TECHNICAL SPECIFICATION

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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)

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Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 204 *Intelligent transport systems*, in cooperation with the Traveller Information Services Association (TISA), TPEG Applications Working Group through Category A Liaison status.

ISO/TS 21219 consists of the following parts, under the general title *Intelligent transport systems — Traffic and travel information (TTI) via transport protocol expert group, generation 2 (TPEG2)*:

— *Part 2: UML modelling rules* [Technical Specification]

— *Part 3: UML to binary conversion rules* [Technical Specification]

— *Part 4: UML to XML conversion rules* [Technical Specification]

— *Part 5: Service framework* [Technical Specification]

— *Part 6: Message management container* [Technical Specification]

— *Part 7: Location referencing container* [Technical Specification]

— *Part 18: Traffic flow and prediction application* [Technical Specification]

The following parts are planned:

— *Part 1: Introduction, numbering and versions* [Technical Specification]

— *Part 9: Service and network information* [Technical Specification]

— *Part 10: Conditional access information* [Technical Specification]

— *Part 14: Parking information application* [Technical Specification]

— *Part 15: Traffic event compact application* [Technical Specification]

— *Part 16: Fuel price information application* [Technical Specification]

— *Part 19: Weather information application* [Technical Specification]

— *Part 20: Extended TMC location referencing* [Technical Specification]

— *Part 21: Geographic location referencing* [Technical Specification]

— Part 22: *OpenLR·location·referencing* [Technical Specification]

— Part 23: *Roads·and·multi-modal·routes·application* [Technical Specification]

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/WG 4, in conjunction with ISO/TC 204/WG 10, established a project group comprising members of the former EBU B/TPEG and they continued the work concurrently. 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 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

With the inauguration of the Traveller Information Services Association (TISA) in December 2007 derived from former Forums and the CEN/ISO development project group, the TPEG Applications Working Group took over development work for TPEG technology.

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 Parts 2, 3, 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 (Part 6), Application (many Parts) and Location Referencing (Part 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:

Toolkit parts: TPEG2-INV (Part 1), TPEG2-UML (Part 2), TPEG2-UBCR (Part 3), TPEG2-UXCR (Part 4), TPEG2-SFW (Part 5), TPEG2-MMC (Part 6), TPEG2-LRC (Part 7)

Special applications: TPEG2-SNI (Part 9), TPEG2-CAI (Part 10)

Location referencing: TPEG2-ULR (Part 11), TPEG2-ETL (Part 20), TPEG2-GLR (Part 21), TPEG2-OLR (Part 22)

Applications: TPEG2-PKI (Part 14), TPEG2-TEC (Part 15), TPEG2-FPI (Part 16), TPEG2-TFP (Part 18), TPEG2-WEA (Part 19), TPEG2-RMR (Part 23)

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 Technical Specification is based on the TISA specification technical/editorial version number: TPEG2-TFP/1.0/003.

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 Technical Specification 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 may be as well presented directly to the user by textual, voiced and graphically output devices.

TFP is status oriented, i.e. the transmitted information updates continuously 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:

— provide dynamic navigation systems with up-to-date traffic state information,

— ensure travel safety for the driver,

— enable the calculation of alternative routes,

— avoid delays (e.g. traffic jams),

— lower traffic load on over-saturated parts of the network,

— keep driver informed about current and upcoming traffic,

— compact and efficient coding of the traffic information.

2 Normative references

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

ISO 17572-1:2008, *Intelligent transport systems (ITS) — Location referencing for geographic databases — Part 1: General requirements and conceptual model*

ISO 17572-2:2008, *Intelligent transport systems (ITS) — Location referencing for geographic databases — Part 2: Pre-coded location references (pre-coded profile)*

ISO 17572-3:2008, *Intelligent transport systems (ITS) — Location referencing for geographic databases — Part 3: Dynamic location references (dynamic profile)*

ISO/TS 18234-1:2013, *Intelligent transport systems — Traffic and travel information via transport protocol experts group, generation 1 (TPEG1) binary data format — Part 1: Introduction, numbering and versions (TPEG1-INV)*

ISO/TS 18234-6:2006, *Traffic and Travel Information (TTI) — TTI via Transport Protocol Expert Group (TPEG) data-streams — Part 6: Location referencing applications*

ISO/TS 21219-2, *Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2) — Part 2: UML modelling rules*

ISO/TS 21219-3, *Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2) — Part 3: UML to binary conversion rules*

ISO/TS 21219-4, *Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2) — Part 4: UML to XML conversion rules*

ISO/TS 21219-5, *Intelligent transport systems — Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2 — Part 5: Service framework (TPEG2-SWF)*

ISO/TS 21219-6, *Intelligent transport systems — Traffic and travel information via transport protocol experts group, generation 2(TPEG2) — Part 6: Message management container (TPEG2-MMC)*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

3.1.1
Message Management Container
concept applied to the grouping of all message elements including Message Management Information of a TPEG-Message together in one place

3.1.2
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.

3.1.3
Location Referencing Container
concept applied to the grouping of all the Location Referencing elements, of a TPEG-Message, together in one place

3.2 Abbreviated terms

ADC	Application Data Container
AID	TPEG Application ID
CEN	Comité Européen de Normalization
EBU	European Broadcasting Union
LRC	Location Referencing Container
MMC	Message Management Container
OSI	Open Systems Interconnection
SSF	TPEG Specification: Syntax, Semantics and Framing Structures
TPEG	Transport Protocol Expert Group
TTI	Traffic and Traveller Information
UML	Unified Modelling Language
XML	Extensible Markup Language
XSD	XML Schema Definition

4 Application specific constraints

Ordered Components

TPEG-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 the *Application Data Container* component 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 6.1).

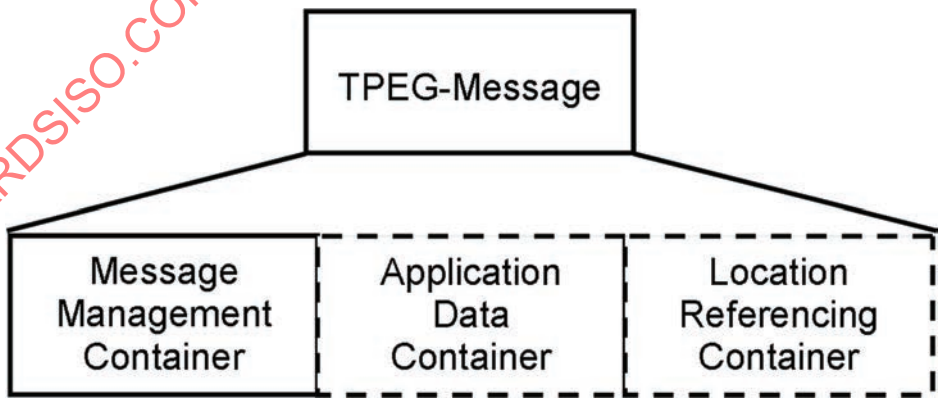


Figure 1 — Composition of TPEG messages

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. That means a TFP decoder shall be able to detect and skip unknown components.

For reasons of efficiency some data structures of TFP which may potentially require extensions in future are defined as TPEG *DataStructures* though these structures are not extensible in a backward compatible way. To ensure extensibility dedicated extension components are added to these DataStructures which may be used for future TFP extensions of TFP (DataStructures 'FlowVectorSection', 'StatusParameters', 'Restrictions', 'StatisticalParameters', see also 6.1).

TPEG Service Component Frame

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

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.

For services basing on this TFP specification the following version numbers shall be signalled in the SNI:

— major version number 1

— minor version number 0

Application ID (AID)

The TFP application ID is assigned by ISO/TS 18234-1:2013. As this document requires some time for update with the recent AIDs it may not include all assigned AIDs. In this case, please contact TISA for further information.

5 TFP Structure

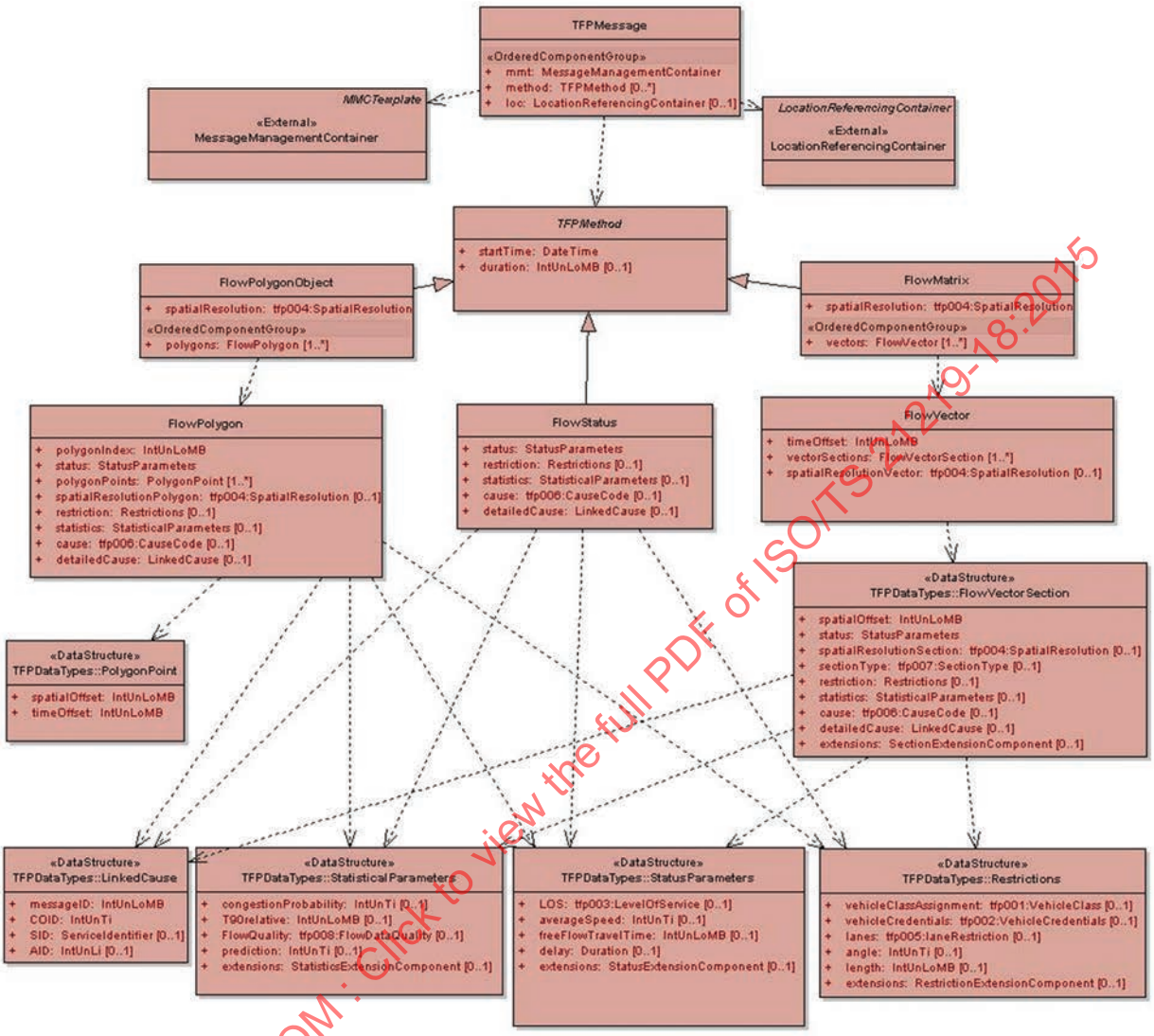


Figure 2 — UML Class Model of TPEG-TFP

6 TFP Message components

6.1 TFPMessage

A 'TFPMessage' component is the top container of a TFP message. It contains all information about a particular part of the network, for example 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/TS 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/TS 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', 6.5).

— FlowStatus-Method: A flow status applied to the overall road stretch defined by the LRC of the message (see description of component 'FlowStatus', 6.7). 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', 6.8). 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 6.3). 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 6.8).

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

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

6.2 MessageManagementContainer

The MessageManagementContainer is a placeholder for the MessageManagementContainer as defined in the MMC-toolkit specification (ISO/TS 21219-6). It assigns the Traffic Flow and Prediction application specific local component ID for the MMC container (see A.3.4).

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 (ISO/TS 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.

6.3 LocationReferencingContainer

The LocationReferencingContainer component is a placeholder for the LocationReferencingContainer (LRC) as described in the LRC toolkit specification (ISO/TS 18234-6:2006). It assigns the Traffic Flow and Prediction (TFP) application specific local component ID for the LRC container (see also A.3.5). 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 if the LRC is not present in a TFP message the receiver shall use the LRC of the most recently received message with the same Message ID (MID) for determining the location. 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, 6.5) or delimiters of road sections (see description of the Flow-Matrix-Method, see 6.8).

If TMC location referencing (ISO 17572-3:2008) 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.

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).

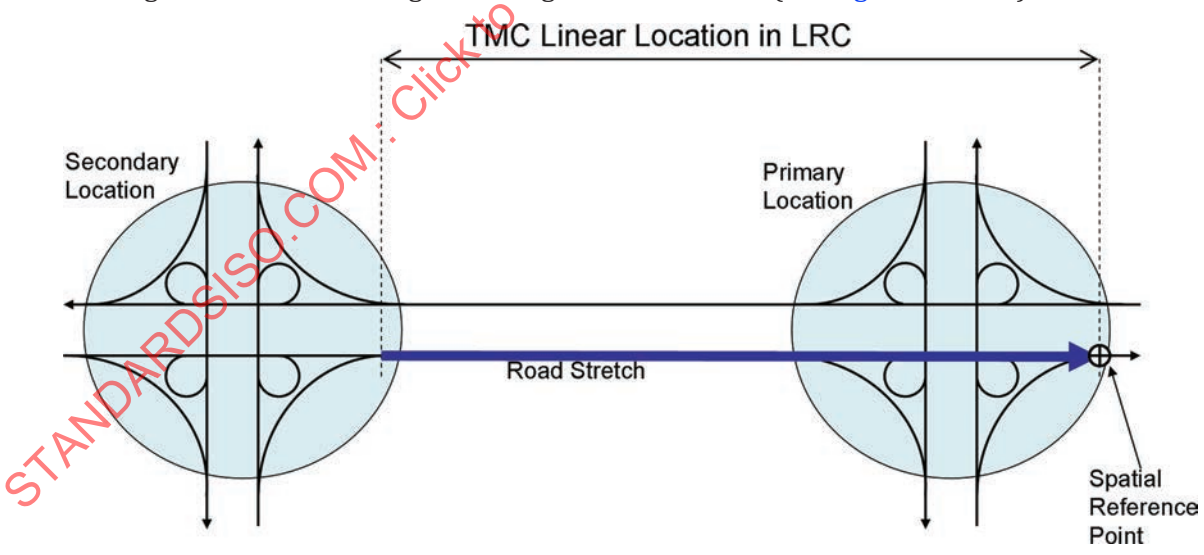


Figure 3 — Application of TMC location references in TFP

6.4 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' (see 6.5), FlowStatus' (see 6.7) and FlowMatrix' (see 6.8).

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.

6.5 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).

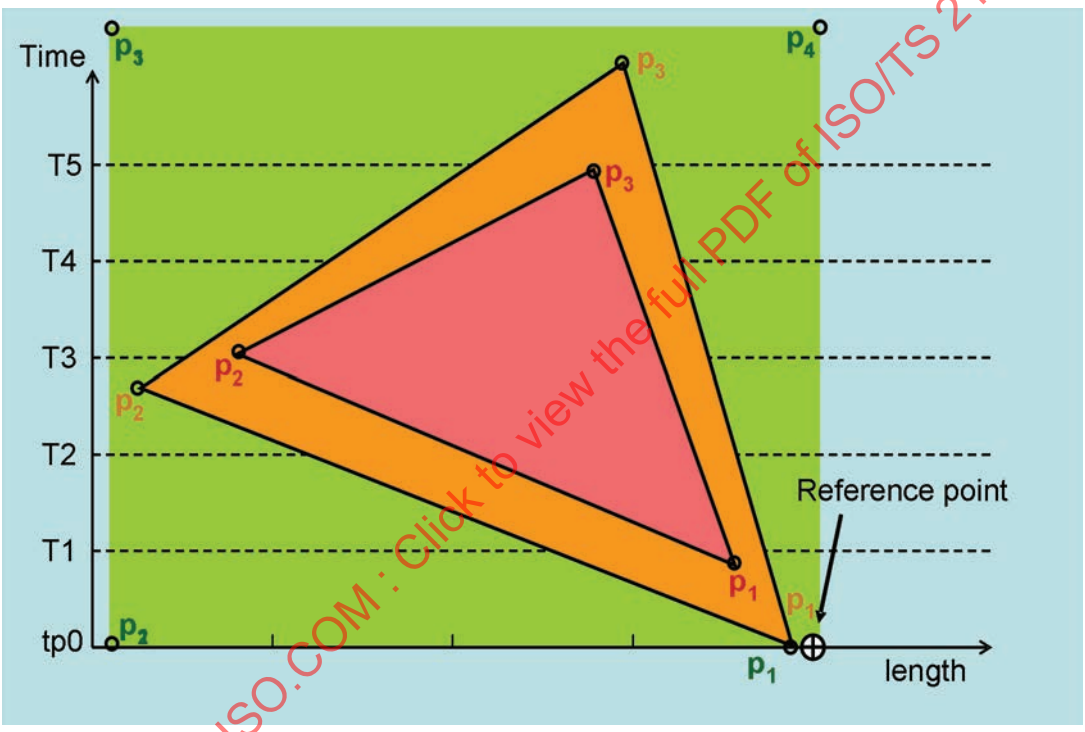


Figure 4 — Example of a Flow Polygon Object with 2 Flow Polygons

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 are using 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'.

Name	Type	Multiplicity	Description
startTime	DateTime	1	See 6.4
duration	IntUnLoMB	0..1	See 6.4; this attribute shall be present in the 'FlowPolygon-Object' component as it is required for the temporal interval flow polygon
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.
polygons	Component FlowPolygon	1..*	Flow polygon data; see 6.6

6.6 FlowPolygon

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

Name	Type	Multiplicity	Description
polygonIndex	IntUnLoMB	1	Unique within related 'FlowPolygonObject'. Used for ordering the FlowPolygons within the 'FlowPolygonObject' (see 6.5).
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 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 should 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)

6.7 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.

Name	Type	Multiplicity	Description
startTime	DateTime	1	See 6.4
duration	IntUnLoMB	0..1	See 6.4; this attribute shall be used in the 'FlowStatus' component if forecast or tendency data are provided by the message and may be omitted 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
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)

6.8 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 15/30/45/60min 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 also relative offsets to the beginning of the following section may be used (see use case 6 below)

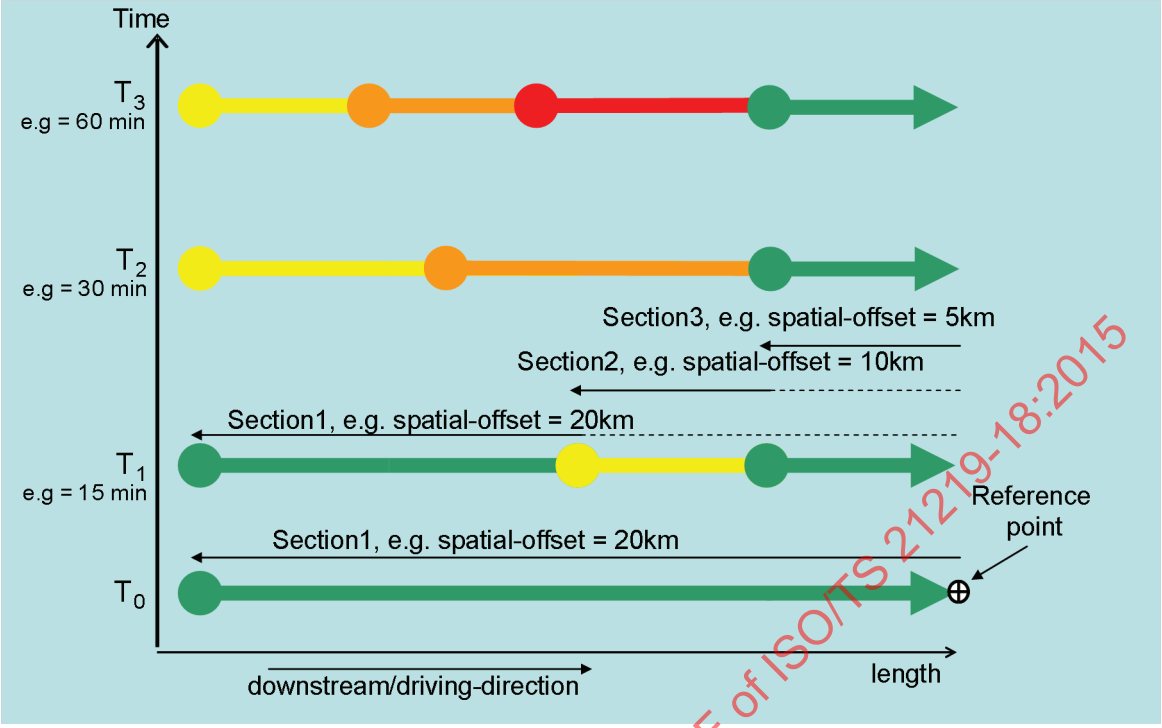
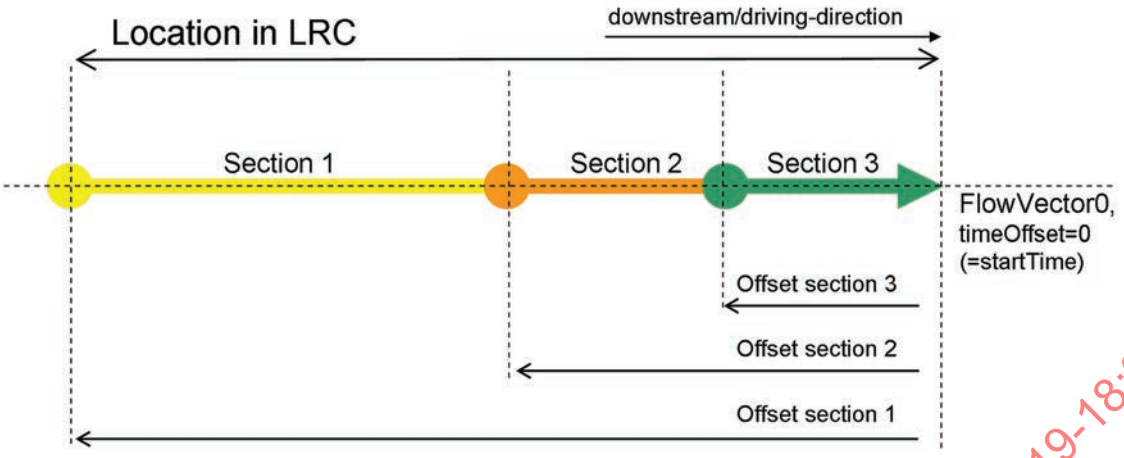


Figure 5 — Example of a Flow Matrix Object with 4 Flow Vectors (1 for current status, 3 for prognosis)

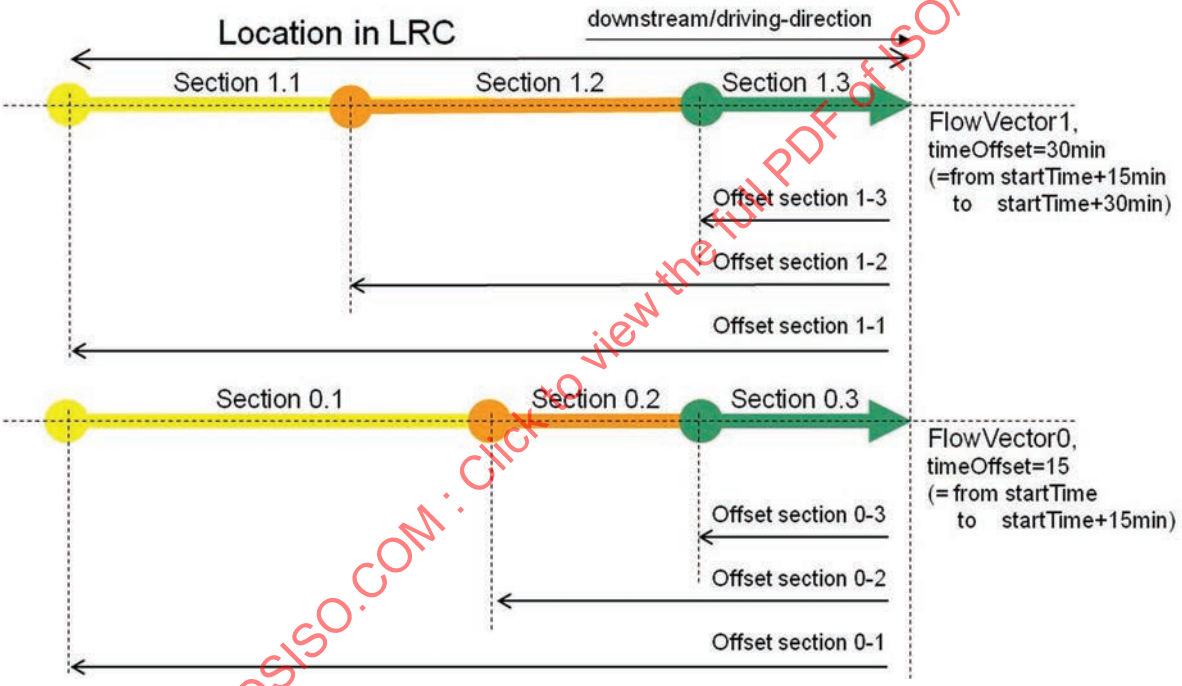
Name	Type	Multiplicity	Description
startTime	DateTime	1	See 6.4
duration	IntUnLoMB	0..1	See 6.4, this attribute shall be used in the 'FlowMatrix' component if forecast or tendency data are provided by the message and may be omitted otherwise.
spatialResolution	tfp004: SpatialResolution	1	Resolution of 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 datastructure 'FlowVectorSection'). Relative spatial offsets (table entries 5 and 6) shall not be used for this attribute.
vectors	Component FlowVector	1..*	Flow vector data; see 6.9

Examples and Use Cases:

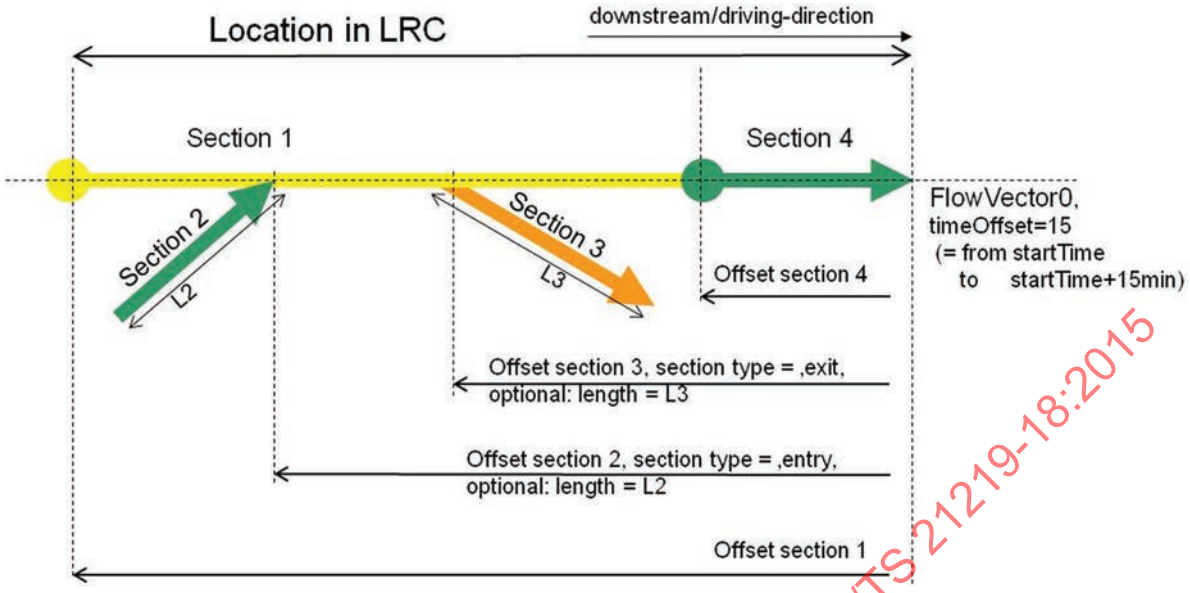
1. UC1: Flow Matrix with one Flow Vector for current traffic and with 3 Flow Sections along the road stretch



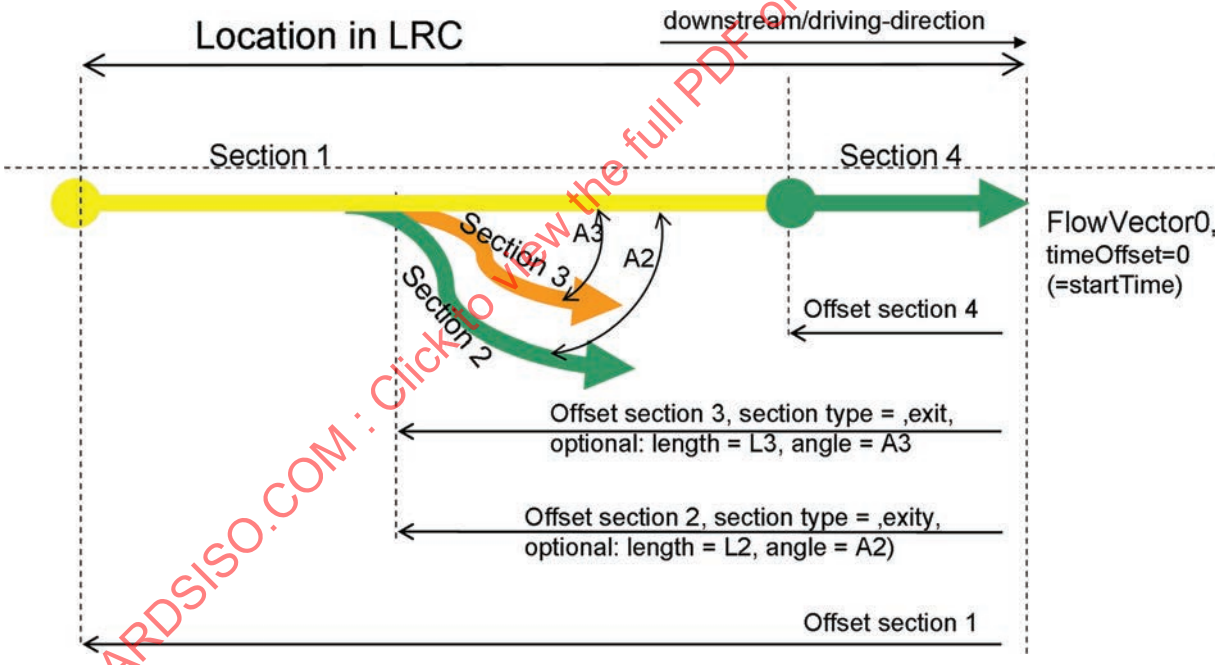
2. UC2: Flow Matrix with two Flow Vectors (current traffic and 30min forecast) each with 3 Flow Sections along the road stretch



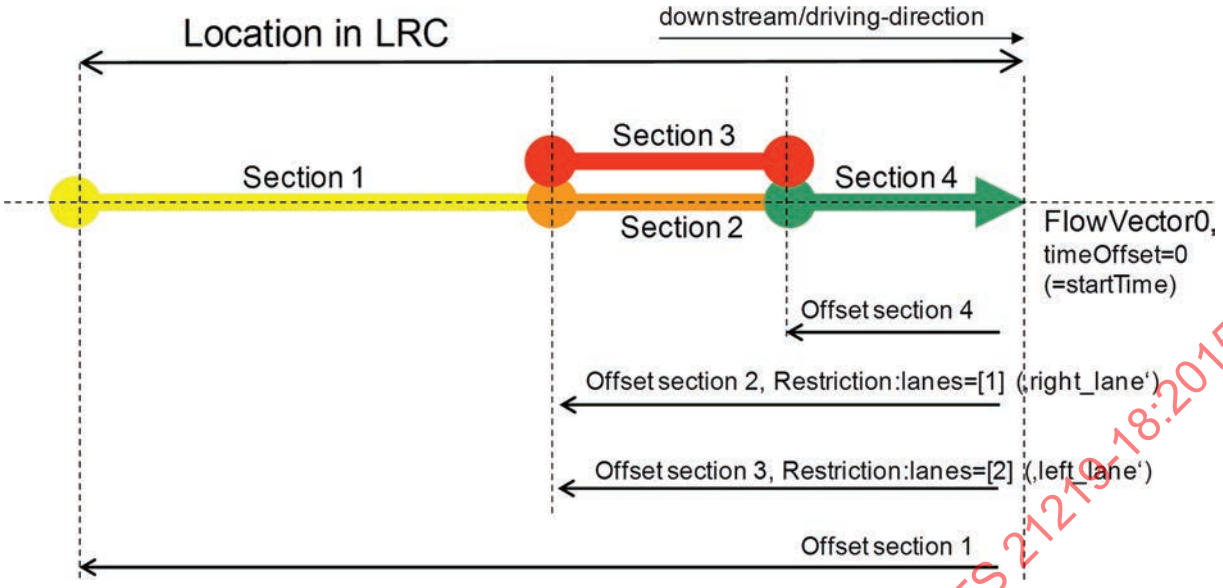
3. UC3: Flow Matrix with one Flow Vector for current traffic including a Flow Section for an entry and a Flow Section for an exit



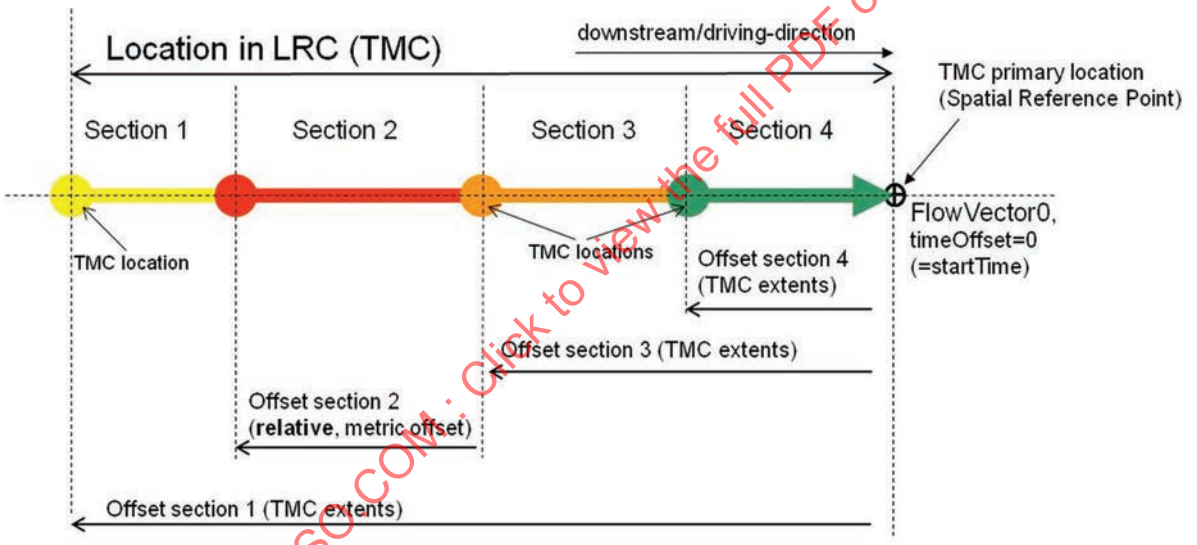
4. UC4: Flow Matrix with one Flow Vector for current traffic including two exit Flow Sections leaving the road at the same position, differentiated by the 'angle' attribute (datastructure 'Restrictions', see 7.4)



5. UC5: Flow Matrix with one Flow Vector for current traffic including two Flow Sections with lane restrictions (datastructure 'Restrictions', see 7.4); 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.



6.9 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.

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.

6.10 SectionExtensionComponent

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

6.11 RestrictionExtensionComponent

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

6.12 StatusExtensionComponent

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

6.13 StatisticsExtensionComponent

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

7 TFP Data Types

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

7.1 PolygonPoint

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

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 are signalled by 'spatialResolution 'attribute of the related FlowPolygonObject (see 6.5). 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'.

7.2 FlowVectorSection

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

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 6.3) 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. 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.
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. 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.
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)
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

7.3 StatusParameters

This datastructure 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' or '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 or closed road this shall be indicated by a 'LOS' attribute with value ' no traffic flow (with or without tendency, tfp003 values 006, 014, 030, 046)

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 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 (see 6.4).
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; Relation: overall travel time = free flow travel time + delay for the road segment
extensions	Component 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.

7.4 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' datastructure.

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
angle	IntUnTi	0..1	Angle of an entry/exit 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 entry/exit 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.

Name	Type	Multiplicity	Description
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.
extensions	Component RestrictionExtensionComponent	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.

7.5 StatisticalParameters

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

Name	Type	Multiplicity	Description
congestionProbability	IntUnTi	0..1	The risk [%] that a congestion (LOS levels 'stationary traffic' or 'no traffic flow ') 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; 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
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.
extensions	Component 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.

7.6 LinkedCause

This datastructure 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.

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
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 TFP Tables

8.1 tfp001: VehicleClass

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

Code	CEN 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		
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		

8.2 tfp002: VehicleCredentials

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

Code	CEN English 'Word'	Comment	Example
000	unknown		
001	high occupancy		
002	disabled passenger		
003	paid privileges		

8.3 tfp003: LevelOfService

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

Code	CEN 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 flow	
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	
007	rfu		
008	rfu		
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	
015	rfu		
016	rfu		
017	free traffic increasing	Current status: free traffic flow, Tendency: heavy traffic	
018	heavy traffic increasing	Current status:heavy traffic, Tendency: slow traffic	

Code	CEN English 'Word'	Comment	Example
019	slow traffic increasing	Current status:slow traffic, Tendency: queuing traffic	
020	queuing traffic increas-ing	Current status:queuing traffic, Tendency: stationary traffic	
021	rfu		
022	rfu		
023	rfu		
024	rfu		
025	rfu		
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 decreas-ing	Current status:queuing traffic, Tendency: slow traffic	
029	stationary traffic decreasing	Current status:stationary traffic, Tendency: queuing traffic	
030	no traffic flow decreas-ing	Current status:no traffic flow, Tendency: queuing traffic	
031	rfu		
032	rfu		
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	
036	rfu		
037	rfu		
038	rfu		
039	rfu		
040	rfu		
041	rfu		
042	rfu		
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 accord-ing to the three-phase-traffic theory, The client may interpret this status as 'heavy traffic' if it can't model synchronized flow. Tendency: unknown	

Code	CEN 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	

8.4 tfp004: SpatialResolution

Code	CEN 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 10m steps upstream to the begin of the following section; this value may be used only by the spatialResolutionSection of the 'flowVectorSection' datastructure; it shall not be used by other TFP attributes; offset = value*10 [m]	
006	relative-100-m-resolution	spatial offset is delivered in 100m steps upstream to the begin of the following section; this value may be used only by the spatialResolutionSection of the 'flowVectorSection' datastructure; it shall not be used by other TFP attributes; offset = value*100 [m]	

8.5 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).

Code	CEN 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		

Code	CEN English 'Word'	Comment	Example
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		
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)	

8.6 tfp006: CauseCode

A simple cause code.

Code	CEN English 'Word'	Comment	Example
000	unknown		
001	traffic congestion	In case that the capacity of that part of the street causes this traffic state.	

Code	CEN English 'Word'	Comment	Example
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	impassibility	In case that in general the given part of a road is impassible.	
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.	
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 adaption.	
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.	

Code	CEN English 'Word'	Comment	Example
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 an 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.	
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.	

Code	CEN English 'Word'	Comment	Example
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.	
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 the road is closed by the regulatory authorities	

8.7 tfp007: SectionType

Code	CEN English 'Word'	Comment	Example
000	unknown		
001	entry	Section affected is an entry	
002	exit	Section affected is an exit	

8.8 tfp008: FlowDataQuality

Code	CEN 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 Introduction

This sub-clause defines the format of the TFP message components, data-structures and its attributes for the TPEG binary representation of TFP as described in ISO/TS 21219-2 and ISO/TS 21219-3. For further descriptions of these objects see related Clauses 6 and 7.

A.2 Framing

TFP makes use of the "Service Component Frame with dataCRC, groupPriority, and messageCount" according to ISO/TS 21219-5. For explanatory purpose this is repeated here.

<**ServCompFramePrioritisedCountedProtected**>: =	: CRC protected Service Component Frame with group priority and message count
<**ServCompFrameHeader**>(header),	: Service Component Frame header as defined in ISO/TS 21219-5.
<**typ007:Priority**>(groupPriority)	: group priority applicable to all messages in the ApplicationContent
<**IntUnTi**>(messageCount),	: count of messages in this ApplicationContent
external<**ApplicationContent**>(content),	: actual payload of the application
<**CRC**>(dataCRC);	: CRC starting with first byte after the Service Component Header CRC

The main frame of TFP defines ApplicationContent as follows:

<**ApplicationContent**>: =	: Service component frame template : derived header from [SSF]
messageCount *<**TFPMessage**>(msg);	: Any number of any TFP message components (ISO/TS 21219-5)

A.3 Message components

A.3.1 List of Generic Component Ids

Name	Id
TFPMessage	0
MessageManagementContainer	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.3.2 Clarification of usage of general TPEG attributes

A.3.2.1 Component Length and Attribute Length

Each binary representation of a TPEG component includes attributes for the related Component Length and Attribute Length (parameters 'lengthComp' and 'lengthAttr' in the component definitions below). According to ISO/TS 21219-3 these parameters are defined as follows:

— The **Component Length** is overall the number of bytes of this component following (not including) the 'lengthComp' parameter. In particular this includes the attribute block with the Attribute Length parameter 'lengthAttr', the mandatory attributes (if present), the selector bitarray (if present), the optional attributes (if present) and the sub-components (if present).

— The **Attribute Length** is overall the number of bytes of the attribute Block of this component following (not including) the 'lengthAttr' parameter and not including the sub-components (if present). In particular this includes the mandatory attributes, the selector bitarray (if present) and optional attributes (if present).

A.3.2.2 Selector Bitarray

TPEG provides a general mechanism for signalling optional attributes in a datastructure or a component, the selector bitarray. Each optional attribute corresponds to a bit in the selector bitarray. If a bit representing an optional attribute is set (=1), the corresponding optional attribute is present. In case the bit is unset the attribute is not available and the next following attribute shall be processed in the stream (ISO/TS 21219-3).

The bitarray itself is of variable length using a continuation flag in each byte to signal the presence of the next byte. A TPEG sender may restrict the length of a selector bitarray to the sequence of bytes up to the last byte with at least one set bit (=1). Thus, the aforementioned **selector status 'unset' equals both to bit=0 or bit='not present'.**

Example:

A component C includes 10 optional attributes a1 … a10. As each byte of the selector bitarray includes seven selector bits, two bytes are required for the selector: In this example bits 1…7 of the first selector byte correspond to attributes a1…a7 and bits 1…3 of the second selector byte correspond to attributes a8…a10.

— If at least one of the attributes a8…a10 is present in component C, respectively one of the bits in the second selector byte is set, the selector must have 2 bytes

— If none of the attributes a8…a10 is present in component C, respectively all bits are zero in the second selector byte, the selector may both have

  — one byte, indicating the absence of a8…a10 by the absence of the corresponding bits and

  — 2 bytes, indicating the absence of a8…a10 by bit-value=0 of the corresponding bits

The parser of a TPEG receiver shall support both of the aforementioned representations. Moreover, as TPEG supports backward-compatible enhancements of components a later version of the component C may even include three or more selector bytes. The parser shall also be able to deal with this enhancements.

A.3.3 TFPMessage

<TFPMessage(0)>: =	: Traffic Flow and Prediction Message Component
<IntUnTi>(id),	: Identifier=0, unique within scope of the application
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding id and length indicator
<IntUnLoMB>(lengthAttr),	: Length of attributes of this component in bytes
<MessageManagementContainer>(mmt),	: Message Management data component
n * **<TFPMethod>**(method),	: Traffic flow data component(s)
m ***<LocationReferencingContainer>**(loc)[0..1];	: Location data (external) component

For description of this object, see 6.1.

A.3.4 MessageManagementContainer

The content of this component is defined in the specification of the MMC (ISO/TS 21219-6). For the component IDs of the particular MMC components see A.3.1.

See also 6.2.

A.3.5 LocationReferencingContainer

The content of this component is defined in the specification of the LRC toolkit (ISO/TS 18234-6:2006).

The application specific local LRC component ID is defined A.3.1.

All component IDs within the LRC container are local to the LRC toolkit.

See also 6.3.

A.3.6 TFPMethod

<TFPMethod(x)>: =	: Template for TFP flow model methods
<IntUnTi>(id),	: Identifier assigned by specific method
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr),	: Length of attributes of this component in bytes
<DateTime>(startTime),	
<BitArray>(selector),	: 1 byte containing 1 switch.
If bit 0 of selector is set:	
<IntUnLoMB>(duration),	: see 6.4

This is a virtual class and will not occur as such in a message but only by its child classes 'FlowPolygonObject' (A.3.7, A.3.9, A.3.10), 'FlowStatus' and 'FlowMatrix'.

For description of this object, see also 6.4.

A.3.7 FlowPolygonObject

<FlowPolygonObject(3)<TFPMethod()>>: =	
<IntUnTi>(id),	: Identifier=3
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr),	: Length of attributes of this component in bytes
<DateTime>(startTime),	: see 6.5
<BitArray>(selector),	: 1 byte containing 1 switch.
If bit 0 of selector is set:	
<IntUnLoMB>(duration),	: see 6.5
<tfp004:SpatialResolution>(spatialResolution),	: see 6.5
n * **<FlowPolygon>**(polygons);	Flow polygon data

For description of this object, see also 6.5.

A.3.8 FlowPolygon

<FlowPolygon(4)>: =	
<IntUnTi>(id),	: Identifier=4
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr),	: Length of attributes of this component in bytes
<StatusParameters>(status),	: see 6.6
<IntUnLoMB>(n),	: Number of entries in array attribute, between 1 and infinity.
n * **<PolygonPoint>**(polygonPoints),	: Vector with polygon points
<BitArray>(selector),	: 1 byte containing 5 switches.
If bit 0 of selector is set:	
<tfp004:SpatialResolution>(spatialResolutionPolygon),	: see 6.6
If bit 1 of selector is set:	

<Restrictions>(restriction),	: Information on restrictions related to the reported information
If bit 2 of selector is set:	
<StatisticalParameters>(statistics),	: see 6.6
If bit 3 of selector is set:	
<tfp006:CauseCode>(cause),	: see 6.6
If bit 4 of selector is set:	
<LinkedCause>(detailedCause);	: see 6.6

For description of this object, see also 6.6.

A.3.9 FlowStatus

<FlowStatus(5)<TFPMethod()>>: =	
<IntUnTi>(id),	: Identifier=5
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr),	: Length of attributes of this component in bytes
<DateTime>(startTime),	: see 6.7
<BitArray>(selector),	: 1 byte containing 5 switches.
If bit 0 of selector is set:	
<IntUnLoMB>(duration),	: see 6.7
<StatusParameters>(status),	: see 6.7
If bit 1 of selector is set:	
<Restrictions>(restriction),	: see 6.7
If bit 2 of selector is set:	
<StatisticalParameters>(statistics),	: see 6.7
If bit 3 of selector is set:	
<tfp006:CauseCode>(cause),	: see 6.7
If bit 4 of selector is set:	
<LinkedCause>(detailedCause);	: see 6.7

For description of this object, see also 6.7.

A.3.10 FlowMatrix

<FlowMatrix(6)<TFPMethod()>>: =	
<IntUnTi>(id),	: Identifier=6
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr),	: Length of attributes of this component in bytes
<DateTime>(startTime),	: see 6.8
<BitArray>(selector),	: 1 byte containing 1 switch.
If bit 0 of selector is set:	
<IntUnLoMB>(duration),	: see 6.8
<tfp004:SpatialResolution>(spatialResolution),	: see 6.8
n * **<FlowVector>**(vectors);	: Flow vector data

For description of this object, see also 6.8.

A.3.11 FlowVector

<FlowVector(7)>: =	
<IntUnTi>(id),	: Identifier=7
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr),	: Length of attributes of this component in bytes
<IntUnLoMB>(timeOffset),	: see 6.9
<IntUnLoMB>(n),	: Number of entries in array attribute, between 1 and infinity.
n * **<FlowVectorSection>**(vectorSections);	: Flow section data
<BitArray>(selector),	: 1 byte containing 1 switch.
If bit 0 of selector is set:	
<tfp004:SpatialResolution>(spatialResolutionVector),	: see 6.9

For description of this object, see also 6.9.

A.3.12 SectionExtensionComponent

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

<SectionExtensionComponent(8)>: =	
<IntUnTi>(id),	: Identifier=8
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr);	: Length of attributes, always 0 since this component has no attributes

For description of this object, see also 6.10.

A.3.13 RestrictionExtensionComponent

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

<RestrictionExtensionComponent(9)>: =	
<IntUnTi>(id),	: Identifier=9
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr);	: Length of attributes, always 0 since this component has no attributes

For description of this object, see also 6.11.

A.3.14 StatusExtensionComponent

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

<StatusExtensionComponent(10)>: =	
<IntUnTi>(id),	: Identifier=10
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr);	: Length of attributes, always 0 since this component has no attributes

For description of this object, see also 6.12.

A.3.15 StatisticsExtensionComponent

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

<StatisticsExtensionComponent(11)>: =	
<IntUnTi>(id),	: Identifier=11
<IntUnLoMB>(lengthComp),	: Length of component in bytes, excluding the id and length indicator
<IntUnLoMB>(lengthAttr);	: Length of attributes, always 0 since this component has no attributes

For description of this object, see also 6.13.

A.4 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.4.1 PolygonPoint

<PolygonPoint>: =	
<IntUnLoMB>(spatialOffset),	: see 7.1
<IntUnLoMB>(timeOffset);	: see 7.1

For description of this object, see also 7.1.

A.4.2 FlowVectorSection

<FlowVectorSection()>: =	
<IntUnLoMB>(spatialOffset),	: see 7.2
<StatusParameters>(status),	: see 7.2
<BitArray>(selector),	: 1 byte containing 7 switches.
If bit 0 of *selector* is set:	
<tfp004:SpatialResolution>(spatialResolutionSection),	: see 7.2
If bit 1 of *selector* is set:	
<tfp007:SectionType>(sectionType),	: see 7.2
If bit 2 of *selector* is set:	

<Restrictions>(restriction),	: see 7.2
If bit 3 of *selector* is set:	
<StatisticalParameters>(statistics),	: see 7.2
If bit 4 of *selector* is set:	
<tfp006:CauseCode>(cause),	: see 7.2
If bit 5 of *selector* is set:	
<LinkedCause>(detailedCause),	: see 7.2
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

For description of this object, see also 7.2.

A.4.3 StatusParameters

<StatusParameters>: =	
<BitArray>(selector),	: 1 byte containing 5 switches.
If bit 0 of *selector* is set:	
<tfp003:LevelOfService>(LOS),	: see 7.3
If bit 1 of *selector* is set:	
<IntUnTi>(averageSpeed),	: see 7.3
If bit 2 of *selector* is set:	
<IntUnLoMB>(freeFlowTravelTime),	: see 7.3
If bit 3 of *selector* is set:	
<Duration>(delay),	: see 7.3
If bit 4 of *selector* is set:	
<StatusExtensionComponent>(extensions);	: see 7.3

For description of this object, see also 7.3.

A.4.4 Restrictions

<Restrictions>: =	
<BitArray>(selector),	: 1 byte containing 6 switches.
If bit 0 of *selector* is set:	
<tfp001:VehicleClass>(vehicleClassAssignment),	: see 7.4
If bit 1 of *selector* is set:	
<tfp002:VehicleCredentials>(vehicleCredentials),	: see 7.4
If bit 2 of *selector* is set:	
<tfp005:laneRestriction>(lanes),	: see 7.4
If bit 3 of *selector* is set:	
<IntUnTi>(angle),	: see 7.4
If bit 4 of *selector* is set:	
<IntUnLoMB>(length),	: see 7.4
If bit 5 of *selector* is set:	
<RestrictionExtensionComponent>(extensions);	: see 7.4

For description of this object, see also 7.4.

A.4.5 StatisticalParameters

<StatisticalParameters>: =	
<BitArray>(selector),	: 1 byte containing 4 switches.
If bit 0 of selector is set:	
<IntUnTi>(congestionProbability),	: see 7.5
If bit 1 of selector is set:	
... <IntUnLoMB>(T90relative),	: see 7.5
If bit 2 of selector is set:	
<tfp008:FlowDataQuality>(FlowQuality),	: see 7.5
If bit 3 of selector is set:	
<IntUnTi>(prediction),	: see 7.5
If bit 4 of selector is set:	
<StatisticsExtensionComponent>(extensions);	: see 7.5

For description of this object, see also 7.5.

A.4.6 LinkedCause

<LinkedCause>: =	
<IntUnLoMB>(messageID),	: The related message ID
<IntUnTi>(COID),	: see 7.6
<BitArray>(selector),	: 1 byte containing 2 switches.
If bit 0 of *selector* is set:	
<ServiceIdentifier>(SID),	: see 7.6
If bit 1 of *selector* is set:	
<IntUnLi>(AID);	: see 7.6

For description of this object, see also 7.6.

Annex B
(normative)

Traffic Flow and Prediction, TPEG-ML Representation

NOTE In the course of ISO processing, XML-compliant quotation marks are replaced with non-compliant quotation marks. When taking over material from these sections, be advised to substitute any double quote to the XML-compliant equivalent quotation mark (Unicode U +0022).

B.1 Introduction

This section contains the tpegML physical format representation (ISO/TS 21219-4) of the TFP application. For further descriptions of these objects see related Clauses 6 and 7.

B.2 XSD Schema Framing

The schema definition of this toolkit is maintained in an XSD file, where the actual definitions are embedded in the following XML framing:

```
<?xml version="1.0"encoding="UTF-8"?>
<xs:schema  xmlns="http://www.tisa.org/TPEG/TFP_1_0"
            targetNamespace="http://www.tisa.org/TPEG/TFP_1_0"
            xmlns:xs="http://www.w3.org/2001/XMLSchema"
            xmlns:tdt="http://www.tisa.org/TPEG/TPEGDataTypes_1_0"
            xmlns:tsf="www.tisa.org/TPEG/TPEGFraming_1_0"
            xmlns:mmc="http://www.tisa.org/TPEG/MessageManagementContainer_1_1"
            xmlns:lrc="http://www.tisa.org/TPEG/LocationReferencingContainer_1_0"
            elementFormDefault="qualified"
            attributeFormDefault="qualified">

<xs:import  namespace="http://www.tisa.org/TPEG/TPEGDataTypes_1_0"
            schemaLocation="TPEGDataTypes_1_0.xsd"/>
<xs:import  namespace="http://www.tisa.org/TPEG/TPEGFraming_1_0"
            schemaLocation="TPEGFraming_1_0.xsd"/>
<xs:import  namespace="http://www.tisa.org/TPEG/MessageManagementContainer_1_1"
            schemaLocation="MessageManagementContainer_1_1.xsd"/>
<xs:import  namespace="http://www.tisa.org/TPEG/LocationReferencingContainer_1_0"
            schemaLocation="LocationReferencingContainer_1_0.xsd"/>
</xs:schema>
```

NOTE In the box above the schemaLocations of the XSD files are described as the local directory. The real locations are left to the implementer's discretion. In particular, TISA may provide in future an URL with the addressed XSD files.

B.3 Element Definition

B.3.1 TFP Message

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