INTERNATIONAL STANDARD

ISO 21219-18

First edition
2019-07

Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2) —

Part 18: Traffic flow and prediction application (TPEG2-TFP)

Systèmes intelligents de transport — Informations sur le trafic et le tourisme via le groupe expert du protocole de transport, génération 2 (TPEG2) —

Partie 18: Flux de trafic et application de prédiction (TPEG2-TFP)

Reference number
ISO 21219-18:2019(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

This first edition cancels and replaces ISO/TS 21219-18:2015, which has been technically revised.

A list of all parts in the ISO 21219 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

History

TPEG technology was originally proposed by the European Broadcasting Union (EBU) Broadcast Management Committee, who established the B/TPEG project group in the autumn of 1997 with a brief to develop, as soon as possible, a new protocol for broadcasting traffic and travel-related information in the multimedia environment. TPEG technology, its applications and service features were designed to enable travel-related messages to be coded, decoded, filtered and understood by humans (visually and/or audibly in the user's language) and by agent systems. Originally, a byte-oriented data stream format, which may be carried on almost any digital bearer with an appropriate adaptation layer, was developed. Hierarchically structured TPEG messages from service providers to end-users were designed to transfer information from the service provider database to an end-user's equipment.

One year later, in December 1998, the B/TPEG group produced its first EBU specifications. Two documents were released. Part 2 (TPEG-SSF, which became ISO/TS 18234-2) described the syntax, semantics and framing structure, which was used for all TPEG applications. Meanwhile, Part 4 (TPEG-RTM, which became ISO/TS 18234-4) described the first application for road traffic messages.

Subsequently, in March 1999, CEN/TC 278, in conjunction with ISO/TC 204, established a group comprising members of the former EBU B/TPEG and this working group continued development work. Further parts were developed to make the initial set of four parts, enabling the implementation of a consistent service. Part 3 (TPEG-SNI, ISO/TS 18234-3) described the service and network information application used by all service implementations to ensure appropriate referencing from one service source to another.

Part 1 (TPEG-INV, ISO/TS 18234-1) completed the series by describing the other parts and their relationship; it also contained the application IDs used within the other parts. Additionally, Part 5, the public transport information application (TPEG-PTI, ISO/TS 18234-5), was developed. The so-called TPEG-LOC location referencing method, which enabled both map-based TPEG-decoders and non-map-based ones to deliver either map-based location referencing or human readable text information, was issued as ISO/TS 18234-6 to be used in association with the other applications of parts of the ISO/TS 18234 series to provide location referencing.

The ISO/TS 18234 series has become known as TPEG Generation 1.

TPEG Generation 2

When the Traveller Information Services Association (TISA), derived from former forums, was inaugurated in December 2007, TPEG development was taken over by TISA and continued in the TPEG applications working group.

It was about this time that the (then) new Unified Modelling Language (UML) was seen as having major advantages for the development of new TPEG applications in communities who would not necessarily have binary physical format skills required to extend the original TPEG TS work. It was also realized that the XML format for TPEG described within the ISO/TS 24530 series (now superseded) had a greater significance than previously foreseen, especially in the content-generation segment and that keeping two physical formats in synchronism, in different standards series, would be rather difficult.

As a result, TISA set about the development of a new TPEG structure that would be UML-based. This has subsequently become known as TPEG Generation 2.

TPEG2 is embodied in the ISO/TS 21219 series and it comprises many parts that cover introduction, rules, toolkit and application components. TPEG2 is built around UML modelling and has a core of rules that contain the modelling strategy covered in ISO 21219-2, ISO 21219-3 and ISO 21219-4 and the conversion to two current physical formats: binary and XML; others could be added in the future. TISA uses an automated tool to convert from the agreed UML model XMI file directly into an MS Word document file, to minimize drafting errors, that forms the annex for each physical format.

TPEG2 has a three-container conceptual structure: message management (ISO 21219-6), application (several parts) and location referencing (ISO/TS 21219-7). This structure has flexible capability and can accommodate many differing use cases that have been proposed within the TTI sector and wider for hierarchical message content.

TPEG2 also has many location referencing options as required by the service provider community, any of which may be delivered by vectoring data included in the location referencing container.

The following classification provides a helpful grouping of the different TPEG2 parts according to their intended purpose. Note that the list below may be incomplete, e.g. new TPEG2 parts may be introduced after publication of this document.

— Toolkit parts: TPEG2-INV (ISO/TS 21219-1), TPEG2-UML (ISO 21219-2), TPEG2-UBCR (ISO 21219-3), TPEG2-UXCR (ISO 21219-4), TPEG2-SFW (ISO 21219-5), TPEG2-MMC (ISO 21219-6), TPEG2-LRC (ISO/TS 21219-7).

— Special applications: TPEG2-SNI (ISO/TS 21219-9), TPEG2-CAI (ISO/TS 21219-10), TPEG2-LTE (ISO/TS 21219-24).

— Location referencing: TPEG2-OLR (ISO/TS 21219-22), TPEG2-GLR (ISO/TS 21219-21), TPEG2-TLR (ISO 17572-2), TPEG2-DLR (ISO 17572-3).

— Applications: TPEG2-PKI (ISO/TS 21219-14), TPEG2-TEC (ISO/TS 21219-15), TPEG2-FPI (ISO/TS 21219-16), TPEG2-TFP (ISO 21219-18), TPEG2-WEA (ISO/TS 21219-19), TPEG2-RMR (ISO/TS 21219-23), TPEG2-EMI (ISO/TS 21219-25), TPEG2-VLI (ISO/TS 21219-26).

TPEG2 has been developed to be broadly (but not totally) backward compatible with TPEG1 to assist in transitions from earlier implementations, while not hindering the TPEG2 innovative approach and being able to support many new features, such as dealing with applications having both long-term, unchanging content and highly dynamic content, such as parking information.

This document is based on the TISA specification technical/editorial version reference: SP17001.

Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2) —

Part 18:
Traffic flow and prediction application (TPEG2-TFP)

1 Scope

This document specifies the TPEG application Traffic Flow and Prediction (TFP). It has been specifically designed to provide information to a variety of receivers using different channels, including in the first instance digital broadcasting and Internet technologies. Traffic flow and prediction messages are intended for in-car applications and can also be presented directly to the user by textual, voice and graphical output devices.

TFP is status oriented, i.e. the transmitted information continuously updates the receiver's knowledge for a dedicated road network. In particular the traffic states are delivered any time and for all road sections of the network, even when there are no abnormal traffic situations.

Generally, TFP focuses on the following requirements:

— provides dynamic navigation systems with up-to-date traffic state information;

— ensures travel safety for the driver;

— enables the calculation of alternative routes;

— avoids delays (e.g. traffic jams);

— lowers traffic load on over-saturated parts of the network;

— keeps the driver informed about current and upcoming traffic;

— compact and efficient coding of the traffic information.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
Message Management Container
concept applied to the grouping of all message elements, including Message Management Information, of a TPEG-Message together in one place

3.2
Location Referencing
means to provide information that allows a system to accurately identify a location

Note 1 to entry: The content of a location reference allows the location to be presented in a graphical or textual manner to the end-user (e.g. coloured network graphs) as well as to be used for navigational systems purposes.

3.3
Location Referencing Container
concept applied to the grouping of all the Location Referencing elements, of a TPEG-Message, together in one place

Note 1 to entry: See ISO/TS 21219-7 for full details of the Location Referencing container.

4 Abbreviated terms

ACID	Application and Content Identifier
ADC	Application Data Container
AID	(TPEG) Application IDentification
CEN	Comité Européen de Normalisation
EBU	European Broadcasting Union
ITS	Intelligent Transport Systems
LRC	Location Referencing Container
MMC	Message Management Container
OSI	Open Systems Interconnection
SFW	(TPEG) Service Framework
SID	Service and Network Information
SNI	Service and Network Information
TISA	Traveller Information Services Association
TFP	Traffic Flow and Prediction
TMC	Traffic Message Channel
TPEG	Transport Protocol Expert Group
TTI	Traffic and Traveller Information
UML	Unified Modelling Language
XML	Extensible Markup Language
XSD	XML Schema Definition

5 Application specific constraints

5.1 Application identification

The word 'application' is used in the TPEG specifications to describe specific subsets of the TPEG structure. An application defines a limited vocabulary for a certain type of message, e.g. parking information or road traffic information. Each TPEG application is assigned a unique number, called the Application IDentification (AID). An AID is defined whenever a new application is developed. These are all listed in ISO/TS 21219-1.

The application identification number is used within the TPEG2-SNI application (ISO/TS 21219-9) to indicate how to process TPEG content and facilitates the routing of information to the appropriate application decoder.

5.2 Version number signalling

Version numbering is used to track the separate versions of an application through its development and deployment. The differences between these versions may have an impact on client devices.

The version numbering principle is defined in ISO/TS 21219-1.

Table 1 shows the current version numbers for signaling TFP within the SNI application.

Table 1 — Current version numbers for signalling of TFP

major version number	**1**
minor version number	**1**

5.3 Ordered components

TPEG2-TFP requires a fixed order of TPEG components. The order for the TFP message component is shown in Figure 1; the first component shall be the *Message Management Container*. This shall be the only component if the message is a cancellation message. Otherwise, the MMC component shall be followed by one or more *Application Data Container* components, which includes the traffic flow information. This shall be followed by the *Location Referencing Container* component, if the LRC is present in this message (see also 7.1).

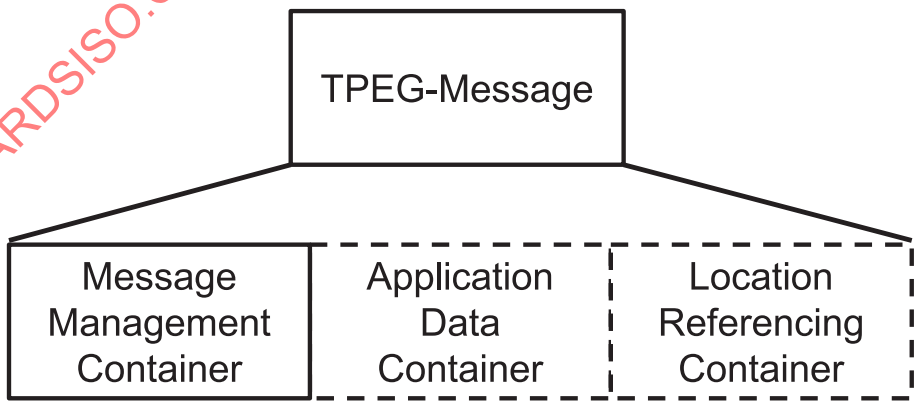


Figure 1 — Composition of TPEG messages

5.4 Extendibility

The requirement of a fixed component order does not affect the extension of TFP. Future application extensions may insert new components or may replace existing components by new ones without

losing backward compatibility. This means that a TFP decoder shall be able to detect and skip unknown components.

5.5 TPEG Service Component Frame

TPEG2 TFP makes use of the "Service Component Frame with dataCRC, groupPriority, and messageCount" according to ISO 21219-5.

6 TFP structure

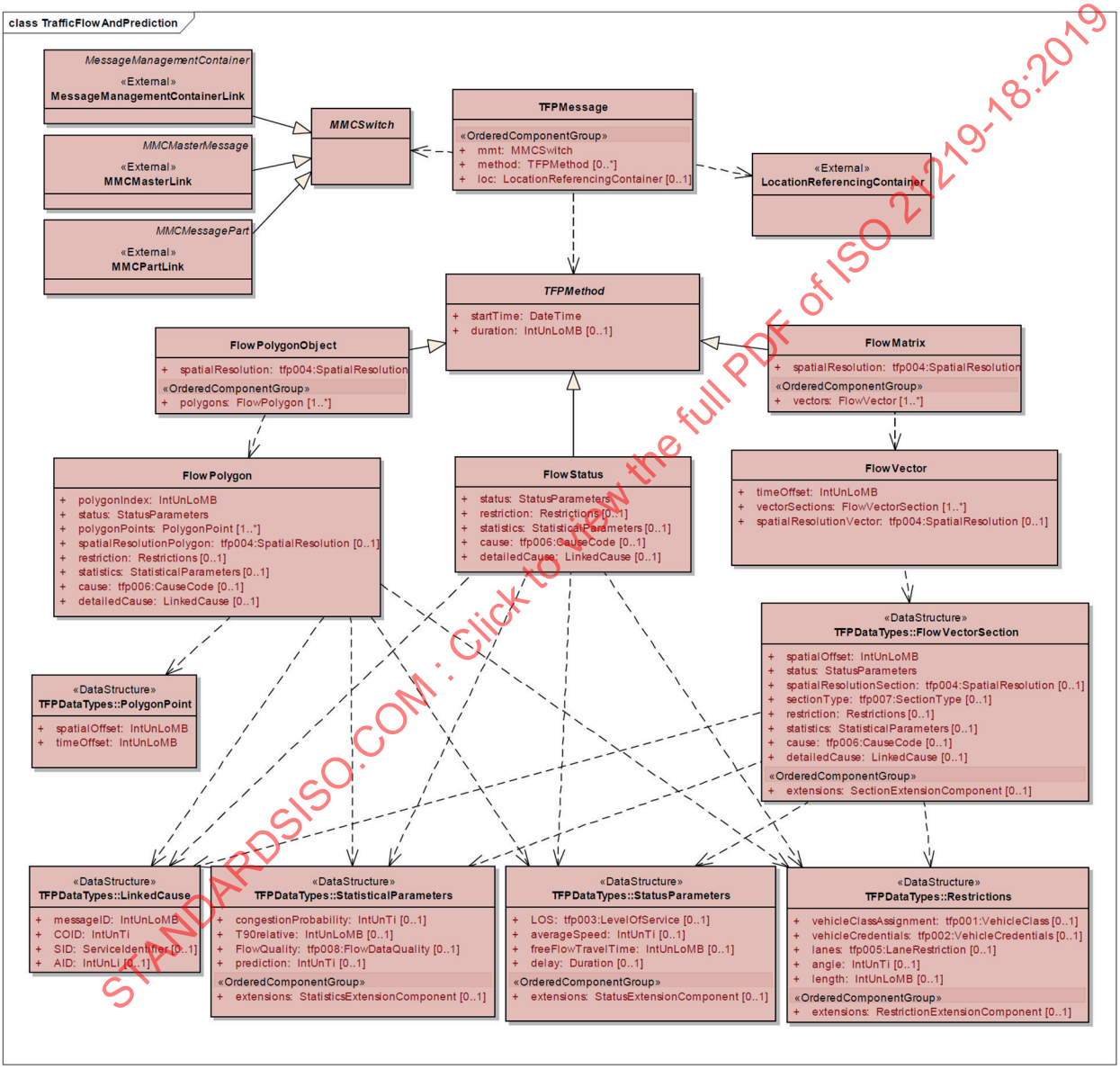


Figure 2 — TFP message structure

7 TFP Message components

7.1 TFPMessage

A 'TFPMessage' component is the top container of a TFP message. It contains all information about a particular part of the network, e.g. the traffic state for a road segment.

The traffic flow content of a TFPMessage is typically highly dynamic while the affected road stretch defined by the Location Referencing Container (LRC) shall remain static during the life cycle of a message. Thus, partial message management (ISO 21219-6) may be applied to update the traffic flow states of a message frequently whereas the LRC may be repeated with a longer repetition interval. Accordingly, a TFP message can include alternatively:

— One MMC only in case of a cancellation message (ISO 21219-6);

— One MMC, one or several ADCs and one LRC in case of monolithic message management (ISO/TS 21219-6);

— Partial message management (ISO/TS 21219-6):

  — One MMC only, including the multipart message directory,

  — One MMC and one or several ADCs,

  — One MMC and one LRC.

TFP provides three methods for the representation of current and predicted traffic flow states which may be used alternatively, i.e. just one method shall be applied within one TFP message:

— Flow-Polygon-Method: The traffic flow is modelled by a number of spatial/temporal 'FlowPolygonObjects' (see description of component 'FlowPolygonObject', 7.8).

— FlowStatus-Method: A flow status applied to the overall road stretch defined by the LRC of the message (see description of component 'FlowStatus', 7.10). A TFP message using this method and which is not a cancellation message shall contain exactly one 'FlowStatus' container.

— Flow-Matrix-Method: The road stretch is divided into sections each with a homogenous flow state, thus building a 'FlowVector'. A 'FlowMatrix' consists of one or several FlowVectors for dedicated temporal intervals, e.g. with one FlowVector for the current flow status and another one for prognosis in 15 min (see description of components 'FlowMatrix', 7.11). A TFP message using this method and which is not a cancellation message shall contain exactly one 'FlowMatrix' container.

To minimize the length of TFP messages the spatial positions of the Flow-Matrix and Flow-Polygon methods are coded by spatial offsets to the location reference in the LRC. These offsets shall be calculated in upstream direction to the end of the road stretch as defined by the location reference of the message (see also 8.3). The location reference in the LRC shall cover the entire road stretch required for this TFP message. The Flow-Matrix method allows also the usage of relative offsets (see 7.11).

The attributes of the 'TFPMessage' component are listed hereunder:

Table 2 — TFPMessage

Name	Type	Multiplicity	Description
Ordered Components			
mmc	MessageManagementContainer (external)	1	Message Management Container
method	Component TFPMethod	0..*	Traffic flow data
loc	LocationReferencingContainer (external)	0..1	Location Referencing Container

7.2 TFPMethod

Traffic conditions are modelled as traffic flow objects. TFP provides three different methods to define such an object, for details see descriptions of components 'FlowPolygonObject', FlowStatus' and FlowMatrix'.

The template 'TFPMethod' is the generalization of these three methods.

Name	Type	Multiplicity	Description
startTime	DateTime	1	The start of the time period for which the provided content is valid.
duration	IntUnLoMB	0..1	The duration [min] of the time period for which the provided content is valid. The period starts at 'startTime' and ends at 'startTime'+'duration'. This attribute shall be used by the 'PolygonFlowObject' component and may be used if required otherwise.

7.3 MMCSwitch

The MMCSwitch component is an abstract component, allowing the flexible use of monolithic or multi-part message management.

7.4 MessageManagementContainerLink

The MessageManagementContainerLink is a placeholder for the MessageManagementContainer as defined in the MMC-toolkit specification (see ISO 21219-6). It assigns the Traffic Flow and Prediction application specific local component ID for the MMC container (see Annex A).

This component contains all and only information related to message management. The TPEG server side, especially the instance generating the transmission data, has to ensure that the message management information allows unambiguous interpretation over time and in appropriate scenarios with disturbed reception specific to the transmission channel.

TFP implementations may use both monolithic and partial message management (see ISO 21219-6). A TPEG service may contain messages with both MMC methods but it shall be used alternatively for a particular message, i.e. a dedicated message shall not be transmitted with an alternating partial/monolithic MMC.

7.5 MMCMasterLink

The MMCMasterLink is a placeholder for the Master-Message MMC for Multi-part message management, as defined in the MMC-toolkit specification (see ISO 21219-6). It assigns the Traffic Flow and Prediction application specific local component ID for the MMC container (see Annex A).

The TPEG server side, especially the instance generating the transmission data, has to ensure that the message management information allows unambiguous interpretation over time and in appropriate scenarios with disturbed reception specific to the transmission channel.

TFP implementations may use both monolithic and partial message management (see ISO 21219-6). A TPEG service may contain messages with both MMC methods but it shall be used alternatively for a particular message, i.e. a dedicated message shall not be transmitted with an alternating partial/monolithic MMC.

7.6 MMCPartLink

The MMCPartLink is a placeholder for the external Partial-Message MMC (MMCMessagePart) for multi-part message management, as defined in the MMC-toolkit specification (see ISO 21219-6). It assigns the Traffic Flow and Prediction application specific local component ID for the MMC container (see Annex A).

The TPEG server side, especially the instance generating the transmission data, has to ensure that the message management information allows unambiguous interpretation over time and in appropriate scenarios with disturbed reception specific to the transmission channel.

TFP implementations may use both monolithic and partial message management (see ISO 21219-6). A TPEG service may contain messages with both MMC methods but it shall be used alternatively for a particular message, i.e. a dedicated message shall not be transmitted with an alternating partial/ monolithic MMC.

7.7 LocationReferencingContainer

The LocationReferencingContainer component is a placeholder for the LocationReferencingContainer (LRC) as described in the LRC toolkit specification defined in ISO/TS 21219-7. It assigns the Traffic Flow and Prediction (TFP) application specific local component ID for the LRC container (see also Annex A). All component IDs within the LRC container are local to the LRC toolkit.

The location of a TFP message (e.g. a road stretch) may be quite stable where the related traffic flow values may change dynamically. Thus, the LRC may not be required in each version of the message. The MMC Partial Update mechanism shall be used if the LRC is not present in a TFP message. Accordingly, the sender side shall use a new message ID if the location respectively the LRC is changed.

The LRC component contains all information describing the location where the situation described in TFP is taking place. TFP shall use only linear locations to define the road stretch affected, but no area or point locations.

The **end of the LRC location** (in driving direction) defines the **Spatial Reference Point**. Based on this Reference Point offsets are used to dedicated points on the road stretch, e.g. Polygon Points (see description of the Flow-Polygon-Method, see 7.8) or delimiters of road sections (see description of the Flow-Matrix-Method, see 7.11).

If TMC location referencing (ISO 17572-3) is used in the LRC, the Spatial Reference Point shall be always the Primary Location. As the TMC Primary Location defines only an intersection and is thus not very accurate the following convention shall be applied in TFP for TMC locations (see also Figure 3).

It is strongly recommended that TFP services use only one-directional but no bi-directional location references.

As TFP uses linear locations only the TMC extent defining the secondary location shall be greater than 0, whenever it is feasible to construct an “TMC extent > 0” location reference for the TMC primary location, i.e. when this primary location has a predecessor TMC location against driving direction in the TMC location table.

Only in the exceptional case, when for a linear (road segment) location only a “TMC extent 0” location reference is possible (e.g. typically for P4.0 type link roads), then a TMC extent 0 location reference is permitted under the following condition. Any first spatial offset in an TMC extent 0 location reference shall always be assigned a spatial resolution of type ‘tfp004:start-of-location’ (for backward compatibility reasons).

The Spatial Reference Point for TMC locations is the position on the road stretch where the last entry or exit in driving direction is entering or leaving the road stretch (see Figure 3 below).

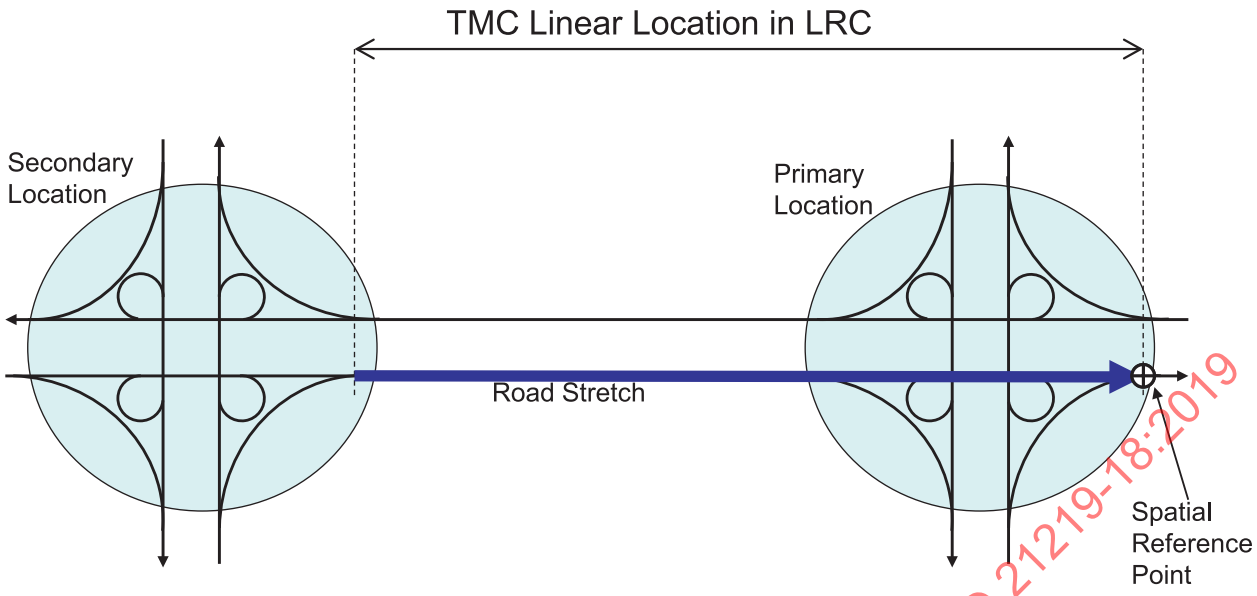


Figure 3 — Application of TMC location references in TFP

7.8 FlowPolygonObject

The Flow Polygon method describes the traffic situation within the network by a number of 'FlowPolygonObjects'. Each of these objects defines a spatial and temporal area with critical or congested conditions, whereas the rest of the considered road network is assumed to be in a free-flow state (see Figure 4 below).

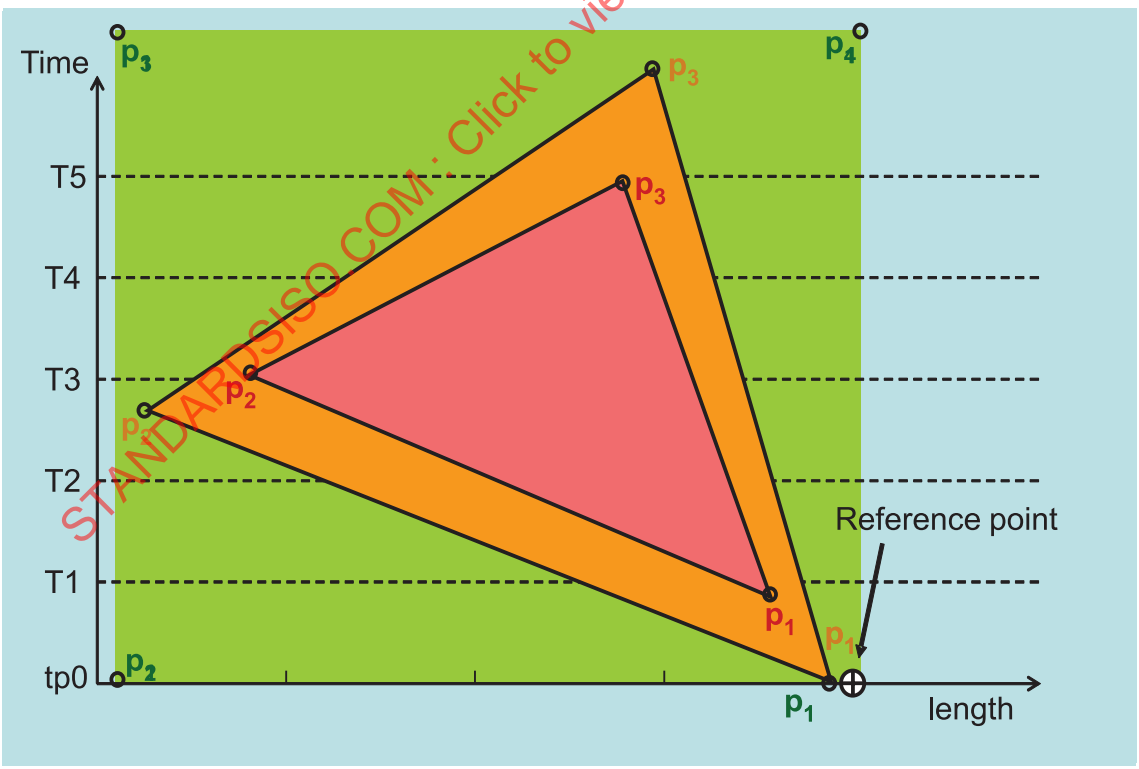


Figure 4 — Example of a Flow Polygon Object with 2 Flow Polygons

A particular 'FlowPolygonObject' consists of a set of nested 'FlowPolygons'. A Flow Polygon represents a distinct traffic flow state within a spatial and temporal area surrounded by a polygon, which is defined

by a vector of 'PolygonPoints'. For reasons of efficiency, these polygon points use the following offset information:

— spatial offsets to the end of location reference related to the message (Spatial Reference Point);

— temporal offsets to the start-time defined by the 'validityPeriod' of the surrounding 'FlowPolygonObject'.

The following requirements shall be fulfilled for the construction of the FlowPolygonObjects:

— Within a 'FlowPolygonObject' a traffic flow state related to a 'FlowPolygon' shall 'overwrite' in its temporal/spatial area the traffic status of a Flow Polygon with a lower value of the attribute 'polygonIndex' (e.g. in figure above the red polygon overrides the orange one).

— For that, the Flow Polygons of a Flow Polygon Object shall be ordered from 'outer to inner', i.e. the temporal/spatial area covered by the Flow Polygon with polygonIndex A shall be a sub-area of the Flow Polygon with polygonIndex B, if B is smaller than A (see also definition of component 'FlowPolygon').

— Only convex Flow Polygons shall be used in TFP, i.e. very internal angle of the surrounded area is less than 180 degrees.

— The vector of 'PolygonPoints' of a 'FlowPolygon' shall be ordered in clockwise direction starting with Polygon Point with the minimum value of attribute 'timeOffset'.

Table 3 defines the FlowPolygonObject component.

Table 3 — FlowPolygonObject

Name	Type	Multiplicity	Description
startTime	DateTime	1	The start of the time period for which the provided content is valid.
duration	IntUnLoMB	0..1	The duration [min] of the time period for which the provided content is valid. The period starts at 'startTime' and ends at 'startTime'+'duration'. This attribute shall be used by the 'PolygonFlowObject' component and may be used if required otherwise.
spatialResolution	tfp004: SpatialResolution	1	Resolution of the spatial offset used in this structure in steps of 10/50/100/500 m or TMC-locations. This spatial resolution value shall be used for all spatial offsets in the embedded 'FlowPolygon' components if not overridden there by the corresponding attribute 'spatialResolutionPolygon'. Relative spatial offsets (table entries 5 and 6) shall not be used. The 'start-of-location' spatial offset (table entry 7) shall neither be used.
polygons	Component FlowPolygon	1..*	Flow polygon data.

7.9 FlowPolygon

A 'FlowPolygon' includes a spatial/temporal area with a consistent traffic flow status.

Table 4 defines the FlowPolygon component.

Table 4 — FlowPolygon

Name	Type	Multiplicity	Description
polygonIndex	IntUnLoMB	1	Unique index within related 'FlowPolygonObject'. Used for ordering the FlowPolygons within the 'FlowPolygonObject'.
status	StatusParameters	1	Attributes describing the traffic flow status within the polygon
polygonPoints	PolygonPoint	1..*	Vector with polygon points
spatialResolutionPolygon	tfp004: SpatialResolution	0..1	Resolution of the spatial offset used for this polygon, in steps of 10/50/100/500 m or TMC-locations. The value of this attribute — if present — overrides for this FlowPolygon the attribute value 'spatialResolution' of the related 'FlowPolygonObject' component. Relative spatial offsets (table entries 5 and 6) shall not be used.
restriction	Restrictions	0..1	Information on restrictions related to the reported traffic flow.
statistics	StatisticalParameters	0..1	Statistical information related to the reported flow status.
cause	tfp006: CauseCode	0..1	A simple cause for the reported traffic flow status may be added by this attribute; this parameter shall be omitted if a detailed cause is available by an external message (see attribute 'linked cause')
detailedCause	LinkedCause	0..1	A detailed cause may be reported by a linked message (e.g. a TEC-message)

7.10 FlowStatus

The 'FlowStatus' component includes the information about the traffic flow status at a dedicated location defined by the LRC and for a distinct time interval.

A message may contain more than one 'FlowStatus' component in order to provide information for several vehicle classes or for several time intervals.

Table 5 defines the FlowStatus component.

Table 5 — FlowStatus

Name	Type	Multiplicity	Description
startTime	DateTime	1	The start of the time period for which the provided content is valid.
duration	IntUnLoMB	0..1	The duration [min] of the time period for which the provided content is valid. The period starts at 'startTime' and ends at 'startTime'+'duration'. This attribute shall be used by the 'PolygonFlowObject' component and may be used if required otherwise.
status	StatusParameters	1	Attributes describing the traffic flow status at the related location.
restriction	Restrictions	0..1	Information on restrictions related to the reported traffic flow.

Table 5 *(continued)*

Name	Type	Multiplicity	Description
statistics	StatisticalParameters	0..1	Statistical information related to the reported flow status.
cause	tfp006:CauseCode	0..1	A simple cause for the reported traffic flow status may be added by this attribute; this parameter shall be omitted if a detailed cause is available by an external message (see attribute 'linked cause').
detailedCause	LinkedCause	0..1	A detailed cause may be reported by a linked message (e.g. a TEC-message).

7.11 FlowMatrix

The Flow Matrix method describes the traffic situation of the considered road network using temporal and spatial matrices of traffic flow states, such that the overall considered network is covered by the transmitted matrix objects (see Figure 5 below):

— A particular 'FlowMatrix' component covers a dedicated part of the road network, e.g. a road or a section of a road. It is composed of a number of 'FlowVectors'. In particular a Flow Matrix may include one Flow Vector, e.g. if no forecast data are available and only the current traffic status on the network part is transmitted.

— Each 'FlowVector' of a 'Flow Matrix' covers the same network part but only for a dedicated time interval (e.g. the FlowVectors in Figure 5 may have one vector for current status and each one for 15/30/45/60 min prognosis). The temporal partition is determined by temporal offsets to the value of attribute 'startTime' of the related 'FlowMatrix' object.

— The spatial area of a Flow Vector is divided into 'FlowVectorSections' with consistent traffic flow states. This spatial partition is determined by spatial offsets to the end point of the affected road stretch defined by the LRC (see also use cases below). For the Flow Matrix method relative offsets to the beginning of the following section may also be used (see use case 6 below).

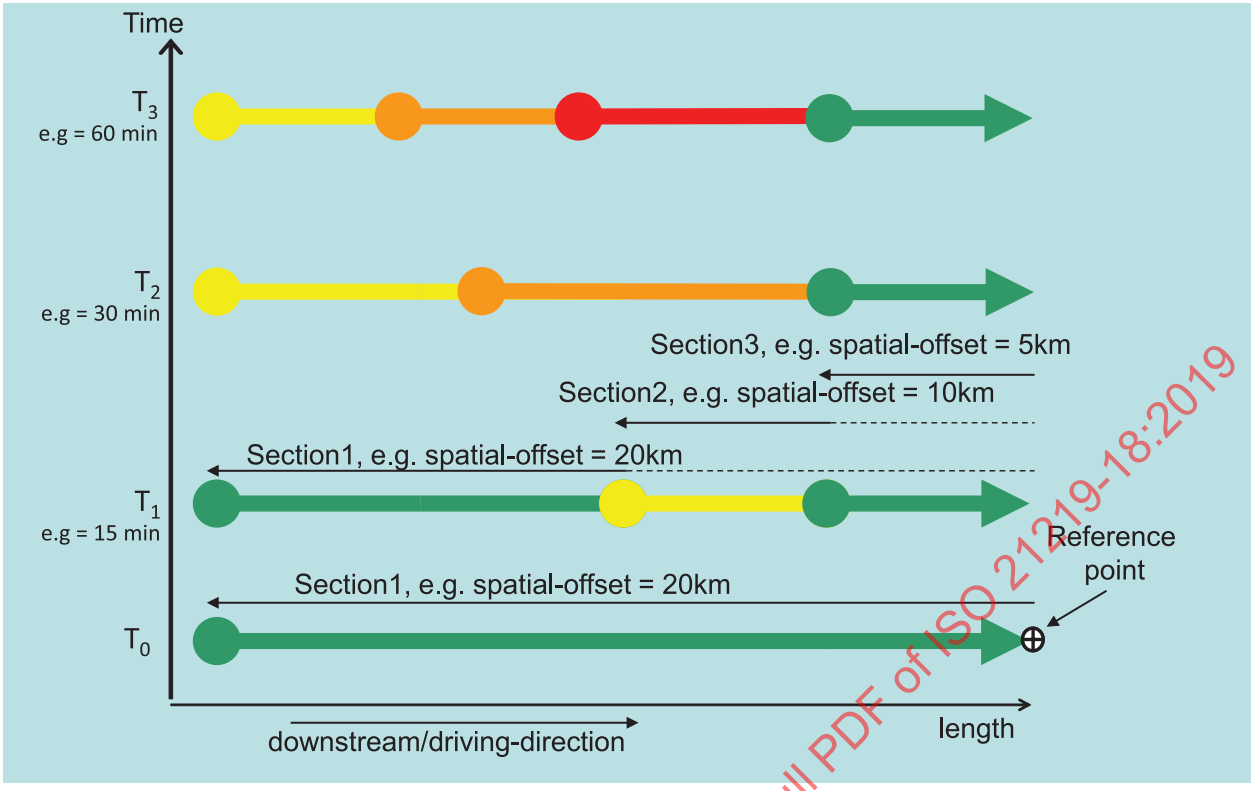


Figure 5 — Example of a Flow Matrix Object with 4 Flow Vectors (1 for current status, 3 for prognosis)

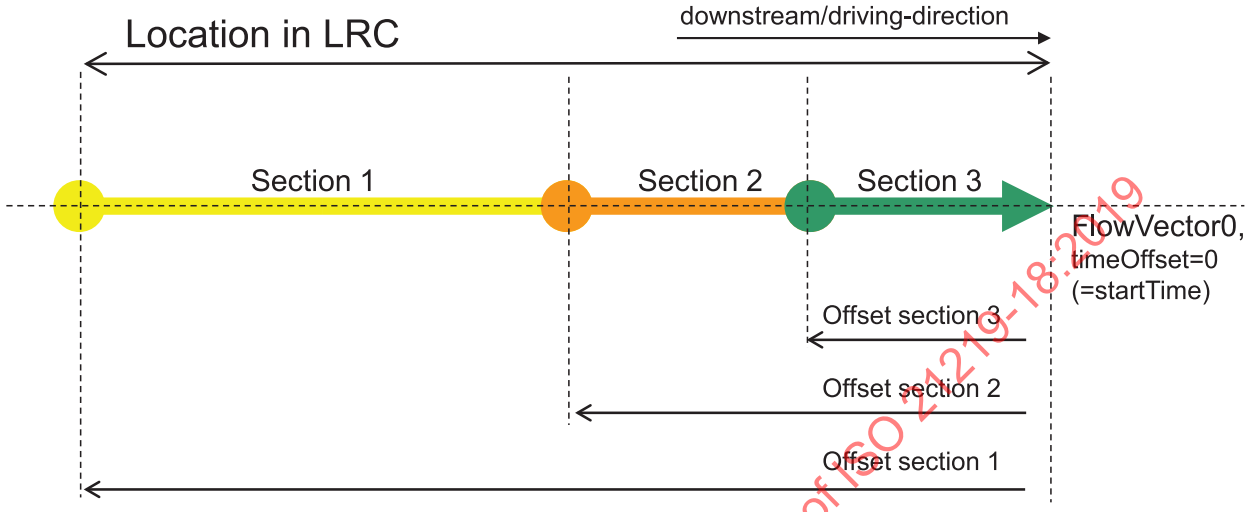
Table 6 defines the FlowMatrix component.

Table 6 — FlowMatrix

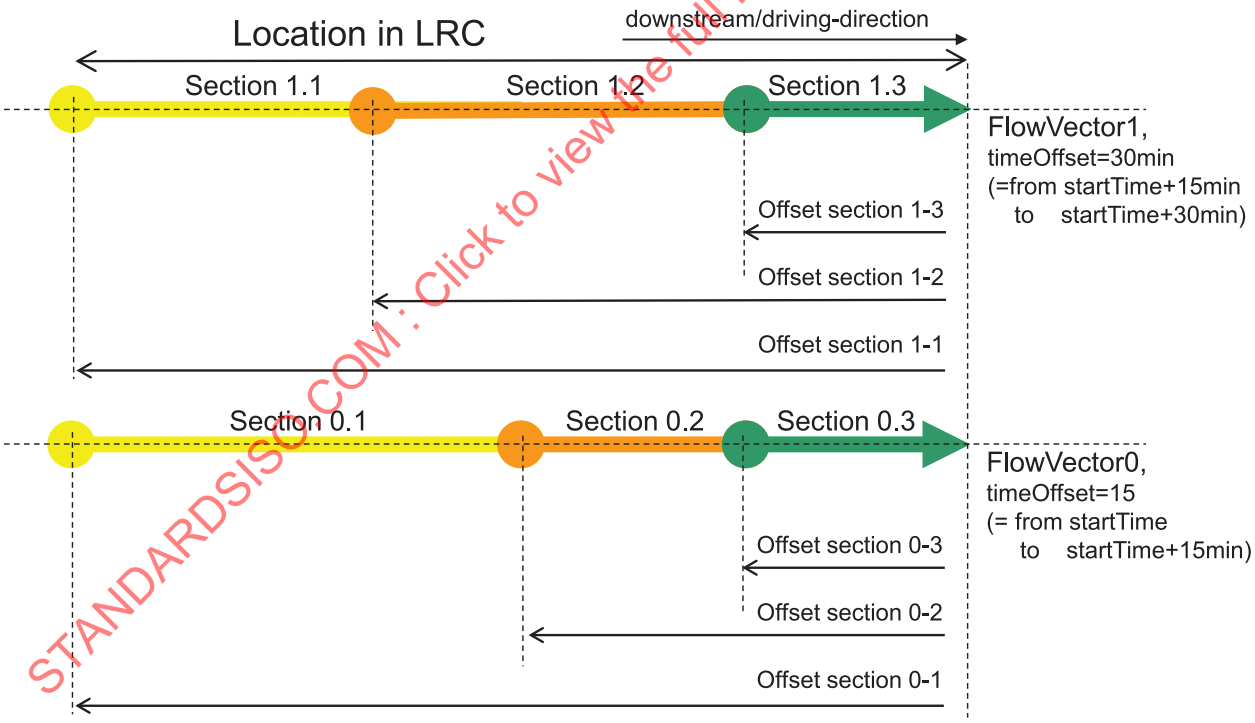
Name	Type	Multiplicity	Description
startTime	DateTime	1	The start of the time period for which the provided content is valid.
duration	IntUnLoMB	0..1	The duration [min] of the time period for which the provided content is valid. The period starts at 'startTime' and ends at 'startTime'+'duration'. This attribute shall be used by the 'PolygonFlowObject' component and may be used if required otherwise.
spatialResolution	tfp004: SpatialResolution	1	Resolution of the spatial offset used in this structure in steps of 10/50/100/500 m or TMC-locations. This spatial resolution value shall be used for all spatial offsets in the embedded data objects if not overridden there by the corresponding attributes (i.e. 'spatialResolutionVector' in component 'FlowVector' and 'spatialResolutionSection' in data structure 'FlowVectorSection'). Relative spatial offsets (table entries 5 and 6) shall not be used for this attribute. The 'start-of-location' spatial offset (table entry 7) shall neither be used for this attribute.
Ordered Components			
vectors	FlowVector	1..*	Flow Vector data.

Examples and use cases:

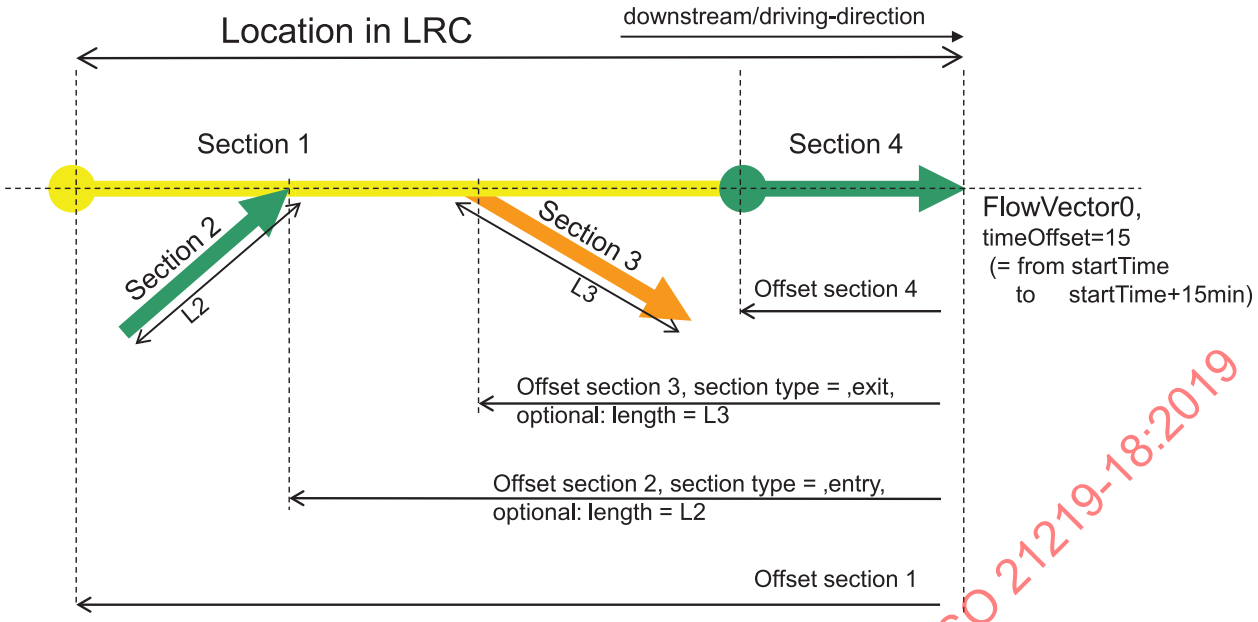
1) UC1: Flow Matrix with one Flow Vector for current traffic and with 3 Flow Sections along the road stretch. The value of 'timeOffset' is set to zero (=current status valid until message update or expiry).



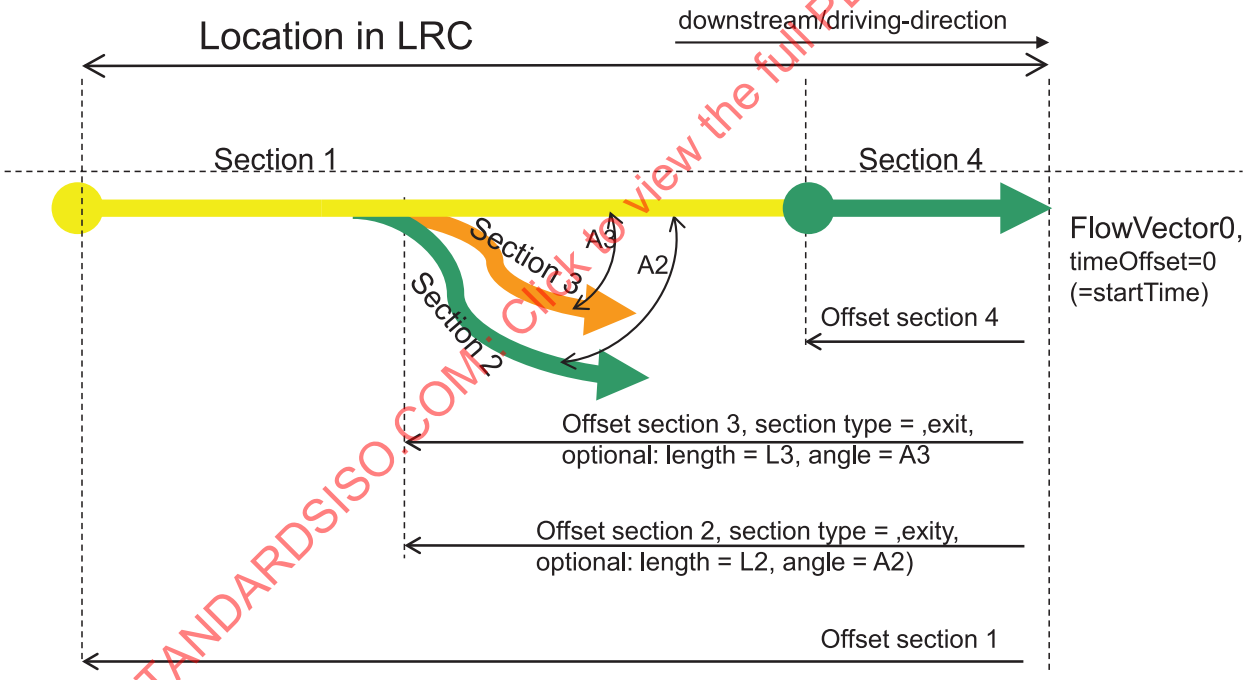
2) UC2: Flow Matrix with two Flow Vectors, i.e. current traffic and 30 min forecast, each with 3 Flow Sections along the road stretch.



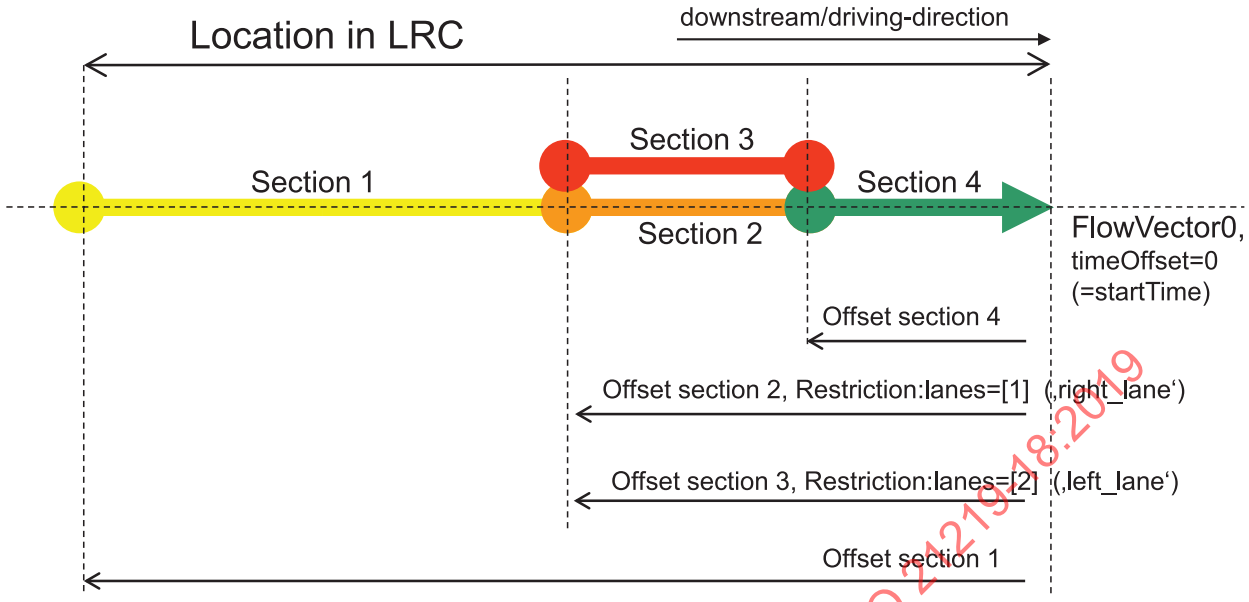
3) UC3: Flow Matrix with one Flow Vector for current traffic including a Flow Section for an entry and a Flow Section for an exit. The 'timeOffset' value is set to 15 min (=current status valid for 15 min if not updated before).



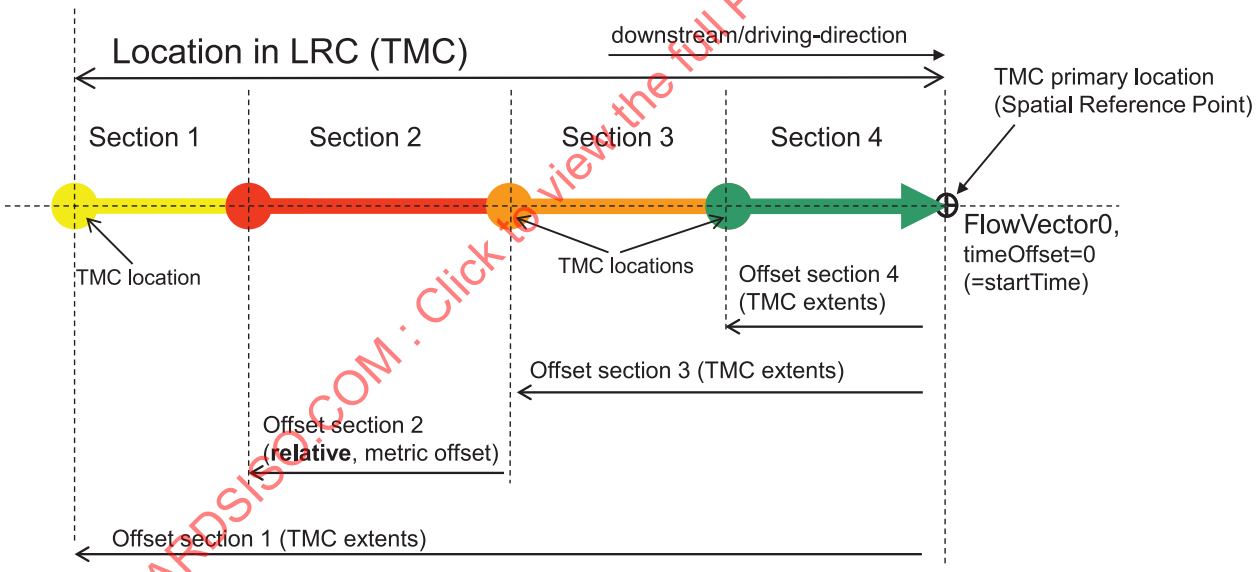
4) UC4: Flow Matrix with one Flow Vector for current traffic including two exit Flow Sections leaving the road at the same position, differentiated by the 'angle' attribute (data structure 'Restrictions', see 8.6)



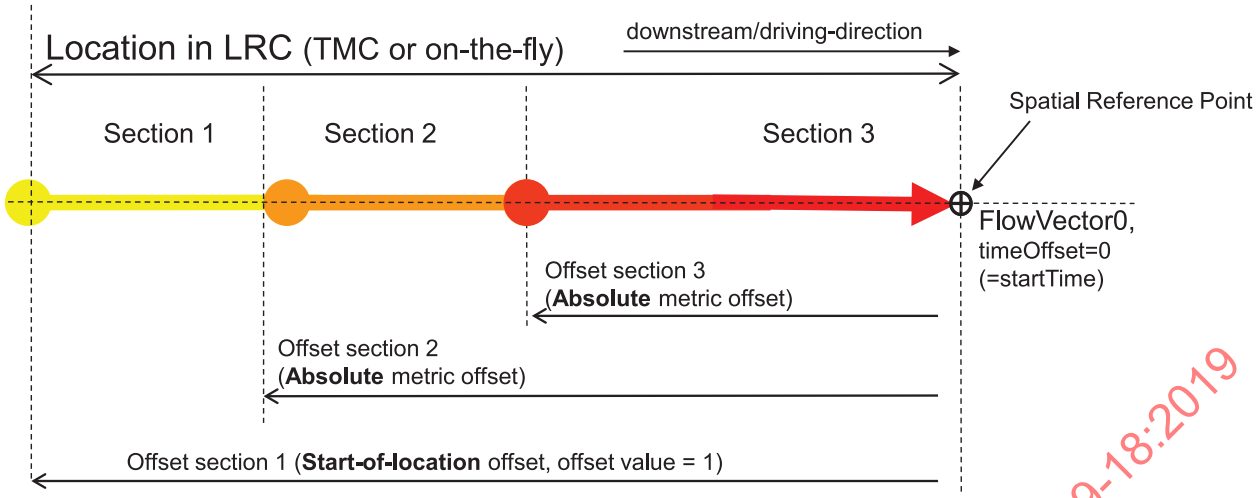
5) UC5: Flow Matrix with one Flow Vector for current traffic including two Flow Sections with lane restrictions (data structure 'Restrictions', see 8.6); other restrictions may be used in the same way.



6) UC6: Flow Matrix one Flow Vector for current traffic and with 4 Flow Sections along the road stretch; the beginning of sections 1, 3 and 4 are defined by absolute offsets in TMC-extents, the beginning of section 2 is defined by a relative metric offset to the TMC location determining the beginning of section 3.



7) UC7: Flow Matrix one Flow Vector for current traffic and with 3 Flow Sections along the road stretch; the beginning of section 1 is defined by a ‘start-of-location’ offset (i.e. SpatialResolutionSection is set to ‘start-of-location’, spatialOffset is set to a default value of 1); the beginning of sections 2 and 3 are defined in this use case by absolute metric offsets (but given a TMC location could also have been chosen as TMC offsets).



NOTE If the location is referenced as a TMC extent 0 location, where the primary TMC location has no predecessor in the TMC location table, then the beginning of any Flow Vector (section 1) shall be mandatorily defined by a 'start-of location' offset to the beginning of the TMC-internal-road-segment of this TMC location (see 7.7).

7.12 FlowVector

A 'FlowVector' includes traffic flow status information for the road stretch covered by the surrounding Flow Matrix, but only for a dedicated time interval. The 'FlowVector' consists of a number of 'FlowVectorSections' which shall be ordered in the 'vectorSections' attribute in downstream direction i.e. in descending order of the related 'spatialOffset' attributes.

Table 7 defines the FlowVector component.

Table 7 — FlowVector

Name	Type	Multiplicity	Description
timeOffset	IntUnLoMB	1	Temporal offset [min] to the 'startTime' of the surrounding 'FlowMatrix' object, defining the end of the related time interval. In case of a current status the beginning of the time interval is the 'startTime' of the related 'FlowMatrix' object. In case of a prognosis the beginning of the time interval is the end of the previous interval. May be zero for the FlowVector of the current status if there are no further flow vectors with forecast data (0 equals to 'end undefined').
vectorSections	FlowVectorSection	1..*	Flow section data; the 'FlowVectorSections' objects in this attribute shall be ordered in driving direction, i.e. the section with the highest spatial offset first (see also 7.2).
spatialResolutionVector	tfp004: SpatialResolution	0..1	Resolution of the spatial offset used for this vector, in steps of 10/50/100/500 m or TMC-locations. The value of this attribute — if present — overrides for this Flow Vector the attribute 'spatialResolution' of the corresponding 'FlowMatrix' component. Relative spatial offsets (table entries 5 and 6) shall not be used for this attribute. The 'start-of-location' spatial offset (table entry 7) shall neither be used for this attribute.

7.13 SectionExtensionComponent

This component is not used yet. It enables future backward-compatible extensions to the containing 'FlowVectorSection' data structure.

7.14 RestrictionExtensionComponent

This component is not used yet. It enables future backward-compatible extensions to the containing 'Restrictions' data structure.

7.15 StatusExtensionComponent

This component is not used yet. It enables future backward-compatible extensions to the containing 'StatusParameters' data structure.

7.16 StatisticsExtensionComponent

This component is not used yet. It enables future backward-compatible extensions to the containing 'StatisticalParameters' data structure.

8 TFP Data Types

8.1 General

TFP data types are specific, composite attributes defined for use in this TPF applications.

8.2 FlowVectorSection

A 'FlowVectorSection' includes traffic flow status information for a dedicated section of a road stretch.

Table 8 defines the FlowVectorSection datatype.

Table 8 — FlowVectorSection

Name	Type	Multiplicity	Description
spatialOffset	IntUnLoMB	1	Start of the section as spatial offset in upstream direction (i.e. opposite to the driving direction, see also 8.3) to the end of the road stretch defined by the location reference of the message (the spatial reference point). The value shall always be greater than 0.

Table 8 *(continued)*

Name	Type	Multiplicity	Description
			The beginning of the section shall not exceed the beginning of the overall location. The end of a section is defined by the start of the following section in downstream (driving) direction or by the end of the location reference. If the section is of type 'entry' (see attribute 'sectionType') the offset defines the point where the entry joins the road. If the section is of type 'exit' the offset defines the point where the exit separates from the road. The units used for the offset is signalled by the 'spatialResolution' attribute of the related objects 'FlowMatrx', 'FlowVector' or 'FlowVectorSection' and may be in TMC locations or metric units, or a default value 1 in case of a 'start-of-location' spatial resolution. The determination of the metric spatial offset is defined by the following equation: spatial offset (m) = spatialOffset * spatialResolution (m)
status	StatusParameters	1	Attributes describing the traffic status at this section
spatialResolutionSection	tfp004: SpatialResolution	0..1	Resolution of the spatial offset used for this section, in steps of 10/50/100/500 m or TMC-locations, or relative offsets in steps of 10/100 m, or a fixed value 1 for the spatialOffset attribute in case of a 'start-of-location' spatialResolutionSection value. The value of this attribute — if present- overrides for this 'FlowVectorSection' the attributes 'spatialResolution' of the related 'FlowMatrix' component and/or 'spatialResolutionVector' of the related 'FlowVector' component. To avoid aggregated inaccuracies, relative offsets should be used only exceptionally, e.g. for precise delimiters of particular sections within a road stretch with TMC location referencing.

Table 8 *(continued)*

Name	Type	Multiplicity	Description
sectionType	tfp007: SectionType	0..1	Type of section; shall be used if and only if no normal road section (entry or exit)
restriction	Restrictions	0..1	Information on restrictions related to the reported information
statistics	StatisticalParameters	0..1	Statistical information related to the reported flow status
cause	tfp006: CauseCode	0..1	A simple cause for the reported traffic flow status may be added by this attribute; this parameter shall be omitted if a detailed cause is available by an external message (see attribute 'linked cause')
detailedCause	LinkedCause	0..1	A detailed cause may be reported by a linked message (e.g. a TEC-message)
Ordered Components			
extensions	Component SectionExtensionComponent	0..1	The extensions component is not used yet but may be used in future TFP versions to add further attributes to this data structure without losing backward-compatibility

8.3 PolygonPoint

A 'PolygonPoint' defines a spatial/temporal point within a 'FlowPolygon'.

Table 9 defines the PolygonPoint datatype.

Table 9 — PolygonPoint

Name	Type	Multiplicity	Description
spatialOffset	IntUnLoMB	1	Position of the 'PolygonPoint' as (absolute) spatial offset to the end of the road stretch defined by the Location Reference of the message in upstream direction. The units used for the offset is signalled by the 'spatialResolution' attribute of the related objects 'FlowPolygon' or 'FlowPolygonObject' and may be in TMC locations or metric units. The determination of the metric spatial offset is defined by the following equation: spatial offset (m) = spatialOffset * spatialResolution (m) Relative spatial offsets (table entries 5 and 6) shall not be used for this attribute.
timeOffset	IntUnLoMB	1	Temporal offset [min] to the 'startTime' of the surrounding 'FlowPolygonObject'.

8.4 LinkedCause

This data structure may be used if required to link to a TPEG message with more details about the cause for this traffic status. A link to another message is uniquely specified by the combination of ServiceID, ContentID, ApplicationID and messageID.

Table 10 defines the LinkedCause datatype.

Table 10 — LinkedCause

Name	Type	Multiplicity	Description
messageID	IntUnLoMB	1	The related message ID
COID	IntUnTi	1	Content ID of the TPEG service component related to the linked message
SID	ServiceIdentifier	0..1	The TPEG service ID related to the service of the linked message; this attribute may be omitted if the linked message is in the same TPEG service like this TFP message. Note that the originator service SID may differ from the carrier service SID (see ISO/TS 21219-9).
AID	IntUnLi	0..1	Application ID of the TPEG service component related to the linked message; the default value is = 5 (TEC) so this attribute may be omitted if the linked message is of this application type

8.5 StatusParameters

This data structure contains the parameters defining the traffic flow status on the corresponding road section. The following requirements shall be fulfilled for the StatusParameters:

— At least one of the attributes 'LOS', 'averageSpeed' and 'delay' shall be delivered;

— The 'delay' attribute should be used if the speed on the related road section is near to zero, to avoid inaccurate or infinite travel time calculations;

— In case of a blocked road this shall be indicated by a 'LOS' attribute with value 'no traffic flow' (with or without tendency, tfp003 values 006, 014, 030, 046).

Table 11 defines the StatusParameters datatype.

Table 11 — StatusParameters

Name	Type	Multiplicity	Description
LOS	tfp003: LevelOfService	0..1	The 'LOS' (Level-of-Service) attribute indicates the current traffic quality and (optionally) its tendency. The LOS level is dependent on the road category; e.g. an average speed of 40 km/h may be 'Free Traffic' on a city road and may be 'Queuing Traffic' on a highway. The tendency shall be the predicted LOS level in the next time period, which starts at startTime + duration of this the current period.

Table 11 *(continued)*

Name	Type	Multiplicity	Description
averageSpeed	inUnTi	0..1	The achievable average speed in km/h. This value may differ from the measured average speed on the related road section as it should exclude vehicle classes with inherent speed limitations (e.g. lorries).
freeFlowTravelTime	IntUnLoMB	0..1	The time in seconds it takes to traverse the affected road segment under free flow traffic conditions.
delay	Duration	0..1	Delay on the road segment in seconds; as this value shall be used only if the average speed is near to 0 m/sec this value equals the overall travel time, i.e. the time it takes to traverse the road segment.
Ordered Components			
extensions	StatusExtensionComponent	0..1	The extensions component is not used yet but may be used in future TFP versions to add further attributes to this data structure without losing backward-compatibility.

8.6 Restrictions

The traffic state reported by the element containing the 'Restrictions' is restricted to vehicle types, type of sections, lanes etc. as defined by this 'Restrictions' data structure.

Table 12 defines the Restrictions datatype.

Table 12 — Restrictions

Name	Type	Multiplicity	Description
vehicleClassAssignment	tfp001: VehicleClass	0..1	The purpose of the vehicle class attribute is to be able to supply traffic flow and prediction values for particular types of vehicles rather than describe a particular vehicle itself. The attribute indicates that the status conveyed in the current TFP object only concerns a specific type of vehicle.
vehicleCredentials	tfp002: VehicleCredentials	0..1	Where special restrictions or access conditions apply for a particular type of vehicle then these credentials can be indicated by this element.
lanes	tfp005: LaneRestriction	0..1	Assignment to lanes for which the reported traffic status is valid

Table 12 *(continued)*

Name	Type	Multiplicity	Description
angle	IntUnTi	0..1	Angle of an entry/exit to the road stretch in 360/255 degree steps clockwise to the direction of the road stretch at the entry/ exit point. Only required to differentiate between several entries/exits if more than one exit/ entry is going in/out at the same point on the road, so no exact angle values are required. If an entry/exit can't be referenced unambiguously in this way, an extra TFP message with a dedicated location reference (e.g. DLR1 reference) for this entry/exit should be used.
length	IntUnLoMB	0..1	Length affected in 10 meter steps. This parameter may be used for sections of type 'entry' or 'exit' to restrict the traffic flow to parts of the related section. In case of an entry, the length determines the start of the section, in case of an exit it determines the end of the section. In case of a section on the road stretch this parameter shall not be used because the section length is determined by the 'spatialOffset' attribute of the following section or the end of the Location Reference.
Ordered Components			
extensions	RestrictionExtension Component	0..1	The extensions component is not used yet but may be used in future TFP versions to add further attributes to this data structure without losing backward-compatibility.

8.7 StatisticalParameters

This data structure contains statistical parameters and quality indicators of the related corresponding status flow parameters.

Table 13 defines the StatisticalParameters datatype.

Table 13 — StatisticalParameters

Name	Type	Multiplicity	Description
congestionProbability	IntUnTi	0..1	The risk [%] that a congestion (LOS level 'stationary traffic' or 'blocked') will occur at this road section. This value shall be in range 0..100.
T90relative	IntUnLoMB	0..1	Used to determine the risk that the travel time may exceed the expected travel time considerably may exceed the expected travel time considerably. The value is delivered in 1/10 percentages. A low value is equal to a high probability that the transmitted 'averageSpeed' is reliable.

Table 13 *(continued)*

Name	Type	Multiplicity	Description
			In detail, the attribute 'T90relative' is used to determine a Travel Time value T90 where 90 % of the measured travel times on the affected road section are below T90. In other words, a driver can rely on with 90 % probability that his travel time will not exceed T90. The determination of T90 shall be done by the following approach: — The average travel time Tav at the affected road section is determined by Tav = section-length [m]/ averageSpeed [m/sec] — The T90 value is computed by T90 = Tav * T90relative
FlowQuality	tfp008: FlowDataQuality	0..1	Expresses the accuracy of the data source(s) used for the determination of the traffic status, e.g. accurate measurement data will have a higher quality level than estimations made from video surveys.
prediction	IntUnTi	0..1	This parameter may be used to link to a LOS prediction pattern. The service provider is responsible for exact definitions of these patterns.
Ordered Components			
extensions	StatisticsExtensionComponent	0..1	The extensions component is not used yet but may be used in future TFP versions to add further attributes to this data structure without losing backward-compatibility.

9 TFP Tables

9.1 tfp001: VehicleClass

The VehicleClass table lists vehicle classes relevant to filtering congestion and travel time messages.

Table 14 enumerates the possible values for type tfp001:VehicleClass.

Table 14 — tfp001:VehicleClass

Code	Reference-English 'word'	Comment	Example
000	unknown		
001	car		
002	lorry		
003	light goods vehicle		
004	heavy goods vehicle		
005	bus		
006	transport of abnormal load		
007	emergency vehicle		

Table 14 *(continued)*

Code	Reference-English 'word'	Comment	Example
008	works vehicle		
009	exceptional size vehicle		
010	trailer		
011	military vehicle		
012	motorcycle		
013	taxi		
014	transport of dangerous goods		
015	unmotorised vehicle		
016	motorised vehicle		

9.2 tfp002: VehicleCredentials

Some special conditions may apply to vehicles with special credentials, the VehicleCredentials table lists those credentials.

Table 15 enumerates the possible values for type tfp002:VehicleCredentials.

Table 15 — tfp002:VehicleCredentials

Code	Reference-English 'word'	Comment	Example
000	unknown		
001	high occupancy		
002	disabled passenger		
003	paid privileges		

9.3 tfp003: LevelOfService

The LevelOfService table lists the level of service and its tendency.

Table 16 enumerates the possible values for type tfp003:LevelOfService.

Table 16 — tfp003:LevelOfService

Code	Reference-English 'word'	Comment	Example
000	unknown	traffic status unknown, Tendency: unknown or no information	
001	free traffic	Free flowing traffic, the traffic is not disturbed, Tendency: unknown or no information	
002	heavy traffic	Heavy traffic causing minor problems in the traffic, Tendency: unknown or no information	
003	slow traffic	Slow moving traffic, Tendency: unknown or no information	
004	queuing traffic	The traffic is in queues but still moves slowly, Tendency: unknown or no information	
005	stationary traffic	Stationary traffic, congestion, Tendency: unknown or no information	
006	no traffic flow	No traffic flow due to blockage or closure, Tendency: unknown or no information	

Table 16 *(continued)*

Code	Reference-English 'word'	Comment	Example
009	free traffic constant	Current status: free traffic flow, Tendency: free traffic flow	
010	heavy traffic constant	Current status: heavy traffic, Tendency: heavy traffic	
011	slow traffic constant	Current status: slow traffic, Tendency: slow traffic	
012	queuing traffic constant	Current status: queuing traffic, Tendency: queuing traffic	
013	stationary traffic constant	Current status: stationary traffic, Tendency: stationary traffic	
014	no traffic flow constant	Current status: no traffic flow, Tendency: no traffic flow	
017	free traffic increasing	Current status: free traffic flow, Tendency: heavy traffic	
018	heavy traffic increasing	Current status: heavy traffic, Tendency: slow traffic	
019	slow traffic increasing	Current status: slow traffic, Tendency: queuing traffic	
020	queuing traffic increasing	Current status: queuing traffic, Tendency: stationary traffic	
026	heavy traffic decreasing	Current status: heavy traffic, Tendency: free traffic flow	
027	slow traffic decreasing	Current status: slow traffic, Tendency: heavy traffic	
028	queuing traffic decreasing	Current status: queuing traffic, Tendency: slow traffic	
029	stationary traffic decreasing	Current status: stationary traffic, Tendency: queuing traffic	
030	no traffic flow decreasing	Current status: no traffic flow, Tendency: queuing traffic	
033	free traffic rapidly increasing	Current status: free traffic flow, Tendency: slow traffic	
034	heavy traffic rapidly increasing	Current status: heavy traffic, Tendency: queuing traffic	
035	slow traffic rapidly increasing	Current status: slow traffic, Tendency: stationary traffic	
043	slow traffic rapidly decreasing	Current status: slow traffic, Tendency: free traffic flow	
044	queuing traffic rapidly decreasing	Current status: queuing traffic, Tendency: heavy traffic	
045	stationary traffic rapidly decreasing	Current status: stationary traffic, Tendency: slow traffic	
046	no traffic flow rapidly decreasing	Current status: no traffic flow, Tendency: slow traffic	
047	synchronized flow	Current status: synchronized flow according to the three-phase-traffic theory, The client may interpret this status as 'heavy traffic' if it can't model synchronized flow. Tendency: unknown	

Table 16 *(continued)*

Code	Reference-English 'word'	Comment	Example
048	wide moving jam	Current status: wide moving jam according to the three-phase-traffic theory, The client may interpret this status as 'stationary' if it can't model wide moving jams. Tendency: unknown	

9.4 tfp004: SpatialResolution

Table 17 enumerates the possible values for type tfp004:SpatialResolution.

Table 17 — tfp004:SpatialResolution

Code	Reference-English 'word'	Comment	Example
000	TMCLocations	Resolution of related offset value is in TMC locations (extents); this type shall be used only if the LRC container is a TMC location	
001	10-m-resolution	resolution of related offset is in 10-Meter steps as absolute offsets to the spatial reference point, offset = value*10 [m]	
002	50-m-resolution	resolution of related offset is in 50-Meter steps as absolute offsets to the spatial reference point, offset = value*50 [m]	
003	100m-resolution	resolution of related offset is in 100-Meter steps as absolute offsets to the spatial reference point, offset = value*100 [m]	
004	500m-resolution	resolution of related offset is in 500-Meter steps as absolute offsets to the spatial reference point, offset = value*500 [m]	
005	relative-10-m-resolution	spatial offset is delivered in 10 m steps upstream to the begin of the following section; this value may be used only by the spatialResolutionSection of the 'flowVectorSection' data structure; it shall not be used by other TFP attributes; offset = value*10 [m]	
006	relative-100-m-resolution	spatial offset is delivered in 100 m steps upstream to the begin of the following section; this value may be used only by the spatialResolutionSection of the 'flowVectorSection' data structure; it shall not be used by other TFP attributes; offset = value*100 [m]	
007	start-of-location	spatial offset is the start of the location as resolved on the client digital roadmap. The associated offset value shall be set to 1. This tfp004:spatialResolution value may be used only by the spatialResolutionSection of the 'flowVectorSection' data structure; it shall not be used by other TFP attributes; offset = 1 (default, fixed value).	

9.5 tfp005:LaneRestriction

Lanes for lane restrictions are ordered from right to left counted looking in driving direction, i.e. lane 1 is the right-most driving lane, lane 8 is the left-most driving lane. This order is independent from the country-related driving direction (left-hand or right-hand traffic).

Table 18 enumerates the possible values for type tfp005:LaneRestriction.

Table 18 — tfp005:LaneRestriction

Code	Reference-English 'word'	Comment	Example
000	unknown		
001	driving lane 1	the right-most driving lane	
002	driving lane 2		
003	driving lane 3		
004	driving lane 4		
005	driving lane 5		
006	driving lane 6		
007	driving lane 7		
008	driving lane 8	the left-most driving lane	
009	driving lanes 1 and 2		
010	driving lanes 2 and 3		
011	driving lanes 3 and 4		
012	driving lanes 4 and 5		
013	driving lanes 5 and 6		
014	driving lanes 6 and 7		
015	driving lanes 7 and 8		
016	driving lanes 1–2 and 3		

Table 18 *(continued)*

Code	Reference-English 'word'	Comment	Example
017	driving lanes 2–3 and 4		
018	driving lanes 3–4 and 5		
019	driving lanes 4–5 and 6		
020	driving lanes 5–6 and 7		
021	driving lanes 6–7 and 8		
022	driving lanes 1–2-3 and 4		
023	driving lanes 2–3-4 and 5		
024	driving lanes 3–4-5 and 6		
025	driving lanes 4–5-6 and 7		
026	driving lanes 5–6-7 and 8		
027	driving lanes 1–2-3–4 and 5		
028	driving lanes 2–3-4–5 and 6		
029	driving lanes 3–4-5–6 and 7		
030	driving lanes 4–5-6–7 and 8		
031	driving lanes 1–2-3–4-5 and 6		
032	driving lanes 2–3-4–5-6 and 7		
033	driving lanes 3–4-5–6-7 and 8		
034	driving lanes 1–2-3–4-5–6 and 7		
035	driving lanes 2–3-4–5-6–7 and 8		
037	all driving lanes		
039	hard shoulder	the hard shoulder, may be left or right dependent on country (right hand or left-hand traffic)	

9.6 tfp006: CauseCode

A simple cause code to indicate the cause of the traffic congestion.

Table 19 enumerates the possible values for type tfp006:CauseCode.

Table 19 — tfp006:CauseCode

Code	Reference-English 'word'	Comment	Example
000	unknown		
001	traffic congestion	In case that the capacity of that part of the street causes this traffic state.	
002	accident	In case of an accident.	
003	roadworks	In case that road works are the reason.	
004	narrow lanes	In case of lanes being smaller as typical for the given country.	
005	impassability	In case that in general the given part of a road is impassable.	
006	slippery road	In case that a slippery road is the reason.	
007	aquaplaning	In case that big areas of water are on the road surface.	
008	fire	In case that a traffic affecting fire is the reason.	

Table 19 *(continued)*

Code	Reference-English 'word'	Comment	Example
009	hazardous driving conditions	In case that natural conditions require high caution by the driver. The reason is mostly expected to appear suddenly.	
010	objects on the road	In case that objects impede the drive.	
011	animals on roadway	In case that animals are on the carriage way.	
012	people on roadway	In case that people are walking on the carriage way.	
013	broken down vehicles	In case that broken down car lies on the carriage way.	
014	vehicle on wrong carriageway (Ghostdriver)	In case that cars are driving against the one way direction of the carriage way. (not standing)	
015	rescue and recovery work in progress	In case that rescue and recovery work is in progress.	
016	regulatory measure	In case that regulatory measure is the reason.	
017	extreme weather conditions	In case that extreme weather conditions are the reason.	
018	visibility reduced	In case the reduced visibility needs a speed adaptation.	
019	precipitation	In case that increased precipitation is the reason. This cause is mostly combined with time delays.	
020	reckless persons	In case that reckless persons are the reason.	
021	overheight warning system triggered	In case that an overheight warning system trigger is the reason for e.g. the closure.	
022	traffic regulations changed	In case that changed traffic regulations and therefore high risk of accident are the reason.	
023	major event	In case that a major event is the reason.	
024	service not operating	In case that a transport service is not operating.	
025	service not useable	In case that a service is not usable although it is operating. (e.g. overcrowded or paused)	
026	slow moving vehicles	In case that slow moving vehicles are the reason.	
027	dangerous end of queue	In case that a dangerous end of queue could cause an accident.	
028	risk of fire	In case that a risk of fire exists. Open fire or glow should be extinguished.	
029	time delay	In case that a time delay exists.	
030	police checkpoint	In case that there is a spot for checking purposes	
031	malfunctioning roadside equipment	In case that a malfunctioning roadside equipment is the reason.	
032	serious accident	In case of a serious accident with expected long lasting rescue and recovery work	
033	earlier accident	In case of an earlier accident	
034	accident reported	In case of a reported accident	
035	accident investigation work	In case of an accident investigation in progress	
036	multi-vehicle accident	In case that many cars are involved in the accident	
037	accident involving lorry	In case of an accident involving a lorry.	

Table 19 *(continued)*

Code	Reference-English 'word'	Comment	Example
038	accident traffic being directed around	In case of an accident where traffic is directed around the accident area	
039	long-term road works	In case that long-term road works are the reason.	
040	construction work	In case that road construction work is the reason	
041	bridge maintenance work	In case that bridge maintenance work is the reason	
042	resurfacing work	In case that road resurfacing work is the reason	
043	major road works	In case that major road works are the reason.	
044	road maintenance work	In case that road maintenance work is the reason	
045	road works during night	In case that road works during the night are the reason.	
046	road works with single line traffic-alternate directions	In case of road works where traffic is alternately directed over one single lane	
047	flooding	In case that flooding water is reason for impassability	
048	snow on road	In case that a slippery road is caused by snow on the road.	
049	ice on road	In case that a slippery road is caused by ice on the road.	
050	black ice on road	In case that a slippery road is caused by black ice on the road.	
051	grass fire	In case that a grass fire is the reason.	
052	forest fire	In case that a forest fire is the reason.	
053	overturned vehicle	In case that the vehicle lying on the road is overturned.	
054	broken down lorry	In case that a broken down lorry lies on the carriageway.	
055	vehicle spun around	In case that a vehicle spun around lies on the carriageway.	
056	vehicle on fire	In case that the car lying on the road also is burning.	
057	gusty winds	In case that gusty winds, especially cross winds, are the reason.	
058	strong winds	In case that strong winds, especially cross winds, are the reason.	
059	thunderstorm	In case that a strong thunderstorm affects driving.	
060	visibility reduced due to fog	In case that the visibility is reduced by fog.	
061	visibility reduced due to low sun glare	In case that the visibility is reduced by low sun glare.	
062	snow	In case that snowfall is the reason.	
063	rain	In case that rain is the reason.	
064	hail	In case that hail is the reason.	
065	sports event	In case that a sports event is the reason.	

Table 19 *(continued)*

Code	Reference-English 'word'	Comment	Example
066	traffic control signals not working	In case that traffic control signals are not functioning at all.	
067	traffic control signals working incorrectly	In case that traffic control signals are malfunctioning.	
068	closure	In case that a closure is the reason.	

9.7 tfp007: SectionType

Table 20 enumerates the possible values for type tfp007:SectionType.

Table 20 — tfp007:SectionType

Code	Reference-English 'word'	Comment	Example
000	unknown		
001	entry	Section affected is an entry	
002	exit	Section affected is an exit	

9.8 tfp008: FlowDataQuality

Table 21 enumerates the possible values for type tfp008:FlowDataQuality.

Table 21 — tfp008:FlowDataQuality

Code	Reference-English 'word'	Comment	Example
000	unknown		
001	very low	Very low quality of the delivered information, Proposed to use map database instead, if possible	
002	low	Low quality of the delivered information, expected not to be better than a historic measurements database (e.g. in navigation map)	
003	moderate	Quality of the delivered information is on a moderate level, proposed to rely partly on the information of this flow status and add other data sources if possible	
004	sufficient	Sufficient quality of the delivered information, proposed to rely mainly on the information of this flow status	
005	high	High quality of the delivered information e.g. basing on accurate measurements, proposed to rely nearly exclusively on the information of this flow value	
006	very high	Very high quality of the delivered information e.g. based on accurate and up-to-date measurements, proposed to 100 % rely on the information of this flow status	

Annex A
(normative)

Traffic Flow and Prediction, TPEG-Binary Representation

A.1 General

This annex provides the TPEG-Binary representation derived via application of the UML to binary conversion rules specified in ISO 21219-3.

A.2 Message components

A.2.1 List of Generic Component Ids

Name	Id
TFPMessage	0
MessageManagementContainerLink	1
LocationReferencingContainer	2
FlowPolygonObject	3
FlowPolygon	4
FlowStatus	5
FlowMatrix	6
FlowVector	7
SectionExtensionComponent	8
RestrictionExtensionComponent	9
StatusExtensionComponent	10
StatisticsExtensionComponent	11
MMCMasterMessage	12
MMCMessagePart	13

A.2.2 TFPMessage

<TFPMessage(0)>:=	
<IntUnTi>(0),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr),	: Number of bytes in attributes
ordered {	
<MMCSwitch>(mmt),	
n ***<TFPMethod>**(method),	
m ***<LocationReferencingContainer>**(loc)[0..1]	
};	

A.2.3 TFPMethod

<TFPMethod(x)>:=	

<**IntUnTi**>(x),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr),	: Number of bytes in attributes
<DateTime>(startTime),	: The start of the time period for which the provided content is valid.
BitArray(selector),	
if (bit 0 of selector is set)	
<IntUnLoMB>(duration);	: The duration [min] of the time period for which the provided content is valid. The period starts at 'startTime' and ends at 'startTime'+' duration'. This attribute shall be used by the 'PolygonFlowObject' component and may be used if required otherwise.

A.2.4 MMCSwitch

<MMCSwitch(x)>:=	
<**IntUnTi**>(x),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr);	: Number of bytes in attributes

A.2.5 MessageManagementContainerLink

<MessageManagementContainerLink(1)<MMCSwitch()>>:=	
External<**MessageManagementContainer(1)**>;	: see MessageManagementContainer specification

A.2.6 MMCMasterLink

<MMCMasterLink(12)<MMCSwitch()>>:=	
External<**MMCMasterMessage(12)**>;	: see MMCMasterMessage specification

A.2.7 MMCPartLink

<MMCPartLink(13)<MMCSwitch()>>:=	
External<**MMCMessagePart(13)**>;	: see MMCMessagePart specification

A.2.8 LocationReferencingContainer

<LocationReferencingContainer(2)>:=	
External<**LocationReferencingContainer(2)**>;	: See LocationReferencingContainer specification

A.2.9 FlowPolygonObject

<FlowPolygonObject(3)<TFPMethod(3)>>:=	
<IntUnTi>(3),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr),	: Number of bytes in attributes
<DateTime>(startTime),	: The start of the time period for which the provided content is valid.
BitArray(selector),	
if (bit 0 of selector is set)	
<IntUnLoMB>(duration);	: The duration [min] of the time period for which the provided content is valid. The period starts at 'startTime' and ends at 'startTime'+'duration'. This attribute shall be used by the 'PolygonFlowObject' component and may be used if required otherwise.
<tfp004:SpatialResolution> (spatialResolution),	: Resolution of the spatial offset used in this structure in steps of 10/50/100/500 metres or TMC-locations. This spatial resolution value shall be used for all spatial offsets in the embedded 'FlowPolygon' components if not overridden there by the corresponding attribute 'spatialResolutionPolygon'. Relative spatial offsets (table entries 5 and 6) shall not be used. The 'start-of-location' spatial offset (table entry 7) shall neither be used.
ordered {	
n ***<FlowPolygon>**(polygons)	: Flow Polygon data.
};	

A.2.10 FlowPolygon

<FlowPolygon(4)>:=	
<IntUnTi>(4),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr),	: Number of bytes in attributes
<IntUnLoMB>(polygonIndex),	: Unique index within related 'FlowPolygonObject'. Used for ordering the FlowPolygons within the 'FlowPolygonObject'
<StatusParameters>(status),	: Attributes describing the traffic flow status within the polygon
<IntUnLoMB>(n),	
n ***<PolygonPoint>**(polygonPoints),	: Vector with polygon points
BitArray(selector),	
if (bit 0 of selector is set)	

<tfp004:SpatialResolution> (spatialResolutionPolygon),	: Resolution of the spatial offset used for this polygon, in steps of 10/50/100/500 metres or TMC-locations. The value of this attribute — if present — overrides for this FlowPolygon the attribute value 'spatialResolution' of the related 'FlowPolygonObject' component. Relative spatial offsets (table entries 5 and 6) shall not be used.
if (bit 1 of selector is set)	
<Restrictions>(restriction),	: Information on restrictions related to the reported traffic flow
if (bit 2 of selector is set)	
<StatisticalParameters> (statistics),	: Statistical information related to the reported flow status
if (bit 3 of selector is set)	
<**tfp006:CauseCode**>(cause),	: A simple cause for the reported traffic flow status may be added by this attribute; this parameter shall be omitted if a detailed cause is available by an external message (see attribute 'linked cause')
if (bit 4 of selector is set)	
<LinkedCause>(detailedCause);	: A detailed cause may be reported by a linked message (e.g. a TEC-message).

A.2.11 FlowStatus

<FlowStatus(5)<TFPMethod(5)>>:=	
<**IntUnTi**>(5),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr),	: Number of bytes in attributes
<DateTime>(startTime),	: The start of the time period for which the provided content is valid.
BitArray(selector),	
if (bit 0 of selector is set)	
<IntUnLoMB>(duration);	: The duration [min] of the time period for which the provided content is valid. The period starts at 'startTime' and ends at 'startTime'+'duration'. This attribute shall be used by the 'PolygonFlowObject' component and may be used if required otherwise.
<**StatusParameters**>(status),	: Attributes describing the traffic flow status at the related location
if (bit 1 of selector is set)	
<Restrictions>(restriction),	: Information on restrictions related to the reported traffic flow
if (bit 2 of selector is set)	
<StatisticalParameters> (statistics),	: Statistical information related to the reported flow status
if (bit 3 of selector is set)	

<**tfp006:CauseCode**>(cause),	: A simple cause for the reported traffic flow status may be added by this attribute; this parameter shall be omitted if a detailed cause is available by an external message (see attribute 'linked cause')
if (bit 4 of selector is set)	
<LinkedCause>(detailedCause);	: A detailed cause may be reported by a linked message (e.g. a TEC-message)

A.2.12 FlowMatrix

<FlowMatrix(6)<TFPMethod(6)>>:=	
<**IntUnTi**>(6),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr),	: Number of bytes in attributes
<DateTime>(startTime),	: The start of the time period for which the provided content is valid.
BitArray(selector),	
if (bit 0 of selector is set)	
<IntUnLoMB>(duration);	: The duration [min] of the time period for which the provided content is valid. The period starts at 'startTime' and ends at 'startTime'+'duration'. This attribute shall be used by the 'PolygonFlowObject' component and may be used if required otherwise.
<**tfp004:SpatialResolution**> (spatialResolution),	: Resolution of the spatial offset used in this structure in steps of 10/50/100/500 metres or TMC-locations. This spatial resolution value shall be used for all spatial offsets in the embedded data objects if not overridden there by the corresponding attributes (i.e. 'spatialResolutionVector' in component 'FlowVector' and 'spatialResolutionSection' in datastructure 'FlowVectorSection'). Relative spatial offsets (table entries 5 and 6) shall not be used for this attribute. The 'start-of-location' spatial offset (table entry 7) shall neither be used for this attribute.
ordered {	
n *<**FlowVector**>(vectors)	: Flow Vector data
};	

A.2.13 FlowVector

<FlowVector(7)>:=	
<**IntUnTi**>(7),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr),	: Number of bytes in attributes

<IntUnLoMB>(timeOffset),	: Temporal offset [min] to the 'startTime' of the surrounding 'FlowMatrix' object, defining the end of the related time interval. In case of a current status the begin of the time interval is the 'startTime' of the related 'FlowMatrix' object. In case of a prognosis the begin of the time interval is the end of the previous interval. May be zero for the FlowVector of the current status if there are no further flow vectors with forecast data (0 equals to 'end undefined').
<**IntUnLoMB**>(n),	
n ***<FlowVectorSection>** (vectorSections),	: Flow section data; the 'FlowVectorSections' objects in this attribute shall be ordered in driving direction, i.e. the section with the highest spatial offset first (see also 7.2).
BitArray(selector),	
if (bit 0 of selector is set)	
<tfp004:SpatialResolution> (spatialResolutionVector);	: Resolution of the spatial offset used for this vector, in steps of 10/50/100/500 metres or TMC-locations. The value of this attribute — if present- overrides for this Flow Vector the attribute 'spatialResolution' of the corresponding 'FlowMatrix' component. Relative spatial offsets (table entries 5 and 6) shall not be used for this attribute. The 'start-of-location' spatial offset (table entry 7) shall neither be used for this attribute.

A.2.14 SectionExtensionComponent

This component is not used yet. It enables future backward-compatible extensions to the containing 'FlowVectorSection' data structure.

<SectionExtensionComponent(8)>:=	
<**IntUnTi**>(8),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr);	: Number of bytes in attributes

A.2.15 RestrictionExtensionComponent

This component is not used yet. It enables future backward-compatible extensions to the containing 'Restrictions' data structure.

<RestrictionExtensionComponent(9)>:=	
<**IntUnTi**>(9),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr);	: Number of bytes in attributes

A.2.16 StatusExtensionComponent

This component is not used yet. It enables future backward-compatible extensions to the containing 'StatusParameters' data structure.

<StatusExtensionComponent(10)>:=	
<**IntUnTi**>(10),	: Id of this component
<IntUnLoMB>(lengthComp),	: Number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr);	: Number of bytes in attributes

A.2.17 StatisticsExtensionComponent

This component is not used yet. It enables future backward-compatible extensions to the containing 'StatisticalParameters' data structure.

<StatisticsExtensionComponent(11)>:=	
<**IntUnTi**>(11),	: id of this component
<IntUnLoMB>(lengthComp),	: number of bytes in component, excluding the id and lengthComp indicator
<IntUnLoMB>(lengthAttr);	: number of bytes in attributes

A.3 TFP data types

TFP data types are specific, composite attributes defined for use in this TPF applications. When used inside a TFP component, their length is added to the attribute Length 'lengthAttr' of the enclosing component.

A.3.1 FlowVectorSection

<FlowVectorSection>:=	
<IntUnLoMB>(spatialOffset),	: Start of the section as spatial offset in upstream direction (i.e. opposite to the driving direction, see also 8.3) to the end of the road stretch defined by the Location Reference of the message. The end of a section is defined by the start of the following section in downstream (driving) direction. If the section is of type 'entry' (see attribute 'sectionType') the offset defines the point where the entry joins the road. If the section is of type 'exit' the offset defines the point where the exit separates from the road. The units used for the offset is signalled by the 'spatialResolution' attribute of the related objects 'FlowMatrx', 'FlowVector' or 'FlowVectorSection' and may be in TMC locations or metric units, or a default value 1 in case of a 'start-of-location' spatial resolution. The determination of the metric spatial offset is defined by the following equation: spatial offset (m) = spatialOffset * spatialResolution (m)
<**StatusParameters**>(status),	: Attributes describing the traffic status at this section
BitArray(selector),	
if (bit 0 of selector is set)	

<tfp004:SpatialResolution> (spatialResolutionSection),	: Resolution of the spatial offset used for this section, in steps of 10/50/100/500 metres, or TMC-locations, or relative offsets in steps of 10/100 metres, or a fixed value 1 for the spatialOffset attribute in case of a 'start-of-location'. spatialResolutionSection value. The value of this attribute — if present — overrides for this 'FlowVectorSection' the attributes 'spatialResolution' of the related 'FlowMatrix' component and/or 'spatialResolutionVector' of the related 'FlowVector' component. To avoid aggregated inaccuracies, relative offsets should be used only exceptionally, e.g. for precise delimiters of particular sections within a road stretch with TMC location referencing.
if (bit 1 of selector is set)	
<**tfp007:SectionType**>(sectionType),	: Type of section; shall be used if and only if no normal road section (entry or exit)
if (bit 2 of selector is set)	
<Restrictions>(restriction),	: Information on restrictions related to the reported information
if (bit 3 of selector is set)	
<**StatisticalParameters**>(statistics),	: Statistical information related to the reported flow status
if (bit 4 of selector is set)	
<**tfp006:CauseCode**>(cause),	: A simple cause for the reported traffic flow status may be added by this attribute; this parameter shall be omitted if a detailed cause is available by an external message (see attribute 'linked cause')
if (bit 5 of selector is set)	
<LinkedCause>(detailedCause),	: A detailed cause may be reported by a linked message (e.g. a TEC-message)
if (bit 6 of selector is set)	
<**SectionExtensionComponent**> (extensions);	: The extensions component is not used yet but may be used in future TFP versions to add further attributes to this data structure without losing backward-compatibility

A.3.2 PolygonPoint

<PolygonPoint>:=	
<IntUnLoMB>(spatialOffset),	: Position of the 'PolygonPoint' as (absolute) spatial offset to the end of the road stretch defined by the Location Reference of the message in upstream direction. The units used for the offset is signalled by the ‘spatialResolution‘ attribute of the related objects ‘FlowPolygon’ or ‘FlowPolygonObject’ and may be in TMC locations or metric units. The determination of the metric spatial offset is defined by the following equation: spatial offset (m) = spatialOffset * spatialResolution (m) Relative spatial offsets (table entries 5 and 6) shall not be used for this attribute.
<IntUnLoMB>(timeOffset);	: Temporal offset [min] to the 'startTime' of the surrounding 'FlowPolygonObject'.

A.3.3 LinkedCause

<LinkedCause>:=	
<IntUnLoMB>(messageID),	: The related message ID
<**IntUnTi**>(COID),	: Content ID of the TPEG service component related to the linked message

BitArray(selector),	
if (bit 0 of selector is set)	
<**ServiceIdentifier**>(SID),	: The TPEG service ID related to the service of the linked message; this attribute may be omitted if the linked message is in the same TPEG service like this TFP message
if (bit 1 of selector is set)	
<**IntUnLi**>(AID);	: Application ID of the TPEG service component related to the linked message; the default value is = 5 (TEC) so this attribute may be omitted if the linked message is of this application type

A.3.4 StatusParameters

<StatusParameters>:=	
BitArray(selector),	
if (bit 0 of selector is set)	
<**tfp003:LevelOfService**>(LOS),	: The 'LOS' (Level-of-Service) attribute indicates the current traffic quality and (optionally) its tendency. The LOS level is dependent on the road category; e.g. an average speed of 40km/h may be 'Free Traffic' on a city road and may be 'Queuing Traffic' on a highway. The tendency shall be the predicted LOS level in the next time period, which starts at startTime + duration of this the current period
if (bit 1 of selector is set)	
<**IntUnTi**>(averageSpeed),	: The achievable average speed in km/h. This value may differ from the measured average speed on the related road section as it should exclude vehicle classes with inherent speed limitations (e.g. lorries).
if (bit 2 of selector is set)	
<**IntUnLoMB**>(freeFlowTravelTime),	: The time in seconds it takes to traverse the affected road segment under free flow traffic conditions.
if (bit 3 of selector is set)	
<**Duration**>(delay),	: Delay on the road segment in seconds; as this value shall be used only if the average speed is near to 0 m/sec this value equals the overall travel time, i.e. the time it takes to traverse the road segment.
if (bit 4 of selector is set)	
<**StatusExtensionComponent**>(extensions);	: The extensions component is not used yet but may be used in future TFP versions to add further attributes to this data structure without losing backward-compatibility.

A.3.5 Restrictions

<Restrictions>:=	
BitArray(selector),	
if (bit 0 of selector is set)	
<**tfp001:VehicleClass**> (vehicleClassAssignment),	: The purpose of the vehicle class attribute is to be able to supply traffic flow and prediction values for particular types of vehicles rather than describe a particular vehicle itself. The attribute indicates that the status conveyed in the current TFP object only concerns a specific type of vehicle.
if (bit 1 of selector is set)	
<**tfp002:VehicleCredentials**> (vehicleCredentials),	: Where special restrictions or access conditions apply for a particular type of vehicle then these credentials can be indicated by this element.

if (bit 2 of selector is set)	
<**tfp005:LaneRestriction**>(lanes),	: Assignment to lanes for which the reported traffic status is valid
if (bit 3 of selector is set)	
<**IntUnTi**>(angle),	: Angle of an entry/exit to the road stretch in 360/255 degree steps clockwise to the direction of the road stretch at the entry/exit point. Only required to differentiate between several entries/exits if more than one exit/entry is going in/out at the same point on the road, so no exact angle values are required. If an entry/exit can't be referenced unambiguously in this way, an extra TFP message with a dedicated location reference (e.g. DLR1 reference) for this entry/exit should be used.
if (bit 4 of selector is set)	
<**IntUnLoMB**>(length),	: Length affected in 10 meter steps. This parameter may be used for sections of type 'entry' or 'exit' to restrict the traffic flow to parts of the related section. In case of an entry, the length determines the start of the section, in case of an exit it determines the end of the section. In case of a section on the road stretch this parameter shall not be used cause the section length is determined by the 'spatialOffset' attribute of the following section or the end of the Location Reference.
if (bit 5 of selector is set)	
<**RestrictionExtensionComponent**> (extensions);	: The extensions component is not used yet but may be used in future TFP versions to add further attributes to this data structure without losing backward-compatibility.

A.3.6 StatisticalParameters

<StatisticalParameters>:=	
BitArray(selector),	
if (bit 0 of selector is set)	
<IntUnTi>(congestionProbability),	: The risk [%] that a congestion (LOS level 'stationary traffic' or 'blocked') will occur at this road section. This value shall be in range 0..100.
if (bit 1 of selector is set)	
<IntUnLoMB>(T90relative),	: Used to determine the risk that the travel time may exceed the expected travel time considerably. The value is delivered in 1/10 percentages. A low value is equal to a high probability that the transmitted 'averageSpeed' is reliable. In detail, the attribute 'T90relative' is used to determine a Travel Time value T90 where 90% of the measured travel times on the affected road section are below T90. In other words, a driver can rely on with 90% probability that his travel time will not exceed T90. The determination of T90 shall be done by the following approach: The average travel time Tav at the affected road section is determined by: Tav = section-length [m] / averageSpeed [m/sec] The T90 value is computed by: T90 = Tav * T90relative

if (bit 2 of selector is set)	
<**tfp008:FlowDataQuality**>(FlowQuality),	: Expresses the accuracy of the data source(s) used for the determination of the traffic status, e.g. accurate measurement data will have a higher quality level than estimations made from video surveys.
if (bit 3 of selector is set)	
<IntUnTi>(prediction),	: This parameter may be used to link to a LOS prediction pattern. The service provider is responsible for exact definitions of these patterns.
if (bit 4 of selector is set)	
<**StatisticsExtensionComponent**> (extensions);	: The extensions component is not used yet but may be used in future TFP versions to add further attributes to this data structure without losing backward-compatibility.

Annex B
(normative)

Traffic Flow and Prediction, TPEG-ML Representation

B.1 General

This annex provides the tpegML representation derived via application of the UML to XML conversion rules specified in ISO/TS 21219-4.

B.2 Message Components

B.2.1 TFP Message

```
<xs:element name="TFPMessage" type="TFPMessage"/>
   <xs:complexType name="TFPMessage">
      <xs:complexContent>
         <xs:extension base="tsf:ApplicationRootMessageML">
            <xs:sequence>
               <xs:element name="mmt" type="MMCSwitch"/>
               <xs:element name="method" type="TFPMethod" minOccurs="0"
maxOccurs="unbounded"/>
               <xs:element name="loc"
type="lrc:LocationReferencingContainer" minOccurs="0"/>
            </xs:sequence>
         </xs:extension>
      </xs:complexContent>
   </xs:complexType>
```

B.2.2 TFP Method

```
<xs:complexType name="TFPMethod">
      <xs:sequence>
         <xs:choice minOccurs="1" maxOccurs="1">
            <xs:element name="optionFlowPolygonObject"
type="FlowPolygonObject" minOccurs="1" maxOccurs="1"/>
            <xs:element name="optionFlowStatus" type="FlowStatus"
minOccurs="1" maxOccurs="1"/>
            <xs:element name="optionFlowMatrix" type="FlowMatrix"
minOccurs="1" maxOccurs="1"/>
         </xs:choice>
      </xs:sequence>
   </xs:complexType>
```

B.2.3 FlowPolygonObject

```
<xs:complexType name="FlowPolygonObject">
      <xs:sequence>
         <xs:element name="startTime" type="tdt:DateTime"/>
         <xs:element name="duration" type="tdt:IntUnLoMB"
minOccurs="0"/>
         <xs:element name="spatialResolution"
type="tfp004_SpatialResolution"/>
         <xs:element name="polygons" type="FlowPolygon"
maxOccurs="unbounded"/>
      </xs:sequence>
```

B.2.4 FlowPolygon

```
<xs:complexType name="FlowPolygon">
      <xs:sequence>
         <xs:element name="polygonIndex" type="tdt:IntUnLoMB"/>
         <xs:element name="status" type="StatusParameters"/>
         <xs:element name="polygonPoints" type="PolygonPoint"
maxOccurs="unbounded"/>
         <xs:element name="spatialResolutionPolygon"
type="tfp004_SpatialResolution" minOccurs="0"/>
         <xs:element name="restriction" type="Restrictions"
minOccurs="0"/>
         <xs:element name="statistics" type="StatisticalParameters"
minOccurs="0"/>
         <xs:element name="cause" type="tfp006_CauseCode"
minOccurs="0"/>
         <xs:element name="detailedCause" type="LinkedCause"
minOccurs="0"/>
      </xs:sequence>
   </xs:complexType>
```

B.2.5 FlowStatus

```
<xs:complexType name="FlowStatus">
      <xs:sequence>
         <xs:element name="startTime" type="tdt:DateTime"/>
         <xs:element name="duration" type="tdt:IntUnLoMB"
minOccurs="0"/>
         <xs:element name="status" type="StatusParameters"/>
         <xs:element name="restriction" type="Restrictions"
minOccurs="0"/>
         <xs:element name="statistics" type="StatisticalParameters"
minOccurs="0"/>
         <xs:element name="cause" type="tfp006_CauseCode"
minOccurs="0"/>
         <xs:element name="detailedCause" type="LinkedCause"
minOccurs="0"/>
      </xs:sequence>
</xs:complexType>
```

B.2.6 FlowMatrix

```
   <xs:complexType name="FlowMatrix">
      <xs:sequence>
         <xs:element name="startTime" type="tdt:DateTime"/>
         <xs:element name="duration" type="tdt:IntUnLoMB"
minOccurs="0"/>
         <xs:element name="spatialResolution"
type="tfp004_SpatialResolution"/>
         <xs:element name="vectors" type="FlowVector"
maxOccurs="unbounded"/>
      </xs:sequence>
   </xs:complexType>
```

B.2.7 FlowVector

```
<xs:complexType name="FlowVector">
  <xs:sequence>
  <xs:element name="timeOffset" type="tdt:IntUnLoMB" />
  <xs:element name="vectorSections" type="FlowVectorSection"
maxOccurs="unbounded" />
  <xs:element name="spatialResolutionVector"
type="tfp004_SpatialResolution" minOccurs="0" />
  </xs:sequence>
</xs:complexType>
```

B.2.8 SectionExtensionComponent

```
<xs:complexType name="SectionExtensionComponent">
</xs:complexType>
```

B.2.9 StatusExtensionComponent

```
<xs:complexType name="StatusExtensionComponent">
</xs:complexType>
```

B.2.10 RestrictionExtensionComponent

```
<xs:complexType name="RestrictionExtensionComponent">
</xs:complexType>
```

B.2.11 StatisticsExtensionComponent

```
<xs:complexType name="StatisticsExtensionComponent">
</xs:complexType>
```

B.2.12 MMCSwitch

```
<xs:complexType name="MMCSwitch">
   <xs:sequence>
      <xs:choice minOccurs="1" maxOccurs="1">
         <xs:element name="optionMessageManagementContainerLink"
type="mmc:MessageManagementContainer" minOccurs="1" maxOccurs="1"/>
         <xs:element name="optionMMCMasterLink"
type="mmc:MMCMasterMessage" minOccurs="1" maxOccurs="1"/>
         <xs:element name="optionMMCPartLink" type="mmc:MMCMessagePart"
minOccurs="1" maxOccurs="1"/>
      </xs:choice>
   </xs:sequence>
</xs:complexType>
```

B.3 Data Types

B.3.1 FlowVectorSection

```
<xs:complexType name="FlowVectorSection">
   <xs:sequence>
      <xs:element name="spatialOffset" type="tdt:IntUnLoMB"/>
      <xs:element name="status" type="StatusParameters"/>
      <xs:element name="spatialResolutionSection"
type="tfp004_SpatialResolution" minOccurs="0"/>
      <xs:element name="sectionType" type="tfp007_SectionType"
minOccurs="0"/>
      <xs:element name="restriction" type="Restrictions" minOccurs="0"/>
      <xs:element name="statistics" type="StatisticalParameters"
minOccurs="0"/>
      <xs:element name="cause" type="tfp006_CauseCode" minOccurs="0"/>
      <xs:element name="detailedCause" type="LinkedCause"
minOccurs="0"/>
      <xs:element name="extensions" type="SectionExtensionComponent"
minOccurs="0"/>
   </xs:sequence>
</xs:complexType>
```

B.3.2 PolygonPoint

```
<xs:complexType name="PolygonPoint">
   <xs:sequence>
      <xs:element name="spatialOffset" type="tdt:IntUnLoMB"/>
      <xs:element name="timeOffset" type="tdt:IntUnLoMB"/>
   </xs:sequence>
</xs:complexType>
```