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Intelligent Transport Systems (ITS);
Infrastructure to Vehicle Communication;
Part 2: Communication system specification to support application requirements for
Tyre Information System (TIS) and
Tyre Pressure Gauge (TPG) interoperability

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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

The present document is part 2 of a multi-part deliverable covering Infrastructure to Vehicle Communication as identified below:

Part 1: "Electric Vehicle Charging Spot Notification Specification";

Part 2: "Communication system specification to support application requirements for Tyre Information System (TIS) and Tyre Pressure Gauge (TPG) interoperability";

Part 3: "Communications system for the planning and reservation of EV energy supply using wireless networks".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

ITS stations are interacting together to satisfy a large diversity of customers' services.

The present document is developed in relation to the European Commission Mandate M/457 and in cooperation with CEN TC 301 TF2b.

Any communication technology enabling I2V communication can be supporting this application as long as the Tyre Pressure Monitoring System application functional and operational requirements are satisfied.

This TPMS application belongs to road safety application class but also to sustainability class through the possible CO_2 reduction provided that the vehicle tyres pressures are properly adjusted.

1 Scope

The present document provides a specification of the communication system required to support the requirements of Tyre Information System (TIS) application, TPG (Tyre Pressure Gauge) application and TPG operator application.

The TIS application has the objective to monitor in real time the pressure of the vehicle tyres, to advise the driver and to support him for the tyre(s) refilling if one or several tyre(s) are not at the recommended pressure. TPG application and TPG operator application have the objective to notify the TPG to road users and provide tyre pressure refilling service to vehicles, either manually, or automatically. Consequently, the communication system specification considers the various phases of the driver support process starting with the provisioning of available Tyre Pressure Gauge (TPG) locations, pairing the vehicle with a selected TPG and ensuring the data elements exchange required for the selected TPG to refill the concerned tyre(s) until reaching recommended pressure(s).

The present document is developed in accordance with requirements defined in CEN EN 16661 [1].

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] CEN EN 16661:2015: "Road vehicles and Tyre Pressure Gauges (TPG) - Interoperability between Tyre Information Systems (TIS) and TPG - Interfaces and Requirements".

[2] ETSI EN 302 665 (V1.1.1): "Intelligent Transport Systems (ITS); Communications architecture".

[3] ECE/TRANS/WP.29/78/Rev.2: "United Nations Economic and Social Council; Economic Commission for Europe; Consolidated Resolution on the Construction of Vehicles (R.E.3); Revision 2".

NOTE: Available at: http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29resolutions/ECE-TRANS-WP29-78-r2e.pdf

[4] ETSI TS 101 556-1: "Intelligent Transport Systems (ITS); Infrastructure to Vehicle Communication; Electric Vehicle Charging Spot Notification Specification".

[5] ETSI TS 102 894-2 (V1.2.1): "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary".

[6] ISO 639-1:2002: "Codes for the representation of names of languages - Part 1: Alpha-2 code".

[7] ISO/IEC 8825-2:2008: "Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] IEEE 802.11p™: "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".

[i.2] ETSI TS 103 097: "Intelligent Transport Systems (ITS); Security; Security header and certificate formats".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in CEN EN 16661 [1], ETSI EN 302 665 [2] and the following apply:

TIS application: vehicle ITS-S application implementing the application logic to trigger, manage and terminate the data exchange between vehicle ITS-S and TPG ITS Station or between vehicle ITS-S and TPG operator

TPG application: ITS-S application embedded at TPG ITS Station implementing application logic to trigger, manage and terminate the data exchange between TPG ITS-S and vehicle ITS-S, or between TPG ITS-S and TPG operator

TPG operator: operator in charge of managing at least one or a set of TPGs for at least one of the maintenance, operation, and/or reservation services

NOTE: Functionalities of the TPG operator may be embedded in TPG ITS-S or at central ITS-S.

TPG station: local facility that provides tyre pressure refilling service and is equipped with at least one TPG

NOTE 1: One TPG station may include more than one TPG.

NOTE 2: Typically, a TPG station includes other local facilities to support the tyre pressure refilling service provisioning, e.g. parking facilities, access control facilities. A TPG station may be combined with other local facilities such as parking station, public transport stations, etc.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AAA	Authentication, Authorization, Accounting/Auditing
ASN.1	Abstract Syntax Notation One
DE	Date Element
DRM	Discovery Request Message
EOFM	End Of File Message
HMI	Human - Machine Interface
ITS	Intelligent Transport System
ITS-G5	Intelligent Transport System - Frequency band comprised between 5 855 MHz to 5 925 MHz
ITS-S	ITS station
MAC	Medium Access Control
PDU	Protocol Data Unit
PER	Packet Encoding Rules

TCM	TPG reservation Confirmation Message
SNM	Service Notification Message
TRM	TPG Reservation Message
TIN	Tyre Identification Number.
TIS	Tyre Information System
TPG	Tyre Pressure Gauge
TPMS	Tyre Pressure Monitoring System
URL	Uniform Resource Location
VDPM	Vehicle Data Provisioning Message
VDRM	Vehicle Data Request Message
WFC	Wheel Fitted Component

4 TIS, TPG application description

4.0 Introduction

The TIS application targets at improving the driving safety through the monitoring and adjustment of the vehicles' tyres pressures in case of unadapted pressure or under driver request. Moreover, the TIS application also contributes to reduce the CO_2 emissions for thermal propulsion vehicles since unadapted tyres' pressures also impact the vehicle fuel consumption. The tyre pressure refilling service is provided by a TPG to a vehicle. It may be realized manually or automatically, as defined in CEN EN 16661 [1]. For automatic refilling service, vehicle provides a set of vehicle data e.g. tyre placard table, tyre pressure level to TPG, for it to calculate the appropriate tyre pressure to be applied for vehicle tyres.

The TIS application, TPG application and TPG operator applications interact with each other for data exchanges to manage the TPG discovery, TPG reservation and tyre pressure refilling.

4.1 Application context overview

An example of the high level data exchanges between the TIS application, TPG application and TPG operator is illustrated in figure 4.1.1. It includes the following sub systems:

- TIS application embedded in vehicle: it is in charge of identifying the tyre pressure event e.g. low tyre pressure event, discovering the TPG nearby or along its itinerary, if applicable requesting the reservation of a TPG, and providing data to TPG for refilling;
- TPG application at road side: it is in charge of exchanging data with TIS application tp manage the refilling;
- TPG operator application at central server: it is in charge of providing TPG availability information to road users, managing the TPG reservation and managing TPGs in its operation networks.

In one possible implementation, other elements may be added to support the customers' services.

EXAMPLE: Personal ITS-S may be used for TPG discovery and reservation from user, whilst a telematics service provider may manage some tasks for TPG operators from backend.

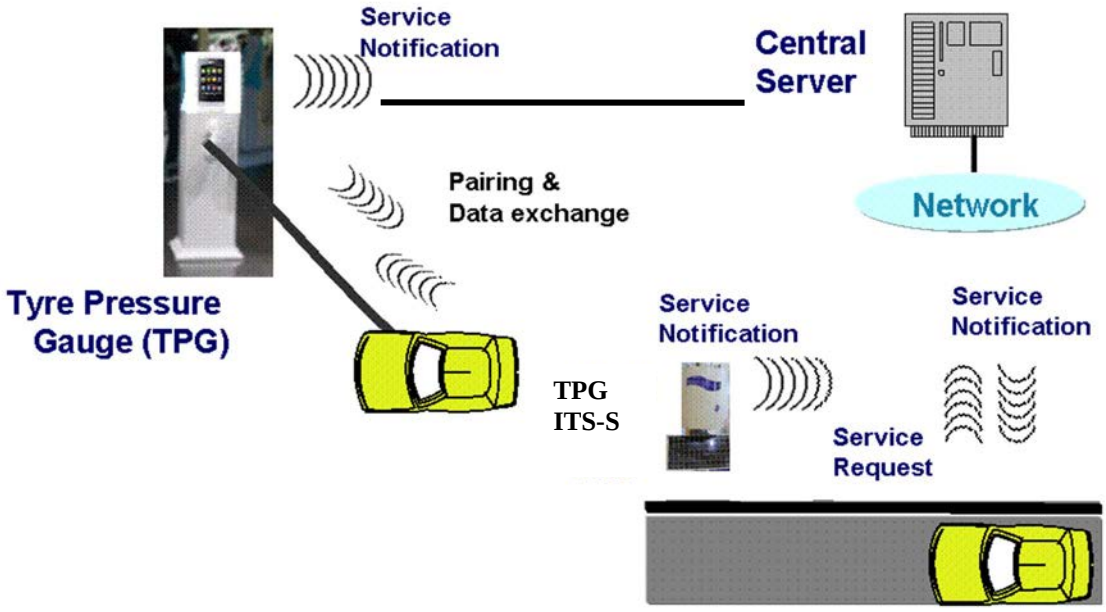

Figure 4.1.1: TIS, TPG, and TPG operator interaction overview

When the vehicle Tyre Pressure Monitoring System (TPMS) detects an abnormal tyre pressure event (e.g. under-inflation of one or more tyres), or when the driver wants to check or inflate at least one of its tyres, the TIS application triggers the TPG discovery and looks for the possible nearest available TPG stations. According to its embedded resources (communication, digital map) and available functionalities, the discovery may be realized by initiating a discovery request to the TPG operator at central server or at TPG station, or by receiving a service notification from the TPG operator, or by consulting the information contained in the embedded digital map containing the TPG station information.

A road side ITS Station (ITS-S) may be directly embedded into the TPG or connected with TPGs or with TPG operators, in order to receive real time availability information of TPGs. This road side ITS-S may be positioned on a geographical spot near by the road network, e.g. at the entry of a city or at the entry of a highway, in order to notify the local TPGs, their positions and availability to road users by a broadcasting service. A vehicle ITS-S may process the received TPG service notifications for the discovery purpose, or to update the embedded digital map for later usage.

Upon the discovery of an available TPG, the driver may decide to refill the vehicle's tyre(s). If the refilling need is confirmed, the driver may request the TIS application via the vehicle HMI to initiate the reservation of a TPG, or may directly go to the TPG station without reservation. In both cases, the driver can be guided to the selected TPG by means of its navigation system.

NOTE: The availability of reservation support may be included in a TPG service notification message.

Upon arrival at the TPG station, the TIS application pairs with a selected or the reserved TPG, then the TPG ITS-S establishes a point to point communication with the vehicle ITS-S for refilling operation. Data exchange requirements in this step is specified in CEN EN 16661 [1]. At the end of the refilling process, the TPG ITS-S sends an "End of Pairing" message which may contain the values of the tyre pressures actually provided.

4.2 Application evolution steps

The main application evolution steps are represented in the application state diagram as illustrated in figure 4.2.1.

Consequently, the following three steps are identified for TIS application:

- The discovery step of the nearest TPG by the vehicle, triggered by the detection of an abnormal tyre pressure event by the TPMS, or by the driver via HMI. The discovery step may further comprise an optional reservation process to enable end user to reserve one TPG, if the reservation service is offered by the TPG operator.
- The pairing step which consists of pairing the vehicle ITS-S with the TPG ITS-S which has been reserved/selected by the driver. This step is triggered by the driver at the arrival of the TPG.

- The tyre(s) refilling step which consists of adjusting the tyre(s) pressure(s) by TPG to vehicle according to data provided by the vehicle. This step is triggered by the TPG request message to TIS and is terminated with the reception of "end of pairing" message at vehicle ITS-S.

For the TPG application, the following steps are defined:

- Available: the TPG is available and operates correctly to provide refilling services. This step may be triggered by local TPG (e.g. system is ignited and correctly launched), or by a remote TPG operator.
- Reserved: the TPG is reserved during a time period. The refilling service is expected to be provided to the customer who has reserved the time slot. This step is triggered by the TPG operator that has confirmed the reservation with one customer.
- The pairing step which consists of pairing the vehicle ITS-S with the TPG ITS-S which has been reserved/selected by the driver. This step is triggered at the reception of the pairing data from customer or from vehicle ITS-S.
- Refilling ready: the TPG is correctly paired with the vehicle ITS-S. The TPG is ready to serve the customer for refilling. This step is triggered by the successful pairing and is terminated upon transmission of end of pairing" message to vehicle ITS-S after the refilling.

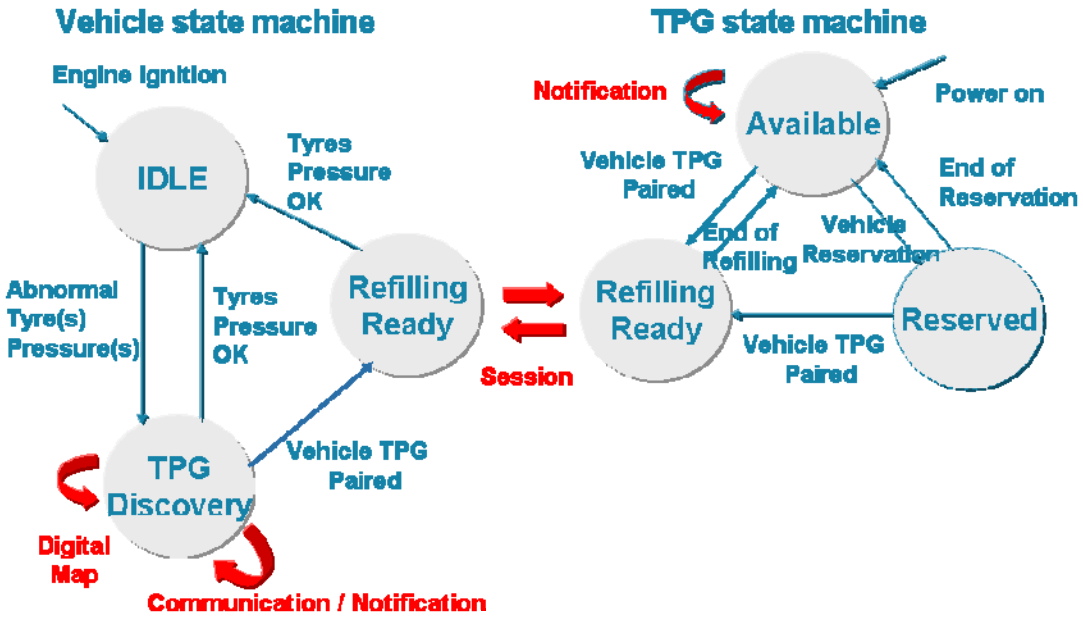

Figure 4.2.1: Application state machines

The interactions between the TIS application, the TPG application and the TPG operator are classified into three processes:

- TPG discovery process as defined in clause 4.3;
- TIS and TPG pairing process as defined in clause 4.4;
- Tyre refilling process as defined in clause 4.5.

4.3 TPG discovery process

The TPG discovery process identifies and locates one or more than one available TPGs being in the proximity of the vehicle or of a specific geographical location indicated by the driver. Following scenarios may be used for discovery process:

- If the vehicle is equipped with a navigation system, the TPG presence discovery may be realized by consulting its digital map data base which contains the TPG POIs. No communication is required for this scenario.

- A road side ITS-S broadcasts the availability of the TPG in local wireless network e.g. via ITS-G5 (IEEE 802.11p [i.1]) to oncoming vehicle ITS-Ss.

NOTE 1 : A service announcement message may be broadcasted before the transmission of the TPG service notification message. The service announcement message announces the availability of the service (i.e. TPG notification), and communication parameters for vehicle ITS-S to receive the service data.

NOTE 2: The specification of the service announcement message is out of scope of the present document.

- Vehicle ITS-S has Internet connectivity, it establishes communication directly with TPG operator by issuing a request, the TPG operator replies with TPG availability in accordance to customer request conditions e.g. search position, search range, TPG type, etc.

- The road side ITS-S provides Internet router functionalities to vehicle ITS-Ss that do not have Internet connectivity. It routes vehicle ITS-S request to the TPG operator and forwards the replies back to the requesting vehicle ITS-S.

NOTE 3: The availability of routing service at road side ITS-S may also be announced via a service announcement message.

NOTE 4: Access to the TPG operator service may be subject to conditions, e.g. contract, subscription.

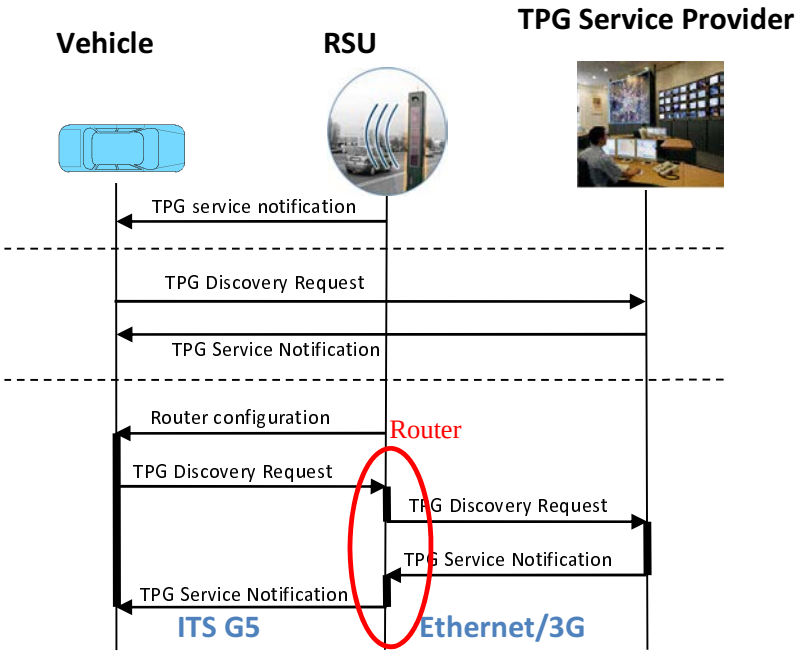

Figure 4.3.1: Examples of discovery scenarios

The discovery process enables TIS application to discover the available TPG according to its refilling needs. The available TPGs may be shown to users via e.g. HMI or over navigation system. The user then may select one of the available TPG as the next navigation way point.

Optionally and upon discovery of one available TPG, the customer may initiate the reservation request of a TPG if the reservation possibility is offered by the TPG operator. The reservation is triggered by the user (driver or passenger of the vehicle) by transmitting a reservation request to the TPG operator. The TPG operator verifies the reservation conditions and the availability of the relevant TPG, and proposes a reservation confirmation or declination message to the requesting user, including all reservation details and conditions.

If the reservation is confirmed, a reservation code may be generated by the TPG operator and transmitted to the requesting users. This reservation code may be used in TIS and TPG pairing step.

If the reservation is confirmed, the TPG operator changes the reserved TPG state from available to reserved, during the time period in which the reservation is effective. In case of cancellation (e.g. user no show up on time, reservation cancellation), the TPG operator puts the TPG back to available state for other users.

4.4 TIS and TPG pairing

Upon arrival at TPG, the TIS application may be required to pair with TPG application. An identification code is used for the pairing for vehicle and TPG to identify each other. This identification code is used by the TPG to address the vehicle for the provisioning of data required for the calculation of the pressures recommended for each tyre to be refilled. Optionally, an Authentication, Authorization, Accounting/Auditing (AAA) procedure may be launched for the pairing purpose:

- If a TPG has been reserved and the reservation has been confirmed by the TPG operator. A unique confirmation identification code is used for pairing. Optionally in addition, a TPG identifier may also be provided together with the reservation code. The provision of the identification code may be entered by driver on TPG HMI, or automatically by using a smart card.
- If the driver has not reserved a TPG, another identification code may be used. This identification code could be the vehicle registration number, the vehicle ITS-S network address (e.g. IPv6 address), the vehicle ITS-S MAC address, or simply a randomly assigned code assigned by the TPG operator on site.

NOTE 1: Depending on the implementation and the business model being used for the service provision, data being used for pairing may vary.

NOTE 2: It is out of the scope of the present document to specify the pairing procedure and data exchange needs.

NOTE 3: In one possible implementation, data exchange for pairing may not be required. For example, if the TPG service is free of charge and open to public, the identification of the vehicle ITS-S and TPG with each other is therefore not required. In this case, the pairing may be done by e.g. detection of physically connection of refilling cable to vehicle tyre, or by user confirmation via the TPG HMI.

4.5 Tyre refilling process

Data exchange for tyre refilling process and example of communication scenario are illustrated in figure 4.5.1.

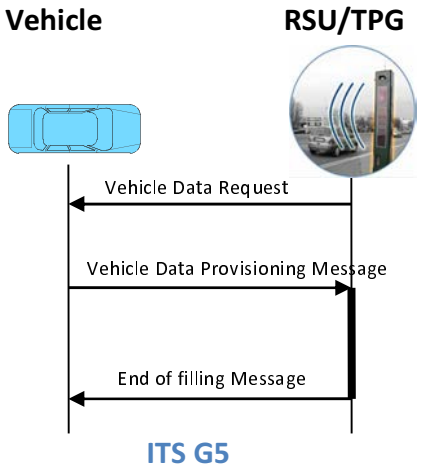

Figure 4.5.1: Flow diagram for the exchange of data between TIS and the TPG

As soon as the TPG and the TIS are paired, the TPG ITS-S sends a request to the Vehicle ITS-S, indicating basic operation information of the TPG. In CEN EN 16661 [1], the TPG may operate in three modes, respectively the fully automated mode, semi-automated mode and manual mode. Different vehicle data is required to be received by the TPG to support one mode. Therefore, the operation mode information is included in the vehicle data request, for TIS application to provide necessary data to the TPG application.

Upon reception of the vehicle data request, the TIS application transmits vehicle data to the requesting TPG.

Once the TPG receives vehicle data from the TIS application, the TPG application may adjust the refilling parameters accordingly e.g. calculation of the recommended refilling pressure. The tyres refilling process then starts. The refilling process may be illustrated by the TPG HMI. At the end of the tyres refilling process, the TPG application sends an "end of refilling" message to the TIS application, which may contain a service execution report.

Point to point communication should be used for data exchange between the vehicle ITS-S and TPG ITS-S during this process.

5 Communication system functional requirements

5.0 General requirements

5.0.1 Introduction

The present clause specifies the functional requirements for the communications between the TIS application, TPG application and TPG operator application. The manual manipulation of TPG for refilling is out of the scope of the present document.

Multiple communication technologies can be used to meet the functional requirements. Consistent set of technologies and protocols should be selected to ensure the communication interoperability.

The present document specifies the protocols and message formats. In particular, data exchange requirements for refilling process are inherited from CEN EN 16661 [1].

5.0.2 Encoding rules

By default, the Unaligned packet encoding rules (PER) as defined in ISO/IEC 8825-2 [7] shall be used for encoding and decoding of messages as specified in the present document.

5.0.3 Message format ASN.1 representation

The ASN.1 representation of the messages shall be as specified in Annex A of the present document.

5.1 TPG discovery protocol and messages specification

5.1.1 Request based discovery

5.1.1.1 Vehicle request for local discovery

This protocol is based on the transmission of a TPG discovery request message (DRM) from vehicle ITS-S to road side ITS-S to initiate the TPG discovery at local area. Upon reception of the DRM, a road side ITS-S transmits information of available TPGs at local area by transmitting a Service Notification Message (SNM) as specified in clause 5.1.2.

5.1.1.2 Vehicle request via Internet

This protocol is initiated by vehicle ITS-S, by addressing to a central ITS-S via its URL or its IPv6 address. In this case, a communication session is established, and a DRM such as specified in table 5.1.1.4.1 is directly transmitted by the vehicle ITS-S to the central ITS-S. TIS application may further set search parameters for TPG discovery, such as search position, search range, TIS profile, etc.

NOTE: TIS profile defines set of data being available at TIS for refilling operation. It is defined in CEN EN 16661 [1], clause 9.

Upon reception of a DRM, central ITS Station application responds by a SNM as specified in table 5.1.2.2.1. In such case, this SNM may include a subset of TPG list being relevant to the requesting Vehicle ITS Station.

5.1.1.3 General protocol operation

The DRM transmission shall be triggered by the TIS application. The triggering conditions may be one of but not limited to the following:

- TIS application receives a service announcement message broadcasted by the road side ITS-S, announcing the available TPG notification services to road users.
- Triggered by end user via in-vehicle HMI sending a request to TIS application.

Depending on the communication technology being used, the DRM may be broadcasted (topology based broadcast or geographic broadcast) by the requesting vehicle ITS-S. Alternatively, a point to point communication may be used for DRM communication.

Once triggered, the DRM transmission may persist at a given frequency in conformity with the operational requirement specified in clause 6.2.2.

The DRM transmission may be terminated either at the expiry of a pre-defined time, at the reception of at least one SNM, or requested by end user via HMI.

5.1.1.4 DRM data structure

The DRM shall be structured as specified in table 5.1.1.4.1. Data elements may be imported from ETSI TS 102 894-2 [5]. In this case, the data presentation, including type and unit shall be as specified in ETSI TS 102 894-2 [5]. Otherwise, the data element shall be as presented as specified in the present clause.

Table 5.1.1.4.1: DRM data structure specification

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
ItsPduHeader	1	Protocol version			M	Protocol version, shall be set to 1 for the present document. It shall be presented as *ItsPduHeader* as specified in ETSI TS 102 894-2 [5].
	2	Message ID			M	DRM message ID. It shall be presented as *ItsPduHeader* as specified in ETSI TS 102 894-2 [5]. For the present document, the value of the *messageID* is extended, and shall be set to 8 (tistpg).
	3	Originator ID				ID of the ITS-S that generates and transmits the message. It shall be presented as *StationID* as specified in ETSI TS 102 894-2 [5].
Management Container	4	Generation Time			M	Time at which the message is generated. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].
	5	Vehicle type			M	Type of the requesting vehicle as defined in ECE/TRANS/WP.29/78/Rev.2 [3]. It shall be presented as specified in Annex A of the present document.
	6	Customer service contract number	IA5String		O	Provides the customer service contract number. It shall be presented as specified in Annex A of the present document. This DE is optional; it shall be present if the information is available.
	7	TIS profile	BIT STRING		M	TIS profile as supported by the TIS. Its definition is specified in CEN EN 16661 [1], clause 9. The first bit shall be set to 0. If one profile is supported by the TIS, the corresponding bit shall be set to one. It shall be presented as specified in Annex A of the present document. See note below.

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
Situation Container	8	Cause Code			M	Tyre Pressure not conforming to recommendations. It shall be set to *CauseCode* as specified in ETSI TS 102 894-2 [5]. The *causeCode* shall be set to *vehicleBreakdown* (91). For the present document, two sub cause codes are defined for tyre pressure event: - In case of tyre puncture, the *subCauseCode* (VehicleBreakdownSubCauseCode) is set to 8 (tyrePuncture(8)); - In case of low tyre pressure, the *subCauseCode* is extended and set to 9 (tyrePressureProblem).
Location Container	9	Vehicle position			M	Position and position accuracy of the requesting vehicle at the generation time. It shall be presented as *ReferencePosition* as specified in ETSI TS 102 894-2 [5].
	10	Vehicle Speed			M	Vehicle speed and accuracy at the generation time. It shall be presented as *Speed* as specified in ETSI 102 894-2 [5].
	11	Vehicle Heading			M	Movement heading and accuracy of the requesting vehicle at the generation time. It shall be presented as *Heading* as specified in ETSI TS 102 894-2 [5].
	12	Requested position			O	Position for TPG search. This DE is optional; it shall be present if the request position is different from the vehicle position. It shall be presented as *ReferencePosition* as specified in ETSI TS 102 894-2 [5]. The position accuracy shall be set to "unavailable".
	13	Search range	Interger	500m	O	Range of search, in the unit of 0,5 km. This DE is optional; it shall be present if the data is available from TIS application. It shall be presented as specified in Annex A of the present document.
	14	searchCondition			O	Additional conditions for the TPG look up, e.g. nearest TPG, fastest reachable TPG. This DE is optional; it shall be present if the data is available from TIS application. It shall be presented as specified in Annex A of the present document.
NOTE: The TIS profile may be used to select appropriate TPG suitable for TIS refilling.						

5.1.2 Notification from road side ITS-S or from central ITS-S

5.1.2.1 General protocol operation

A TPG Service Notification Message (SNM) may be transmitted by a TPG ITS-S, a road side ITS-S or central ITS-S. SNM may be broadcasted, geo-broadcasted from road side ITS-S to road users, or be transmitted point to point from road side ITS-S/central ITS-S to requesting vehicle ITS-S.

The SNM transmission shall be triggered by the TPG application or an ITS-S applications embedded at road side ITS-S or central ITS-S. The triggering conditions may be one of but not limited to the following:

- TPG application is launched based on predefined conditions (e.g. power on).
- Triggered by TPG operator via HMI.

Once triggered, the SNM transmission may persist at a given frequency in conformity with the operational requirement specified in clause 6.2.2.

The SNM transmission may be terminated either at the expiry of a pre-defined time, or requested by TPG operator via HMI.

Upon reception of a SNM, vehicle ITS-S may check the relevance of the message, ignore the received message, or store the message, and present relevant TPGs to end user. End user may choose to ignore the notification, decide to reserve a TPG, or set one TPG as navigation destination.

5.1.2.2 SNM data structure

The Service Notification Message (SNM) shall be structured as specified in table 5.1.2.2.1. Data elements may be imported from ETSI TS 102 894-2 [5]. In this case, the data presentation, including type and unit shall be as specified in ETSI TS 102 894-2 [5]. Otherwise, the data element shall be as presented as specified in the present clause.

Table 5.1.2.2.1: SNM data structure specification

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
ItsPduHeader	1	Protocol version			M	Shall be as specified in table 5.1.1.4.1.
	2	Message ID			M	Shall be as specified in table 5.1.1.4.1.
	3	Originator ID				ITS-S ID of the ITS-S that generates and transmits the SNM. It shall be presented as specified in table 5.1.1.4.1.
Management Container	4	Generation Time			M	Time at which the message is generated. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].
	5	Total number of TPG Stations	Interger		M	Total number of TPG stations notified by the SNM.
TPG Station 1 container	6	TPG Station Identifier			M	ID of the TPG station. It shall be presented as *StationID* as specified in ETSI TS 102 894-2 [5].
	7	TPG automation level	BIT STRING		M	Automation level supported by TPG station. In case one or more than one automation levels are supported by TPGs of the TPG station, the corresponding bit shall be set to one. It shall be presented as specified in Annex A of the present document.
	8	Number of TPG	Interger		M	Total number of TPGs managed by the TPG station.
	9	TPG provider Identifier (brand)	UTF8String		M	TPG provider identification. Maximum size is 32 characters. It shall be presented as specified in Annex A.
	10	TPG Station geographical location			M	Geographical position of the TPG Station. It shall be presented as *ReferencePosition* as specified in ETSI TS 102 894-2 [5]. The value of the position accuracy shall be set to "unavailable" value.
	11	TPG accessibility conditions	UTF8String		M	Open to all or restricted to some communities. Free of access or paying access. It shall be as specified in Annex B of the ETSI TS 101 556-1 [4] and in annex A of the present document.
	12	TPG Address	UTF8String		O	Number, Street Name, City Name, Country Name. Shall be as specified in Annex B of the ETSI TS 101 556-1 [4] and in annex A of the present document. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
	13	TPG Telephone number	NumericString		O	Telephone number to reach the TPG service agent. Shall be as specified in Annex B of the ETSI TS 101 556-1 [4] and in annex A of the present document. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.
	14	Digital map of the access			O	To help the application to guide the driver to the TPG charging station. Shall be as specified in Annex B of the ETSI TS 101 556-1 [4] and in annex A of the present document. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.
	15	Opening days/hours	UTF8String		O	Opening days and hours. Shall be as specified in Annex B of the ETSI TS 101 556-1 [4] and in annex A of the present document. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.
	16	Booking information	UTF8String		O	If the reservation is possible, provide either the URL or IPv6 address of the reservation ITS Station. Shall be as specified in Annex B of the ETSI TS 101 556-1 [4] and in annex A of the present document. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.
	17	Number of available TPG	Interger		O	Number of currently available TPGs at the Generation Time. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.
	18	Cancellation condition	UTF8String		O	Cancellation conditions (e.g. payable or not), Maximum size is 32 characters. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.
TPG Station 2 container Up to 8 TPG Stations data						Information related to TPG station 2, including data elements as described from item 6 to item 18.

5.3 TPG reservation protocol and message specification

5.3.0 General protocol operation

Upon receiving a TPMS SNM, a Vehicle ITS Station may start a TPG reservation process after the driver's validation. The reservation protocol includes the transmission of a TPG Reservation Message (TRM) such as specified in table 5.3.1.1 to TPG operator. The TPG operator may confirm or decline the reservation request by transmitting a TPG reservation Confirmation Message (TCM). A confirmation code is provided in the TCM, in case the reservation is confirmed.

Optionally and if the service is offered, the vehicle ITS-S may cancel the reservation. The cancellation request is confirmed or declined by the TPG operator.

The TRM transmission shall be triggered by the TIS application. The triggering conditions may be one of but not limited to the following:

- Upon reception of SNM indicating the reservation possibility and booking info, and based on request from end user.
- Triggered by end user via HMI.

Once triggered, a point to point communication should be used between vehicle ITS-S and TPG operator.

The TCM transmission shall be triggered by the TPG operator application after processing the received TRM.

Once triggered, a point to point communication is established between vehicle ITS-S and TPG operator.

The TRM and TCM transaction may be managed in the same communication session.

By default, the TCM and TRM shall be transmitted at least once. Optionally, the ITS-S application or TPG operator application may repeat the transmission for several times, to increase the message reception probability.

5.3.1 TRM data structure

The TPG Reservation Message (TRM) shall be structured as specified in table 5.3.1.1. Data elements may be imported from ETSI TS 102 894-2 [5]. In this case, the data presentation, including type and unit shall be as specified in ETSI TS 102 894-2 [5]. Otherwise, the data element shall be as presented as specified in the present clause. In case of reservation cancellation, the situation container and location container may be omitted from TRM.

Table 5.3.1.1: TRM data structure specification

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
ItsPduHeader	1	Protocol version			M	Shall be as specified in table 5.1.1.4.1.
	2	Message ID			M	Shall be as specified in table 5.1.1.4.1.
	3	Originator ID				ITS-S ID of the ITS-S that generates and transmits the TRM. It shall be presented as specified in table 5.1.1.4.1.
Management Container	4	Generation Time			M	Time at which the message is generated. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].
	5	Vehicle type			M	Vehicle type of the reservation requesting vehicle. It shall be presented as specified in Annex A.
	6	TPG Station Identifier			M	ID of the TPG station to be reserved. It shall be presented as *StationID* as specified in ETSI TS 102 894-2 [5].
	7	ReservationStatus			M	To indicate the reservation status. It shall be as specified in Annex A of the present document. For the reservation request, the value shall be set to 0 (request). For the cancellation request, the value shall be set to cancellation(5).
	8	Customer service contract number			O	The customer service contract number if available. It shall be presented as specified in Annex A of the present document. This DE is optional; it shall be present if the data is available from TIS application.
	9	Reservation ID	String		O	ID of the reservation. This DE is optional, it shall be present in case of the cancellation of reservation, i.e. if the reservation status is set to cancellation(5). It shall be presented as specified in Annex A.
Situation Container	10	Estimated time of arrival			M	Time estimated to reach one of the nearest available TPG. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
	11	Proposed vehicle pairing ID	String		O	Proposed unique vehicle identifier for the TPG - Vehicle pairing, e.g. the vehicle registration number. It shall be as specified in Annex A of the present document. This DE is optional; it shall be present if the data is available from TIS.
Location Container	12	Vehicle position			M	Position and position accuracy of the requesting vehicle at the generation time. It shall be presented as *ReferencePosition* as specified in ETSI TS 102 894-2 [5].
	13	Vehicle speed			M	Vehicle speed and accuracy at the generation time. It shall be presented as *Speed* as specified in ETSI TS 102 894-2 [5].
	14	Vehicle heading			M	Movement heading and accuracy of the requesting vehicle at the generation time. It shall be presented as *Heading* as specified in ETSI TS 102 894-2 [5].

5.3.2 TCM data structure

The TPG reservation Confirmation Message (TRM) shall be structured as specified in table 5.3.2.1. Data elements may be imported from ETSI 102 894-2 [5]. In this case, the data presentation, including type and unit shall be as specified in ETSI TS 102 894-2 [5]. Otherwise, the data element shall be as presented as specified in the present clause. In case of reservation cancellation, the situation container and location container may be omitted from TCM.

Table 5.3.2.1: TPG TCM data structure specification

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
ItsPduHeader	1	Protocol version			M	Shall be as specified in table 5.1.1.4.1.
	2	Message ID			M	Shall be as specified in table 5.1.1.4.1.
	3	Originator ID				ITS-S ID of the ITS-S that generates and transmits the TRM. It shall be presented as specified in table 5.1.1.4.1.
TPMS TCM Management Container	4	Generation Time			M	Time at which the message is generated. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].
	5	TPG Station identifier			M	Reserved TPG identifier. It shall be presented as *StationID* as specified in ETSI TS 102 894-2 [5].
	6	ReservationIn status			M	To indicate the reservation confirmation result. It shall be as specified in Annex A of the present document.
	7	Reserved TPG number			O	Provide the number of the corresponding reserved TPG number, in case one TPG station includes more than one TPG. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application. The DE shall be presented as specified in Annex A.
	8	Customer service contract number			O	The customer service contract number if available. It shall be presented as specified in Annex A of the present document. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.
	9	Reservation ID	String		O	ID of the reservation. This DE is optional, it shall be present in case the reservation is confirmed, or cancellation request is confirmed. It shall be presented as specified in Annex A.

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
	10	TPG automation level	BIT STRING		O	Automation level supported by the reserved TPG. In case one or more than one automation levels are supported by TPGs of the TPG station, the corresponding bit shall be set to one. This DE is optional; it shall be present in case the reservation is confirmed. It shall be presented as specified in Annex A of the present document.
TPMS TCM Situation Container	11	Pairing identification code			O	Identification code to be used for the pairing. It could be the proposed vehicle identification code. This DE Is optional; it shall be present in case the pairing ID is different from the reservation ID. It shall be presented as specified in Annex A of the present document.
	12	Time limit of the reservation			M	Provides the time limit in hours/minutes from the current time until which the reservation is granted. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].
	13	Cancellation conditions	UTF8String		O	Cancellation conditions (e.g. payable or not), maximum size is 32 characters. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.
Location Container	14	Selected TPG station position			O	Position and position accuracy of the reserved TPG station. It shall be presented as *ReferencePosition* as specified in ETSI TS 102 894-2 [5]. This DE is optional; it shall be present in case the information is available at TPG application or at TPG operator application,
	15	TPG Address	UTF8String		O	Number, Street Name, City Name, Country Name. Shall be as specified in Annex B of the ETSI TS 101 556-1 [4] and in annex A of the present document. This DE is optional; it shall be present if the data is available from TPG application or TPG operator application.

5.4 TIS - TPG pairing

When reaching at TPG and if required by the TPG operator, the customer shall provide at least an identification code to pair with the TPG. This identification may have been provided beforehand during the reservation process directly by the TPG ITS-S or the Central ITS-S, or is made available to the customer at the access to TPG. In one possible implementation, the vehicle identification may be used as pairing identification code.

For the pairing purpose, the point to point communication should be used. If BTP/GeoNetworking is used, the unicast communication should be used.

5.5 TIS - TPG communication protocol and messages specification during tyres refilling

5.5.0 General protocol operation

The first step for refiling process starts from TPG ITS-S by transmitting a Vehicle Data Request Message (VDRM) to the paired vehicle ITS-S. VDRM shall include the TPG automation level data as specified in CEN EN 16661 [1], clause 6.1, in order that the TIS application determinates the data to be provided to TPG. Upon reception of the VDRM, TIS application at the vehicle-ITS-S transmits a Vehicle Data Provisioning Message (VDPM), containing data required at TPG to calculate the tyres pressures to be provided to all the tyres of the vehicle requiring pressure adjustment. Nevertheless, depending on the profile that is supported by the TIS, TIS application may not be able to provide all required data by for full automated TPG operator. For example, TIS profile 3 as defined in CEN EN 16661 [1], clause 9 do not provide vehicle specific tyre pressure data to TPG. The TIS profile and data provision requirements shall be as specified in CEN EN 16661 [1], clause 9. At the end of refilling, an End of Filling Message (EOFM) is transmitted from TPG application to TIS application.

The filling process is specified in CEN EN 16661 [1]. VDRM, VDPM and EOFM data structure are specified based on requirements as defined in CEN EN 16661 [1].

For the refilling process, the point to point communication should be used. If BTP/GeoNetworking is used, the unicast communication should be used.

The VDRM transmission shall be triggered by the TPG application. The triggering conditions may be one of but not limited to the following:

- End of pairing process.
- Start of the refilling process requested by the end user.

The VDPM transmission shall be triggered by the TIS application upon reception of the VDRM.

The EOFM transmission shall be triggered by the TPG application at the end of refilling.

Unless specified otherwise, the VDRM, VDPM, and EOFM are transmitted once and should not be repeated.

5.5.1 VDRM data structure

The VDRM shall be structured as specified in table 5.5.1.1. Data elements may be imported from ETSI TS 102 894-2 [5]. In this case, the data presentation, including type and unit shall be as specified in ETSI TS 102 894-2 [5]. Otherwise, the data element shall be as presented as specified in the present clause.

Table 5.5.1.1: VDRM data structure specification

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
ItsPduHeader	1	Protocol version			M	Shall be as specified in table 5.1.1.4.1.
	2	Message ID			M	Shall be as specified in table 5.1.1.4.1.
	3	Originator ID				ITS-S ID of the ITS-S that generates and transmits the TRM. It shall be presented as specified in table 5.1.1.4.1.
TPMS VDRM Management Container	4	Generation Time			M	Time at which the message is generated. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].
	5	Filling status			M	To indicate the filling status. It shall be as specified in Annex A of the present document. For the VDRM message, the value shall be set to requestVehicleData(0).
	6	AutomationLevel	BIT STRING		M	Automated level supported by the TPG as specified in CEN EN 16661 [1], clause 6.1. When an automation level is supported, the corresponding bit shall be set to 1. The reserved bit shall be set to 0.
	7	PairingID			O	Pairing ID being used for refilling.

5.5.2 VDPM data structure

The VDPM shall be structured as specified in table 5.5.2.1 and shall be compliant to requirements as defined in CEN EN 16661 [1], table 1, table 2 and table 3. The VDPM encapsulates the data structure as defined CEN EN 16661 [1] with ITS PDU Header as specified in ETSI TS 102 894-2 [5] ItsPduHeader.

Data elements may be imported from ETSI TS 102 894-2 [5]. In this case, the data presentation, including type and unit shall be as specified in ETSI TS 102 894-2 [5]. Otherwise, the data elements shall be as presented as specified in the present clause.

NOTE: When Unaligned PER encoding scheme is used, the length indication of data elements as defined in CEN EN 16661 [1] is obsolete.

Table 5.5.2.1: VDPM data structure specification

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
ItsPduHeader	1	Protocol version			M	Shall be as specified in table 5.1.1.4.1.
	2	Message ID			M	Shall be as specified in table 5.1.1.4.1.
	3	Originator ID				ITS-S ID of the ITS-S that generates and transmits the TRM. It shall be presented as specified in table 5.1.1.4.1.
VDPM Management Container	4	Generation Time			M	Time at which the message is generated. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].
	5	TIS profile			O	TIS profile as specified in CEN EN 16661 [1], clause 9. It shall be presented as Annex A of the present document.
	5	Language	String		M	Language selected by driver for synchronization of display language between vehicle and TPG HMI. The data setting rule shall be as specified in ISO 639-1 [6]. The DE shall be presented as specified in Annex A and as specified in table 1, clause 6.2 of CEN EN 16661 [1].
	6	Vehicle type	ENUMERATED		M	Type of the vehicle as defined in ECE/TRANS/WP.29/78/Rev.2 [3]. It shall be presented as specified in Annex A of the present document.

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
	7	tyreTempCondition	ENUMERATED		M	Applicable in case the vehicle manufacturer considers a supplementary pressure value, i.e. concerning warm tyre condition. The value shall be set as specified in table 1, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A.
	8	Filling status	Integer		M	To indicate the filling status. It shall be as specified in Annex A of the present document. For the present message, the value shall be set to *sendVehicleData(1).*
	9	PairingID			O	Pairing ID being used for refilling.
Placard table		Number of tyre sets			M	Total number of tyre sets variants. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	10	ID of tyre set variant	Integer		O	ID of the Tyre Set Variant in the placard table. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document. In case of no tyre size dependency (i.e. the number of tyre set is set to 0), this DE shall not be included.
	11	Front axle tyre dimension	BIT STRING		O	Dimension of the front axle, including aspect ratio, rim diameter, load index and speed index. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document. In case of no tyre size dependency (i.e. the number of tyre set is set to 0), this DE shall not be included.
	12	Tyre type Front Axle			O	Type of the front axle tyre. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document. In case of no tyre size dependency (i.e. the number of tyre set is set to 0), this DE shall not be included.
	13	Rear axle Tyre dimension			O	Dimension of the rear axle, including aspect ratio, rim diameter, load index and speed index. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document. In case of no tyre size dependency (i.e. the number of tyre set is set to 0), this DE shall not be included.

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
	14	Tyre type Rear Axle			O	Type of the rear axle tyre. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document. In case of no tyre size dependency (i.e. the number of tyre set is set to 0), this DE shall not be included.
	15	Amount of pressure variants			M	Number of pressure variants contained each tyre set variant. It corresponds to the number of repetition of the data element 16 *pressure variant value*. Up to 15 pressure variants may be contained in one VDPM. See note below. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	16	Pressure variant value			M	Configuration of the pressure variant, including the load configuration, driving type configuration, speed type configuration, front axle placard pressure, as well as rear axle placard pressure. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
Vehicle specific data (Optional)	17	Current vehicle pressure configuration				Configuration of the current vehicle pressure, including the load configuration, driving type Configuration, speed type configuration, front Axle placard pressure, as well as rear Axle placard pressure. The value shall be set as specified in table 3, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	18	Wheel specific data definition				This data element provides type of information (wheel specific data) that will be provided for each tyre i.e. front left tyre, front right tyre, rear left tyre, rear right tyre, spare tyre. It provides the definition of data elements that will follow. The value shall be set as specified in table 2, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
Wheel specific data (front left tyre)	19	Current Tyre Pressure - front left tyre		2,5 kPaabs		Current tyre pressure measured for front left tyre. The value shall be set as specified in table 3, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
	20	Tyre Side Wall Information - front left tyre				Tyre side wall information of front left tyre, including dimension, load index and speed index. The value shall be set as specified in table 3, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	21	Tyre type - front left tyre				Type of the front left tyre. The value shall be set as specified in table 3, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	22	Air temperature inside tyre - front left tyre		1 °C		Current Air temperature inside tyre as measured for front left tyre. The value shall be set as specified in table 3, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	23	Recommended Pressure - front left tyre	8 bits	5 kPa		Recommended pressure (Pa) based on current vehicle configuration and wheel specific data. The value shall be set as specified in table 3, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	24	TIN - front left tyre	64 bits			Tyre Identification Number. The value shall be set as specified in table 3, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	25	Sensor state - front left tyre	16 bits			Wheel Fitted Component sensor state reflects diagnosis information, provided by TIS. E.g. WFC functionality or battery life time. The value shall be set as specified in table 3, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
Wheel specific data (front right tyre)	26					Wheel specific data for front right tyre, as defined in data element 19 to 25.
Wheel specific data (Rear Left tyre)	27					Wheel specific data for rear left tyre, as defined in data element 19 to 25.
Wheel specific data (Rear right tyre)	28					Wheel specific data for rear right tyre, as defined in data element 19 to 25.
Spare tyre	29					Wheel specific data for spare tyre, as defined in data element 19 to 25.
NOTE: More than one pressure configuration may be transmitted per tyre set variant.						

5.5.3 EOFM data structure

The EOFM shall be structured as specified in table 5.5.3.1 and shall be compliant to requirements as defined in CEN EN 16661 [1], table 4. The EOFM encapsulates the data structure as defined CEN EN 16661 [1] with ITS PDU Header as specified in ETSI 102 894-2 [5] *ItsPduHeader*.

Data elements may be imported from ETSI TS 102 894-2 [5]. In this case, the data presentation, including type and unit shall be as specified in ETSI TS 102 894-2 [5]. Otherwise, the data elements shall be as presented as specified in the present clause.

NOTE: When Unaligned PER encoding scheme is used, the length indication of data elements as defined in CEN EN 16661 [1] is obsolete.

Table 5.5.3.1: EOFM data structure specification

Container	#	Data Element	Type	Unit	M/O	Description and data setting rules
ItsPduHeader	1	Protocol version			M	Shall be as specified in table 5.1.1.4.1.
	2	Message ID			M	Shall be as specified in table 5.1.1.4.1.
	3	Originator ID				ITS-S ID of the ITS-S that generates and transmits the TRM. It shall be presented as specified in table 5.1.1.4.1.
TPMS EOFM Management Container	4	Generation Time			M	Time at which the message is generated. It shall be presented as *TimestampIts* as specified in ETSI TS 102 894-2 [5].
	5	Filling status			M	To indicate the filling status. The value shall be set and presented as specified in Annex A of the present document.
	6	Number of applied tyre pressure			M	Number of applied tyre pressure values. It indicates the number of repetition of data element 7 *Applied Tyre pressures.* The value shall be set as specified in table 4, clause 6.2 of CEN EN 16661 [1]. It shall be presented as specified in Annex A of the present document.
	7	Applied Tyre pressures	String	2,5 kPa	O	Applied tyre pressure, as defined in CEN EN 16661 [1] $P_{applied}$. The data element shall be repeated if the number of pressure is more than one. It shall be presented as specified in Annex A of the present document.
	9	PairingID			O	Pairing ID being used for refilling.

6 Communication system operational requirements

6.1 Security requirements

For message exchanges in refilling process, authenticity service in accordance with ETSI TS 103 097 [i.2] should be used, i.e. message signature. Unless specified otherwise, the general profile as defined in ETSI TS 103 097 [i.2] should be used. Data exchanged within this process depends on the TIS profile and the TPG automation level, no specific service permission is required.

For message exchanges in discovery and reservation process, the security profile may vary depending on the implementation.

EXAMPLE: In case the discovery and reservation services are provided by private company (e.g. telematics service provider), users may be required to have specific user account to access to service.

6.2 System performances requirements

6.2.1 Void

6.2.2 Messages broadcasting frequencies

When applicable, the messages specified in clause 5 should have a maximum frequency of 0,1 Hz by default.

Annex A (normative): ASN.1 message descriptions

```
-- TIS-TPG Transactions message definitions
-- ASN.1 Start Definition

TIS-TPG-Transactions-Descriptions {
itu-t (0) identified-organization (4) etsi (0) itsDomain (5)
wg1 (1) i2vApplications (101556) tpms (2) transactions (1) version (1)}
DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
ItsPduHeader, CauseCode, ReferencePosition, Speed, Heading, TimestampIts, StationID
FROM ITS-Container {
 itu-t (0) identified-organization (4) etsi (0) itsDomain (5) wg1 (1) ts (102894) cdd (2) version
(1)
};



-- Root Message PDU: TisTpgTransactionsPdu

TisTpgTransactionsPdu ::= SEQUENCE {
    header ItsPduHeader,
    tisTpgTransaction TisTpgTransaction
}

TisTpgTransaction ::= CHOICE {
    drm TisTpgDRM,
    snm TisTpgSNM,
    trm TisTpgTRM,
    tcm TisTpgTCM,
    vdrm TisTpgVDRM,
    vdpm TisTpgVDPM,
    eofm TisTpgEOFM
}

-- TisTpgDRM

TisTpgDRM ::= SEQUENCE {
 management TisTpgDRM-Management,
 situation TisTpgDRM-Situation,
 location TisTpgDRM-Location,
 ...
}

TisTpgDRM-Management ::= SEQUENCE {
 generationTime TimestampIts,
 vehicleType UNVehicleClassifcation,
 costumerContract CustomerContract OPTIONAL,
 tisProfile TisProfile,
 ...
}

TisTpgDRM-Situation ::= SEQUENCE {
 causeCode  CauseCode,
 ...
}

TisTpgDRM-Location ::= SEQUENCE {
 vehiclePosition ReferencePosition,
 vehicleSpeed Speed,
 vehicleHeading Heading,
 requestedPosition ReferencePosition OPTIONAL,
 searchRange SearchRange OPTIONAL,
 searchCondition SearchCondition OPTIONAL,
 ...
}

-- TisTpgSNM

TisTpgSNM ::= SEQUENCE {
 management TisTpgSNM-Management,
```

```
 tpgContainer TpgNotifContainer
}

TisTpgSNM-Management ::= SEQUENCE {
 generationTime TimestampIts,
 totalTpgStations TotalTpgStations,
 ...
}

-- TisTpgTRM

TisTpgTRM ::= SEQUENCE {
 management TisTpgTRM-Management,
 situation TisTpgTRM-Situation OPTIONAL,
 location TisTpgTRM-Location OPTIONAL,
 ...
}

TisTpgTRM-Management ::= SEQUENCE {
 generationTime TimestampIts,
 vehicleType UNVehicleClassifcation,
 tpgStationID StationID,
 reservationStatus ReservationStatus,
 costumercontract CustomerContract OPTIONAL,
 reservationID ReservationID OPTIONAL,
 ...
}

TisTpgTRM-Situation ::= SEQUENCE {
 estArrivalTime TimestampIts,
 proposedPairingID PairingID OPTIONAL
}

TisTpgTRM-Location ::= SEQUENCE {
 vehiclePosition ReferencePosition,
 vehicleSpeed Speed,
 vehicleHeading Heading,
 ...
}

-- TisTpgTCM

TisTpgTCM ::= SEQUENCE {
 management TisTpgTCM-Management,
 situation TisTpgTCM-Situation OPTIONAL,
 location TisTpgTCM-Location OPTIONAL,
 ...
}

TisTpgTCM-Management ::= SEQUENCE {
 generationTime TimestampIts,
 tpgStationID StationID,
 reservationStatus ReservationStatus,
 reservedTpg INTEGER(1..65535)  OPTIONAL,
 costumercontract CustomerContract OPTIONAL,
 reservationID  ReservationID OPTIONAL,
 tpgAutomationLevel TpgAutomation OPTIONAL,
 ...
}

TisTpgTCM-Situation::= SEQUENCE {
 pairingID PairingID OPTIONAL,
 reservationTimeLimit TimestampIts,
 cancellationCondition CancellationCondition OPTIONAL,
 ...
}

TisTpgTCM-Location::= SEQUENCE {
 tpgLocation ReferencePosition OPTIONAL,
 address UTF8String(SIZE(1..128)) OPTIONAL,
 ...
}

-- TisTpgVDRM

TisTpgVDRM ::= SEQUENCE {
 management TisTpgVDRM-Management,
 ...
```

```
}

TisTpgVDRM-Management ::= SEQUENCE {
 generationTime TimestampIts,
 fillingStatus FillingStatus,
 automationLevel TpgAutomation,
 pairingID  PairingID OPTIONAL,
 ...
}

-- TisTpgVDPM

TisTpgVDPM ::= SEQUENCE {
 management TisTpgVDPM-Management,
 placardTable PlacardTable,
 vehicleSpecificData VehicleSpecificData OPTIONAL,
 ...
}

TisTpgVDPM-Management ::= SEQUENCE {
 generationTime TimestampIts,
 tisProfile TisProfile  OPTIONAL,
 language Language,
 vehicleType UNVehicleClassifcation,
 tyreTempCondition TyreTempCondition,
 fillingStatus FillingStatus,
 pairingID PairingID OPTIONAL,
 ...
}

VehicleSpecificData ::= SEQUENCE {
 currentVehicleConfiguration PressureConfiguration,
 frontLeftTyreData TyreData,
 frontRightTyreData TyreData,
 rearLeftTyreData TyreData,
 rearRightTyreData TyreData,
 spareTyreData TyreData,
 ...
}

-- TisTpgEOFM

TisTpgEOFM ::= SEQUENCE {
 management TisTpgEOFM-Management,
 ...
}

TisTpgEOFM-Management ::= SEQUENCE {
 generationTime TimestampIts,
 fillingStatus FillingStatus,
 numberOfAppliedPressure NumberOfAppliedPressure,
 appliedTyrePressures AppliedTyrePressures OPTIONAL,
 pairingID  PairingID OPTIONAL,
 ...
}

PlacardTable ::= SEQUENCE(SIZE(0..15)) OF TyreSetVariant

TyreSetVariant ::= SEQUENCE
{
    variantID TyreSetVariantID,
    frontAxleDimension TyreSidewallInformation OPTIONAL,
    rearAxleDimension TyreSidewallInformation OPTIONAL,
    pressureVariantsList PressureVariantsList
}

PressureVariantsList ::= SEQUENCE(SIZE(1..15)) OF PressureVariant

PressureVariant ::= SEQUENCE
{
    pressureConfiguration PressureConfiguration,
    frontAxlePressure AxlePlacardPressure,
    rearAxlePressure AxlePlacardPressure
}

TyreData ::= SEQUENCE
{
    currentTyrePressure CHOICE {
```

```
      tyrePressureValue TyrePressure,
      unavailable NULL
    } OPTIONAL,
    tyreSidewallInformation CHOICE {
      tyreSidewallInformationValue TyreSidewallInformation,
      unavailable NULL
    } OPTIONAL,
    currentInsideAirTemperature CHOICE {
      tyreAirTemperatureValue TyreAirTemperature,
      unavailable NULL
    } OPTIONAL,
    recommendedTyrePressure CHOICE {
      axlePlacardPressureValue AxlePlacardPressure,
      unavailable NULL
    } OPTIONAL,
    tin CHOICE {
     tinValue TIN,
     unavailable NULL
    } OPTIONAL,
    sensorState CHOICE {
      sensorStateValue SensorState,
      unavailable NULL
    } OPTIONAL,
    ...
}

AppliedTyrePressure ::=  CHOICE {
 tyrePressureValue TyrePressure,
 unavailable NULL
}

TpgStationData ::= SEQUENCE {
 tpgStationID StationID,
 tpgAutomationLevel TpgAutomation,
 tpgNumber TpgNumber,
 tpgProvider TpgProvider,
 tpgLocation ReferencePosition,
 accessibility Accessibility,
 address UTF8String(SIZE(1..128))  OPTIONAL,
 phoneNumber PhoneNumber OPTIONAL,
 digitalMap DigitalMap OPTIONAL,
 openingDaysHours OpeningDaysHours OPTIONAL,
 bookingInfo BookingInfo OPTIONAL,
 availableTpgNumber AvailableTpgNumber OPTIONAL,
 cancellationCondition CancellationCondition OPTIONAL,
 ...
}

TyreSidewallInformation ::= BIT STRING (SIZE (60))

CurrentVehicleConfiguration ::= BIT STRING (SIZE (9))

AxlePlacardPressure ::= INTEGER { zero (0), fiveKPa (1) } (0..255)

SensorState ::= INTEGER { malfunction(65534), unavailable(65535) } (0..65535)

TyrePressure ::= INTEGER { invalid (0), lessThanOneBar (1), oneBar (2), oneBarPlusTwoAndHalfKPa (3),
inflation (254), overflow(255)  } (0..255)

DriverLanguage ::= INTEGER {english (0), german (1), french (2), italian (3), spanish (4) } (0..15)

TyreTempCondition ::= ENUMERATED {pressure-cold (0),pressure-warm (1), unavailable (2), ...  }

TyreAirTemperature ::= INTEGER { invalid (0), lessThanMinus50Celsius(1), minus50Celsius(2),
minus49Celsius(3), zeroCelsius(52), overflowThreshold1(240), overflowThreshold2(241),
overflowThreshold3(242), overflowThreshold4(243), overflowThreshold5(244), overflowThreshold6(245),
overflowThreshold7(246), overflowThreshold8(247), overflowThreshold9(248), overflowThreshold10(249),
overflowThreshold11(250), overflowThreshold12(251), overflowThreshold13(252),
overflowThreshold14(253), overflowThreshold15(254), overflowThreshold16(255) } (0..255)

TIN ::= BIT STRING (SIZE(64))

PressureConfiguration ::= BIT STRING (SIZE (9))

CustomerContract ::= IA5String(SIZE(1..32))

ReservationStatus ::= ENUMERATED { reservationOK (0), noReservationService (1), noTpmsAvailable (2),
...}
```

```
PairingID ::= INTEGER(0..9999)

AppliedTyrePressures ::= SEQUENCE (SIZE(1..5)) OF AppliedTyrePressure

SearchRange ::= INTEGER(0..255)

TotalTpgStations ::= INTEGER(0..65535)

TpgNotifContainer ::= SEQUENCE (SIZE(1..8)) OF TpgStationData

DigitalMap ::= SEQUENCE (SIZE(1..256)) OF ReferencePosition

TpgNumber ::= INTEGER(1..65535)

TpgProvider ::= UTF8String (SIZE(1..32))

TpgLocation ::= ReferencePosition

Accessibility ::= UTF8String (SIZE(1..32))

PhoneNumber ::= NumericString (SIZE(1..16))

OpeningDaysHours ::= UTF8String

BookingInfo ::= UTF8String

AvailableTpgNumber ::= INTEGER(1..65535)

CancellationCondition ::= UTF8String (SIZE(1..32))

TpgAutomation ::= BIT STRING  {fullAutomated(0), semiAutomated(1), manual(2), reserved (3)}
(SIZE(4))

FillingStatus ::= INTEGER {requestVehicleData(0), sendVehicleData(1), started(2),
fillingProcessFailed (3), fillingProcessCompleted (4) } (0..7)

NumberOfAppliedPressure ::= INTEGER {oneAppliedPressure(1), twoAppliedPressure (2)} (1..5)

UNVehicleClassifcation ::= INTEGER {reserved(0), categoryL1(1), categoryL2(2), categoryL3(3),
categoryL4(4), categoryL5(5), categoryL6(6), categoryL7(7), categoryL8(8)} (0..63)

SearchCondition ::= INTEGER {nearest(0), quickest(1), paylessRoad(2)} (0..7)

TisProfile ::= BIT STRING  {reserved(0),profileOne(1), profileTwo(2), profileThree(3)} (SIZE(8))

ReservationID ::= UTF8String (SIZE(1..32))

Language ::= BIT STRING (SIZE (10))

TyreSetVariantID ::= INTEGER (0..15)

END
```

History

Document history		
V1.1.1	February 2016	Publication