



**Recommendation ITU-R M.2084-1**  
**(11/2019)**

**Radio interface standards of vehicle-to-vehicle and vehicle-to-infrastructure two-way communications for Intelligent Transport System applications**

**M Series**  
**Mobile, radiodetermination, amateur and related satellite services**



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(Also available online at <http://www.itu.int/publ/R-REC/en>)

| Series     | Title                                                                                |
|------------|--------------------------------------------------------------------------------------|
| <b>BO</b>  | Satellite delivery                                                                   |
| <b>BR</b>  | Recording for production, archival and play-out; film for television                 |
| <b>BS</b>  | Broadcasting service (sound)                                                         |
| <b>BT</b>  | Broadcasting service (television)                                                    |
| <b>F</b>   | Fixed service                                                                        |
| <b>M</b>   | <b>Mobile, radiodetermination, amateur and related satellite services</b>            |
| <b>P</b>   | Radiowave propagation                                                                |
| <b>RA</b>  | Radio astronomy                                                                      |
| <b>RS</b>  | Remote sensing systems                                                               |
| <b>S</b>   | Fixed-satellite service                                                              |
| <b>SA</b>  | Space applications and meteorology                                                   |
| <b>SF</b>  | Frequency sharing and coordination between fixed-satellite and fixed service systems |
| <b>SM</b>  | Spectrum management                                                                  |
| <b>SNG</b> | Satellite news gathering                                                             |
| <b>TF</b>  | Time signals and frequency standards emissions                                       |
| <b>V</b>   | Vocabulary and related subjects                                                      |

**Note:** This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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## RECOMMENDATION ITU-R M.2084-1

**Radio interface standards of vehicle-to-vehicle and vehicle-to-infrastructure two-way communications for Intelligent Transport System applications**

(Question ITU-R 205-5/5)

(2015-2019)

**Scope**

This Recommendation identifies specific radio interface standards of vehicle-to-vehicle and vehicle-to-infrastructure<sup>1</sup> communications for Intelligent Transport System applications. The technical characteristics described in this Recommendation are based on current Intelligent Transport Systems (ITS) applications in the mobile service.

**Keywords**

ITS, vehicle-to-vehicle communications, vehicle-to-infrastructure communications

**Acronyms and abbreviations**

|         |                                                                           |
|---------|---------------------------------------------------------------------------|
| 3GPP    | 3 <sup>rd</sup> Generation Partnership Project                            |
| ARIB    | Association of Radio Industries and Businesses                            |
| ATIS    | Alliance for Telecommunications Industry Solutions                        |
| ATS     | Abstract test suite                                                       |
| BPSK    | Binary phase shift keying                                                 |
| CCSA    | China Communications Standards Association                                |
| CEN     | European Committee for Standardization (Comité européen de normalisation) |
| CSMA/CA | Carrier sense multiple access/collision avoidance                         |
| DCC     | Decentralized congestion control                                          |
| DSRC    | Dedicated short range communications                                      |
| EFC     | Electronic Fee Collection                                                 |
| eNB     | E-UTRAN NodeB                                                             |
| ETSI    | European Telecommunications Standards Institute                           |
| FDD     | Frequency Division Duplex                                                 |
| FDM     | Frequency Division Multiplexing                                           |
| FEC     | Forward error correction                                                  |
| GNSS    | Global Navigation Satellite System                                        |
| HARQ    | Hybrid automatic repeat request                                           |
| IEEE    | Institute of Electrical and Electronics Engineers                         |
| IMDA    | Infocomm Media Development Authority of Singapore                         |

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<sup>1</sup> Vehicle-to-infrastructure communications includes two-way communications between vehicle and infrastructure.

|          |                                                       |
|----------|-------------------------------------------------------|
| ITS      | Intelligent transport systems                         |
| LTE      | Long term evolution                                   |
| OFDM     | Orthogonal frequency-division multiplexing            |
| OFDMA    | Orthogonal frequency division multiple access         |
| PICS     | Protocol implementation conformance statement         |
| PIXIT    | Protocol Implementation eXtra Information for Testing |
| QAM      | Quadrature amplitude modulation                       |
| QPSK     | Quadrature phase shift keying                         |
| SC-FDM   | Single carrier-frequency division multiplexing        |
| SC-FDMA  | Single-carrier frequency division multiple access     |
| TDD      | Time division duplex                                  |
| TDM      | Time division multiplexing                            |
| TSS & TP | Test suite structure and test purposes                |
| TTA      | Telecommunications Technology Association             |
| UE       | User equipment                                        |
| V2I      | Vehicle-to-infrastructure                             |
| V2N      | Vehicle-to-network                                    |
| V2P      | Vehicle-to-pedestrian                                 |
| V2V      | Vehicle-to-vehicle                                    |
| WAVE     | Wireless access in vehicular environments             |

### Related ITU Recommendations

|                                                          |                                                                    |
|----------------------------------------------------------|--------------------------------------------------------------------|
| Recommendation ITU-R M.1453<br>communications at 5.8 GHz | Intelligent Transport Systems – dedicated short-range              |
| Recommendation ITU-R M.1890                              | Intelligent Transport Systems – Guidelines and Objectives          |
| Recommendation ITU-R M.2121<br>in the mobile service     | Harmonization of frequency bands for Intelligent Transport Systems |

The ITU Radiocommunication Assembly,

*considering*

- a) that standards development organizations (SDOs) are developing specific standards for vehicle-to-vehicle and vehicle-to-infrastructure communications in Intelligent Transport Systems (ITS);
- b) that using the ITU-R Recommendation identifying these standards, manufacturers and operators should be able to determine the most suitable standards for their needs,

*recommends*

that the radio interface standards and technical specifications in Annexes 1 to 8 should be used for vehicle-to-vehicle and vehicle-to-infrastructure communications.

Table 1 provides a summary of the standards and technical specifications found in the respective Annexes.

TABLE 1  
Standards and technical specifications

|                                                         | Annex 1 | Annex 2 | Annex 3 | Annex 4 | Annex 5 | Annex 6 | Annex 7 | Annex 8 |
|---------------------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Standardization/<br>technical<br>specifications<br>body | ETSI    | IEEE    | ARIB    | TTA     | IMDA    | CCSA    | 3GPP    | ATIS    |

NOTE – The technical characteristics of these standards and technical specifications are summarized in Annex 9.

## Annex 1

### ETSI standards

ETSI standards developed for the access and media layer are based on features such as:

- 5.9 GHz spectrum usage and spectrum access;
- multichannel operation;
- decentralized congestion control (DCC) and security;
- coexistence of ITS and EFC (using CEN DSRC) applications in the 5.8 GHz and 5.9 GHz bands; and
- ITS testing standards.

The technical characteristics of vehicle-to-vehicle and vehicle-to-infrastructure communications for ETSI ITS-G5 are shown in Table 2.

TABLE 2  
Characteristics of the transmission scheme

| Item                            | Transmission characteristic                  |
|---------------------------------|----------------------------------------------|
| Operating frequency range (MHz) | 5 855-5 925                                  |
| RF channel bandwidth (MHz)      | 10                                           |
| RF Transmit Power/e.i.r.p.      | Typical limit of up to 33 dBm e.i.r.p.       |
| Modulation scheme               | BPSK OFDM, QPSK OFDM, 16QAM OFDM, 64QAM OFDM |
| Forward error correction        | Convolutional coding, rate = 1/2, 2/3, 3/4   |
| Data transmission rate (Mbit/s) | 3, 4.5 , 6 , 9 , 12 , 18 , 24 , 27           |
| Media access control            | CSMA/CA                                      |
| Duplex method                   | TDD                                          |

TABLE 3

**Base standards for the access and media layer**

| Standard title                                                                                                                                                                                                                                   | Standard number |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Intelligent Transport Systems (ITS);<br>Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band;<br>Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU                  | ETSI EN 302 571 |
| Intelligent Transport Systems (ITS);<br>Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band                                                                                                       | ETSI EN 302 663 |
| Intelligent Transport Systems (ITS);<br>Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range;<br>Access layer part                                                                         | ETSI TS 102 687 |
| Intelligent Transport Systems (ITS);<br>Mitigation techniques to avoid interference between European CEN Dedicated Short-Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range | ETSI TS 102 792 |
| Intelligent Transport Systems (ITS);<br>Harmonized Channel Specifications for Intelligent Transport Systems (ITS) operating in the 5 GHz frequency band                                                                                          | ETSI TS 102 724 |
| Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium                                                                                                                           | ETSI TS 103 175 |

TABLE 4

**Testing standards for the access and media layer**

| Testing Standard title                                                                                                                                                                                                                                   | Standard number   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Intelligent Transport Systems (ITS);<br>Test specifications for the channel congestion control algorithms operating in the 5.9 GHz range;<br>Part 1: Protocol Implementation Conformance Statement (PICS)                                                | ETSI TS 102 917-1 |
| Intelligent Transport Systems (ITS);<br>Test specifications for the channel congestion control algorithms operating in the 5.9 GHz range;<br>Part 2: Test Suite Structure and Test Purposes (TSS & TP)                                                   | ETSI TS 102 917-2 |
| Intelligent Transport Systems (ITS);<br>Test specifications for the channel congestion control algorithms operating in the 5.9 GHz range;<br>Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) | ETSI TS 102 917-3 |
| Intelligent Transport Systems (ITS);<br>Test specifications for the methods to ensure coexistence of Cooperative ITS G5 with RTTT DSRC;<br>Part 1: Protocol Implementation Conformance Statement (PICS)                                                  | ETSI TS 102 916-1 |

TABLE 4 (*end*)

| Testing Standard title                                                                                                                                                                                                                                 | Standard number   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Intelligent Transport Systems (ITS);<br>Test specifications for the methods to ensure coexistence of Cooperative ITS G5 with RTTT DSRC;<br>Part 2: Test Suite Structure and Test Purposes (TSS&TP)                                                     | ETSI TS 102 916-2 |
| Intelligent Transport Systems (ITS);<br>Test specifications for the methods to ensure coexistence of Cooperative ITS G5 with RTTT DSRC;<br>Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) | ETSI TS 102 916-3 |

Radio interface technologies supporting Vehicle-to-Everything (V2X) communications for ITS applications have been developed as part of 3GPP technical specifications. As a founding partner of 3GPP, ETSI automatically transposes technical specifications and technical reports developed in 3GPP to ETSI deliverables. ETSI technical specifications that are transposed from 3GPP technical specifications supporting V2V and V2I communication are described in Annex 7.

TABLE 5

**Base standards for security**

| Standard title                                                                                                  | Standard number |
|-----------------------------------------------------------------------------------------------------------------|-----------------|
| Intelligent Transport Systems (ITS); Security; Security header and certificate formats                          | ETSI TS 103 097 |
| Intelligent Transport Systems (ITS); Security; ITS communications security architecture and security management | ETSI TS 102 940 |
| Intelligent Transport Systems (ITS); Security; Trust and Privacy Management                                     | ETSI TS 102 941 |

The deployment of any radio interface technology based on standards listed in Tables 3, 4 and 12 has to follow the regional and national regulations.

**Annex 2****IEEE standards**

IEEE Standards developed for the access and media layer are based on features such as:

- 5.9 GHz spectrum usage;
- multichannel operation;
- coexistence of ITS and other existing services in the 5 850-5 925 MHz band.

The requirement for use of multi-channel wireless communications is based on IEEE Std 802.11p™-2010 – IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY)

Specifications Amendment 6: Wireless Access in Vehicular Environments, originally developed as an amendment to IEEE 802.11™-2007 that has been incorporated into the revision of IEEE 802.11™-2016 – IEEE Standard for Information technology – Telecommunications and information exchange between systems Local and metropolitan area networks – Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications. The upper layer protocols and services requirements are described in the IEEE 1609 family of standards that use IEEE Std 802.11. Standardization of the upper layer protocols and services support the vehicle-to-vehicle and vehicle-to-roadside communication requirements of the National ITS Architecture and the Joint Program Office initiatives. Benefits for the ITS program in enabling wireless communications is for vehicle operators, dispatch centres, traffic management centres, emergency response centres, route guidance, safety and amber alerts, and response to traveller emergencies, traceable to the National ITS Architecture.

The published IEEE Std 802.11-2016 is available for free download at the IEEE Get program: <http://standards.ieee.org/about/get/802/802.11.html>

A list of the IEEE 1609 family of standards is as follows:

IEEE 1609.0™-2013 – IEEE Guide for Wireless Access in Vehicular Environments (WAVE) – Architecture

IEEE 1609.2™-2016 – IEEE Standard for Wireless Access in Vehicular Environments – Security Services for Applications and Management Messages

IEEE 1609.3™-2016 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Networking Services

IEEE 1609.4™-2016 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Multi-channel Operation

IEEE 1609.11™-2010 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Over-the-Air Electronic Payment Data Exchange Protocol for Intelligent Transportation Systems (ITS)

IEEE 1609.12™-2016 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Identifier Allocations

## Annex 3

### ARIB standard

In Japan, for the use of the safe driving support systems, a part of the 700 MHz band (755.5-764.5 MHz) has been assigned in a new spectrum allocation on a primary basis in the digital dividend band. The technical characteristics of vehicle-to-vehicle and vehicle-to-infrastructure communications for safe driving support systems are shown in Table 6.