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For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

DRAFT INTERNATIONAL STANDARD

ISO/DIS 15638-23

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Intelligent transport systems — Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV) —

Part 23: Tyre pressure monitoring (TPM)

Systèmes intelligents de transport — Cadre pour applications télématiques collaboratives pour véhicules de fret commercial réglementé (TARV) —

Partie 23: Suivi de la pression des pneus

ICS: 03.220.20; 35.240.60

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15638-23 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*, Working Group 7, Freight and Fleet.

ISO 15638 consists of the following parts, under the general title *Intelligent transport systems — Framework for cooperative Telematics Applications for Regulated Vehicles (TARV)*:

- 15638 -1 TARV – Framework and architecture
- 15638 -2 TARV – Common platform parameters using CALM
- 15638 -3 Operating requirements, 'Approval Authority' approval procedures, and enforcement provisions for the providers of regulated services
- 15638 -4 TARV – System security requirements
- 15638 -5 TARV – Generic vehicle information
- 15638 -6 TARV – Regulated applications
- 15638 -7 TARV – Other applications
- 15638 -8 Vehicle access management and monitoring
- 15638 -9 Remote digital tachograph monitoring
- 15638 -10 Emergency messaging system/eCall
- 15638 -11 Driver work records
- 15638 -12 Vehicle mass monitoring
- 15638 -13 Mass information for control and enforcement
- 15638 -14 Vehicle access control
- 15638 -15 Vehicle location monitoring
- 15638 -16 Vehicle speed monitoring
- 15638 -17 Consignment and location monitoring
- 15638 -18 ADR (Dangerous Goods) monitoring

- 15638 -19 *Vehicle parking facilities*
- 15638 -20 *Tyre pressure monitoring*
- 15638 -21 *Monitoring of regulated vehicles using roadside sensors and data collected from the vehicle for enforcement and other purposes*
- 15638 -22 *Freight container road transport monitoring*
- 15638 -23 *Tyre pressure monitoring (this deliverable)*

Introduction

Many ITS technologies have been embraced by commercial transport operators and freight owners, in the areas of fleet management, safety and security. Telematics applications have also been developed for governmental use. Such regulatory services in use or being considered vary from jurisdiction to jurisdiction, but include electronic on-board recorders, digital tachograph on-board mass monitoring, 'mass' data for regulatory control and management, tyre pressure monitoring, vehicle access methods, hazardous goods tracking and eCall. Additional applications with a regulatory impact being developed include fatigue management, speed monitoring and vehicle penalties imposed based on location, distance and time.

The TARV suite of standards addresses and defines the framework for a range of cooperative telematics applications for regulated vehicles (such as access methods, driver fatigue management, speed monitoring, on-board mass monitoring, Remote Tachograph Monitoring, ADR management etc.). The overall scope includes the concept of operation, legal and regulatory issues, and the generic cooperative provision of services to regulated vehicles, using an on-board ITS platform. The framework is based on a (multiple) service-provider oriented approach with provisions for the approval and auditing of service providers.

This suite of standards documents both provides the means to achieve current requirements for telematics applications for regulated vehicles and provides basis for future development of cooperative telematics applications for regulated vehicle.

The TARV family of Standards has been developed over a decade with the objective of enabling telematics applications with whatever wireless communications are available at the time and location, and providing a migration path to the cooperative ITS technologies and techniques that are steadily emerging.

Many new freight tractors/trucks use "Tyre Pressure Monitoring Systems" to advise the operator whether or not tyres on the vehicle are properly inflated (or are, indeed, missing entirely). However older freight tractors/trucks and most trailers do not use this technology. As a result, many freight vehicles operate with underinflated or missing tyres. These vehicles are potentially unsafe as their braking performance is degraded, their stability is compromised, their fuel efficiency is reduced thus increasing greenhouse gas emissions and they are non-compliant with roadway and bridge weight limitations thus reducing pavement and bridge life resulting in increased roadway infrastructure costs. This standards deliverable is designed to improve freight vehicle road transport safety and timely freight delivery while reducing accidents.

This specification addresses the realization of safer road transport of freight vehicles utilizing the existing ISO 15638 standard basic architecture framework, together with ISO 21750:2006, *Road vehicles — Safety enhancement in conjunction with tyre inflation pressure monitoring*, and UNECE Regulation 141 "Tyre Pressure Monitoring Systems (TPMS): Uniform provisions concerning the approval of vehicles with regard to their Tyre Pressure Monitoring Systems (TPMS)".

A vehicle on-board sensor identifies whether a tyre is underinflated or missing and provides this data to an in-vehicle system (IVS). Either at predetermined intervals, on registering an anomaly, or on request from the service provider, the IVS sends the most recent TPMS data to a predetermined address provided by the service provider.

The service provider advises vehicle operators or commercial vehicle enforcement agencies in order for corrective action to be taken to correct the tyre deficiency.

This part of the ISO 15638 family of standards documents provides specifications for tyre pressure monitoring and supports several defined communication profiles by which this function may be performed.

Consistent with other parts of the ISO 15638 series of standards, this International Standard does not prescribe nor proscribe particular modes of operation, but provides a number of defined communication and data profiles within which jurisdictions and operators may achieve their objectives for tyre

pressure monitoring within the objectives and constraints of their regulations. This International Standard recognises that those requirements and constraints will differ between jurisdictions.

NOTE 1 The definition of what comprises a 'regulated' vehicle is regarded as an issue for National decision, and may vary from jurisdiction to jurisdiction. This suite of standards documents does not impose any requirements on nations in respect of how they define a regulated vehicle.

NOTE 2 The definition of what comprises a 'regulated' service is regarded as an issue for National decision, and may vary from jurisdiction to jurisdiction. This suite of standards documents does not impose any requirements on nations in respect of which services for regulated vehicles jurisdictions will require, or support as an option, but will provide standardised sets of requirements descriptions for identified services to enable consistent and cost efficient implementations where implemented.

Intelligent transport systems — Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV) —

Part 23: Tyre pressure monitoring (TPM)

1 Scope

This part of ISO 15638 addresses the provision of tyre pressure monitoring and specifies the form and content of the transmission of such data required to support such systems, and access methods to that data.

The scope of this part of ISO 15638 is to provide specifications for common communications and data exchange aspects of the application service “tyre pressure monitoring” (TPM) that a jurisdiction regulator, or operator, may elect to require or support as an option, including:

- a) High level definition of the service that a service provider has to provide, (The service definition describes common service elements; but does not define the detail of how such an application service is instantiated, nor the acceptable value ranges of the data concepts defined)
- b) Means to realise the service
- c) Application data naming, content and quality that an IVS has to deliver, including a number of TPM profiles or data (noting that requirements and constraints of what can/cannot be transmitted over the air may vary between jurisdictions)
- d) Support for a number of defined communication profiles to enable remote inspection.

The present version of this International Standard provides specifications for the following application profiles:

Application Profile A1 : The cyclical initiation of TPM message by on-board equipment (TPM-C)

Application Profile A2 : The exceptional initiation of TPM message by on-board equipment (TPM-E)

Application Profile A3: The provision of TPM data as the result of an offboard request (TPM-R)

Application Profile A4: The provision of TPM data as the result of an offboard reading of tyre pressures of vehicles which may be unequipped (TPM-O)

The present version of this International Standard provides specifications for the following communication profiles:

Communication Profile C1: Remote inspection addressed via an ITS-station instigating a download of data to an application service provider via a wireless communications interface (as defined in ISO 15638-2).

Communication Profile C2: Remote inspection addressed via a packet switched cellular network (3G LTE, 4G LTE, 5G SRE) instigating a download of data to an application service provider via a wireless communications interface.

Communication Profile C3: Roadside inspection using an (EN, ARIB, TTAK compliant) short range wireless communication interrogator to an application service provider via a wireless communications interface (as defined in ISO 15638-2).

Profile C3a: via a hand aimed or temporary roadside mounted and aimed interrogator

Profile C3b: via a vehicle mounted and directed interrogator

Profile C3cc: via a permanent or semi-permanent roadside or overhead gantry

Communication Profile C4: Roadside inspection using an (EN, ARIB, TTAK compliant) short range wireless communication interrogator instigating a physical roadside inspection (master--slave)

Profile C3a: via a hand aimed or temporary roadside mounted and aimed interrogator

Profile C3b: via a vehicle mounted and directed interrogator

Profile C3cc: via a permanent or semi-permanent roadside or overhead gantry

Communication Profile C5: Roadside inspection using in-road equipment

Subsequent versions of this International Standard may support additional communication *profiles*.

Systems claiming compliance with this part of ISO 15638 (ISO 15638-23) may support one or multiple application profiles but shall clearly declare which application profiles of this International Standard that they support. (A1 (TPM-C), A2(TPM- E, A3(TPM-R), A4(TPM-O)

Systems claiming compliance with this part of ISO 15638 (ISO 15638-23) may support one or multiple communication profiles but shall clearly declare which communication profiles of this International Standard that they support. (C1, C2, C3 a-c).

NOTE 1 Jurisdictions requiring and regulating the use of remotely monitored TPM systems are recommended to specifically regulate to determine which communications profiles are required to be supported, and may also wish to regulate regarding which application profiles are required to be supported. It is further recommended (but not required) that jurisdictions whose regulations require support of communications Profile C3 for regulatory enforcement purposes also at least encourage the ability to technically support Profile C1 in addition (for later potential migration purposes).

NOTE 2 The definition of what comprises a 'regulated' service is regarded as an issue for National decision, and may vary from jurisdiction to jurisdiction. This document does not impose any requirements on nations in respect of which services for regulated vehicles jurisdictions will require, or support as an option, but provides standardised sets of requirements descriptions for identified services to enable consistent and cost efficient implementations where instantiated.

NOTE 3 ISO 15638 has been developed for use in the context of regulated commercial freight vehicles (hereinafter referred to as 'regulated vehicles') There is nothing however to prevent a jurisdiction extending or adapting the scope to include other types of regulated vehicles, as it deems appropriate.

2 Conformance

Requirements to demonstrate conformance to any of the general provisions or specific application services described in this part of ISO 15638 shall be within the regulations imposed by the jurisdiction where they are instantiated. Conformance requirements to meet the provisions of this International Standard are therefore deemed to be under the control of, and to the specification of, the jurisdiction where the application service(s) is/are instantiated.

Systems claiming conformance with this part of ISO 15638 (ISO 15638-23) may support one or more application (application profiles 1, 2, and/or 3) as defined in [Clause 6.4](#), but shall support at least one of these options.

Systems claiming conformance with this part of ISO 15638 (ISO 15638-23) may support one or more of communication profiles C1, C2 and C3 as defined in [clause 6.5](#), but shall support at least one of these options.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15638-1, *Intelligent transport systems — Framework for collaborative Telematics Applications for Regulated commercial freight Vehicles (TARV) — Part 1: Framework and architecture*

ISO 15638-2, *Intelligent transport systems — Framework for collaborative Telematics Applications for Regulated commercial freight Vehicles (TARV) — Part 2: Common platform parameters using CALM*

ISO 15638-3, *Intelligent transport systems — Framework for collaborative telematics applications for regulated commercial freight vehicles (TARV) — Part 3: Operating requirements, 'Approval Authority' procedures, and enforcement provisions for the providers of regulated services*

ISO 15638-4, *Intelligent transport systems – Framework for cooperative telematics applications for regulated vehicles (TARV) – System security requirements*

ISO 15638-5, *Intelligent transport systems — Framework for collaborative Telematics Applications for Regulated commercial freight Vehicles (TARV) — Part 5: Generic vehicle information*

ISO 15638-6, *Intelligent transport systems — Framework for collaborative Telematics Applications for Regulated commercial freight Vehicles (TARV) — Part 6: Regulated applications*

ISO 15638-9, *Intelligent transport systems — Framework for cooperative telematics applications for regulated commercial freight vehicles (TARV) — Part 9: Remote digital tachograph monitoring*

ISO 21750:2006, *Road vehicles — Safety enhancement in conjunction with tyre inflation pressure monitoring*

REGULATION NO UN, 141 Tyre Pressure Monitoring Systems (TPMS): Uniform provisions concerning the approval of vehicles with regard to their Tyre Pressure Monitoring Systems (TPMS)

EN ETSI 300-674-1, *ETSI EN 300 674-1 V1.2.1 (2004-08) Electromagnetic compatibility and Radio spectrum Matters (ERM); Road Transport and Traffic Telematics (RTTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5,8 GHz Industrial, Scientific and Medical (ISM) band; Part 1: General characteristics and test methods for Road Side Units (Interrogator) and On-Board Units (OBU)*

ARIB STD-T75 *Dedicated Short-Range Communication (Japan)*

TTAS KO-06.0025 Standard of DSRC Radio Communication between Road-side Equipment and On-board Equipment in 5,8 GHz band (Korea)

EN 12795, *Road transport and traffic telematics - Dedicated Short Range Communication (DSRC) - DSRC data link layer: medium access and logical link control*

EN 12834, *Road transport and traffic telematics - Dedicated Short Range Communication (DSRC) - DSRC application layer*

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply / the terms and definitions given in ISO 15638-1 and the following apply.

4.1

app

small (usually) Java™ applets, organised as software bundles, that support application services by keeping the data pantry provisioned with up to date data

4.2

application profile

characteristics and specification of the information and transaction detail required to meet a set of user needs; within the common high-level framework of this International Standards, this allows different jurisdictions to receive different detail of transaction or to specify a particular communications means

4.3

application service

service provided by a service provider enabled by accessing data from the IVS of a regulated vehicle via a wireless communications network

4.4

application service provider

ASP

party that provides an application service

4.5

app library

separately secure area of memory in IVS where apps are stored (with different access controls to data pantry)

4.6

approval

formal affirmation that an applicant has satisfied all the requirements for appointment as an application service provider or that an application service delivers the required service levels.

4.7

approval agreement

written agreement made between an approval authority (regulatory) and a service provider

Note 1 to entry: An approval authority (regulatory) approval agreement recognises the fact that a service provider, having satisfied the approval authority's requirements for appointment as a service provider, is appointed in that capacity, and sets out the legal obligations of the parties with respect to the on-going role of the service provider

4.8

approval authority (regulatory)

organisation (usually independent) which conducts approval and ongoing audit for service providers on behalf of a jurisdiction

4.9

architecture

formalised description of the design of the structure of TARV and its framework

4.10

audit/auditing

review of a party's capacity to meet, or continue to meet, the initial and ongoing approval agreements as a service provider

4.11

basic vehicle data

data that shall be maintained/provided by all IVS (regardless of jurisdiction)

4.12**CALM****communications access for land mobiles**

layered solution that enables continuous or quasi continuous communications between vehicles and the infrastructure, or between vehicles, using such (multiple) wireless telecommunications media that are available in any particular location, and which have the ability to migrate to a different available media where required and where media selection is at the discretion of user determined parameters by using a suite of standards based on ISO 21217 architecture and ISO 21210 C-ITS-station networking that provide a common platform for a number of standardised media using ITS-stations (4.22) to provide wireless support for applications, such that the application is independent of any particular wireless medium

4.13**Cold tyre inflation pressure**

tyre pressure at ambient temperature, in the absence of any pressure build-up due to tyre usage

4.14**commercial application(s)**

ITS applications in regulated vehicles for commercial (non-regulated) purposes

EXAMPLE asset tracking, vehicle and engine monitoring, cargo security, driver management etc.

4.15**communications profile**

characteristics and specification of the communication detail required to meet a set of user needs using a selected wireless medium.

4.16**core data**

basic vehicle data plus any additional data required to provide an implemented regulated application service

4.17**data pantry**

secure area of memory in IVS where data values are stored (with different access controls to app library)

4.18**driver**

person driving the regulated vehicle at any specific point in time

4.19**facilities layer**

layer that sits on top of the communication stack and helps to provide data interoperability and reuse, and to manage applications and enable dynamic real time loading of new applications

4.20**framework**

particular set of beliefs, ideas referred to in order to describe a scenario or solve a problem

4.21**in-vehicle system****IVS**

ITS-station and/or connected TPM equipment on board a vehicle

4.22**in service operating pressure (P_{warm})**

inflation pressure for each tyre position elevated from the cold pressure (P_{rec}) by temperature effects during vehicle usage;

4.23

interrogator

offboard device which can establish a wireless communications session with the IVS (including 5,8 GHz DSRC) and request the provision of Tyre pressure monitoring data; often a mobile device under the control of an agent of the jurisdiction

4.24

ITS-station

ITS-s

entity in a communication network, comprised of application, facilities layer, networking and access layer components specified in ISO 21217 that operate within a bounded secure management domain

4.25

Java™

object oriented open source operating language developed by SUN systems

4.26

jurisdiction

government, road or traffic authority which owns the regulatory applications

EXAMPLE country, state, city council, road authority, government department (customs, treasury, transport), etc.

4.27

jurisdiction regulator

agent of the jurisdiction appointed to regulate and manage TARV within the domain of the jurisdiction; may or may not be the approval authority (regulatory)

4.28

Maximum axle load

maximum value, as indicated by the manufacturer, of the total vertical force between the contact surfaces of the tyres or tracks of one axle and the ground and resulting from the part of the vehicle mass supported by that axle; this load may be higher than the "authorized axle load" laid down by the national administration. The sum of the axle loads may be greater than the value corresponding to the total mass of the vehicle

4.29

Maximum mass

maximum value of the vehicle stated by the manufacturer to be technically permissible (this mass may be higher than the "permissible maximum mass" laid down by the national administration)

4.30

operator

fleet manager of a regulated vehicle, operator of interrogation equipment

4.31

physical roadside inspection

physical inspection of the tyre pressure monitoring data of a stopped vehicle by agents of the application service provider (most usually police or inspectors appointed by the jurisdiction)

4.32

prime service provider

service provider who is the first contractor to provide regulated application services to the regulated vehicle, or a nominated successor on termination of that initial contract; the prime service provider is also responsible to maintain the installed IVS; if the IVS was not installed during the manufacture of the vehicle, the prime service provider is also responsible to install and commission the IVS

4.33

profile

common and consistent elaboration of content and sequence of a set of chosen classes, conforming subsets, options, parameters, and/or data concepts to accomplish a particular function/specification

4.34**Recommended cold inflation pressure (P_{rec})**

pressure recommended for each tyre position by the vehicle manufacturer, for the intended service conditions (e.g. speed and load) of the given vehicle, as defined on the vehicle placard and/or the vehicle owner's manual;

4.35**regulated/regulatory application**

application arrangement using TARV utilised by jurisdictions (4.24) for granting certain categories of commercial vehicles rights to operate in regulated circumstances subject to certain conditions, or indeed to permit a vehicle to operate within the jurisdiction; may be mandatory or voluntary at the discretion of the jurisdiction

4.36**regulated application service**

TARV application service to meet the requirements of a regulated application that is mandated by a regulation imposed by a jurisdiction, or is an option supported by a jurisdiction

4.37**regulated vehicle**

vehicle that is subject to regulations determined by the jurisdiction as to its use on the road system of the jurisdiction in regulated circumstances, subject to certain conditions, and in compliance with specific regulations for that class of regulated vehicle; at the option of jurisdictions; this may require the provision of information via TARV or provide the option to do so

4.38**service provider**

party which is certified by an approval authority (regulatory) as suitable to provide regulated or commercial ITS application services

4.39**session**

wireless communication exchange between the ITS-station of an IVS and the ITS-station of its application service provider to achieve data update, data provision, upload apps, or otherwise manage the provision of the application service, or a wireless communication provision of data to the ITS-station of an IVS from any other ITS-station

4.40**specification**

explicit and detailed description of the nature and functional requirements and minimum performance of equipment, service or a combination of both

4.41**tachograph**

sender unit usually mounted to a vehicle gearbox, a tachograph head and a digital driver card, which records the regulated vehicle speed and the times at which it was driven and aspects of the driver's activity selected from a choice of modes

4.42**telematics**

use of wireless media to obtain and transmit (data) from a distant source

4.43**Test Pressure (P_{test})**

actual pressure of the tyre(s) selected for each tyre position after deflation during the test procedure.

4.44

Tyre

pneumatic tyre, being a reinforced flexible envelope that is provided with, or forms in conjunction with the wheel on which it is mounted, a continuous, essentially toroidal, closed chamber containing a gas (usually air) or a gas and liquid, that is intended normally to be used at a pressure greater than atmospheric pressure;

4.45

Tyre Pressure Monitoring System (TPMS)

system fitted on a vehicle, able to perform a function to evaluate the inflation pressure of the tyres or the variation of this inflation pressure over time by the generation of tyre pressure from equipment onboard (iTPM) or embedded in the tyre assembly (dTPM) and to transmit relevant information to relevant parties

4.46

user

individual or party that enrolls in and operates within a regulated or commercial application service ([4.2](#))

EXAMPLE driver, transport operator, freight owner, etc.

5 Symbols (and abbreviated terms)

ANPR

Automatic number plate recognition

app

applet (JAVA™ application or similar) ([4.1](#))

ASN.1

Abstract Syntax Notation One [ISO/IEC 8824-1:2002]

ASP

application service provider

CALM

communications access for land mobiles

CAN

controller area network

DSRC

Dedicated Short-Range Communication [EN ISO 14906:2004]

dTPM

direct tyre pressure management

EN

European Norm (Standard)

GNSS

Global Navigation Satellite System

ID

identity

iTPM

indirect tyre pressure management

ITS-s

ITS station

IVS

In-vehicle system

SE

service element

SRE

strong radio evolution

TARV

telematics applications for regulated vehicles

TPM

tyre pressure monitoring

TPM-C

Cyclical tyre pressure monitoring from onboard equipment

TPM-E

Exceptional tyre pressure monitoring from onboard equipment

TPM-R

Tyre pressure monitoring from onboard equipment on request

TPM-O

Tyre pressure monitoring by offboard equipment (vehicle may be unequipped)

VST

vehicle service table

6 General overview and framework requirements

6.1 General

This part of ISO 15638 addresses the provision of ‘Tyre pressure monitoring’ and specifies the form and content of the transmission of such data required to support such systems, and access methods to that data. The data may be transferred by a variety of means (as ITS-station >< ITS-station data transfers in a C-ITS environment using 5,9 GHz DSRC-WAVE/G5; cellular(3G, 4G LTE, 5G SRE or similar), transfers using interrogations from short range dedicated communication systems (such as 5,8 GHz DSRC), etc.

6.2 TARV general principals

ISO 15638-1 provided a framework and architecture for TARV. It provided a general description of the roles of the actors in TARV and their relationships.

To understand clearly the TARV framework, architecture and detail and specification of the roles of the actors involved, the reader is referred to ISO 15638-1.

ISO 15638-6 provides the core requirements for all regulated applications. To understand clearly the general context into which the provision of this application service is provided, the reader is referred to ISO 15638-6.

6.3 TPMS

6.3.1 General

A pneumatic tyre is a flexible component which is deflected when loaded. A tyre needs to be sufficiently inflated in order to be used at a limited deflection adapted to carry the wheel load as part of an axle load at a given speed and to transmit the expected longitudinal and transversal forces. The deflection is at the origin of the fatigue of a pneumatic tyre. Repeated excessive deflection may lead to tyre failure.

In real driving conditions, the physical parameter that most correlates to the tyre deflection is the tyre inflation pressure. Therefore, the inflation pressure surveillance of pneumatic tyres for road vehicles has been identified as a major way to increase the active safety of the vehicles in service and to reduce the risks for the users.

The inflation pressure of pneumatic tyres for road vehicles shall be set by the vehicle users according to the vehicle manufacturer's recommendations in coherency with the tyre standards and manufacturer's instructions which apply. The vehicle user is responsible for setting the correct tyre inflation pressure and its maintenance.

Tyres can sometimes look normal even though they are underinflated. One or more significantly under-inflated tyres reduce the vehicle performances, especially the behaviour related to safety. Tyre pressures outside of the range recommended by the tyre or the vehicle manufacturer may permanently alter the tyre characteristics and can be the cause of a sudden pressure loss.

A 'Tyre Pressure Monitoring System' (TPMS) is an in-vehicle electronic system that warns the driver when tyre pressure drops. The primary objective of a TPMS is to alert the driver when an unsafe condition related to incorrect tyre inflation pressure is detected.

6.3.2 Types of TPMS

There are two types of TPMS available:

- **Direct TPMS (dTPM)**– sensors within each tyre monitor actual pressure levels and report any anomalies directly to the driver via the dashboard.
- **Indirect TPMS (iTTPM)**– the antilock braking system (ABS) uses wheel speed sensors to measure the rate of revolutions for each wheel. When the system detects that a wheel is spinning faster than expected due to it being under-inflated, it sends an alert to the driver

Direct TPMS use directly measuring, hardware-based, systems. They provide in each wheel, (most often on the inside of the valve), a battery-driven pressure sensor which transfers pressure information to a central control unit which reports it to the vehicle's instrument cluster or a corresponding monitor. Some units also measure and alert temperatures of the tyre as well. These systems can identify under-inflation in any combination, be it one tyre or all, simultaneously. Although the systems vary in transmitting options, many TPMS products (both OEM and aftermarket) can display real time tyre pressures at each location monitored - whether the vehicle is moving or parked.

There are many different solutions. Some are powered by batteries (which limit their useful life). Others use an RFID wireless power system which solves the problem of limited battery life by electromagnetic induction.

If the sensors are mounted on the outside of the wheel, as in some aftermarket systems, they can be subjected to mechanical damage, aggressive fluids, as well as theft. When mounted on the inside of the rim, they are no longer easily accessible for battery change and the RF link must overcome the attenuating effects of the tyre which increases the energy need.

A TPMS (both dTPM and iTPM) is functionally composed of:

- sensing devices;
- information channel hardware;
- central information processing unit (CPU); and
- human machine interface (HMI).

A direct TPMS (dTPM) sensor consists of the following main features requiring only a few external components — e.g. battery, housing, PCB — to get the sensor module that is mounted to the valve stem inside the tyre

- Housing
- unique reference id
- pressure sensor;
- analogue-digital converter;
- microcontroller;
- system controller;
- oscillator;
- radio frequency transmitter;
- low frequency receiver, and
- voltage regulator (battery management).

6.3.3 TPMS Regulations and Standards

6.3.3.1 Summary

ISO 21750 Road vehicles — Safety enhancement in conjunction with tyre inflation pressure monitoring specifies electronic Tyre Pressure Monitoring Systems (TPMS) for tubeless tyres in association or not with an extended mobility system, with a reference pressure lower or equal to 375 kPa, fitted in single formation on four wheeled vehicles. The systems are able to survey all tyres in use (but not necessarily those in temporary use) and provide information to the driver. (Cars & light vans)

ISO 21750 establishes overall performance guidelines for the systems and their components, independently of the physical principles and the technological solution which have been selected to monitor the tyre pressure, to compute the difference to the requested level and to deliver a relevant information to the driver if the pressure of one, several or all tyres needs corrective action for the intended service conditions. (Cars & light vans)

It is stated in ISO 21750 that the objective is to expand the categories of vehicle included, but it appears that there has been no progress in this direction.

In June 2016 UN ECE's World Forum for Harmonization of Vehicle Regulations (WP.29) adopted a new Regulation on TPMS which entered into force on 22 January 2017. The new UN Regulation No. 141 is to be seen as a stand-alone regulation on Tyre Pressure Monitoring Systems. While the majority of the TPMS content was taken from UN Regulation No. 64 and imported to the new UN Regulation No. 141 without changes, some amendments had been made. Such changes included a clarification that TPMS should work not only under test conditions, but over a wide range of environmental conditions.

6.3.3.2 ISO 21750

6.3.3.2.1 General

ISO 21750 TPM compliant systems monitor the tyre pressures at speeds exceeding 25 km/h after a successful learning phase if it does exist. The driver is advised if the system malfunctions. ISO 21750 TPMS shall avoid false warnings or alarms. Data is provided to the driver, and there is no provision for communication to parties offboard.

Three types of system are specified

- Tyre Pressure Alerting System (TPAS)
Tyre Pressure Warning System (TPWS)
- Tyre Leak Alerting System (TLAS)

TPM-C, TPM-R, TPM-O systems within this document most closely relate to TPAS

TPM-E systems within this document most closely relate to TPWS if they provide actual pressures, and to TLAS if they provide only a warning. However, TLAS systems may identify pressure differences between tyres.

Because this document deals with different communications paradigms that are not covered in ISO 21750, and those paradigms require different reporting*, while the general terms TPM/TPMS are common to both documents, to avoid misinterpretation, and to make it absolutely clear that this document is not attempting to revise ISO 21750 specifications, this document deliberately does not use the terms TPAS, TPWS, and TLAS in its specifications.

EXAMPLE *In ISO 21750 the tyre position is optional information, and there are in any event only 4 possible positions. In most of the paradigms (all except Data concept TP07) the tyre position is required, and there may be 18 (or more) tyre positions

6.3.3.2.2 ISO 21750 Tyre Pressure Alerting System (TPAS)

The purpose of the TPAS is to avoid driving too often and/or too long distances and/or at too high speed with one, several or all tyres under-inflated/over-deflected by providing the driver with a warning or an alarm.

The alert delivered by a TPAS shall be related to the actual tyre pressure expressed either as an absolute or as a relative pressure of at least one tyre under control. It shall not only be related to pressure differences between tyres or to parameter differences between tyres, even if this parameter directly correlates with the tyre pressure. The identification of the tyre at the origin of the alert is optional.

- A TPAS should separately take into account the *recommended cold tyre inflation pressure* *P_{rec}* for the tyres fitted on the front axle and for the tyres fitted on the rear axle.
- A TPAS shall not monitor the tyre pressure of the unfitted normal spare unit. If the spare unit is in use, the TPAS shall either monitor it in the same conditions as for the other tyres or inform the driver for partial monitoring of the vehicle tyres.
- A TPAS shall be able to take into account all sensors of the vehicle and only those of the vehicle (learn or auto-learn). The identification of the tyre position on the vehicle is optional (localization or auto-localization).

- Optionally, a TPAS may also monitor the tyre pressures when the engine is off.
- A TPAS shall deliver the alert independently road and weather conditions.
- A TPAS shall include a self-diagnostic function delivering information to the user when the system is out of function.

6.3.3.2.3 Tyre Pressure Warning System (TPWS)

The purpose of a TPWS is to allow the vehicle user to maintain the tyre pressures within the range of pressures for optimized tyre and vehicle performances by providing a warning when corrective action is recommended.

- A TPWS shall always be a complement to a TPAS or shall include a TPAS function.
- The alert delivered by a TPWS shall be related to the actual tyre pressure expressed either as an absolute or as a relative pressure of at least one tyre under control. It cannot only be related to pressure differences between tyres or to parameter differences between tyres, even if this parameter adequately correlates with the tyre pressure. The identification of the tyre at the origin of the alert is optional.
- A TPWS shall take into account the different P_{rec} values between front and rear fitted tyres.
- A TPWS does not survey the tyre pressure of the unfitted normal spare unit. If the spare unit is in service, the TPWS shall either survey it in the same conditions as for the other tyres or inform the driver for uncompleted survey of the vehicle.
- TPWS shall be able to take into account all sensors of the vehicle and only those of the vehicle (learn or auto-learn). The identification of the tyre position on the vehicle is optional (localization or auto-localization).
- A TPAS shall deliver the alert independently road and weather conditions
- Optionally, a TPWS may also survey the tyre pressures when the engine is off.
- A TPWS shall only include the self-diagnostic function of the associated TPAS

A TPWS shall provide an alert if one or more of the tyres need a corrective action. The actual pressure is not necessarily compensated in temperature. The alert conditions (threshold levels, time, interface) shall be related to the criticality of the individual situation to reduce the risk.

6.3.3.2.4 Tyre Leak Alerting System (TLAS)

A TLAS is a system that monitors the pressure differences between the tyres in use, or a parameter that adequately correlates, and delivers an alert if a significant pressure difference appears. The goal of the alert is to inform the driver to take proper corrective actions as soon as possible.

All tyre positions of the vehicle shall be monitored by the TLAS. The alert delivered by a TLAS may be unique for the set of tyres in use. The identification of the tyre at the origin of the alert is optional.

A TLAS does not need to measure directly the pressure of each tyre. The information about tyre pressure may be estimated by comparing all tyres in use. The system shall give an alert if one of four tyres is under-inflated related to the other ones. It may also give an alert if two or more tyres are under-inflated. A TLAS is not required to monitor the tyre pressure of the unfitted tyre wheel assemblies or the spare unit even when fitted.

The alert provided by a TLAS may not be related to the minimum cold inflation pressure recommended by the tyre manufacturer's technical standards in relation to service conditions, but to the tyre pressures set by the user when initializing the system. Therefore, a TLAS is not able to deliver an alert at a given minimum absolute pressure threshold.

A TLAS may use a reset program to tune the system. After all tyres in use have been inflated, the reset button shall be activated. After a learning phase, the system will be able to detect when the pressure of at least one tyre is below that of the others. The system is not able to detect that a wrong inflation pressure has been set.

6.3.3.2.5 Lifetime

ISO 21750 requires wheel fitted systems to last at least for six years or 100 000 km whichever comes first.

6.3.3.2.6 Measurement accuracy

ISO 21750 requires wheel fitted systems are designed in order to ensure that the overall minimal system accuracy is guaranteed, regardless of all tolerances which may come into effect due to the elements which build the pressure information delivered to the final user.

In case of direct pressure measurement, the minimal accuracy required should respect the following criteria:

- $\pm 2\%$ FS between $0\text{ }^{\circ}\text{C}$ and $+70\text{ }^{\circ}\text{C}$, with a maximum of $\pm 10\text{ kPa}$,
- $\pm 5\%$ FS elsewhere a maximum of $\pm 25\text{ kPa}$, where FS is the full pressure scale.

6.3.3.2.7 Environmental characteristics

- Temperature: Wheel Fitted Components shall be designed to survive at all temperatures they may be subjected to during their operational life as specified.
- Operational: The temperature range of full operation of Wheel Fitted Components shall be at least between $-40\text{ }^{\circ}\text{C}$ and

$+85\text{ }^{\circ}\text{C}$. The system shall be able to inform the end user of temporary unavailability of pressure information.

- Maximum survival temperature: If temperatures are outside the above described range, a degraded functionality is accepted, as long as normal functionality is resumed whenever conditions return to the operational limits above.
- Maximum vehicle speed/acceleration: Wheel Fitted Components shall operate within the entire speed and acceleration profile of the wheel of application.
- Maximum survival pressure: Wheel Fitted Components shall survive undamaged a pressure value of at least $1\text{ }200\text{ kPa}$ applied for at least the time duration of the wheel assembly process.
- Fluid (gas and liquid) and particles contamination resistance: Wheel Fitted Components shall comply with the contamination profile designed for the wheel of application. It is possible to test resistance to contamination in final application mounting conditions.
- Electro-magnetic compatibility (EMC): According to the technology employed, Wheel Fitted Components shall comply with the applicable EMC legislative and regulatory requirements.
- Recycling: According to the technology employed, Wheel Fitted Components shall comply with the applicable recycling legislative and regulatory requirements.

6.3.3.2.8 Mechanical requirements

ISO 21750 requires wheel fitted systems to be designed in order to be fully compatible with the application rims and tyres, without compromising wheel balance or vehicle handling. Wheel Fitted Components shall not in any way interfere with the mechanical characteristics of the tyre, such as rolling resistance, wet grip, handling, noise, air sealing, etc. A mounting and dismounting procedure

shall be clearly identified for the particular Wheel Fitted Component of use allowing survivability of the Wheel Fitted Component itself.

6.3.4 Technological and legislative feasibility of TPMS for commercial vehicles.

A study for EC DG CLIMA

https://ec.europa.eu/clima/policies/transport/vehicles/heavy/docs/tno_2013_final_report_en.pdf

which reviewed current products and their suppliers concluded that tyre pressure monitoring for application in vans, trucks and buses is technically and economically mature at this stage, and that ideally TPMS:

- Should be capable of detecting over a wide range of road and environmental conditions
- Should not be possible to deactivate
- For M1/N1 should detect a pressure of less than 1,5 bar or detect incorrect set/reset attempt
- Should cover any tyre of approved size, including after-market (different brand) replacement tyres

The study concluded that UNECE Regulation 64 (now replaced by UNECE Regulation 141) contains the relevant prescriptions that can serve as a basis for the inclusion of vehicle categories in addition to M1/N1.

6.3.5 Compliance requirements for TARV TPM systems

In the absence of a UNECE Regulation for TPM for large commercial vehicles, and taking into account the results of the study commissioned by the European Commission, this specification is based on systems that comply to the general provisions of:

- UNECE Regulation 141, and,
- ISO 21750

Providing data to an in-vehicle system (which may be an ITS-station [ISO 21217], a standalone IVS, or part of some other vehicle management system).

6.3.6 Unique identification of wheels

6.3.6.1 General

Commercial vehicles come with many different wheel combinations. In the case of rigid bodies Section 6.4.7.2 and 6.4.7.3 below specifies how to uniquely identify each wheel.

The situation for demountable tractor+ trailer (so called 'semi's', and tractor+ multiple trailer combinations (so called 'road trains' is more complex.)

- Firstly, the tractor will frequently pull different trailers (often several per day);
- Secondly, the number of trailers being pulled may also vary;
- Thirdly, most trailers do not have their own power supply.

This Standards deliverable presents three options:

- a) The towing vehicle IVS is able to read all tractor and trailer wheels (see 6.4.7.4)
- b) Each trailer has its own IVS and can act as if it were a separate vehicle (see 6.4.7.5)

- c) In the event of a short-range interrogation to determine if the vehicle should be stopped. Only the presence of an exception (under/over-inflation warning), on any wheel, is passed back to the interrogator (see 6.4.7.6).

6.3.6.2 General principles for unique identification

TPM systems are either dTPM (directly reading the tyre pressure by sensor) or iTPM (indirectly calculating the tyre pressure). dTPM systems are located on-board, whereas iTPM systems may be on-board or offboard (in-road) (TPM-O). See [Clause 6.3.2](#).

On-board TPM systems have a control system that collects the information from the tyre sensors or on-board equipment and relay that information, in the past, to the driver and/or fleet management software. In the instantiation of TARV TPM (the use case specified in this deliverable), in respect of the application profiles TPM-C, TPM-E, and TPM-R (see [Clauses 6.4.3 – 6.4.5](#)), the in-vehicle control system is responsible to send the data to the jurisdiction or operator, via wireless means, as required by the use-case.

This specification does not seek to standardise the on-board equipment, which is of commercial proprietary design, it simply calls this on-board controlling system the “IVS” (in-vehicle system). While not specifying the design and features of the IVS onboard, this document specifies the communication from that IVS to the jurisdiction or operator, using one of the communications profiles defined in [Clause 6.5](#).

There are many different manufacturers of TPM systems, and their designs are proprietary, including their means to transmit data to the IVS. While it may be laudable and of commercial benefit for manufacturers to work together to standardise some aspects of on-board communication and messaging in TPM systems, this deliverable does not attempt to do this and is simply focussed on standardising the information sent by the IVS to the jurisdiction and/or operator.

Commercial vehicles come in many shapes and forms; electric powered tricycles, rigid 4,6,8,12,14 wheel rigid chassis, semi-tractor-trailer truck (the combination of a tractor unit and one semitrailer) and with different axle configurations), tractor units hauling more than one trailer, to the road trains used in some countries for long distance haulage.



Figure 1 — Examples of commercial vehicle configurations
(courtesy CSi library)

A jurisdiction/operator, needs to be able to identify which wheel is which, so there needs to be a tyre identification system that is regardless of the wheel configurations.

6.3.6.3 Basic unique identification

Unique tyre identification (UTI) shall be reported to the following specification:

The front row of wheels (commonly called the front axle, though in some cases will not be a single axle) shall be identified as Row 1. The leftmost tyre on Row 1 shall be identified semantically as “1.1”.

The next leftmost tyre on Row 1 shall be identified semantically as “1.2”, and so on for all remaining wheels on that row.

Moving next row of wheels from the front, this shall be identified as Row 2. The leftmost tyre on Row 2 shall be identified semantically as “2.1”. The next leftmost tyre on Row 2 shall be identified semantically as “2.2”, and so on for all remaining wheels on that row.

And this shall continue until, and include, the back row of wheels.

For clarity, some examples are provided in the following sections.

6.3.6.4 Wheel identification for rigid vehicles

Following the specification provided in 6.3.6.3, Figure 2 provides some typical examples of configurations for rigid vehicles, with their unique wheel identifications

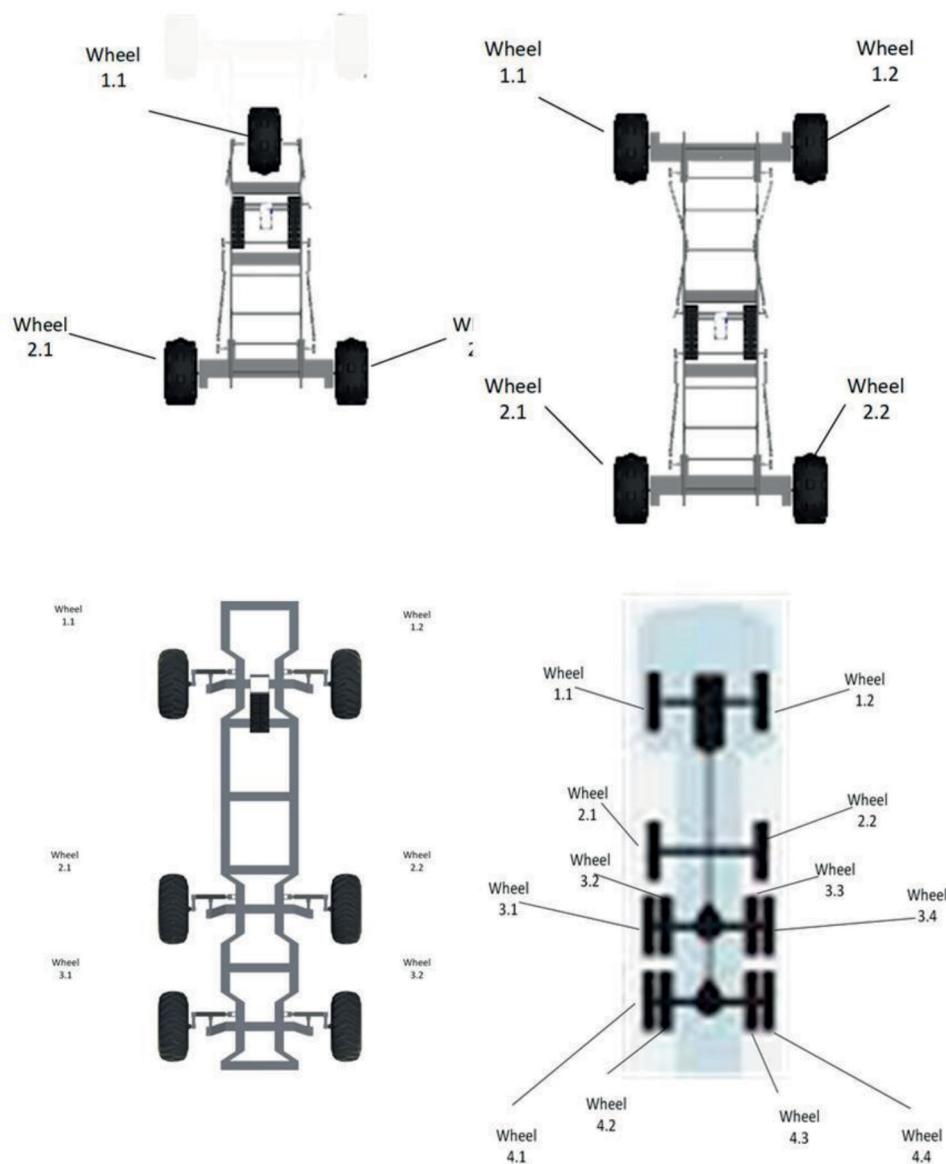


Figure 2 — Example wheel identifications for rigid vehicles
(courtesy CSi library)