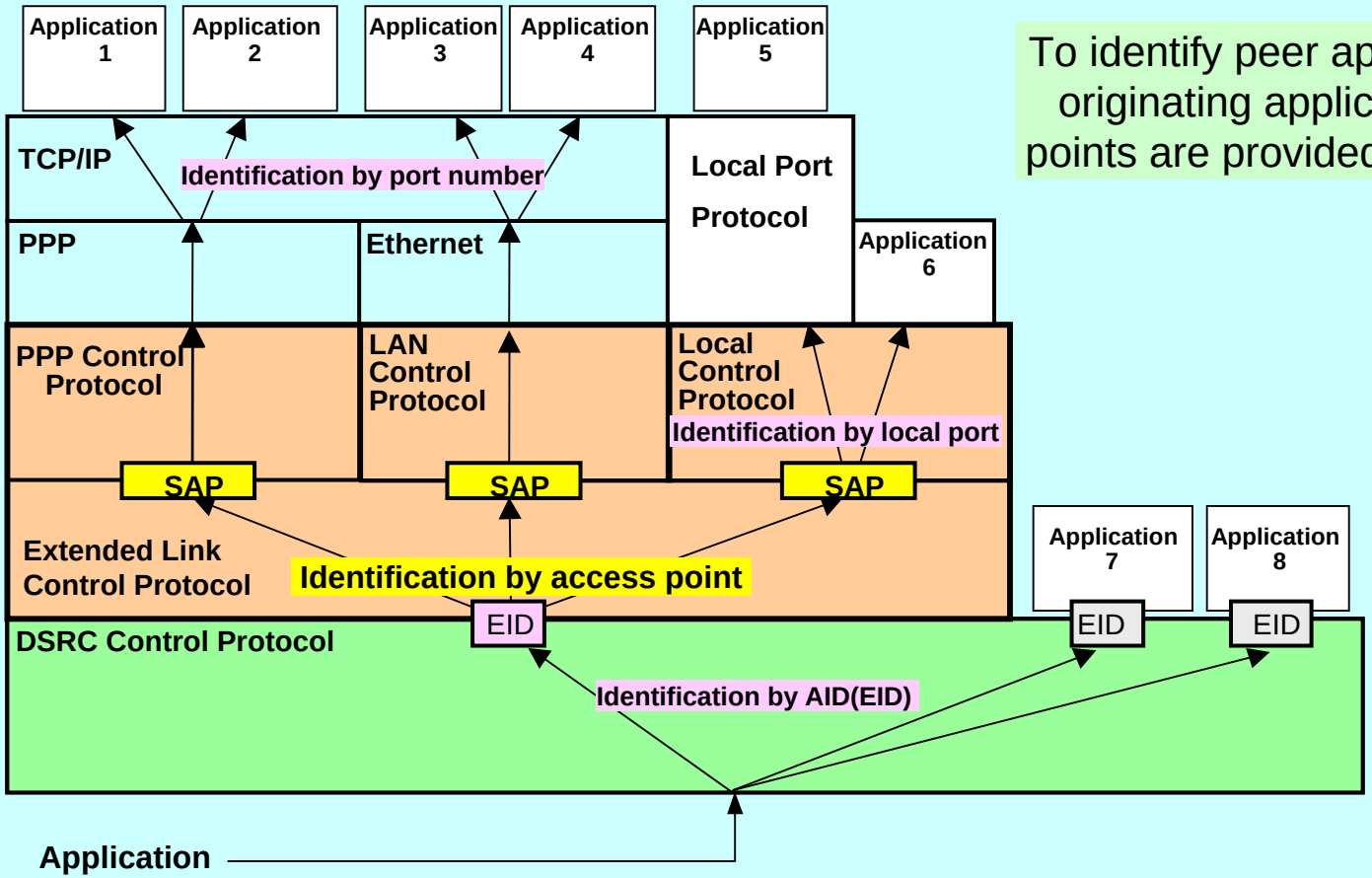
ASDU:
Application Service Data Unit

APDU:
Application Protocol Data Unit

4.4 Conceptual diagram of Application Sub Layer (ASL)

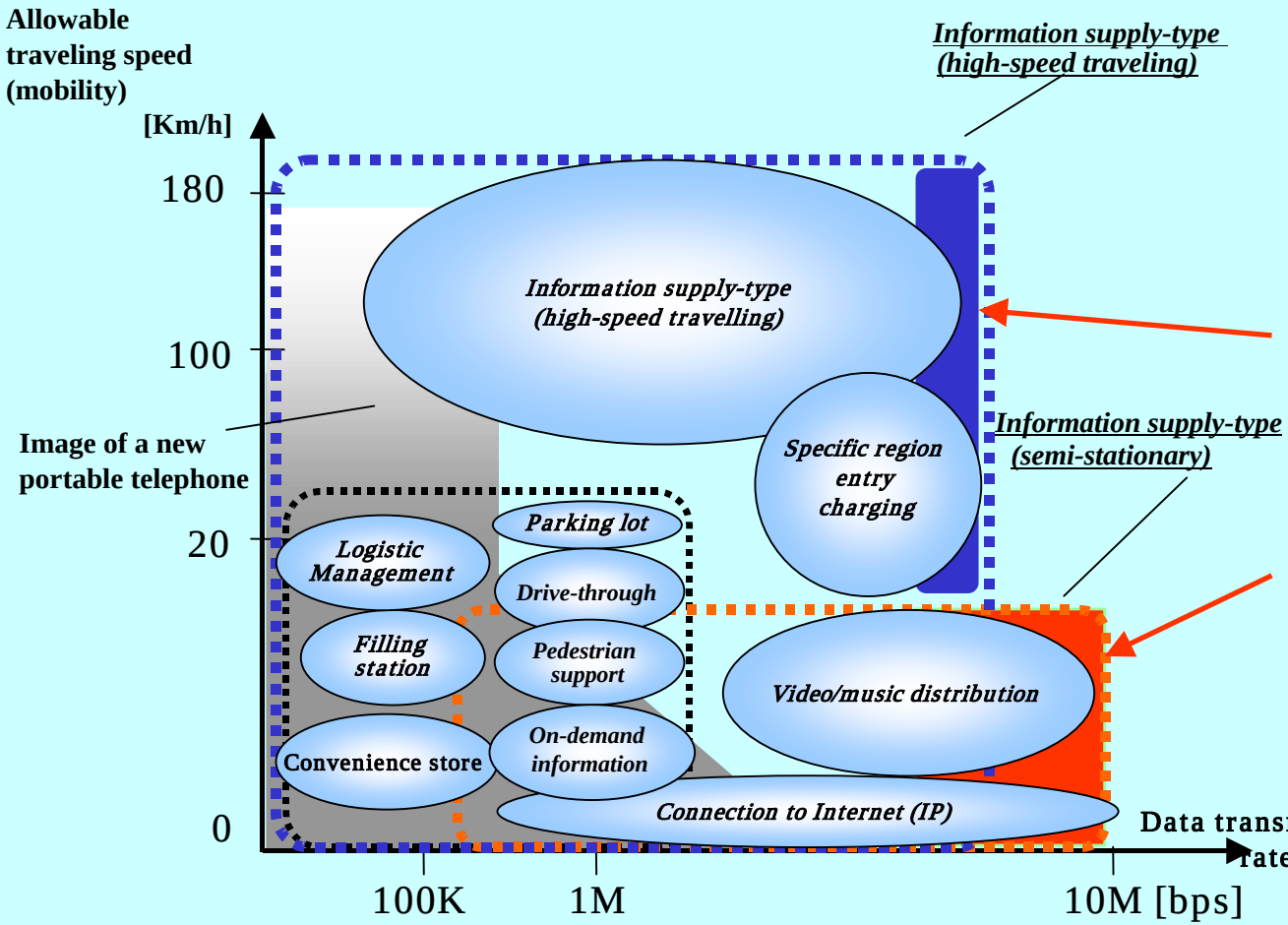


4.5 Concept of connection identification in Application Sub Layer (ASL)



To identify peer application of the originating application, access points are provided in DSRC-ASL

5.1 Data transmission rates requirements for the next generation ITS radio communication



ARIB STD-T75 generally satisfies the requirements except for the very small area shown below.

- high data rate high-speed traveling

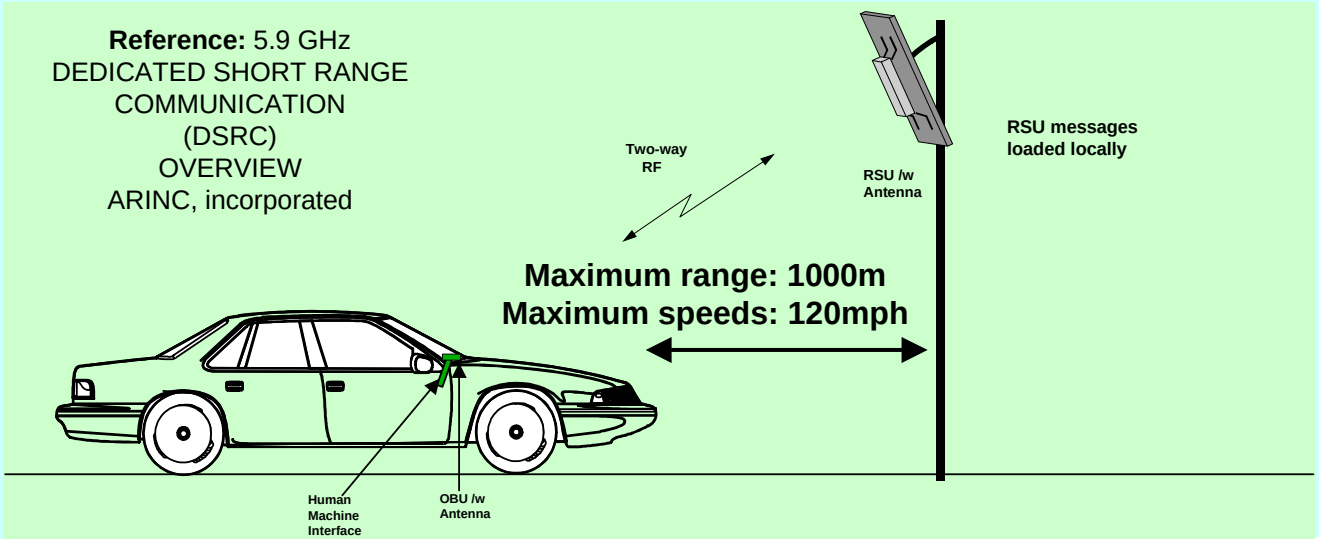
- Very high data rate semi-stationary

5.2 “WAVE”, North American ITS radio communication system

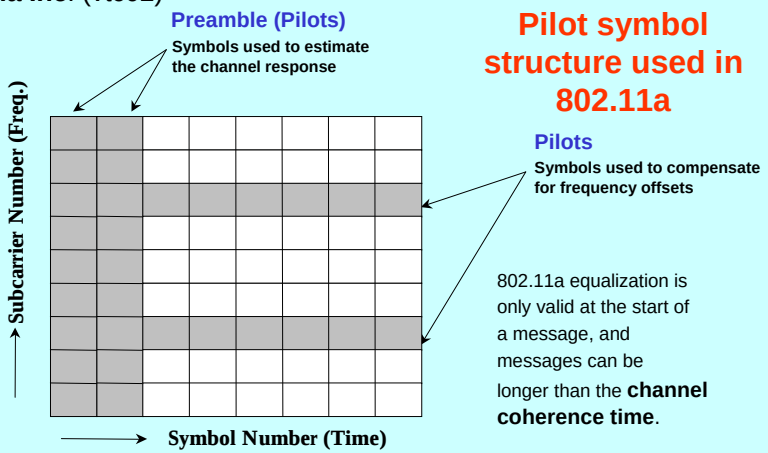
Features of “WAVE” are long communication range and high data rate at high vehicle speed.

(WAVE: Wireless Access in Vehicular Environments)

MAXIMUM RANGE	**1000 m (~ 3000 ft)**
Bandwidth	**75 MHz (5.850 - 5.925 GHz)**
Modulation	**QPSK OFDM (with 16QAM and 64QAM options)**
Channels	**7 channels (optional combinations of 10 and 20 MHz channels)**
Data Rate	**3, 4, 5, 6, 9, 12, 18, 24, and 27 Mbps with 10 MHz Channels**
Packet Error Rate (PER)	**At speeds of 200 km/h, less than 10 % for message lengths of 64 bytes.**

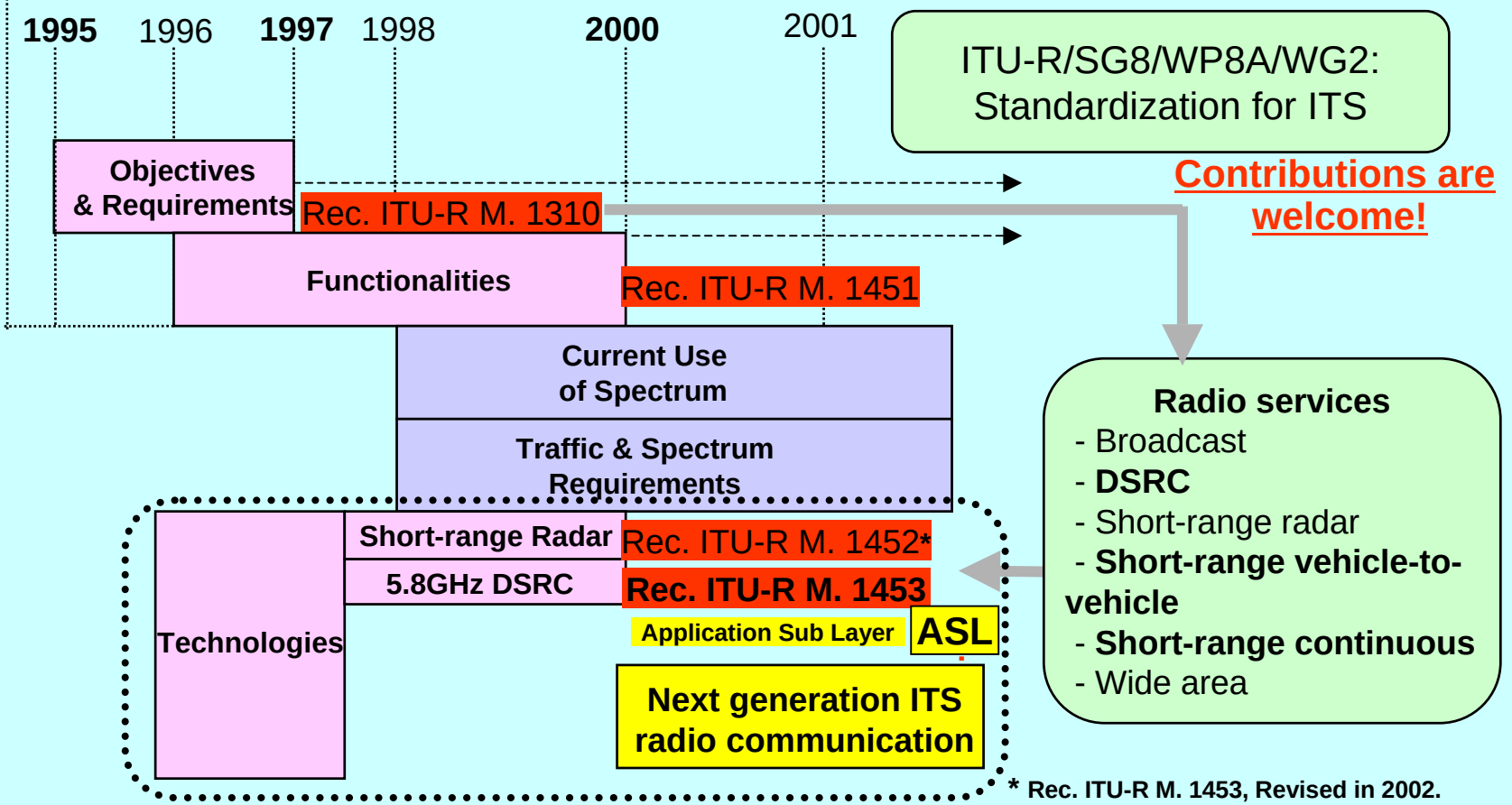


5.3 Technical problems and proposed solutions for the "WAVE"

Technical Problems	Proposed solutions
1. Mobility: "WAVE" is based on 802.11a Radio LAN. Radio LAN devices are generally **not designed to be used at automotive or higher speeds.** **Reference:** "On the suitability of 802.11a/RA for High-mobility DSRC" **by Motorola Inc**. (vtc02)  	• **Adoption of diversity system to reduce the effect of multi path fading.** **Antenna diversity** might be the most simple and effective countermeasure for this problem. • **Pilot symbols structure to be redesigned.** As the 802.11a PHY has to be modified, its realization will be difficult • **Use of Differential modulation, e.g. DQPSK.** This also means 802.11a PHY has to be modified and realization will be difficult
2. Localization: The short distance nature of the "DSRC" is important to correctly localize the entity to communicate. (**e.g. Enforcement**) The long distance nature of the "WAVE" makes the localization of the entity impossible.	• **Map-matching with a GPS receiver and digital maps.** Receivers may become very expensive.

5.4 Standardization of Next generation ITS radio communication in ITU-R

1994, Question on ITS → Recommendations (Answers to the Question)



* Rec. ITU-R M. 1453, Revised in 2002.

5.5 ARIB Standards related to DSRC

ARIB

- **ARIB STD-T75:** Dedicated Short-Range Communication System
- **ARIB TR-T16:** Dedicated Short-Range Communication System. Test Items and Conditions for Mobile Station Compatibility Confirmation
- **ARIB TR-T17:** Application Sub Layer for DSRC
  Submitted to ITU-R WP8A meeting as working document in December 2003

ARIB standards above are based on following international standards

- **ITU-R M.1453:** TRANSPORT INFORMATION AND CONTROL SYSTEMS - DEDICATED SHORT RANGE COMMUNICATIONS AT 5.8 GHz
- **ISO FDIS 15628:** Intelligent transport systems - Dedicated Short-Range Communication (DSRC) - DSRC application layer