GUIDELINE FOR EXPERIMENTS OF COMMUNICATIONS SYSTEM FOR USE CASES OF AUTOMATED DRIVING ON EXPRESSWAYS

ITS FORUM RC-015 Ver. 1.0

Established October 18, 2019

ITS Info-communications Forum

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ITS FORUM RC-015 VERSION 1.0

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ITS Info-communications Forum of Japan

Revision History

Version	Date	Chapter/Section	Reason	Revised Content
1.0	October 18, 2019	Establishment	Newly established	

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Introduction

This guideline examines candidate communication specifications that are expected to be used in automated driving. This examination is a part of efforts towards standardization in Japan.

This guideline comprises five chapters. Chapter 1 describes ITS Forum RC-005 based wireless communication technology, Chapter 2 describes LTE V2X (PC5) based wireless communication technology, Chapter 3 describes LTE V2X (Uu) based wireless communication technology, Chapter 4 describes ARIB STD-T75 based wireless communication technology, and Chapter 5 describes ARIB STD-T109 based wireless communication technology. The structure of this guideline is indicated in the table below.

Structure of the Guideline for Experiments of Communications System for Use Cases of Automated Driving on Expressways

Chapter	Title	Remarks
Chapter 1	ITS Forum RC-005 based wireless communication technology	
Chapter 2	LTE V2X (PC5) based wireless communication technology	
Chapter 3	LTE V2X (Uu) based wireless communication technology	
Chapter 4	ARIB STD-T75 based wireless communication technology	
Chapter 5	ARIB STD-T109 based wireless communication technology	

The purpose of this guideline is to further promote investigation of the use of wireless communications in automated driving through verification of the communication technologies in this guideline by testing.

(1) Background

The Radio System technology task group of Advanced ITS Info-communication Systems Committee has been investigating wireless communications technologies for achieving the use cases described in the 'ITS Communications Use Cases and Communications Procedures for Automated Driving (Draft)' which assumes automated driving on expressways. The draft was prepared by the Japan Automobile Manufacturers

Association, Inc.(hereafter JAMA). Since investigations of communication technologies in automated driving are also being conducted by Cross-ministerial Strategic Innovation Promotion Program (SIP) of the Cabinet Office, within Ministry of Internal Affairs and Communications, and other organizations, those results also took into consideration in this guideline. As a result of prior investigations, several wireless communications technologies were selected, and provisional communications specifications were determined. In order to further investigate the feasibility of use cases and details for communication technologies, it is necessary to conduct field tests. Hence, development of the guidelines that can be commonly shared among test participants for conducting tests of wireless communication technologies are expected.

(2) Purpose

Towards standardization of communication specifications to be expected to apply automated driving, this guideline summarizes candidate wireless communication technologies to support conducting various experiments to verify the use cases for utilizing wireless communication technologies that are under investigation by the SIP, JAMA, and others.

(3) Scope of application and positioning of this guideline

This is a guideline for testing wireless communication systems to verify the use cases for utilizing communication technologies to support automated driving communications on expressways. The communications specifications addressed in this guideline are ARIB STD-T75 (ETC2.0 Services in 5.8 GHz: Traffic information, Road information, Tolling, Safe driving support) and ARIB STD-T109 (ITS Connect in 760 MHz：For safe driving support applications through vehicle-to-vehicle communications, infrastructure-to-vehicle communications, and infrastructure-to-infrastructure communications.) from existing ITS communications standards in Japan, as well as IEEE 802.11p and LTE V2X (PC5 and Uu interfaces) considering global trends. This guideline summarizes investigation of communications specifications, numerical study/computer simulations, conditions for realization, functions that need to be added or modified, and other issues relating to these five specifications. With regard to IEEE 802.11p, ITS Forum RC-005 which refers IEEE 802.11p was investigated.

(4) Technical prerequisites

This guideline contains descriptions of the wireless equipment technical conditions that are necessary for land mobile stations (or onboard units) and base stations (or roadside units). The investigations conducted by Advanced ITS Info-communication System Committee were used in the specifications of each layer, and these specifications, and technical conditions.

Additionally, distribution of look-ahead information, merging and lane change support information, and emergency hazard information on expressways (interurban expressways and urban expressways) are defined as the expected use cases. The expected use cases covered in this guideline are indicated below. These use cases will continuously be supplemented and revised in the future.

Expected Use Cases Covered in this Guideline

Use Case		No.	Category	Details
Look-ahead information	Look-ahead information	1-1	I2V	Look-ahead information that cannot be detected by autonomous sensors such as traffic congestion information, tollbooth information, and temporary lane information is distributed to facilitate route and lane selection in advance, thereby facilitating driving.
	Emergency hazard information from vehicles	1-2-1	V2V	When an event that requires emergency of action, emergency hazard information is distributed to vehicles in behind.
		1-2-2	V2I	Emergency hazard information gathered by vehicles in operation is conveyed to roadside infrastructure.
		1-2-3	I2V	Emergency hazard information gathered by vehicles in operation is redistributed by infrastructure located ahead to vehicles in operation.
		1-2-4	I2V V2V collaboration	Information on emergency hazards in opposing lanes received from infrastructure located ahead is redistributed to oncoming vehicles from the other direction.
Merge support	Merging vehicle support	2-1-1	I2V	Driving information from vehicles driving in the same lane measured by infrastructure is conveyed to merging vehicles to facilitate merging.
		2-1-2	V2V	Driving information from vehicles driving in the same lane is conveyed to vehicles merging into the lane via vehicle-to-vehicle communications to facilitate merging.
	Support to vehicles in main lane	2-2	I2V	Information concerning merging vehicles measured by infrastructure is conveyed to vehicles in the main lane to facilitate merging.
Lane change support		3	V2V	When changing lanes, driving information is exchanged with nearby vehicles to facilitate lane changing.

Numerical study and computer simulation regarding the feasibility of the candidate wireless communications technologies were conducted for the expected use cases described above. The issues identified from the study results are indicated below. For details, see Appendices 1 to 5.

When conducting tests, the followings should be adequately taken into consideration.

・ITS FORUM RC-005

Within the expected use cases, infrastructure-to-vehicle communications and vehicle-to-vehicle communications use cases are considered.

The results of radio link design study show that it may not satisfy the communications requirements (provisional) under the specific conditions of certain use cases. In that case, repetition or other similar compensation scheme will be required as countermeasures. Additionally, when the message size exceeds a certain size under some of the use cases, application data fragmentation function and other similar compensation scheme will be required.

Possible means for achieving these countermeasures include application level compensation or utilization of ITS Forum RC-014.

There is also a possibility that the communications range will not be satisfied during communications under use case 1-2-1. Possible countermeasures include the addition of a relay function on the application layer, addition of a relay function by using multiple roadside units, or use of wide-area LTE V2X (Uu).

・LTE V2X (PC5)

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・LTE V2X (Uu)

It should be kept in mind that communications via a mobile network would result in relatively large communications delay compared to other methods. In addition to the communications network, application servers that process and forward application messages are necessary. It is also necessary to investigate communications network architecture including the application servers.

・ARIB STD-T75

Within the expected use cases, infrastructure-to-vehicle communications use cases are considered.

The results of radio link design show that it may not satisfy the communications conditions (provisional) under the specific conditions of certain use cases. Additionally, when the message size exceeds a certain size under some of the use cases, an application data fragmentation function and other similar compensation scheme will be required.

Possible means to achieve these countermeasures include application level compensation or utilization of ARIB STD-T88.

・ARIB STD-T109

Within the expected use cases, infrastructure-to-vehicle communications and vehicle-to-vehicle communications cases use cases are considered.

The results of radio link design show that it may not satisfy the communications conditions (provisional) under the specific conditions of certain use cases. When the message size exceeds a certain size under some of the use cases, an application data fragmentation function and other similar compensation scheme will be required.

Also, the communications range during communications under use case 1-2-1 may not be satisfied. Possible countermeasures include the addition of a relay function on the application layer, addition of a relay function by using multiple roadside units, or use of wide-range LTE V2X (Uu).

(5) How to use this guideline

This guideline expects specific designs for roadside units and onboard units for testing communications use cases for automated driving on expressways. However, this guideline does not contain information regarding installation methods or system verification methods for installing devices on vehicles and roadside infrastructures to perform experiments. When conducting experiments, it is necessary to adequately consider countermeasures against interference with existing systems.

The following supplementary materials are appended at the end of this guideline as reference to this guideline.

Contents

Chapter 1. ITS Forum RC-005 based Wireless Communication Technology

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Section 1. General Descriptions

1.1 Overview

This guideline specifies communications specification standards documents to be referenced, conditions for implementation, and other matters to be taken into consideration when conducting numerical study/computer simulation and experiments concerning the use cases set forth in the introduction using the communications technologies specified in Section 1.1: Inter-Vehicle Communications Applications and ITS-ASL Compatible Extension Methods or Section 1.2: Inter-Vehicle Communications Application Compatibility Methods in ITS Forum RC-005 Version 3.0: Experimental Guideline for Inter-Vehicle Communications System using 5.8 GHz-Band. This guideline specifies only the differences from ITS Forum RC-005 Version 3.0. This guideline differs from ITS Forum RC-005 Version 3.0 by the addition of a repetition function to layer 7.

1.2 Scope of Application

This guideline specifies wireless interfaces between roadside units and onboard units, and between onboard units when conducting numerical study/computer simulation and experiments concerning the use cases set forth in the introduction by referring ITS Forum RC-005.

1.3 Guideline Principles

In this guideline, in the case of Section 1.1: Inter-Vehicle Communications Applications and ITS-ASL Compatible Extension Methods, repetition functions and application data fragmentation and assembly functions are achieved by application of ITS Forum RC-014 Version 1.0: ITS Application Sub-Layer Specification Guideline to the upper layer. In addition, in the case of Section 1.2: Inter-Vehicle Communications Application Compatibility Methods, this guideline contains new provisions on repetition functions in layer 7. In the case of Section 1.2: Inter-Vehicle Communications Application Compatibility Methods, implementation of application data fragmentation and assembly functions by the application are required.

In cases where relay functions are applied, they are implemented on the application level. In cases where wireless devices (roadside units and onboard units) are operated using ITS Forum RC-005, it is necessary to obtain an experimental radio station license. When operating an experimental radio station, it is necessary to take into consideration the avoidance of interference with existing systems and to satisfy the technical conditions necessary for the experimental radio station.

1.4 Materials

1.4.1 Compliance documents

[1] ITS FORUM RC-005 Version 3.0, “Experimental Guideline for Inter-Vehicle Communications System using 5.8 GHz-Band,” ITS Info-communications Forum of Japan, September 29, 2016

1.4.2 Reference documents

[2] ITS FORUM RC-014 Version 1.0, “ITS Application Sub-Layer Specification Guideline, ITS Info-communications Forum of Japan,” May 25, 2017

The changes to ITS Forum RC-005 Version 3.0 are indicated below. (Only sections with changes are described.)

----- Start of Changes to ITS Forum RC-005 Version 3.0 -----

Section 1.2 Inter-vehicle communications application compatibility methods

4.4 Layer 7 standards (reference)

4.4.1 Overview

Layer 7 provides a means of communications with the application. The application designer builds the application by using the means of communication provided by layer 7.

The operation regarding the application service data unit (ASDU) is performed by the invocation from service primitives (SP).

The following subjects are covered by this guideline:

Services to enable data transfer

This guideline does not cover the transmission time management, time synchronization, relay control, etc., which are supposed to be performed by the application.

4.4.1.1 Structure

As specified in Compliance Document [1], Section 1.2, Clause 4.4.1.1.

4.4.1.2 Definitions (terminology)

As specified in Compliance Document [1], Section 1.2, Clause 4.4.1.2.

4.4.2 Layer 7 interface service specifications

4.4.2.1 Layer 7 service interface

4.4.2.1.1 Overview

As specified in Compliance Document [1], Section 1.2, Clause 4.4.2.1.1.

4.4.2.1.2 Overview of primitive interrelationships

As specified in Compliance Document [1], Section 1.2, Clause 4.4.2.1.2.

4.4.2.1.3 Service content specifications

(1) GET primitive

a) Function

The GET primitive is used to receive search information from the application of another device. The service is not used in this guideline.

b) Format

(2) This guideline does not specify the detailed format.SET primitive

a) Function

The SET primitive is used to change information in the application of another device. The service may use either confirmation types or non-confirmation types, and in the case of a confirmation type, a response is required. This guideline uses a non-confirmation type.

b) Format

As set forth below.

SET.request (EID, Element)

SET.indication (EID, Element)

(3) SENDDATA primitive

a) Function

The SENDDATA primitive is used for a terminal to request a broadcast data transmission to the application of another device, or to receive a broadcast data transmission from the application of the other device.

b) Format

As set forth below.

SENDDATA.request (NumberOfRepetitionTransmitting, LinkAddress, DataLength, ApplicationData)

SENDDATA.indication (NumberOfRepetitionTransmitting, LinkAddress, DataLength, ApplicationData)

4.4.2.1.4 Parameters

The parameters used with the layer 7 specified primitives are indicated below. Unless otherwise specified, bit 7 is MSB. The bit transmission order in layer 7 is transmission of the most significant bit (MSB) first.

(1) EID (Element Identifier)

This indicates identifies of the element. The structure of the EID is shown in Figure 4.4-1. In this guideline, the EID definition is reserved (all 0).

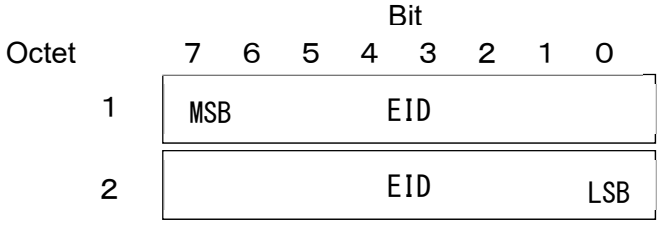

Figure 4.4-1. EID Structure

(2) NumberOfRepetitionTransmitting

This indicates the number of times the PDU is transmitted repeatedly.

4.4.2.1.5 Sequence

Examples of transmission sequences are shown in Figure 4.4-2 and Figure 4.4-3.

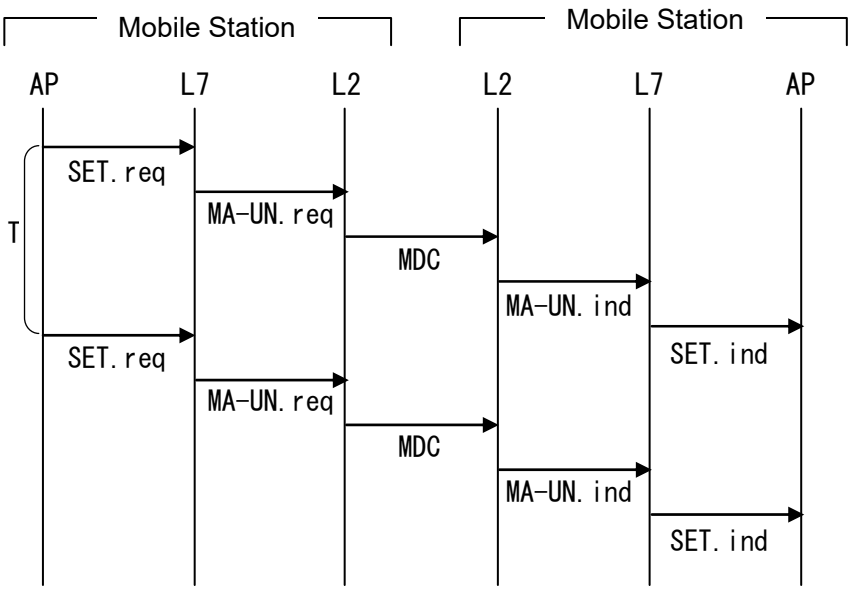

Figure 4.4-2. Transmission Sequence Example

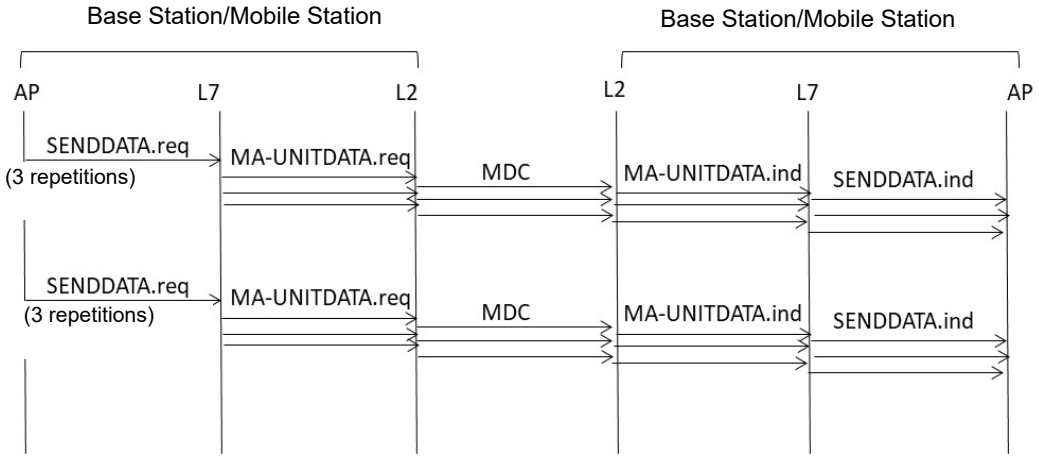

Figure 4.4-3. Transmission Sequence Example

4.4.2.2 Layer 7 management service interface

As specified in Compliance Document [1], Section 1.2, Clause 4.4.2.1.2.

4.4.3 Layer 7 communications control

4.4.3.1 Layer 7 protocol data unit (PDU)

As specified in Compliance Document [1], Section 1.2, Clause 4.4.3.1.

4.4.3.1.1 Layer 7 protocol data unit format

As specified in Compliance Document [1], Section 1.2, Clause 4.4.3.1.1.

4.4.3.1.2 Layer 7 PDU elements

As specified in Compliance Document [1], Section 1.2, Clause 4.4.3.1.2.

4.4.3.2 Layer 7 procedure elements

4.4.3.2.1 Transmission procedure

a) APDU generation

Layer 7 generates the APDU based on the data received in accordance with the SENDDATA request primitive.

b) Transmission requests to LLC sub-layer

After the APDU is generated, the LLC sub-layer DL-UNITDATA request primitive is called the number of times specified by NumberOfRepetitionTransmitting and notice of the transmission request is provided to the LLC sub-layer.

4.4.3.2.2 Reception procedure

As specified in Compliance Document [1], Section 1.2, Clause 4.4.3.2.2.

----- End of Changes to ITS Forum RC-005 Version 3.0 -----

Chapter 2. LTE V2X（PC5）based Wireless Communication Technology

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Section 1. General Descriptions

1.1 Overview

The scope of this guideline is to specify the list of reference documents for communication technical specifications and example RRC parameters to conduct numerical study/computer simulation and field experiments for the use cases defined in introduction in this document by using LTE V2X PC5 interface defined by 3GPP.

1.2 Scope

This guideline defines interfaces between OBU (onboard unit) and OBU, and OBU and RSU (roadside unit).

1.3 Guideline principles

The requirements and procedures for LTE V2X PC5 interface follow the specifications defined by 3GPP. This guideline does not recommend any changes or additions to any 3GPP specifications.

This guideline defines some conditions and functions specifically, it should be understood they are subject to change in the future.

There is no corresponding radio regulation for LTE V2X PC5. In order to operate radio stations (either OBU or RSU) using PC5, it is necessary to obtain the experimental radio license. Interference to other incumbent systems must be avoided. It is also required to comply with technical conditions for the experimental radio license.

1.4 Materials

1.4.1 Compliance documents

Unless it is specifically noted, definitions of terminologies used in this guideline are based on relevant Japanese radio law, Ministerial Ordinance and 3GPP specifications (Release 14). Details can be found in the following sections.

Section 2. LTE V2X PC5 System Overview

LTE V2X has two types of interfaces, i.e., direct communication and network communication. Both interfaces can support various use cases by compensating each other. This section defines LTE V2X PC5 that supports the direct communication. For the network communication, please refer Part 3 LTE V2X Uu in this document.

3GPP defines a set of reference points in the architecture [See TS23.303]. PC5 is a direct communication interface between UEs (User Equipment) which support Proximity Service (ProSe) application. From 3GPP architecture functionality point of view, both OBU and RSUs are UEs.

2.1 System configuration

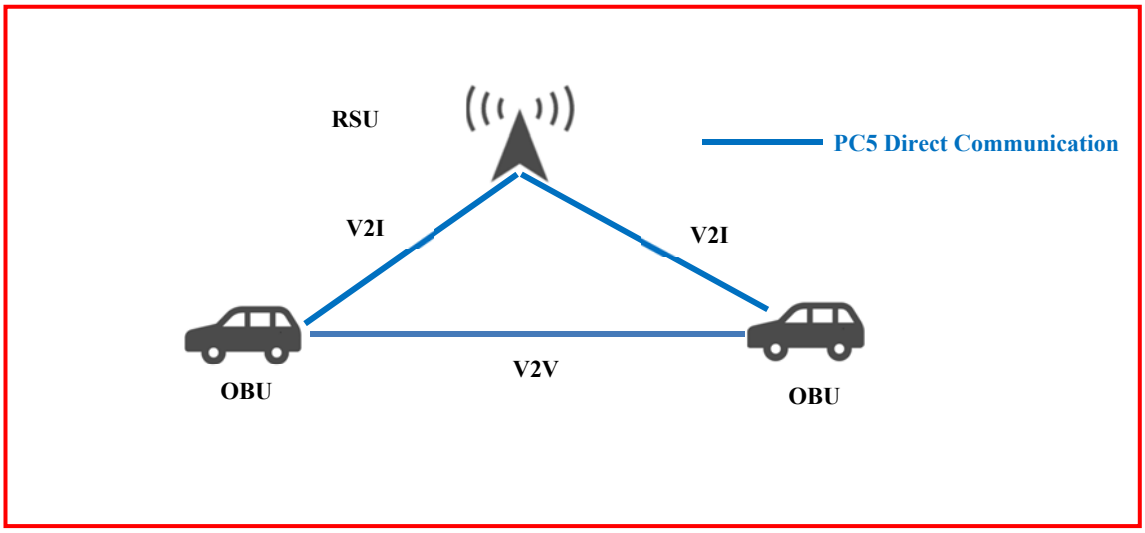

Figure 2.1-1 C-V2X PC5 Mode 4 System Configuration

This system is configured by radio units to be installed in multiple cars (hereafter OBU) and multiple radio units to be deployed in road side (hereafter RSU). (For simplicity, only one RSU is described in Figure 2.1-1.) To avoid confusion with LTE V2X Uu, Section 2 does not use terminologies such as ‘mobile station’ or ‘base station’ to indicate OBU or RSU.

2.1.1 RSU (Road Side Unit)

The RSU supports the land mobile communication to OBUs. Radio equipment for RSU is composed by transmitter, receiver, controller and antenna, etc.

2.1.2 OBU (On Board Unit)

The OBU supports the land mobile communication to other OBUs or RSUs. Radio equipment for OBU is composed by transmitter, receiver, controller and antenna, etc.

2.2 Interface definition

PC5 interface is defined in 3GPP 23.303.

2.3 Fundamental functions of the system

2.3.1 System overview

LTE V2X PC5 has two modes of operation called Mode 3 and Mode 4. (Mode 1 and 2 are also defined in 3GPP. But, those are not applicable to LTE V2X.) In Mode 3, eNB (LTE base station) controls PC5 resource selection. In Mode 4, the resource selection is independently performed by OBU or RSU without having eNB control. In this guideline, only Mode 4 without synchronization signal from eNB is assumed.

The PC5 interface was firstly introduced in Release 12 3GPP when a D2D Discovery and communications system was defined. In Release 14, the interface has been enhanced to deal with high Doppler, improve synchronization, and latency etc. It works both in and out of cellular network coverage. It supports a mechanism where cars can broadcast messages (e.g., their location, speed) to other cars directly at 100s of meters range at 100msec duty cycle.

2.3.2 Services

This guideline does not define the services to be provided by LTE V2X PC5 interface.

2.4 Protocol configuration overview

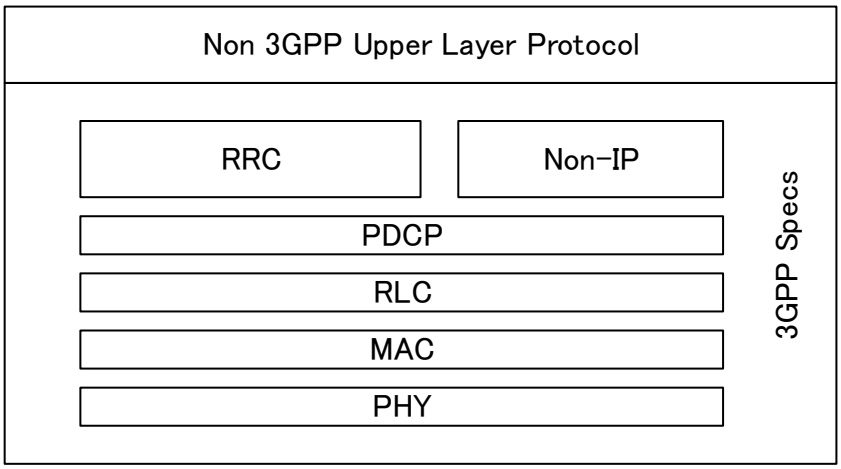

Figure 2.4-1 PC5 Protocol Stack

2.5 Security

Security is not provided by PC5 interface. Instead, non 3GPP upper layer provides security.

2.6 Application

This guideline uses applications, being discussed in SIP (Strategic Innovation Program) and JAMA etc., which aim to develop communication standards expected for autonomous driving support.

Section 3. Radio Interface

3.1 List of 3GPP specifications for PC5

3.1.1 Overview (Stage 1 and Stage 2)

3GPP TS 23.303 Proximity-based services (ProSe) Stage 2

3GPP TS 24.386 User Equipment (UE) to V2X control function; protocol aspects

3.1.2 Physical Layer

3GPP TS 36.211 Physical channels and modulation

3GPP TS 36.212 Multiplexing and channel coding

3GPP TS 36.213 Physical layer procedures

3GPP TS 36.214 Physical layer; Measurements

3.1.3 MAC Layer

3GPP TS 36.321 Medium Access Control (MAC) protocol specification

3.1.4 RLC Layer

3GPP TS 36.322 Radio Link Control (RLC) protocol specification

3.1.4 PDCP Layer

3GPP TS 36.323 Packet Data Convergence Protocol (PDCP) specification

3.1.5 RRC Layer

Direct communication signaling protocol is defined in 3GPP TS 36.331 Radio Resource Control (RRC) protocol specification.

3.2 Example key parameter settings

Since Mode 4 with no synchronization information from eNB is assumed, it is necessary to configure common PC5 interface parameters in advance. In this section, example settings are provided assuming the basic safety features for reference purpose. Those may not be perfectly suitable for use cases being considered in this document. Appropriate parameters are subject for investigation.

Table 3.2-1 RRC Layer (TS 36.331) Parameter Example Configurations

SL-V2X-Preconfiguration-r14		
Parameters	**Example settings**	**Note**
v2x-PreconfigFreqList-r14	One entry of SL-V2X-PreconfigFreqInfo-r14	See SL-V2X-PreconfigFreqInfo-r14
anchorCarrierFreqList-r14	Not configured	
cbr-PreconfigList-r14	Two entries of {65, 100}	2 and 5 are assumed for PPPP values.
SL-V2X-PreconfigFreqInfo-r14		
Parameters	**Example settings**	**Note**
v2x-CommPreconfigGeneral-r14	SL-PreconfigGeneral-r12	See SL-PreconfigGeneral-r12
v2x-CommPreconfigSync-r14	Not configured	
v2x-CommRxPoolList-r14	One entry of SL-V2X-PreconfigCommPool-r14	See SL-V2X-PreconfigComm Pool-r14
v2x-CommTxPoolList-r14	One entry of SL-V2X-PreconfigCommPool-r14	See SL-V2X-PreconfigComm Pool-r14
p2x-CommTxPoolList-r14	Not configured	
v2x-ResourceSelectionConfig-r14	SL-CommTxPool SensingConfig-r14	See SL-CommTxPool SensingConfig-r14
zoneConfig-r14	Not configured	
syncPriority-r14	gnss	
thresSL-TxPrioritization-r14	Not configured	
offsetDFN-r14	Not configured	
SL-PreconfigGeneral-r12		
Parameters	**Example settings**	**Note**
profile0x0001-r12	FALSE	
profile0x0002-r12	FALSE	
profile0x0004-r12	FALSE	
profile0x0006-r12	FALSE	
profile0x0101-r12	FALSE	
profile0x0102-r12	FALSE	
profile0x0104-r12	FALSE	
carrierFreq-r12	To be set experimental frequency	Same as ARFCN-ValueEUTRA-r9

maxTxPower-r12	23 dBm	Same as P-Max
additionalSpectrumEmission-r12	Ignored	
sl-bandwidth-r12	n50 or n100	n50(50RBs) for 10MHz and n100(100RBs) for 20MHz
tdd-ConfigSL-r12	None	
reserved-r12	All 0s	
additionalSpectrumEmission-v1440	NS_33 only for ETSI	
SL-V2X-PreconfigCommPool-r14		
Parameters	**Example settings**	**Note**
sl-OffsetIndicator-r14	Not configured	
sl-Subframe-r14	All 1s	
adjacencyPSCCH-PSSCH-r14	TRUE	
sizeSubchannel-r14	n10	
numSubchannel-r14	n5 or n10	n5 for 10 MHz and n10 for 20 MHz
startRB-Subchannel-r14	0	
startRB-PSCCH-Pool-r14	Not configured	
dataTxParameters-r14	23 dBm	Set to same as P-Max.
zoneID-r14	Not configured	
threshS-RSSI-CBR-r14	9	set to 9 per sub-channel of size 10RB
cbr-pssch-TxConfigList-r14	Two entries of SL-PPPP-TxPreconfigIndex-r14	See SL-PPPP-TxPreconfigIndex-r14
resourceSelectionConfigP2X-r14	Not configured	
syncAllowed-r14	gnss	
restrictResource ReservationPeriod-r14	Not configured	
SL-CommTxPoolSensingConfig-r14		
Parameters	**Example settings**	**Note**
pssch-TxConfigList-r14	One entry of SL-PSSCH-TxConfig-r14	See SL-PSSCH-TxConfig-r14
thresPSSCH-RSRP-List-r14	{2, 11, 2, 11}	These parameters assume two PPPP values of 2 and 5 only. Assume that PPPP value of 2 is greater priority than PPPP value of 5.

restrictResource ReservationPeriod-r14	v1	100ms
probResourceKeep-r14	v0dot8	
p2x-SensingConfig-r14	Not configured	
sl-ReselectAfter-r14	n5	
SL-PPPP-TxPreconfigIndex-r14 (for PPPP values of 5)		
Parameters	**Example settings**	**Note**
priorityThreshold-r14	5	
defaultTxConfigIndex-r14	1	
cbr-ConfigIndex-r14	0	
tx-ConfigIndexList-r14	{0, 1}	
SL-PPPP-TxPreconfigIndex-r14 (for PPPP values of 2)		
Parameters	**Example settings**	**Note**
priorityThreshold-r14	2	
defaultTxConfigIndex-r14	1	
cbr-ConfigIndex-r14	0	
tx-ConfigIndexList-r14	{0, 1}	
SL-PSSCH-TxConfig-r14		
Parameters	**Example settings**	**Note**
typeTxSync-r14	Not configured	
thresUE-Speed-r14	kmph120	
parametersAboveThres-r14	SL-PSSCH-TxParameters-r14	See SL-PSSCH-TxParameters-r14
parametersBelowThres-r14	SL-PSSCH-TxParameters-r14	See SL-PSSCH-TxParameters-r14
SL-PSSCH-TxParameters-r14 for parametersBelowThres-r14		
Parameters	**Example settings**	**Note**
minMCS-PSSCH-r14	5	
maxMCS-PSSCH-r14	11	MCS 8, 9, 10 will be excluded
minSubChannel-NumberPSSCH-r14	1	
maxSubchannel-NumberPSSCH-r14	2	
allowedRetxNumberPSSCH-r14	n1	
maxTxPower-r14	Not configured	
SL-PSSCH-TxParameters-r14 for parametersAboveThres-r14		
Parameters	**Example settings**	**Note**

minMCS-PSSCH-r14	0	
maxMCS-PSSCH-r14	7	
minSubChannel-NumberPSSCH-r14	1	
maxSubchannel-NumberPSSCH-r14	5	
allowedRetxNumberPSSCH-r14	n1	
maxTxPower-r14	Not configured	

Section 4. General Conditions and Wireless Equipment Technical Conditions

3GPP defines PC5 UE radio performance. The radio stations to be used for experiment shall comply with the following specification.

3GPP TS36.101 E-UTRA User Equipment (UE) radio transmission and reception

Section 5. Terminology

5.1 Terminology

The terminologies used in this guideline have the meanings set forth below.

[A]

[B]

[C]

[D]

D2D : Device to Device

[E]

eNB : e Node B

[H]

[I]

IP : Internet Protocol

ITS : Intelligent Transport Systems

[J]

[K]

[L]

LTE : Long Term Evolution

[M]

MAC : Medium Access Control

[N]

[O]

[P]

PDCP : Packet Data Convergence Protocol

PHY : Physical layer

ProSe : Proximity Service

[Q]

[R]

RLC : Radio Link Control

RRC : Radio Resource Control

[S]

SIP : Strategic Innovation promotion Program

[T]

[U]

UE : User Equipment

[V]

V2X : Vehicle-to-Everything communication

[W]

[X]

[Y]

[Z]

[0]

[1]

[2]

[3]

3GPP : 3rd Generation Partnership Project

[4]

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Chapter 3. LTE V2X (Uu) based Wireless Communication Technology

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Section 1. General Descriptions

1.1 Overview

This guideline specifies the reference standard documents for communications specifications and the required conditions (the necessary functions and conditions that need to be restricted within the scope of the options specified by 3GPP) for implementation when conducting numerical study/computer simulation and experiments concerning the use cases described in the introduction using the LTE V2X (Uu) communications specifications defined by 3GPP. However, this guideline does not recommend any changes or additions to any technical specifications designated by 3GPP. When creating test devices, it is not necessary to add functions not specified by 3GPP.

1.2 Scope

This guideline describes the interface of each layer in reference point (Uu interface) between mobile stations and base stations. In addition, this guideline describes behavior of devices other than mobile stations and base stations in relation to communications control in wireless segments.

1.3 Guideline principles

This guideline does not discuss behavior specified by 3GPP, and only lists up compliance documents of them.

This guideline adopts the three-layer structure of the OSI reference model, i.e., layer 1, layer 2, layer 3, and layer 7 is also the subjects of this guideline.

1.4 Materials

1.4.1 Compliance documents

Unless it is specifically noted, definitions of terminologies used in this guideline are based on relevant Japanese radio law, Ministerial Ordinance and 3GPP specifications (Release 14). Details can be found in subsequent sections.

Section 2. System Overview

2.1 System configuration

The overall configuration of the system is described in the figure below.

System configuration for base stations, MME, S-GW, and P-GW provided by mobile operator can also be adopted.

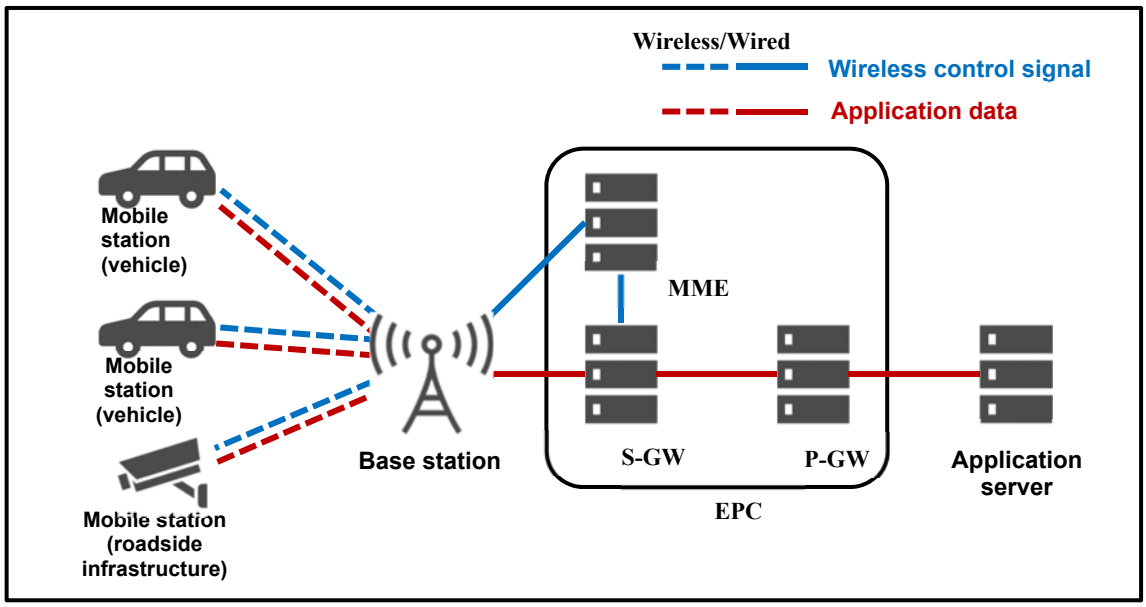

Figure 2.1-1. System Configuration

2.1.1 Mobile station

The mobile station performs land mobile wireless communications with base stations. Mobile station wireless hardware comprises transmitters, receivers, controllers, antennas, and so on.

2.1.2 Base station

The base station performs land mobile wireless communications with multiple mobile stations. Base station wireless hardware comprises transmitters, receivers, controllers, antennas, and so on.

2.1.3 MME

The MME authenticates mobile stations. The MME also request optimal base stations and S-GW that based on mobile station location information to setup the communications paths used for application data

exchange.

2.1.4 S-GW

The S-GW consolidates multiple base stations and relays communications between base stations and P-GW.

2.1.5 P-GW

The P-GW allocates IP addresses to mobile stations. The P-GW also consolidates multiple S-GW and relays communications between S-GW and application servers.

2.1.6 Application server

The applications used by V2X systems are installed on application servers. In this guideline, only one application server is present in the system.

2.2 Interface definitions

The system reference points are as shown in the figure below.

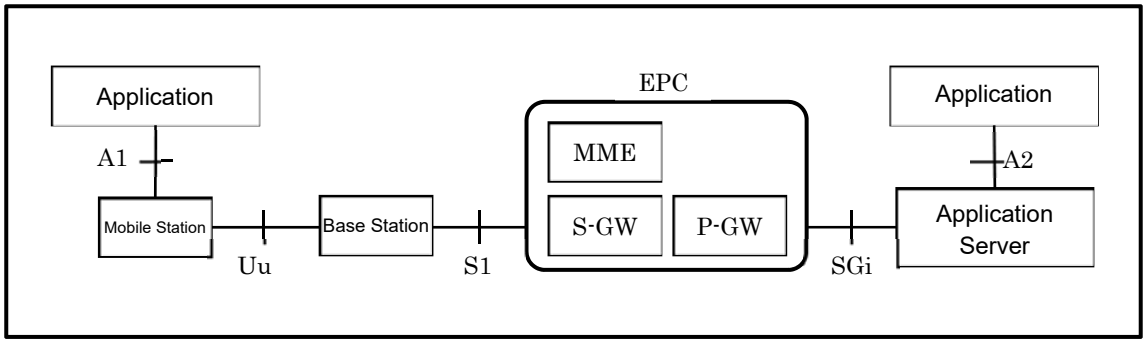

Figure 2.2-1. Interface Points Used in This Guideline

A1 point: A reference point between a mobile station and applications. Not covered in this guideline.

A2 point: A reference point between the application server and applications. Not covered in this guideline.

Uu point: A reference point between mobile stations and base stations. Specified in the standards documents indicated below.*

S1 point: A reference point between base stations and the EPC. Specified in the standards documents indicated below* (not covered in this guideline).

SGi point. A reference point between the EPC and the application server. Specified in the standards documents indicated below.*

* 3GPP TS 23.285: “Architecture enhancements for V2X services”

* 3GPP TS 29.061: “Interworking between the Public Land Mobile Network (PLMN) supporting packet based services and Packet Data Networks (PDN)”

2.3 Basic functions of the system

The system performs communications between base stations and mobile stations. For example,

(a) Transferring and exchanging information that contributes to reduce in traffic accidents, and
(b) Transferring and exchanging information relating to driving support.

2.3.1 System conditions

The conditions of the system are as set forth below.

2.3.1.1 Basic functions

(1) The system is a mobile communication system that connects mobile stations and base stations by high-data speed wireless links. The system is characterized by:

(a) Effective use of frequencies through centralized control of wireless resources by base stations, and
(b) Ability to transmit large volumes of data at high data speed with low delay.

The following onboard connection functions and base station connection functions are also expected.

(c) Connection functions with GPS and other devices to provide subject vehicle information;
(d) Connection functions with onboard display devices and other devices to display information regarding other vehicles; and
(e) Connection functions with traffic status information collection devices and other devices.

(2) The wireless device functions of the system are as follows.

(a) The system comprises multiple mobile stations and a base station and is achieved by wireless communications between the mobile stations and the base station.

However, there may be restrictions on the amount of information depending on the wireless communications zone and traveling speed.

2.3.2 Services that can be used with the system

2.3.2.1 Service types

This guideline does not specify services provided by the system. But examples of services expected are indicated below.

(a) Services for transferring and exchanging information that contributes to reductions in traffic accidents;
(b) Services for transferring and exchanging information relating to driving support;
(c) Services for transferring and exchanging information relating to automated driving; and
(d) Other information provision services.

2.4 Wireless communication specifications

The wireless communication specifications are as specified in the following compliance documents. However, the User Plane transmission method uses a unicast as specified in the compliance documents.

L1:

- 3GPP TS 36.201: “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; General description”.

L2:

- 3GPP TS 36.321: “Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification”.
- 3GPP TS 36.322: “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification”.
- 3GPP TS 36.323: “Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification”.

L3:

- 3GPP TS 36.331: “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control

(RRC) protocol specification".

In consideration of cases where experiments are performed using mobile operator equipment, this guideline does not specify the detailed parameter settings of the wireless communication.

2.5 Protocols

The figure below indicates the protocol stacks specified in this guideline. Details of the protocols for each layer are specified in Section 4. S-GW has been omitted to simplify the figure.

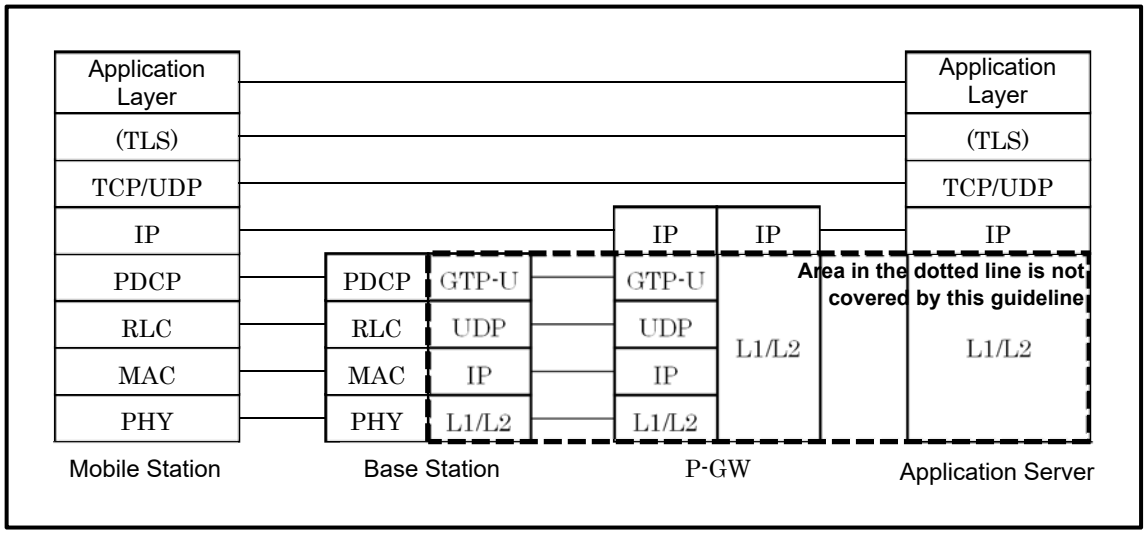

Figure 2.5-1. Protocol Stacks Handled in this Guideline

IP packets are transferred between mobile stations and the application server via the P-GW, and connections are transparently made to base stations and S-GW in between. It is necessary to use Internet standards or regional ITS specifications depending on the required conditions for the protocol above IP because no specification is defined in 3GPP, and in this guideline, use of TCP/UDP and TLS are assumed as examples.

2.6 Security methods

Wireless interface security is specified in the following compliance document.

- 3GPP TS 33.401: "3GPP System Architecture Evolution (SAE); Security architecture"

End-to-end security functions between mobile stations and the application server are not specified in

communication specifications but are implemented by the application. In this guideline, the security function implementation method is out of scope. When conducting experiments, by taking into consideration the communications delay, evaluations may be performed for bidirectional communications between mobile stations and the application server by adding an increased size to the application message set arising from the security functions.

Section 3. General Conditions and Wireless Equipment Technical Conditions

3.1 General conditions

The specified range (location, frequency, antenna power, etc.) for which approval is received for the wireless station shall be used.

3.2 Wireless equipment technical conditions

In accordance with the Ministerial Ordinance on Technical Regulations Conformity Certification of Specified Radio Equipment (the "Certification Ordinance") established by the Ministry of Internal Affairs and Communications, Specified Radio Equipment that has received Technical Regulations Conformity Certification etc. for any of the following types shall be used.

- Specified radio equipment designated in Article 2, Item 11-19 of the Certification Ordinance (land mobile stations for LTE)
- Specified radio equipment designated in Article 2, Item 11-20 of the Certification Ordinance (land base stations etc. for LTE)
- Specified radio equipment designated in Article 2, Item 11-20-2 of the Certification Ordinance (femtocell base stations for LTE)
- Specified radio equipment designated in Article 2, Item 11-20-3 of the Certification Ordinance (indoor compact base stations for LTE)
- Specified radio equipment designated in Article 2, Item 11-21 of the Certification Ordinance (land mobile stations for LTE (2 GHz TDD))
- Specified radio equipment designated in Article 2, Item 11-22 of the Certification Ordinance (base stations etc. for LTE (2 GHz TDD))
- Specified radio equipment designated in Article 2, Item 53 of the Certification Ordinance (base stations etc. for next-generation PHS)
- Specified radio equipment designated in Article 2, Item 54 of the Certification Ordinance (land mobile stations etc. for next-generation PHS)
- Specified radio equipment designated in Article 2, Item 54-2 of the Certification Ordinance (femtocell base stations for next-generation PHS)
- Specified radio equipment designated in Article 2, Item 54-3 of the Certification Ordinance (indoor compact base stations for next-generation PHS)

Section 4. Communications Control Systems

4.1 Overview

Communications control systems are as specified in the following compliance document.

- 3GPPTS 36.300: “Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description”

4.2 Layer 1 (physical layer) standards

The standards are specified in the following compliance documents.

- 3GPP TS 36.211: “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation”
- 3GPP TS 36.212: “Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding”
- 3GPP TS 36.213: “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures”
- 3GPP TS 36.214: “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements”

4.3 Layer 2 (datalink layer) standards

The standards are specified in the following compliance documents.

- 3GPP TS 36.321: “Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification”
- 3GPP TS 36.322: “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification”
- 3GPP TS 36.323: “Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification”

4.4 Layer 3 (network layer) standards

The standards are specified in the following compliance documents.

- 3GPP TS 36.331: “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification”

- IP protocol (RFC791, RFC2460)

4.5 Layer 7 (application layer) standards

The standards are specified in the following compliance document. It should be noted that the uplink transmission from mobile stations to the application server and downlink transmission from the application server to mobile stations use a unicast.

- 3GPP TS 24.386: “User Equipment (UE) to V2X control function protocol aspects Stage 3”

4.5.1 LTE-Uu V2X communications parameter settings

V2X communications over LTE-Uu include the following information.

a) V2X message; and
b) V2X service identifier (a value indicating the V2X service is set).

The LTE-Uu unicast V2X communications server address is set for each V2X service on the application server. The V2X communications server addresses have the following structures.

i) IP address or FQDN
ii) TCP/UDP port

The application server IP address and TCP/UDP port for mobile stations are set in advance, but a configuration specifying the FQDN for each service and resolving the IP address for each service dynamically using DNS may be used.

4.5.2 LTE-Uu V2X communications message forwarding

The layer 7 PDU communication source IP address is appropriately set according to the V2X communications transmitted by unicast from mobile stations to the application server.

IP address that is dynamically or statically assigned to mobile stations by the P-GW related to certain PDN is used in the source IP address in Layer 7 PDU from mobile station application. The application server identifies the mobile station and determines the connecting service from the PDU transmission source IP address and destination port.

4.6 Application

Refer Appendix 1 for information regarding the message sets transmitted and received by the application. The application server application forwards the message and performs the communications indicated for each use case.

Section 5. Terminology

5.1 Terminology

The terms used in this guideline have the meanings set forth below.

Mobile Station

A radio station that moves. Synonymous with on board unit.

Base Station

A radio station that does not move. Synonymous with eNodeB (E-UTRAN NodeB) in the 3GPP technical specifications.

3rd Generation Partnership Project (3GPP)

A standardization project that investigates and prepares specifications relating to LTE.

On Board Unit

A vehicular communications device that is mobile and can transmit and receive information. It is technically the same as mobile station.

V2X Communication (Vehicle-to-Everything Communication)

A general term for communications with vehicles.

Protocol Data Unit

The unit of data exchanged between peer protocols.

Message Set

A group of messages that the application transmits and receives and that are necessary for implementation of the use cases subject to testing.

Mobile Operator

A telecommunications carrier that provides mobile telecommunications services.

User Plane

Data transmitted and received by users.

Unicast

Transmission of data and signals specified by a single particular counterparty on a communications network.

Layer 1

A conceptual layer for signal transmission on physical media. Also referred to as the physical layer. This layer provides the interface for layer 2.

Layer 2

A conceptual layer that performs management and control of data links. Also referred to as the data link layer. This layer provides the interface for layer 3.

Layer 3

A conceptual layer that performs management and control of networks. Also referred to as the network layer. This layer provides the interface for layer 7.

Layer 7

A functional element for general-purpose processing for various applications. This layer provides the interface for the application.

5.2 List of Abbreviation

[A]

[B]

[C]

[D]

DNS : Domain Name System

[E]

EPC : Evolved Packet Core

[F]

FQDN : Fully Qualified Domain Name

[G]

GTP-U : GPRS Tunnelling Protocol for User Plane

GPRS : General Packet Radio Service

GPS : Global Positioning System

[H]

[I]

IP : Internet Protocol

ITS : Intelligent Transport Systems

[J]

[K]

[L]

L1 : Physical Medium Layer

L2 : Data Link Layer

L3 : Network Layer

L7 : Application Layer

LTE : Long Term Evolution

[M]

MAC : Medium Access Control

MME : Mobility Management Entity

[N]

[O]

OSI : Open Systems Interconnection

[P]

PDCP : Packet Data Convergence Protocol
PDN : Packet Data Network
PDU : Protocol Data Unit
PHY : Physical layer
P-GW : PDN Gateway

[Q]

[R]
RLC : Radio Link Control
RRC : Radio Resource Control

[S]
S-GW : Serving Gateway

[T]
TLS : Transport Layer Security
TCP : Transmission Control Protocol

[U]
UDP : User Datagram Protocol

[V]
V2X : Vehicle-to-Everything communication

[W]

[X]

[Y]

[Z]

[0]

[1]

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3GPP : 3rd Generation Partnership Project

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Chapter 4. ARIB STD-T75

Dedicated Short-Range Communication（DSRC）System based Wireless Communication Technology

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Section 1. General Descriptions

1.1 Overview

This guideline specifies the communications specification compliance documents to be referenced, the conditions necessary for implementation, and matters to be taken into consideration when conducting numerical study/computer simulation and experiments concerning the use cases set forth in the introduction using a dedicated short-range communication (DSRC) system specified in ARIB STD-T75. However, this guideline does not recommend any revisions or additions to the technical specifications designated in ARIB STD-T75. When creating test devices, it is not necessary to add functions not specified in ARIB STD-T75.

1.2 Scope of Application

This guideline describes the wireless interfaces between base stations (RSUs) and mobile stations (OBUs) when conducting numerical study/ computer simulation and experiments concerning the use cases categorized as infrastructure-to-vehicle communications from among these cases set forth in the introduction by referring ARIB STD-T75.

1.3 Guideline principles

This communication technology is premised on short-range communication such as ETC 2.0, and therefore, when assessing use cases, it is necessary to adequately take into consideration the possible communications range, data size, installation conditions, and so on.

In this guideline, the π/4 shift QPSK method is only used for modulation, and no specific supplementation or modification of ARIB STD-T75 functions are described. Accordingly, it is necessary to conduct experiments while keeping in mind that the communications conditions may not be satisfied in some of the infrastructure-to-vehicle communications use cases. Furthermore, it is necessary to keep in mind that it may be necessary to collaborate with related organizations from the perspective of impact on radio stations in actual operation depending on the contents of the message set and so on. In cases where supplementation or modification of the communications technology specified in ARIB STD-T75 is performed, it is necessary to obtain an experimental radio station license.

1.4 Materials

1.4.1 Compliance documents

- Dedicated Short-Range Communication (DSRC) System, ARIB STD-T75 Version 1.5

1.4.2 Reference documents

・Dedicated Short-Range Communication (DSRC) Application Sub- Layer, ARIB STD-T88 Version 1.1

Chapter 5. ARIB STD-T109

700 MHz Band Intelligent Transport Systems based Wireless Communication Technology

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Section 1. General Descriptions

1.1 Overview

This guideline specifies the communications specifications compliance documents to be referenced, scope of application, and matters to be taken into consideration when conducting numerical study/computer simulation and experiments concerning the use cases set forth in the introduction using a 700 MHz band intelligent transport system (700MHz band ITS) that has already been put into use for safe driving support applications through vehicle-to-vehicle communications, infrastructure-to-vehicle communications, and infrastructure-to-infrastructure communications.

1.2 Scope of Application

This guideline describes wireless interfaces among and between mobile stations and base stations deployed in roadside (hereafter base station in this chapter) corresponding to the use cases set forth in the introduction from among the wireless interfaces specified in ARIB STD-T109.

When performing application data fragmentation and reassemble processing, and relay transmission in inter-vehicle communication with 700MHz band ITS, such functions need to be executed within the data size of the free field specified in the TD-001, which describes vehicle-to-vehicle communications message specification. The processing of application data fragmentation and reassemble in infrastructure-to-vehicle communications is specified as functions in Extended Layer (EL), and therefore, it is necessary to take these into consideration depending on the use case. A summary of the scopes of application of each standard is set forth below.

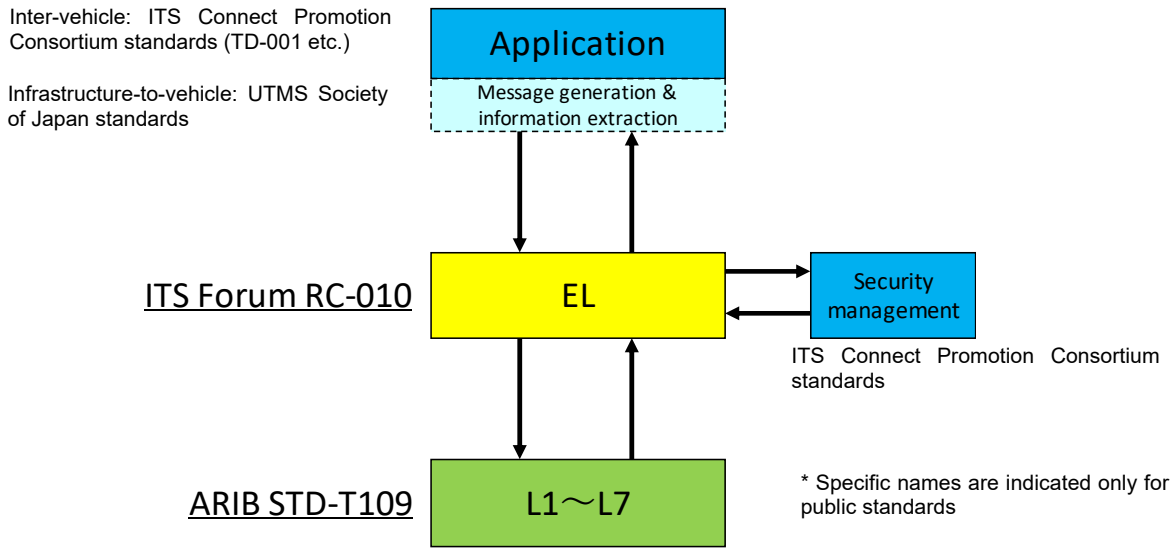


Figure 1.2-1. Scope of Application of Each Standard

1.3 Guideline principles

700 MHz band ITS uses 10 MHz bandwidth communications resources to enable sharing of vehicle-to-vehicle communications, infrastructure-to-vehicle communications, and infrastructure-to-infrastructure communications and has already been put into use for safe driving support applications. ARIB STD-T109 specifies transmission time control functions for sharing these systems and enabling coexistence with neighboring systems, and in the case of vehicle-to-vehicle communications in particular, there are restrictions on transmission period (less than 100 ms), application data fragmentation and reassemble processing large volume data, and relay transmission.

This guideline does not specify any supplementation or modification of ARIB STD-T109. Accordingly, it is necessary to conduct experiments while keeping in mind the possibility that the communications requirements will not be satisfied in some vehicle-to-vehicle communications use cases. Furthermore, it is necessary to keep in mind that it may be necessary to collaborate with related organizations from the perspective of impact on base stations and mobile stations in actual operation depending on the contents of the message set and so on. In cases where supplementation or modification of the communications format specified in ARIB STD-T109 is performed, it is necessary to obtain an experimental radio station license.

1.4 Materials

1.4.1 Compliance documents

・700 MHz Band Intelligent Transport Systems , ARIB STD-T109　Version 1.3

1.4.2 Reference documents

・ 700 MHz Band Intelligent Transport Systems - Extended Functions Guideline, ITS Forum RC-010

・ ITS Connect systems, Inter-Vehicle Communication Message Specifications, TD-001

Appendix 1: Expected Use Case Message Sizes (Provisional)

The message sizes (provisional) transmitted and received by applications in the use cases expected in this guideline are as set forth below. The message sizes do not include message headers and security overhead.

Table A1-1. Message Sizes (Provisional) in the Use Cases Expected in This Guideline

Information title	Use Case									
	Look-ahead information						Merging support			Lane change support
	Look-ahead information	Emergency hazard information from vehicles					Merging vehicle support		Support to vehicles in main lane	
	No.									
	1-1	1-2-1	1-2-2	1-2-3	1-2-4		2-1-1	2-1-2	2-2	3
	Category									
	I2V	V2V	V2I	I2V	I2V, V2V collaboration		I2V	V2V	I2V	V2V
					I2V	V2V				
	Total Message Size [byte]									
	TBD	39	405	405	175 (4175)	30 (1030)	772	Merging: 39 Receiving: 25	202	23
	Message Size for Each Information Type [bit]									
Management	TBD	40	40	40	40	40	40	40	40	40
Event	TBD	64	40×20[*1]	40×20[*1]	40×4[*2]	40	—	—	—	—
Location	TBD	116	116×20[*1]	116×20[*1]	116×4[*2]	116	—	—	—	—
Road restriction	TBD	2	2×20[*1]	2×20[*1]	8×4[*2]	8	—	—	—	—
Distribution specification	TBD	84	—	—	188×4[*2]	36	—	—	—	—
Roadside equipment	TBD	—	—	—	—	—	48	—	48	—
Acceleration lane starting point	TBD	—	—	—	—	—	—	Merging: 124 Receiving: 0	—	—
Vehicle	TBD	—	—	—	—	—	8+150×40[*3]	Merging: 142 Receiving: 158	8+150×10[*4]	142
Reply request range	TBD	—	—	—	—	—	—	—	—	—
Option (Simplified diagram etc.)	TBD	—	—	—	(8000×4[*2])	(8000)	—	—	—	—

*1. Maximum 20 hazards

*2. Maximum 4 hazards

*3. Maximum 40 vehicles

*4. Maximum 10 vehicles

Appendix 2: Expected Use Case Communications Requirements (Provisional)

The communications requirements (provisional) of the use cases expected in this guideline are as set forth below.

Table A2-1. Communications Requirements (Provisional) for Use Cases Expected in This Guideline

Use Case		Look-ahead information						Merging support			Lane change support
		Look-ahead information	Emergency hazard information from vehicles					Merging vehicle support		Support to vehicles in main lane	
No.		1-1	1-2-1	1-2-2	1-2-3	1-2-4		2-1-1	2-1-2	2-2	3
Communicatons format		I2V	V2V	V2I	I2V	I2V, V2V collaboration		I2V	V2V	I2V	V2V
						I2V	V2V				
Subject area (minimum range)		33.3m	Upstream: 750m＋255m Downstream: 0m	33.3m			(Range specified in R2V information)	33.3m	TBD	33.3m	TBD
Communications quality		PER<1E-2 (provisional)									
Required communicatinos range		Not specified	410m - 2m (re-consideration needed)	Not specified			100m-3.5m	Not specified	TBD	Not specified	252m (Front-to-back: 126m)
Communications requirements	Datasize*1	TBD	289byte	655byte		No simplified diagrams: 425 byte With simplified diagrams: 4425 byte	No simplified diagrams: 280 byte With simplified diagrams: 1280byte	1022byte	Merging side: 289byte Receiving side: 275byte	452byte	Merging side 271byte Receiving side 273byte
	Communications frequency (lane units)	TBD	1s (2s interval)	Not specified	1s		1s (2s interval)	1s	— (40km/h 1 sec inter-vehicle time gap s: 1.45s)	1s	TBD (vehicle unit: 100ms)
	No. of transmitting vehicles	TBD	4 vehicles (re-consideration needed)	Not specified (about 3 vehicles in 1 ms)	1 vehicle		1 or more veicles (subjecct area / communication range)	1 vehicle	TBD	1 vehicle	TBD
Transmission delay		Not specified	Upstream: 0- 255m 0.1s or less Downstream 255-1km 0.1s- 30s or less	Not specified							100ms
Communications counterparty		Unspecified vehicle (broadcast transmission)	Unspecified vehicle	Roadside base station	Unspecified vehicle (broadcast transmission)		Unspecified vehicle (opposing lane)	Unspecified vehicle (broadcast transmission)	Unspecified vehicle (Receiving lane)	Unspecified vehicle (broadcast transmission)	Unspecified vehicle (Vehicle in receiving lane)
Traveling speed		40-120 km/h					80-240 km/h (40-120 km/h opposing)	40-120 km/h	Receiving: 40-120 km/h Merging: 40 km/h	40-120 km/h	Receiving: 40-120 km/h Merging: 40km/h →Main lane speed

*1. Overhead: Including 250 bytes

Appendix 3: Relay Function Application Scenarios (Examples)

Among the expected use cases in this guideline, scenarios in which relay functions may be applied are described below.

As shown in the figure below, under the look-ahead information and Emergency hazard information from vehicles (vehicle-to-vehicle) use cases, transmission of emergency hazard information to vehicles that are up to 1 km ahead is expected to facilitate smooth avoidance control. However, under Appendix 4, of the communications technologies in this guideline, the ITS Forum RC-005 based wireless communication technology, LTE V2X (PC5) based wireless communication technology, and ARIB STD-T109 based wireless communication technology for vehicle-to-vehicle communications all would have difficulty ensuring a communications range of 1 km or more under the radio wave propagation environment where fading and shadowing blocked by large vehicles.

Accordingly, the application of a relay function on the application level is a possible countermeasure for satisfying the communications requirements for the look-ahead information and Emergency hazard information from vehicles (vehicle-to-vehicle) use cases. Following vehicles that receive hazard information from vehicles that performed avoidance control can relay the hazard information, making it possible to convey the information to following vehicles even further behind. Other possible countermeasures are addition of a relay function using multiple roadside units and use of LTE V2X (Uu), which is capable of wide area communications.

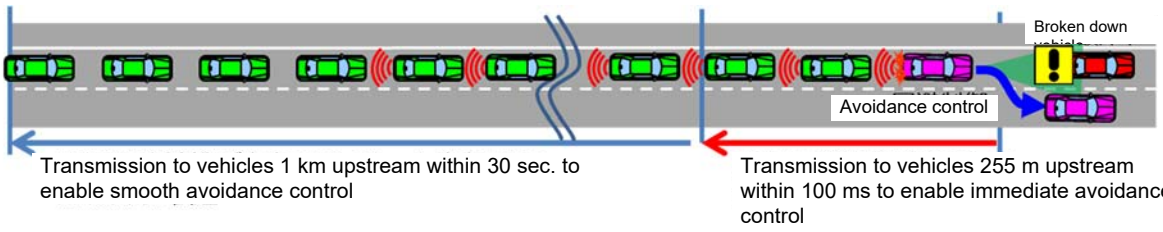


Figure A3-1. Relay Function Applciation Scenario (Example)

Appendix 4. Radio Link Design on Expected Use Case (Provisional)

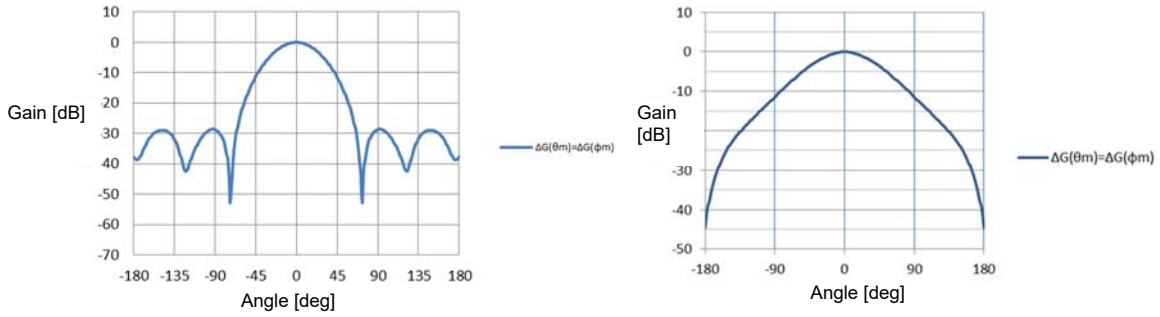
The radio link designs (provisional) for the expected use cases in this guideline are set forth below.

1.1 ITS Forum RC-005 based wireless communication technology, ARIB STD-T109 based wireless communication technology, and ARIB STD-T75 based wireless communication technology

The radio link designs (provisional) for the ITS Forum RC-005 based wireless communication technology, ARIB STD-T109 based wireless communication technology, and ARIB STD-T75 based wireless communication technology are indicated below.

Table A4-1. Evaluation Conditions

Item	Based wireless communication technology			Remarks
	ITS Forum RC-005	ARIB STD-T109	ARIB STD-T75	
Center frequency	5810MHz	760MHz	5810MHz	
Conducted power	10mW/MHz		Roadside unit: 50mW On-board unit: 10mW	
Occupied bandwidth	9MHz		4.4MHz	
Modulation	QPSK/OFDM		π PS shift QPSK	
Error correction	Convolutional code (coding rate: 1/2)		BCH code (63,51)	
Diversity	Used (maximum ratio synthesis)		None	
Noise power density	-173.9 dBm/Hz			T=25℃
Noise figure	10 dB		Roadside unit: 8 dB On-board unit: 13 dB	
Fixed attenuation	5 dB		3 dB	
Antenna absolute gain	Roadside unit: 10 dB On-board unit: 0 dB (omni)	Roadside unit: 0 dB On-board unit: 0 dB (omni)	Roadside unit: 10 dB On-board unit: 2 dB	Refer to the figure below for the antenna pattern of roadside units and ARIB STD-T75 reference method On-board units
Antenna polarization	Vertical		Round	
Glass penetration loss	—		3 dB	Loss from the windshield
Path loss model	ITU-R P.1411 model (central value)			
Instantaneous fading model	Refer to the figure below for the delay profile model		AWGN environment expected	
Shadowing model	8.6 dB (99% value)	10.4 dB (99% value)	8.6 dB (99% value)	Logarithmic normal distribution with standard deviation of 3.68 dB/4.46 dB
Shielding loss from large vehicles	10 dB	4 dB	10 dB	
Antenna height	Roadside unit: 6m On-board unit: 1.5m		Roadside unit: 6m On-board unit: 1.0m (onboard)	
Number of transmissions	1 (no repetition) to 5 times			



a) Roadside Unit b) On-board unit

Figure A4-1. Antenna Patterns

Table A4-2. Delay Profile Model

a) ITS Forum RC-005 based Wireless Communication Technology

Delay [us]	Relative power [dB]	Rician factor [dB]
0	0	9.85
0.1	-7.61	6.05
0.2	-12.78	4.97
0.3	-17.48	4.56
0.4	-19.33	4.24
0.5	-21.65	4.07
0.6	-21.71	4.06
0.7	-24.88	4.39
0.8	-28.48	4.03
0.9	-29.44	4.36
1	-30.49	6.39
1.1	-32.90	6.63
1.4	-32.92	7.27
1.7	-33.70	6.51

b) ARIB STD-T109 based Wireless Communication Technology

Delay [us]	Relative power [dB]	Rician factor [dB]
0	0	13.4
0.1	-1.7	
0.2	-3.4	
0.3	-5.1	
0.4	-6.9	
0.5	-8.6	
0.6	-10.3	
0.7	-12.0	
0.8	-13.7	6.8
0.9	-15.4	
1.0	-17.1	
1.1	-18.9	
1.2	-20.6	
1.3	-22.3	
1.4	-24.0	
1.5	-25.7	
1.8	-19.4	13.1
1.9	-21.3	
2.0	-23.2	
2.1	-25.1	
2.2	-27.0	
2.3	-28.9	
2.4	-30.8	
2.5	-32.7	
2.6	-34.5	7.7
2.7	-36.4	
2.8	-38.3	
2.9	-40.2	
3.0	-42.1	
3.1	-44.0	
3.2	-45.9	
3.3	-47.8	

<Infrastructure-to-Vehicle Communications Use Cases>

The radio link design results for use cases which used the infrastructure-to-vehicle communications are indicated. The radio link margins and maximum communications ranges are showed at the communication condition (PER < 0.01 in the required communications range) without repetition (number of repetition = 1) and with repetition (the minimum number of repetitions when the radio link margin > 0 dB).

The table also indicates that under the ITS Forum RC-005 based wireless communication technology, without repetition, the radio link margin will be insufficient in the look-ahead information/emergency hazard (V2I), look-ahead information/emergency hazard (I2V), and look-ahead information/emergency hazard/with simplified diagrams (I2V) use cases under the radio propagation environment specified in the assessment conditions. Applying three repetitions are needed to have the radio link margin. Similarly, under the ARIB STD-T75 based wireless communication technology, the radio link margin will be insufficient without repetition in the look-ahead information/emergency hazard (V2I) and look-ahead information/emergency hazard/with simplified diagrams (I2V) use cases. Applying five and two repetitions are needed to have the radio link margin, respectively. In order to use repetition function, it is necessary to apply ITS Forum RC-014 to the upper layer with the ITS Forum RC-005 based wireless communication technology and to apply ARIB STD-T88 with the ARIB STD-T75 based wireless communication technology respectively.

Table A4-3. Radio Link Design Results: Infrastructure-to-Vehicle Communications Use Cases

Use Case		**No.**	**Category**	**Value**	**Based wireless communication technology**							**Req.**
					ITS Forum RC-005				ARIB STD-T109	ARIB STD-T75		Required Transmission Range [m]
					Overhead Size [byte]							
					250		V2I: 27、I2V: 56			(Simple encryption scramble)		
Look-ahead information	Emergency hazard	1-2-2	V2I	Number of repetitions [times]	1	3	1	2	1	1	5	33.3
				Radio link margin [dB]	-※1	0.9	-※1	1.8	19.4	-1.6	0.2	
				Max. comm. range [m]	-※1	38	-※1	42	170	30	35	
		1-2-3	I2V	Number of repetitions [times]	1	2	1		1	1		
				Radio link margin [dB]	-※1	9.8	5.7		24.5	0.4		
				Max. comm. range [m]	-※1	103	65		226	36		
	w/o simplified diagrams	1-2-4	I2V	Number of repetitions [times]	1		1		1	1		
				Radio link margin [dB]	7.5		11.4		24.8	0.8		
				Max. comm. range [m]	80		123		230	37		

		w/ simplified diagrams			Number of repetitions [times]	1	2	1	2	1	1	2	
					Radio link margin [dB]	-※1	4.3	-※1	4.9	22.9	-0.2	1.0	
					Max. comm. range [m]	-※1	56	-※1	59	207	33	38	
Merge support	Merging vehicle support		2-1-1	I2V	Number of repetitions [times]	1	2	1	2	1	1		
					Radio link margin [dB]	-※1	8.6	-※1	8.9	24.3	0.3		
					Max. comm. range [m]	-※1	90	-※1	83	224	36		
	Support to vehicles in main lane		2-2	I2V	Number of repetitions [times]	1		1		1	1		
					Radio link margin [dB]	6.6		11.2		24.7	0.6		
					Max. comm. range [m]	72		120		229	37		
*1. An error floor at least equal to the target PER occurs.													

<Vehicle-to-Vehicle Communications Use Case>

The radio link design results for use cases which used the vehicle-to-vehicle communications are indicated. The radio link margins and maximum communications ranges are without repetition and with five repetitions.

The table indicates that under the ITS Forum RC-005 based wireless communication technology without repetition, the radio link margin will be insufficient in all use cases under the radio propagation environment specified in the assessment conditions. Even when five repetitions are applied, the radio link margin is insufficient in all use cases other than the look-ahead information/emergency hazard/without simplified diagrams use case (27-byte overhead size), and further countermeasures such as performance enhancement of equipment (improvement of noise figure or implementation loss) are needed. Under the ARIB STD-T109 based wireless communication technology without repetition, the radio link margin is insufficient in the look-ahead information/emergency hazard/distribution to following vehicles and merge support/merging vehicle support use cases. Even when five repetitions are applied, the radio link margin is insufficient, and countermeasures, e.g., consideration performance enhancement of equipment (improvement of noise figure or implementation loss), are needed.

Table A4-4. Circuit Design Results: Inter-Vehicle Communications Use Cases

Use Case		**No.**	**Category**	**Value**	**Based wireless communication technology**						**Req.**
					ITS Forum RC-005				ARIB STD-T109		Required Transmission Range [m]
					Overhead Size [byte]						
					250		27				
Look-ahead information	Emergency hazard	1-2-1	V2V	Number of repetitions [times]	1	5	1	5	1	5	255
				Radio link margin [dB]	-15.3	-11.0	-13.3	-10.0	-8.6	-6.1	
				Max. comm. range [m]	56	92	70	103	155	179	
	w/o simplified diagrams	1-2-4		Number of repetitions [times]	1	5	1	5	1		100
				Radio link margin [dB]	-※1	-2.1	-3.2	0.2	7.8		
				Max. comm. range [m]	-※1	78	69	101	156		
	w/ simplified diagrams			Number of repetitions [times]	1	5	1	5	1		
				Radio link margin [dB]	-※1	-4.1	-※1	-2.1	5.6		
				Max. comm. range [m]	-※1	62	-※1	78	138		
Merge support	Merging vehicle support	2-1-2		Number of repetitions [times]	1	5	1	5	1	5	212
				Radio link margin [dB]	-12.1	-7.8	-10.1	-6.8	-5.4	-2.9	
				Max. comm. range [m]	56	92	70	103	155	179	
Lane change support		3		Number of repetitions [times]	1	5	1	5	1		126

			Radio link margin [dB]	-6.7	-2.6	-5.0	-1.6	3.7		
			Max. comm. range [m]	58	93	70	104	155		
*1. An error floor at least equal to the target PER occurs.										

1.2 LTE V2X (PC5) based Wireless Communication Technology

The radio link designs (provisional) for the LTE V2X (PC5) based wireless communication technology are indicated below.

The radio link design results indicate that in the case of HARQ 2 repetitions, the communications range that can be achieved with a 1% packet error rate under the assessment conditions is 1 km (AWGN) or 743 m (fading (UMi)).

In cases where HARQ 2 repetitions and fading are present, the radio link margin is 18.8 dB for the required communications area of 255 m under the look-ahead information/emergency hazard information distribution by vehicles (inter-vehicle communications) use cases.

Table A4-5. Assessment Conditions: LTE V2X (PC5) based Wireless Communication Technology

Parameter	Value
Frequency	6 GHz
System bandwidth	10 MHz
Path loss model	ITU-R P.1411
Instantaneous fading model	Urban Micro (UMi) NLOS, relative speed 60 km/h
Antenna height	1.5 m
Antenna gain	0 dB (including cable loss and connector loss)
Antenna structure	1 Tx, 2 Rx、omni antenna
Packet size	320 Byte
Total transmission power (transmission power taking into consideration radio linearity)	23 – 1.5 dBm (QPSK) 23 – 2.0 dBm (16QAM) * Transmission power taking into consideration radio linearity are provisional values
Modulation method and coding rate	QPSK R = 0.58 16QAM R = 0.47
Number of HARQ transmission (number of repetitions)	1, 2 times

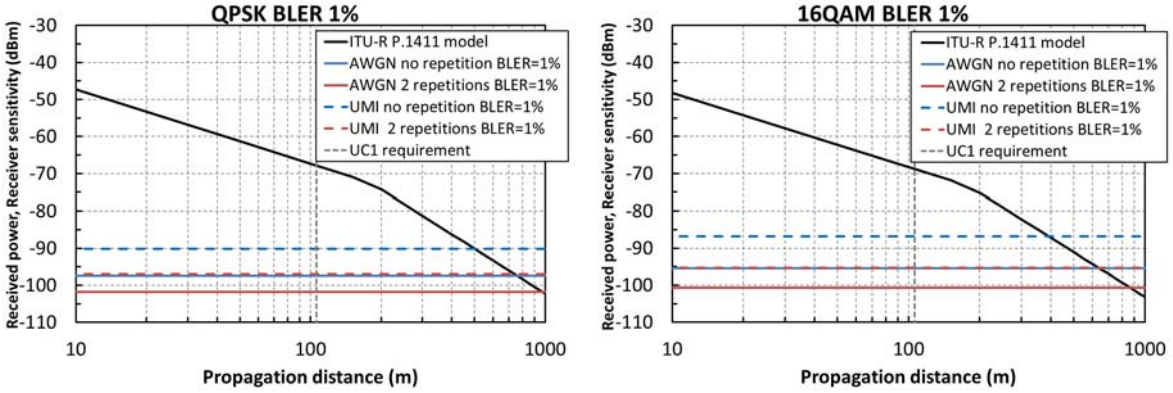


Figure A4-2. Radio Link Design Results: LTE V2X (PC5) based Wireless Communication Technology

Appendix 5: Packet Sizes of Individual Communications Technologies

1.1 ITS Forum RC-005 based Wireless Communication Technology

ITS Forum RC-005 based wireless communication technology packet sizes are indicated as maximum values.

Application data fragmentaion of data is performed in use case 1-2-4 (iinfrastructure-to-vehicle with simplified diagram information) as specified in Appendix 2.

Table A5-1. Packlet Size: ITS Forum RC-005 based Wireless Communication Technology

	MAC Layer (L2)	ITS-LPP Layer
Packet size	Maximum packet size: 2304 bytes	ITS-LPP layer maximum data size: 1386 bytes
Application data fragmentation function		Used
Compatible specifications	ITS Forum RC-005	ITS Forum RC-014

1.2 LTE V2X (PC5) based Wireless Communication Technology

LTE V2X (PC5) based wireless communication technology packet sizes are indicated as layer 1 and layer 2 maximum values.

Both layer 1 and layer 2 satisfies the data sizes specified in Appendix 2.

Table A5-2. Packet Size: LTE V2X (PC5) based Wireless Communication Technology

	Physcial Layer (L1)	**MAC/RLC/PDCP Layer (L2)**
Packet size	Maximum transport block size 9422 bytes (16QAM) * Under the Rel-14 LTE specifications, up to 16QAM is supported. In the case of one transmission, the coding rate may exceed one.	PDCP layer maximum packet size **8188 bytes** Data volume that can be transmitted/received in 1 ms Max. 3963 bytes * SL-C Category 2 terminal values * The actual data size may vary depending on the transmission bandwidth, modulation method, and so on
Application data fragmentation function		Used
Compatible specifications	3GPP TS 36.212, TS 36.213	3GPP TS 36.321, TS 36.322 TS 36.323, TS 36.306

1.3 LTE V2X (Uu) based Wireless Communication Technology

LTE V2X (Uu) based wireless communication technology packet sizes are indicated as layer 1 and layer 2 maximum values.

Both layer 1 and layer 2 satisfies the data sizes specified in Appendix 2.

Table A5-3. Packet Size: LTE V2X (Uu) based Wireless Communication Technology

	Physical Layer (L1)	**MAC/RLC/PDCP Layer (L2)**
Packet size	Maximum Transport block size DL: • 13191 bytes (256QAM) • 9422 bytes (64QAM) UL: • 9422 bytes (64QAM)	PDCP layer maximum packet size **8188 bytes** Data volume that can be transmitted/received in 1 ms DL unicast: 37444/75376 bytes DL multicast: 9422/12237 bytes UL: 9422/12756 bytes * Values are for Category 5/12 terminal types * The actual data size may vary depending on the transmission bandwidth, modulation method, and so on
Application data fragmentation function		Used
Compatible specifications	3GPP TS 36.212, TS 36.213	3GPP TS 36.321, TS 36.322, TS 36.323, TS 36.306

1.4 ARIB STD-T75 based Wireless Communication Technology

ARIB STD-T75 based wireless communication technology packet sizes are indicated as maximum values.

Application data fragmentation is performed in use cases 1-2-3, 1-2-4 (infrastructure-to-vehicle with simplified diagram information), 2-11 and 2-2 as specified in Appendix 2, except for security overhead (use of simple encryption scramble specified in ARIB STD-T75 is expected).

Table A5-4. Packet Size: ARIB STD-T75 based Wireless Communication Technology

	Data Link Layer (L2)
Packet size	Mazimum LSDU size 192bytes
Application data fragmentation function	Used
Compatible specifications	ARIB STD-T75

1.5 ARIB STD-T109 based Wireless Communication Technology

An overview of the ARIB STD-T109 based wireless communication technology packet sizes is provided.

For infrastructure-to-vehicle communications and vehicle-to-vehicle communications, the total transmission time is limited in the table below.

In the case of infrastructure-to-vehicle communications, application data is fragmented to packets in EL according to the message data length. The total data that can be transmitted by one base station within an arbitrary 100 ms is determined depending on the bit rate and fragmentation data size. Even the bitrate is set to 12 Mbps (the lower limit of bit rate at the base station), all the data sizes specified in Appendix 2 can be transmitted within the limited total transmission time.

In the case of vehicle-to-vehicle communications (include vehicle-to-infrastructure commnications), the maximum value of message data size is 100 bytes. With regard to data not defined in TD-001, those are stored in the free application data field. When using data exceeding the size of the free application data field, appliation data fragmentation in the application may be considerd. Since the packet transmission period is 100 ms due to the total transmission time limit, the maximum number of application data fragmentation is the delay or information update period [ms] required by the use case divided by 100.

Table A5-5. Packet Size: ARIB STD-T109 based Wireless Communication Technology

a) Infrastructure-to-Vehicle Communications

	Physical layer (L1)	Extended layer (EL)
Transmission time control	The total transmission time from one transmitter equipment(base station or roadside unit) in arbitrary 100 ms shall be 10.5 ms or less	
Application data fragmentation function		Fragmentation function present
Packet size (Application data size)		Maximum data size after fragmentation in EL (including security and other overhead): 1500 bytes
Compliance specifications	ARIB STD-T109	ITS Forum RC-010

b) Vehicle-to-Vehicle and Vehicle-to-Infrastructure Communications

	Physical layer (L1)	Application
Transmission time control	The total transmission time (from one onboard unit) in arbitrary 100 ms shall be 0.66 ms or less, and the transmission burst length shall to be 0.33 ms or less	

Packet division function		Performed by the application (free field in inter-vehicle communications message)
Packet size (Application data size)		Maximum 100 bytes of which, the maximum value of free application data field is 60 bytes (excluding free application header)
Compliance specifications	ARIB STD-T109	ITS Connect Promotion Consortium TD-001