Multimodal Travel Information Services (MMTIS)

Quality Package

EU EIP 4.1 Task 2: Determining Quality of Multimodal Travel Information Services (MMTIS)

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Authors

Name	Organisation
Mihai Niculescu	ITS Romania
Martin Jansen	RWS / Plannerstack (NL)
Jacqueline Barr	IBI Group (UK)
Peter Lubrich	Federal Highway Research Institute (BASt) Germany

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Preface

The European ITS Platform (EU EIP) has initiated a framework for the quality of European services for Multimodal Travel Information (MMTIS), as well as of their data contents.

This document presents the results in form of a “Quality Package”, containing quality-related definitions and concepts, proposed by EU EIP partners for the use in Europe. The results are based on evidence from conditions and operating requirements in combination with the expert knowledge of the public and private stakeholders involved in the EU EIP quality work.

A previous version of this framework has been published in July 2018. Since then, EU EIP has continued working on the validation of the “Quality Package”. This validation has been based on stakeholder survey, exploring the understandability and applicability of the various quality-related definitions. As a result, some changes to the quality definitions and generic conclusions on how to handle MMTIS quality have been proposed and incorporated.

An important conclusion from the work on Quality-related definitions for MMTIS is that such definitions cannot be determined in a complete and deep manner at this point of time. This is due to the complexities, the multi-layered nature and the diversity of stakeholders in the domain of MMTIS Quality. Consequently, this is document is not considered a formal guideline, but more an aid or source of information for interested stakeholders. Nevertheless, this document is a first approach for a common understanding on how to understand and handle MMTIS Quality.

The document is prepared as part of the sub-activity 4.1 of the EU EIP project.

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1. Introduction

These Quality Definitions have been prepared by EIP+ to make available the main results of the EIP and EIP+ projects concerning quality of Multi-Modal Travel Information Services (MMTIS) for use in Europe. The use of a common quality framework for MMTIS quality description, assurance and assessment is likely to serve the objectives of both the European Commission (EC) as well as the EU member states, because they relate to the delegated regulation of the EC concerning priority action a) (EC 2017) of the ITS Directive. While the delegated act does not set any detailed requirements concerning MMTIS service quality, it requires the member states to consider and manage the quality of these services. The definitions in this document are intended to be used for such purposes and towards validation of the requirements and assessment methods proposed.

This chapter describes the scope and objectives of the EU EIP sub-activity 4.1 as well as the description and objectives of its Task 2 (Propose European minimum quality requirements and quality assessment practices for all ITS Directive's priority services involving road authorities/operators in a major role) according to the Grant Agreement signed with INEA.

Multimodal Travel Information Services, paradoxically, are by nature unimodal in their detailed aspects. For instance, we consider bus services, bike-sharing services, car-sharing services and P+R facilities, each separately. As we continue to work on quality criteria and levels for MMTIS services, however, it's important to keep in mind what these quality definitions are intended to help improve: users' door-to-door journeys.

Multi-Modal Travel Information Services will rarely have the luxury of focusing on just one part of the journey, especially as innovative mobility services and Mobility as a Service concepts evolve. Expectations are high for these services to have an impact in terms of users/travelers making informed, smarter choices and, more often, using other modes besides cars on overcrowded main road networks and therefore in terms of decreasing congestion. If these services are to have that effect, they will need to address the entire door-to -door journey, seamlessly.

Rather sooner than later, these services will have to be capable of presenting travellers with their different options, transparently, at any point during the journey. For instance, they could advise on options (including travel time, cost and emissions) to park cars at P+R locations and continue by public transport (and perhaps a shared bike for the last mile) when roads are congested. Alternatively, they could offer the opportunity to travel to destination 1 by shared car (including locations, cost, emissions, etcetera) and use a combination of walking, tram, train and biking for the journey home via intermediate destinations 2 and 3.

The continuous availability of accurate and reliable information is key to the success of these advices and services. From widespread industry experiences with smartphone apps, it is known that it only takes two or three negative experiences for a user to cast a product aside. Staying in their trusty own car is then the easier option to whose drawbacks travelers are already accustomed. In regions where a 'modal shift' is the aim, i.e. an increase in the share of the multimodal journeys including public transport beyond its current average 18% (2015; https://www.eea.europa.eu/soer-2015/countries-comparison/transport) in the commuting modal split, even 'best effort' requirement levels need to contribute to set objectives.

The multimodal mobility chain is only as strong as its weakest link and so are its information services. Thus, quality levels for MMITS in some instances may need to be higher than for, for instance, the unimodal services, that have been covered by previous EU EIP activities, e.g. for Real-time Traffic Information (RTTI).

1.1. Scope and purpose

1.1.1. ACTIVITIES AND SUB-ACTIVITIES

The EU ITS Platform focuses on cooperation within five activities:

- Activity 1: EU ITS Platform Governance and Management
- Activity 2: Monitoring and Dissemination (including ITS Deployment Guidelines)
- Activity 3: Feasibility study East-West Corridor and first pilot implementation
- Activity 4: Harmonization Cluster
- Activity 5: Evaluation.

The scope of **Activity 4** is to define the specifications to be followed for Directive implementation and it is sub-divided into seven sub-activities, which can be developed simultaneously. Sub-activities of Activity 4 "Harmonization Cluster" are the following:

- ✓ Sub-activity 4.1: Determining Quality of European ITS Services
- ✓ Sub-activity 4.2: Facilitating automated driving
- ✓ Sub-activity 4.3: ITS Deployment Road Map Update
- ✓ Sub-activity 4.4: Cooperative ITS Services Deployment Support
- ✓ Sub-activity 4.5: Liaison and harmonization on interfaces for data exchange
- ✓ Sub-activity 4.6: Monitoring and harmonization of Single Point of Access
- ✓ Sub-activity 4.7: Provision of updates of ITS spatial road data.

The quality definitions in this document were developed under Sub-activity 4.1, which is briefly described below.

1.1.2. Scope and objectives of EU EIP sub-activity 4.1: Determining Quality of European ITS Services

The scope of sub-activity 4.1 is the development of quality requirements and quality assessment practices for all ITS Directive priority services involving the transport and road authorities and operators in a major role, building up on results from EIP and EIP+, widening the scope to EU EIP priority services other than Priority actions b) (The provision of EU-wide real-time traffic information services) and c) (Defining data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users).

To pursue the sub-activity scope definition, four tasks have been identified to be developed to achieve the objectives of the sub-activity. The sub-activity 4.1 tasks are the following:

- Task 1: Identify stakeholders, value chains, recommended work processes, quality assurance, and introduction paths for road operator relevant ITS Directive priority services.
- Task 2: Propose European minimum quality requirements and quality assessment practices for all ITS Directive's priority services involving road authorities/operators in a major role.
- Task 3: Validate and improve the quality criteria, requirements and assessment practices proposed.
- Task 4: Work towards specifying optimum quality for selected priority services.

The quality definitions in this document were drafted as part of Task 2, proposing minimum quality requirements and quality assessment methods for Priority action a) The provision of EU-wide multimodal travel information services (MMTIS).

1.2. Document structure

In Chapter 2, the quality criteria recommended to be used for MMTI services and the related data are described. They have been defined for 13 selected information services, with a primary focus on Level of service 1. This selection was based mainly on the experts' assessments of relevance to road operators as well as expected user benefits of the related services and information types throughout Europe and the availability in practise of the related data.

In Chapter 3, the quality requirements for the different types of MMTI services are compiled. The most important quality requirements are the minimum ones, denoted as the Basic quality level. This level should be met by the services in all member states, because

if the service would be provided at a lower level of service or quality, the user benefits would likely be negligible or even negative according to current knowledge and EU EIP expert experiences. In addition to the Basic level, tentative quality requirement recommendations are also given for two higher levels for reference and assistance to users.

In Chapter 4, the methods currently available for quality assurance and assessment are describes, indicating their applicability for different uses and feasibility for studying different quality criteria. The chapter also provides a compact description of each of the recommended methods in a harmonised manner. These descriptions have been made of best practices and existing quality reporting in member states that have e.g. more advanced information services and NAPs already in place.

Chapter 5 contains conclusions on the scope and use of this quality package for reference in the next phase of sub-activity 4.1, the validating and improving of the quality criteria, requirements and assessment practices proposed (Task 3).

1.3. Quality basics

1.3.1. WHY MEASURE MMTIS QUALITY?

Providing the right and complete multi modal travel information at the right time to travellers improves their door-to-door mobility. In order to be useful, the travel information and the underlying data must be of a certain minimum quality.

Consequently, data suppliers are required to:

- know and to monitor the quality of data,
- set goals for the quality,
- report quality levels, and
- analyse problems and eventually improve the data provision.

In order to be able to do this:

- it must be specified, where to measure quality,
- quality parameters must be defined,
- quality levels must be defined,
- it must be specified, how to measure quality, and
- quality requirements must be set.

These specifications, definitions and requirements (described in the following chapters) should be applicable for different types of multi modal travel information and in different

data supplier environments, thus allowing transparent and comparable quality assessment.

1.3.2. WHERE TO MEASURE MMTIS QUALITY?

This document considers the quality of multi modal travel information within a specific part of the information process.

This information process can be illustrated by the Value Chain borrowed from SRTI (Safety Related Traffic Information) and RTTI (Real Time Traffic Information) services, as shown in Figure 1 below.

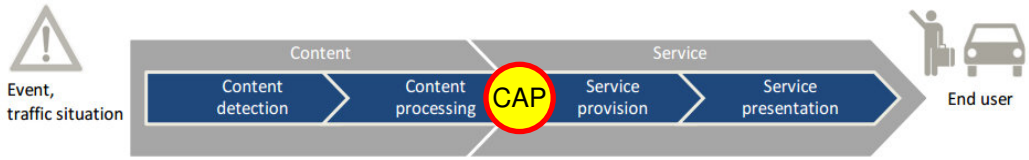

Figure 1: Value Chain of traffic information services (CAP = Content Access Point)

This document focusses on the Content part of the Value Chain for MMTIS. The Content part is typically the responsibility of a data supplier. It covers processes between:

- the initial recording of related static information for a data type or data entity (e.g. in case of static map data),
- planned (temporary) changes (such as works or closures along the travel infrastructure),
- the detection of a real event or a occurrence of a situation (affecting the travel experience of a user),
- and the updates on the status of either of these,

until the provision of related information in a Content Access Point (CAP). At a CAP, the travel information is (typically) made available to many service providers via e.g. a data portal. This point can also be called a Single Point of Access (SPA). This document focuses on the quality of the data provisioning up to this point.

Aspects on the Service part of the Value Chain have been covered by the Traveller Information Services Association (TISA). TISA has published a Position paper on this (Ref 4), describing quality aspects as being important for the end users and to be met by service providers.

Further details about Value Chains specific for MMTIS can be found in the Task 1 deliverable on this topic.

1.3.3. WHAT DEFINES MMTIS QUALITY?

Firstly, certain so-called Service level parameters are considered to apply to all relevant information:

- Geographic coverage
- Availability

Then, as mentioned above, travel information with a good quality is the right and complete travel information at the right time. Thus, the following items must be covered by the quality parameters or criteria:

- Time
- Right information

For **time**, three quality parameters have been defined:

- Timeliness (split up into 'start' and 'update')
- Latency
- Reporting period

For **right information**, five quality parameters have been defined:

- Location accuracy
- Error rate
- Event coverage
- Report coverage
- Completeness of data

Definitions and elaborations of these quality parameters are provided in paragraph 2.3.

1.3.4. DEFINITIONS

The definitions of important terms related to quality and the data chain, as used in this document, are shown in Table 1 below. The hierarchy is the chain from Categories and Services to Data elements is represented is Figure 2.

Table 1: Definition of important terms

Term	Definition
Content Access Point (CAP)	A Content Access Point is a place (e.g. data portal) where information is available for users. The point can also be called a Single Point of Access (SPA). The CAP is shown on figure 1.
National Access Point (NAP)	A National Access Point shall constitute a Single Point of Access (SPA) or CAP for users (national or international), or point to one or more CAPs/SPAs.
First detection	The first detection of an event is the first indication of the event at the traffic centre. The time of the first detection can be the same as the time of acceptance. If some validation or other considerations are needed before acceptance, first detection is before acceptance.
Acceptance	An event is considered accepted when it has been found trustworthy according to an organization's quality policy, so action will be taken to have the event report processed and published at the Content Access Point (CAP).
Validation	An event is considered validated, when it has been detected (manually or based on technical means) by a source different from the source originally detecting the event, as stipulated by an organisation's quality policy. Validation can start/end either before or after the acceptance. Validation is not used in the definitions of the quality parameters (table 1).

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in the field of MMTIS may become quite complex in terms of their variety and characteristics. There is a hierarchy in the chain from Categories and Services to single Data elements, also considering the classification of data types in the Annex of the Commission Delegated Regulation (EU) No 2017/1926. Thus, it is required to clearly define terms describing data structures in the field of MMTIS.

The following Table 2 and Figure 2 show a definition and the hierarchy of data structures being used in the following chapters, including an example for the use case "refuelling stations".

Table 2: Definition of data structures in the field of MMTIS

Term	Definition	Example
Data categories	Data category as listed in the Annex of the Delegated Regulation	Static or dynamic travel data
Level of Service	Level of Service as listed in the Annex of the Delegated Regulation	Level of Service 2
Service	Service as listed in the Annex of the Delegated Regulation	Location Search (demand-responsive modes)
Data type	Data type as listed in the Annex of the Delegated Regulation, being published by a specific Service	"Publicly accessible refuelling stations"
Data set	Set of data, related to one or several Data types	All information about refuelling stations
Instance	One logical unit within the Data set	"Refuelling station X"
Data entity	Sub-set of data related to one Instance	Opening hours
Data element	Specific data element within Data entity	"Week_days_from"
Data attribute	Description of one specific Data element	Time
Data format	Format of one specific Data element	hh:mm
Value	Representation of one specific Data element	07:00

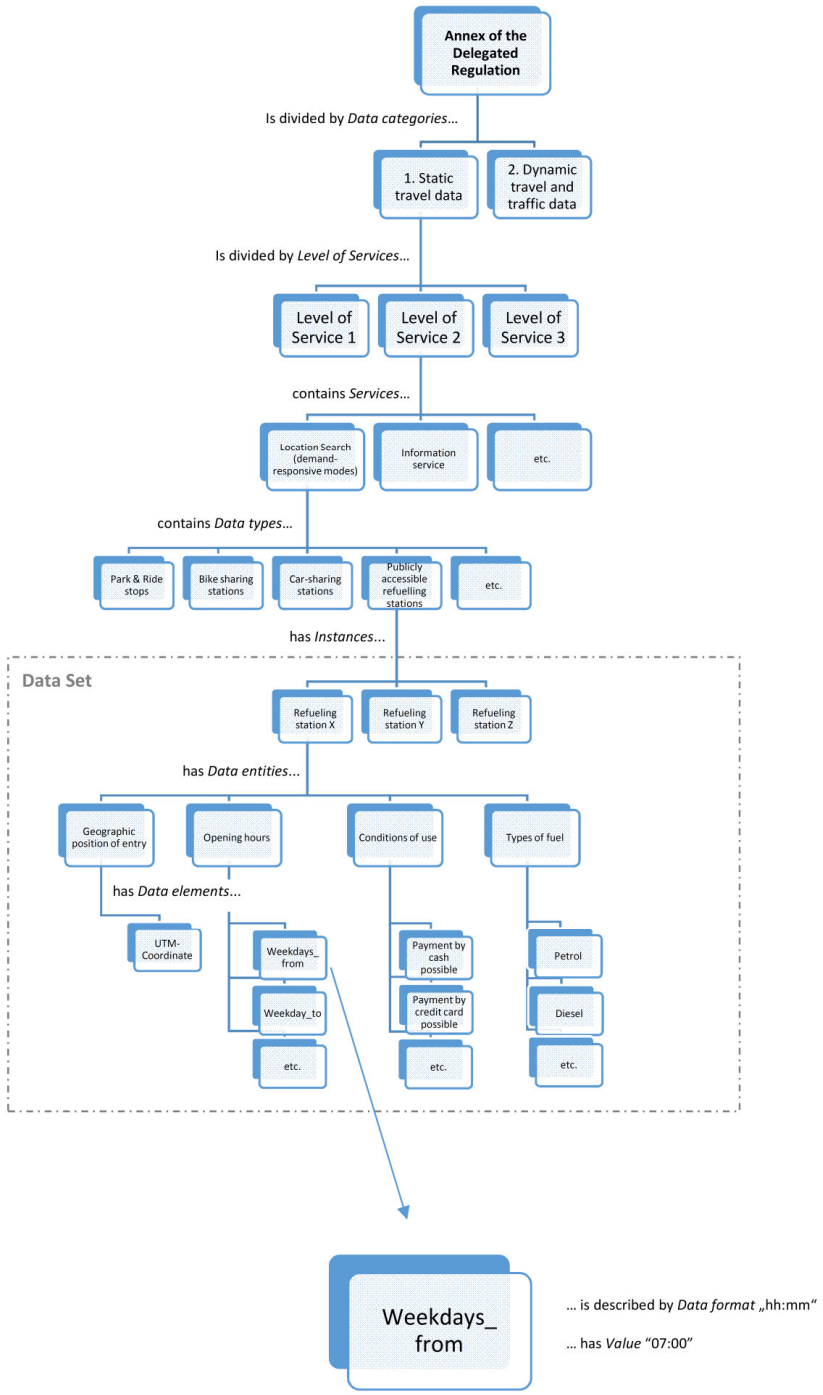


Figure 2: Hierarchy of services and data structures in the field of MMTIS

Further definitions relate to some MMTIS data elements, as defined by applicable data standards in the MMTIS domain, namely INSPIRE, NeTEx and Transmodel, Within these standards, there are sometimes parallel definitions for the same term depending on the context.

A first overview on some definitions, based on these standards, is shown in Table 3.

It is noted, that some inconsistencies between these definitions exist. A harmonization of these definitions is, however, not part of this EU EIP activity.

Table 3: Definition of MMTIS elements based on data standards

Term	Definition	Source
(default) connection	The physical (spatial) possibility for a passenger to change from one public transport vehicle to another to continue the trip. It specifies default times to be used to change from one mode of transport to another at an area or national level as specified by a TOPOGRAPHIC PLACE, STOP AREA or SITE ELEMENT. It may be restricted to a specific MODE or OPERATOR or only apply in a particular direction of transfer, e.g. bus to rail may have a different time for rail to bus.	NeTEx / Transmodel
(network) connection	Represents a logical connection between two or more network elements in different networks.	INSPIRE
functional road class	A classification based on the importance of the role that the road performs in the road network.	INSPIRE
interchange	The scheduled possibility for transfer of passengers between two SERVICE JOURNEYs at the same or different STOP POINTs.	NeTEx
interchange	The scheduled possibility for transfer of passengers between two SERVICE JOURNEYs at the same or different SCHEDULED STOP POINTs.	Transmodel
line (public transport)	A group of ROUTEs which is generally known to the public by a similar name or number.	NeTEx / Transmodel
line (shape)	[Euclidean geometry] On a map, a shape defined by a connected series of unique x,y coordinate pairs. A line may be straight or curved.	esri
link (public transport)	An oriented spatial object of dimension 1 with view to the overall description of a network, describing a connection between two POINTs.	NeTEx / Transmodel

link (path)	Curvilinear network element that connects two positions and represents a homogeneous path in the network. The connected positions may be represented as nodes.	INSPIRE
network	A named grouping of LINEs under which a transport network is known.	NeTEx / Transmodel
(transport) network	Infrastructure related to transport	INSPIRE
network topology	spatial objects (point, line and area features) of the network	esri
node	Represents a significant position in the network that always occurs at the beginning or the end of a link.	INSPIRE
physical path	[network analysis] The connecting lines, arcs, or edges that join an origin to a destination	esri
point	A 0-dimensional node of the network used for the spatial description of the network. POINTs may be located by a LOCATION in a given LOCATING SYSTEM.	NeTEx / Transmodel
road link	A linear spatial object that describes the geometry and connectivity of a road network between two points in the network. Road links can represent paths, bicycle roads, single carriageways, multiple carriageway roads and even fictitious trajectories across traffic squares.	INSPIRE
route	An ordered list of located POINTs defining one single path through the road (or rail) network. A ROUTE may pass through the same POINT more than once.	INSPIRE / NeTEx / Transmodel
segment	Position derived from the related segment of a thoroughfare.	INSPIRE
shape	[data models] The characteristic appearance or visible form of a geographic object as represented on a map. A GIS uses points, lines, and polygons to represent the shapes of geographic objects.	esri
scheduled stop point	A POINT where passengers can board or alight from vehicles	NeTEx / Transmodel
timetable	A set of timetable data (VEHICLE JOURNEYs, etc.) to	NeTEx

	which the same VALIDITY CONDITIONs have been assigned.	
transfer	The possibility of a passenger to transfer between two PLACEs. May have times associated with the transfer.	NeTEx
transfer	A couple of POINTs located sufficiently near that it may represent for a passenger a possibility to reach one of these POINTs when starting at the other one in a timescale which is realistic when carrying out a trip, e.g. ACCESS	Transmodel
transport link	A linear spatial object that describes the geometry and connectivity of a transport network between two points in the network.	INSPIRE
service journey pattern interchange (Planned interchanges between guaranteed scheduled services)	A recognised/organised possibility for passengers to change public transport vehicles using two SCHEDULED STOP POINTs (which may be identical) on two particular SERVICE JOURNEY PATTERNs, including the maximum wait duration allowed and the standard to be aimed at. These may supersede the times given for the DEFAULT INTERCHANGE. Schedulers may use this entity for synchronisation of journeys	Transmodel

1.4. Delegated Regulation on MMTIS

Short descriptions of the ITS Directive and the relevant Delegated Regulations are given below.

1.4.1. ITS DIRECTIVE 2010/40/EU

Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010, establishes a framework in support of the coordinated and coherent deployment and use of Intelligent Transport Systems (ITS) within the European Union.

For the purpose of this Directive, there are some areas considered as priority for its development. Those priority areas are the following:

i. Optimal use of road, traffic and travel data.
ii. Continuity of traffic and freight management ITS services.
iii. ITS road safety and security applications.
iv. Linking the vehicle with the transport infrastructure.

Within previous priority areas, six priority actions for the development and use of specifications and standards have been defined:

a) The provision of EU-wide multimodal travel information services.
b) The provision of EU-wide real-time traffic information services.
c) Data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users.
d) The harmonised provision for an interoperable EU-wide eCall.
e) The provision of information services for safe and secure parking places for trucks and commercial vehicles.
f) The provision of reservation services for safe and secure parking places for trucks and commercial vehicles.

For each priority action, the Commission can develop delegated acts in order to adopt the specifications. For the moment Commission Delegated Acts for priority actions (a), (b), (c), (d) and (e) have been developed.

1.4.2. COMMISSION DELEGATED REGULATION

The Delegated Regulation, related to this Quality Package, is the following:

Priority action a. Commission Delegated Regulation (EU) No 2017/1926 of 31 May 2017 supplementing Directive 2010/40/EU of the European Parliament and of the Council

with regard to the provision of EU-wide multimodal travel information services - No 2017/1926.

The data categories as listed in the Delegated Regulation are:

Partitioned as transport modes by type:

1. Schedule based: air, rail including high speed rail, conventional rail and light rail, long-distance coach, maritime including ferry, metro, tram, bus, trolley-bus, cableways;
2. Transport on demand: shuttle bus, shuttle ferry, taxi, car-pool, ride-share, car-share, car-hire, bike-share, bike-hire, dial-a-ride; and
3. Personal based: car, motorcycle, bicycle, walking.

Partitioned by type:

1. Static travel and traffic data: data relating to different transport modes that does not change at all or does not change often, or change on a regular basis;
2. Dynamic travel and traffic data: data relating to different transport modes that changes often or on a regular basis;

Both types have been subdivided in Levels of service (1-3). The data types defined as Level of service 1 are regarded in the Delegated Regulation as essential for the basic functioning of multimodal travel information services. For the purpose of this task, as described in paragraph 2.1, a prioritised initial set of 8 level 1, 4 level 2 and 1 level 3 criteria has been elaborated.

Looking into details of this Delegated Regulation, some important differences compared to other Delegated Regulations (dealing with other data types) can be identified:

- valid for the entire transport network (while other Regulations are valid for the TERN-network)
- includes further stakeholders: transport authorities/operators, transport-on-demand operators etc.
- includes further data formats: NeTEx CEN/TS 16614; SIRI CEN/TS 15531

It is obvious, that the high complexity of data handled in the field of MMTIS has some implications on the quality descriptions, as explained in the following chapters.

2. Quality criteria for MMTIS

2.1. Questionnaire for selecting targeted services

In the EU Delegated Regulation on MMTIS, 17 services are specified, grouped in 3 levels of priority by timeframe of implementation and divided into 48 (sub)types of data (ref. 2.1.2. Summary of results of the questionnaire, Table 4).

In an early EU EIP meeting a pre-selection of 25 data types (from the then Draft Delegated Regulation) was made, based on expertise of the project partners involved in task 2. Rather than taking all services/data types that have been identified as Level of service 1 (seen as essential for the basic functioning of the MMTIS services), it was decided to focus initially on services (even if Level of service 2 or 3) that lie more closely within the scope of responsibilities of the project partners and for which there is more inherent interest/understanding in terms of the data involved and their underlying quality aspects.

Later partners argued to reduce the number of services handled, to allow deeper inspection of the most relevant ones. The project partners' areas of responsibility are primarily towards road operator's activities. To arrive at practical and usable results sooner, it was decided, it would be more effective to first work through the whole process of quality definitions with a subset of services regarded as most relevant. The next phase would be to apply the experiences and lessons learned and widen the scope to the remaining services and data types of the Delegated Regulation.

In order to focus the initial sub-activity 4.1 work further on the services most relevant to road operators, and reduce the list to a shortlist of services, it was decided to organise a survey among all EU EIP partners/countries.

2.1.1. SHORT LISTING METHODS

For each of the approximately 25 types of data in the pre-selection (made on 16 July 2016), respondents were required to answer four basic questions to determine their relevance.

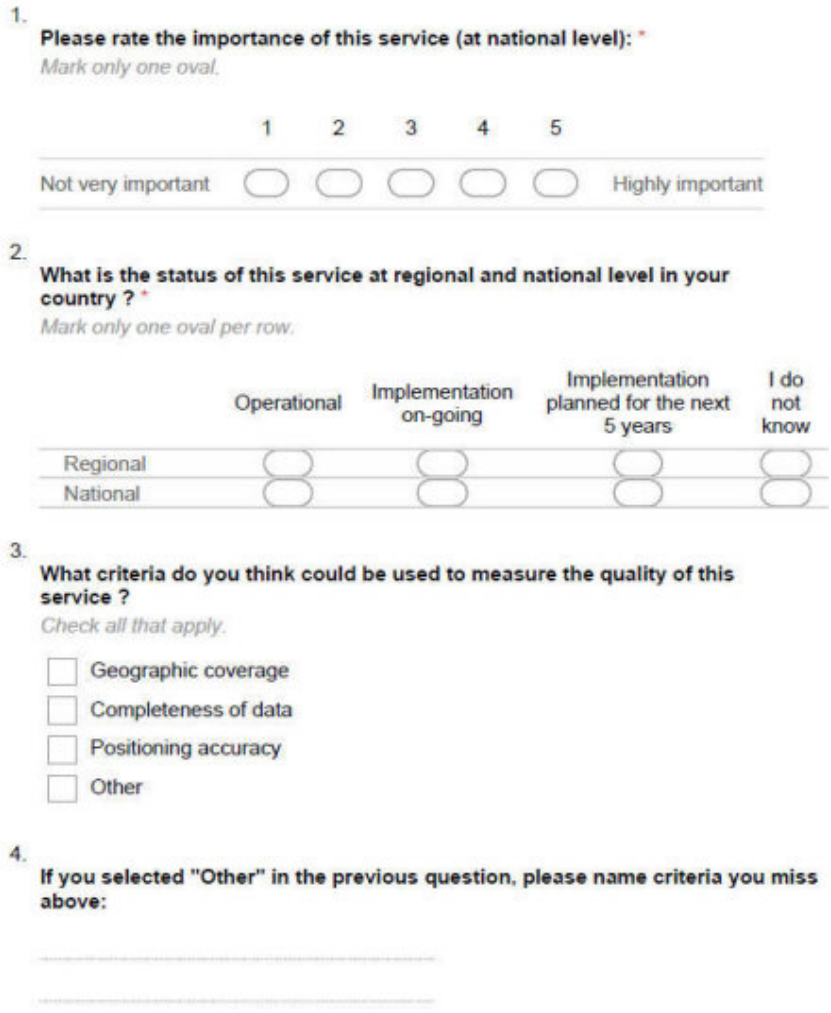
To determine the results, it was determined that the average importance value must be at least 4.0 (on a 1-5 scale).

TLR's report for the European Commission (May 2016), containing contributions from several Member States' experts, describes that the expected functional content of MMTIS and supporting data requirements can be categorised as follows:

1. Minimum expected functionality
2. Additional desirable functionality
3. Nice to have functionality

Based on this, it was determined that relevant services must be categorized at least as 'additional desirable functionality' in TRL's report.

Finally, it was decided to include datasets that received threshold values but that are seen as especially important from the viewpoint of the active project partners' role as road operators.



1. **Please rate the importance of this service (at national level):** *
Mark only one oval.

	1	2	3	4	5	
Not very important	◯	◯	◯	◯	◯	Highly important

2. **What is the status of this service at regional and national level in your country ?** *
Mark only one oval per row.

	Operational	Implementation on-going	Implementation planned for the next 5 years	I do not know
Regional	◯	◯	◯	◯
National	◯	◯	◯	◯

3. **What criteria do you think could be used to measure the quality of this service ?**
Check all that apply.

- ☐ Geographic coverage
- ☐ Completeness of data
- ☐ Positioning accuracy
- ☐ Other

4. **If you selected "Other" in the previous question, please name criteria you miss above:**

Figure 3: Example of questionnaire

2.1.2. SUMMARY OF RESULTS OF THE QUESTIONNAIRE

Responses to this questionnaire were received from the following partners:

- Denmark/Danish Road Directorate
- Finland/Finnish transport agency
- Germany/Ministry for Economics Rheinland-Pfalz
- Netherlands/Rijkswaterstaat
- Norway/Norwegian Public Roads
- Administration
- Sweden/Swedish Transport Administration

Conclusions drawn from these responses include:

- Almost all services (2 exceptions) are operational at national level in at least 1 country
- The suggested criteria:
    - Geographic coverage,
    - Completeness of data and
    - Positioning accuracy

  seem to be agreed on in various mixes depending on the services
- Other commonly proposed criteria:
    - Veracity of data
    - Timeliness

Based on these outcomes the following initial sub-set of services and corresponding 13 data types was decided as seen in the next table:

Table 4: Initial sub-set of services

Type	Level of service	Service	Data type
Static travel data	**1.1 Level of service 1**	d) Trip plan computation – scheduled modes transport	I) Connection links where interchanges may be made, default transfer times between modes at interchanges
		d) Trip plan computation – scheduled modes transport	II) Network topology and routes /lines (topology)s
		d) Trip plan computation – scheduled modes transport	IV) Timetables
		d) Trip plan computation – scheduled modes transport	V) Planned interchanges between guaranteed scheduled services
		e) Trip plan computation – road transport	I) Road network
		e) Trip plan computation – road transport	II) Cycle network (segregated cycle lanes, on-road shared with vehicles, on-path shared with pedestrians)
Static travel data	**1.2 Level of service 2**	f) Location search	I) Park & Ride stops
		f) Location search	II) Bike sharing stations
		f) Location search	III) Car-sharing stations
		f) Location search	IV) Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles
Dynamic travel data	**2.1 Level of service 1**	a) Passing times, trip plans and auxiliary information	I) Disruptions (all modes)
	2.1 Level of service 1	a) Passing times, trip plans and auxiliary information	II) Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes)
	2.3 Level of service 3	e) Trip plans	I) Future predicted road link travel times

2.2. Stakeholder workshops

On 30th March 2017 EU EIP Sub-Activity 4.1 organised an open workshop in Brussels to discuss definitions for quality criteria, quality requirements and assessment methods for Multimodal Travel Information Services (MMTIS).

More than 25 experts on quality of multimodal travel information services from 10 European Member States joined this workshop. The attendance demonstrated a balanced mix of four major stakeholders:

- the European Commission;
- road, railway and public transport administrations and operators;
- representative associations like UITP, TISA, CER and POLIS;
- service providers.

Along with presentations of stakeholders' views on MMTIS, results were presented with regards to 'Task 1.a: Stakeholders, Value Chains and Work Processes for ITS Services' and 'Task 1.b: Proposal for structure of Service 'round tables' in member states (MMTIS)', both preliminary to Task 2, and 'Task 2.a: Proposed quality indicators for ITS (Task 2.a)'.

The stakeholder input was perceived as valuable, as individual quality approaches could be identified for each of the presenters. Although some of the stakeholder presentations did not offer sufficient orientation for further prioritisation of the MMTIS data types, several stakeholders did offer further exchange and collaboration with sub-activity 4.1. It was agreed that the project could get back to them for feedback and validation after refining the quality definitions and criteria.

Group work on the shortlist of 13 selected services proved very valuable for the upcoming work in Task 2. Many questions, definition issues and uncertainties about the proposed MMTIS quality criteria became evident, both in terms of the detail of data type descriptions (as listed in the Delegated Regulation's Annex) and the not self-evident relevance of some quality criteria and levels to specific MMTIS services and data types, static as well as dynamic.

Thus, the workshop served as the first milestone within this EU EIP sub-activity towards a complete definition and delivery of quality criteria and requirements for European MMTIS services.

More details on this workshop can be found at: https://eip.its-platform.eu/highlights/quality-multimodal-traveller-information-services-online-outcome-workshop

To get further in touch with relevant MMTIS stakeholders, a "MMTIS Quality Follow-Up Workshop" was organized by EU EIP on 21st March 2018 at Schiphol Airport, Amsterdam.

The goal of this workshop was to discuss individual insights on the quality topic and to collect a first feedback on the draft of the EU EIP Quality Definitions.

The stakeholder's presentations on MMTS quality revealed that there are already some individual quality concepts (including quality criteria and assessment methods) which could be incorporated in the EU EIP MMTIS Quality Proposal.

On the other hand, the presented draft of the "MMTIS Quality Package" was of great interest to the stakeholders. During the group work, some important inputs were given, which may lead to a first revision of the proposed Quality Criteria and Levels. Further, all criteria and most of the levels were agreed by the stakeholders.

Further, all present stakeholders showed their willingness to participate in the upcoming validation phase of EU EIP activity 4.1.

More details on the Follow-Up Workshop can be found at: https://eip.its-platform.eu/highlights/quality-multimodal-traveller-information-services-outcome-follow-workshop

2.3. Validation Phase

During 2018 and 2019, the former version of the MMTIS Quality Package was validated via a stakeholder survey. The goal was to explore and prove the understandability and applicability of the quality definitions, as elaborated by EU EIP activity 4.1 so far. Specific questions were asked about:

- the interpretation of the proposed Quality criteria,
- the determination of the proposed Quality levels (Basic, Enhanced & Advanced), and
- references about existing quality assessment methods, as implemented at the stakeholder's organisations.

In total, seven returned survey gave valuable insights on the perception of the MMTIS Quality Package and on proposed revisions of its contents.

As a result, some Quality criteria have been updated in this revised version of the Quality Package (see section 2.4). However, the Quality requirements (see section 3) have not been revised, as the survey did not gather evidence of valid Quality requirements. In particular, the responders' feedback was not sufficient to show if the original levels are realistic or achievable. The Quality assessment methods (see section 4) have neither been revised, as the assessment methods as reported by the responders barely match the assessment concepts, as understood by EU EIP. Finally, some high-level

considerations and outstanding issues about MMTIS quality have been added to the conclusions chapter.

A dedicated validation report was produced in July 2019 and is published together with the revised MMTIS Quality Package on the EU EIP website.

2.4. Proposal for quality criteria

Originally, quality criteria for Real-Time Traffic Information (RTTI) and Safety-Related Traffic Information (SRTI) services have been previously defined in the EIP+ project, and later updated by EU EIP. For MMTIS services, as a reference, these existing quality criteria and data types, where possible, were compared to RTTI and SRTI services that are similar in nature. Subsequently, their specific relevance for MMTIS services and data types was considered.

The reason for this is that quality definitions, as developed previously for RTTI and SRTI, have been intensely discussed and validated with various stakeholders, resulting in a proven concept. However, it has been recognised that the specifics of MMTIS data may require some adoptions of the previous quality definitions.

Based on this background, a first proposal of quality criteria and definitions has been elaborated by EU EIP partners, see Table 5 below.

The shown set of quality criteria contains two criteria in the category 'Level of Service" (describing the provision of data) and nine criteria in the category 'Level of Quality" (describing the data as such).

Further, there is a differentiation between 'Event information' and 'Status/Entity information'. This differentiation is in line with the definition of possible processes within the value chain of traffic information services, see chapter 1.3.2.

Table 5: EU EIP definitions of Service and Quality Criteria for MMTIS data and information (minimum; in parentheses)

			Applicable for (as minimum criterion)	
	Definition of Criteria for MMTIS		Event information (actual)	Status / Entity information (actual)
Level of Service	**Geographical coverage**	Percentage of the transport system infrastructure covered by the (content provision) service.	X (yes)	X (yes)
	Availability	Percentage of the time that the (content provision) service is available.	X (yes)	X (yes)
Level of Quality	**Timeliness (start)**	The time between the occurrence of an event and the acceptance of the event.	X (no)	-
	Reporting period	The time interval for refreshing / updating the status reports - *replacing "Timeliness (start)", as with status reporting there is no start.*	-	X (no)
	Timeliness (update)	The time between the end or relevant change of condition and the acceptance of this change.	X (no)	
		The average age of data used in the most recent reporting period - *redefinition of "Timeliness (update)" for status reporting.*		X (no)
	Latency (content side)	The time between the acceptance of the event and the moment the information is provided by the content access point.	X (yes)	
		The time between the calculation of the reporting data and the moment the information is provided by the content access point - *redefinition of "Latency (content side)" for status reporting.*		X (yes)
	Location accuracy	The relative precision of the referenced location for the published entity or event with respect to what is considered as the corresponding true position of the actual entity or event. *(NB: several possibilities - for a point, stop, access node, road or area)*	X (yes)	-
	Error rate	Percentage of the values for a service which are different from the ground truth.	X (no)	-
	Event coverage	Percentage of the actually occurring events which are known to be correctly detected and published by type, time and location (i.e. Detection Rate).	X (no)	-

	Definition of Criteria for MMTIS		Applicable for (as minimum criterion) Event information (actual)	Status / Entity information (actual)
	Report coverage	The percentage of reporting locations for which a status report is received in any given reporting period - *replacing "event coverage" for status reporting.*	-	X (no)
	Completeness of data	Percentage of data entities available in the service provision with respect to the total data entities of that service or data type for which quality criteria have been defined. More precisely, for a given service or data type, are all the data entities foreseen in the Regulation provided?	X (yes)	X (yes)

Additional information on the individual quality criteria is provided below:

- There are three time-related quality criteria 'Timeliness' (split up into 'start' and 'update'), 'Latency' and 'Reporting period', which can be explained as follows (see also Figure 4 below):
  - 'Timeliness' is the time span from the occurrence of an event until it is detected and accepted at the traffic centre.
  - 'Latency' is the time span from the acceptance until the information (message) about the event is available at the CAP.
  - 'Reporting period' is the so-called refresh rate of status reports.
  - There is a differentiation between the validation and the acceptance of an event. Validation can start/end either before or after the acceptance. Validation depends on an organization's quality policy, and it is not used in the definitions of the quality parameters.
  - For an elaborate clarification and examples of the differentiation between 'Timeliness (start)' and 'Latency (content side)' with respect to necessary acceptance of information, readers are kindly referred to the 'Quality package for safety related and real-time traffic information services' (Version 1.06, 29-08-2017).
  - To guarantee comparable results it is strongly recommended, as is the case for RTTI and SRTI service, that quality assessments involving

latency at content side document whether possible validation of the detection is included in the calculated latency values instead of timeliness. It is also recommended that latencies and timeliness are measured separately for the start, update and end of event.

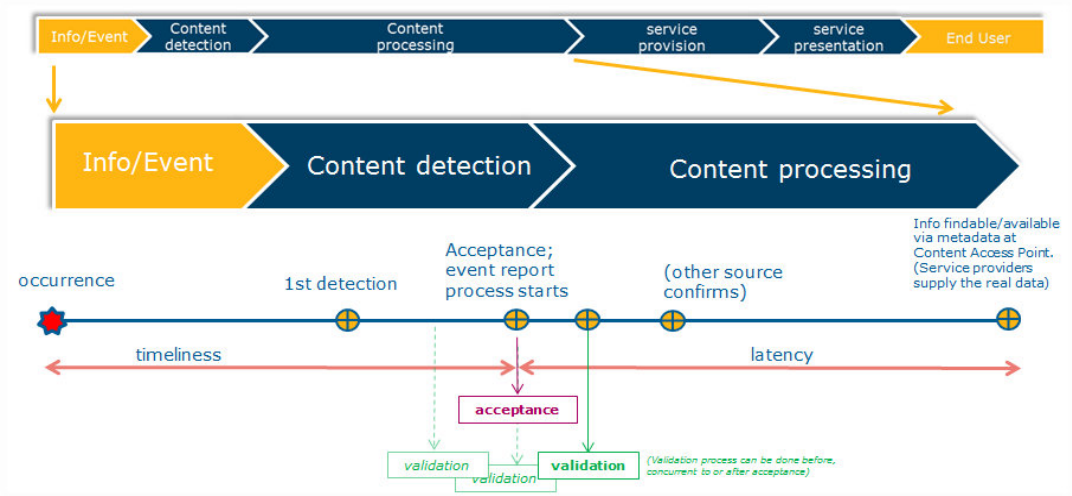


Figure 4: Value Chain with 'Timeliness' and 'Latency' indicated

- 'Location accuracy' indicates how correct the reported location is, 'Error rate' tells which percentage of values for a service are incorrect, 'Event coverage' describes the percentage of the occurred events that have been reported and 'Report coverage' describes the percentage of events for which a status report is given.
- 'Reporting accuracy' was considered a quality criterion less useful and relevant in the context of MMTIS, in view of its wide ranging types of services and data types and hence 'average experiences of users'. It was therefore decided not to include it as a quality criterion, at least for the time being.
- 'Classification correctness' was considered as similarly less relevant, in view of the fact that in MMTIS there are no clearly distinguishable classes as for example in SRTI. It was therefore decided not to include it as a quality criterion.
- Instead, it was considered useful to add 'Error rate' as a quality criterion, to be used especially for those services and data types for which a ground truth can be established. It is recommended to use time and place for matching events between data sets.

  Correctness is considered most important for attributes that relate to GIS/location, timetables, hours and days of operation/opening hours, conditions for use, etcetera.

Mainly because these do influence the user behaviour when they are inaccurate or can be interpreted inaccurately.

- *Example: timetable information related to holidays*
  As a driver I don't want to be informed that I can park my car at a P+R, transfer to public transport and still be at my end destination at the time I've planned, with a LightRail service running once every 15 minutes normally, when in actual fact it's Easter and the LightRail connection only runs once every hour.
- *Example: information about the presence of ferries, bridges or locks in bike routes*
  It is nice to be able to plan a quick bike route for your commute to a public transport access point, but if a bike or pedestrian ferry occurs in that route and operate at irregular intervals or bridges or locks tend to be open for long periods, even as static information this will be relevant to planning this route or choosing a more reliable alternative.

- Both examples, but in fact all the attributes mentioned, touch on the ***reliability*** of the information to plan effortless, efficient door-to-door journeys at any given time.
- Lastly, the need was felt to add 'Completeness of data' as a criterion. A Level of service 1 data type such as Real-time status information (all modes), for instance, contains data entities such as: Delay time, Cancelled lines, Cancelled stops and Real-time/actual vehicle positions. A missing data entity for a service, whether static or dynamic, can mean that either information cannot be provided or validation is impossible. It was therefore decided to include it as a quality criterion.

2.5. Mapping quality criteria to services

In the process of assessing the specific relevance of quality criteria, as introduced above, to individual MMTIS services and data types, several experts among the project partners were asked to map criteria to the initial short list of selected services. Keeping in mind the distinction between event or entity related and status oriented information and their pertinent quality criteria, a set of applicable quality criteria per service/ data type and its relevant data content was agreed upon.

The resulting full set of selected services and data types and their applicable quality criteria is represented in Annex 1.

3. Quality requirements for MMTIS

As a next step, a first proposal of quantitative quality requirements for individual MMTIS services was elaborated by EU EIP partners. These requirements are understood as initial target values, which have to be further discussed and evaluated with MMTIS stakeholders at a later stage. This proposal is accompanied by “interpretation examples” which explain how each quality criterion can be interpreted and handled for an individual MMTIS service.

The proposed quality criteria and the ‘interpretation examples’ are represented in one table per quality criterion. This was done mainly in order to later facilitate easy comparison of concrete quality requirements and levels across services and, perhaps at a later stage, provide easy reference and overview when differentiating between services.

The following tables make a distinction between ‘Level of service’ (Table 6) and ‘Level of quality’ (Table 7 etc.) criteria. Services for which a criterion is not relevant have been left out of the tables.

Table 6: Initial Target Values for MMTIS Level of Service Criteria

	Criterion	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Level of Service Criteria	**Geographical coverage**	**90%**	95%	99%	*100%*
	Availability	**95% of hours/period**	99% **of hours/period**	99,5% **of hours/period**	*99.9% (~ 365 days/year)*

Geographical coverage

This quality criterion is interpreted as Percentage of the network covered (% of total kilometers), except in the case of the following services:

- *Connection links where interchanges may be made, default transfer times between modes at interchanges:* Percentage of interchanges within a given network covered (% of all interchanges; respectively 99, 99,5 and 99,99 may be considered here). Categorical coverage, alternatively, might result in Basic: All train stations where interchanges can be made, Enhanced: All single mode stations, Advanced: All stop areas
- *Time tables:* Percentage of stops within a given network covered (% of all stops)
- *Park & Ride stops: Percentage of park & ride stops within a given network covered (% of all park & ride stops)*
- *Publicly accessible refueling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles:* Percentage of refueling stations within a given network covered (% of all refueling stations)
- *Bike sharing stations:* Percentage of bike sharing stations within a given network covered (% of all stations)
- *Car sharing stations:* Percentage of bike sharing stations within a given network covered (% of all stations)

Availability

This quality criterion is interpreted as Server availability*, except in the case of the following services*, where it is interpreted as Server availability during hours of operation for a relevant measurement period :

- *Connection links where interchanges may be made, default transfer times between modes at interchanges:* basic level could be expected to high (99%)
- *Time tables:* not limited to opening hour and outages limited to 1h, 45min and 30min respectively.
- *Planned interchanges between guaranteed scheduled services*
- *Disruptions (all modes)*
- *Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes*)
- *Car sharing stations:* outages limited to 1h, 45min and 30min respectively

Additional downtime, e.g. at night times for maintenance purposes, may be allowed in accordance to Service Level Agreements with the server provider.

Table 7: Initial Target Values for MMTIS Level of Quality Criterion 'Timeliness (start)'

	Data type	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Timeliness (start)	Disruptions (all modes) Data entity: Type, Vehicle/line/connection, Effect, Duration, GIS attributes of closed locations, stops, segments, etc.	*The time between the occurrence of the disruption and the acceptance of it*	Best effort	<10 min	<5 min	*100%*
	Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) Data entity: Delay time, Cancelled lines, Cancelled stops, Real-time/actual vehicle positions	*Status messages such as 'Initialisation message', 'First message', 'Stops (passage) registrations' and 'Arrival messages last stop' are of little to no use if they're not timely*	Best effort	<2 min	<1 min	*100%*

Note: For Real-time status information, the Basic Level value of 5 min. is meant to reflect Public Transport related information services and 'Best Effort' may apply for other types of services

Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).

Note: Disruptions, depending on their severity, may have a different effect on travellers. The target levels here are proposed for disruptions with MINOR severity, e.g. resulting in smaller delays for a traveller. For higher levels of severity, individual target levels have to be set, e.g. depending on the organisation's policies.

Table 8: Initial Target Values for MMTIS Level of Quality Criterion 'Reporting period'

	Data types (as part of Services)	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Reporting period	Disruptions (all modes) Data entity: Type, Vehicle/line/connection, Effect, Duration, GIS attributes of closed locations, stops, segments, etc.	*Time interval for refreshing elements like effect or duration for all announced disruptions*	Best effort	5 min	1 min	*100%*
	Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) Data entity: Delay time, Cancelled lines, Cancelled stops, Real-time/actual vehicle positions	*Time interval for refreshing delay time for all status information within a network*	5 min - Best effort	1 min	<1 min	*100%*
	Future predicted road link travel times Data entity: Travel time	*Time interval for refreshing travel time value*	Best effort	5 min	1 min	*100%*

Note: For Real-time status information, the Basic Level value of 5 min. is meant to reflect Public Transport related information services and 'Best Effort' may apply for other types of services.

Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).

Table 9: Initial Target Values for MMTIS Level of Quality Criterion 'Timeliness (update)'

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Timeliness (update)	Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles Data entities: Geographic position of entry, Opening hours, Conditions for use, Fuel type	*Time interval for updating any data entity with respect to the actual occurrence of that update (e.g.: after opening hours are changed, how long does it take to propagate that change at the access point?)*	Best effort	Best effort	24h	*100%*
	Disruptions (all modes) Data entity: Type, Vehicle/line/connection, Effect, Duration, GIS attributes of closed locations, stops, segments, etc.	*Time interval for announcing the progress or end of the disruption*	Best effort	<10 min	<5 min	*100%*
	Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) Data entity: Delay time, Cancelled lines, Cancelled stops, Real-time/actual vehicle positions	*The average age of data used in the most recent reporting period*	Best effort	<5 min	<2 min	*100%*
	Future predicted road link travel times Data entity: Travel time	*Time interval for calculating and refreshing new travel times*	Best effort	<5 min	<2 min	*100%*

Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).

Table 10: Initial Target Values for MMTIS Level of Quality Criterion 'Latency (content side)'

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Latency (content side)	Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles Data entities: Geographic position of entry, Opening hours, Conditions for use, Fuel type	*The delay between the updating of any data entity and the moment the information is provided by the CAP*	<10 min	<5 min	<2 min	*100%*
	Disruptions (all modes) Data entity: Type, Vehicle/line/connection, Effect, Duration, GIS attributes of closed locations, stops, segments, etc.	*The delay between the acceptance of the disruption and the moment the information is provided at the CAP*	Best effort	<5 min	<2 min	*100%*
	Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) Data entity: Delay time, Cancelled lines, Cancelled stops, Real-time/actual vehicle positions	*The delay between the acceptance of the disruption and the moment the information is provided at the CAP*	5 min - Best effort	1 min	<1 min	*100%*
	Future predicted road link travel times Data entity: Travel time	*The delay between the calculation of the travel time and the moment the information is provided by the CAP*	<10 min	<5 min	<2 min	*100%*

Note: For Real-time status information, that the Basic Level value of 5 min. is meant to reflect Public Transport related information services and 'Best Effort' may apply for other types of services.

Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).

Table 11: Initial Target Values for MMTIS Level of Quality Criterion 'Location accuracy'

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Location accuracy	Connection links where interchanges may be made, default transfer times between modes at interchanges Data entity: Geographic position, Transfer time, Physical path, Link length	*Accuracy of coordinates of geographic position for all provided links, compared to ground truth, described as:* $\bar{e}$ *= "Mean value of positional uncertainties"*	$\bar{e}$ < 100	$\bar{e}$ < 50	$\bar{e}$ < 10	*100%*
	Network topology and routes /lines (topology)s Data entity: GIS attributes, Line shapes	*Accuracy of coordinates of link nodes for all provided network elements, compared to ground truth, described as:* $\bar{e}$ *= "Mean value of positional uncertainties"*	$\bar{e}$ < 50	$\bar{e}$ < 20	$\bar{e}$ < 10	*100%*
	Planned interchanges between guaranteed scheduled services Data entity: Geographic position, Transfer time	*Accuracy of coordinates of geographic position for all provided interchanges compared to ground truth, described as:* $\bar{e}$ *= "Mean value of positional uncertainties"*	$\bar{e}$ < 100	$\bar{e}$ < 50	$\bar{e}$ < 10	*100%*
	Road network Data entity: GIS attributes including road class, turning restrictions, headroom, driving restrictions, speed limits, presence of ferries in network (non-toll/toll including tariffs)	*Accuracy of coordinates of link nodes for all provided links, compared to ground truth, described as:* $\bar{e}$ *= "Mean value of positional uncertainties"*	$\bar{e}$ < 100	$\bar{e}$ < 50	$\bar{e}$ < 10	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Location accuracy	Cycle network (segregated cycle lanes, on-road shared with vehicles, on-path shared with pedestrians) Data entity: GIS attributes including type of path, direction, possibly also safety coefficient (as present in e.g. OpenStreetMap), presence of ferries in network (non-toll/toll including tariffs)	*Accuracy of coordinates of link nodes for all provided links, compared to ground truth, described as:* $\bar{e}$ *= "Mean value of positional uncertainties"*	$\bar{e}$ < 100	$\bar{e}$ < 50	$\bar{e}$ < 10	*100%*
	Park & Ride stops Data entity: Geographic position of entry, Opening hours, Available PT lines, Conditions for use, Occupancy	*Accuracy of entry positions for each provided stop, compared to the actual position of the entry. It is measured on the ground as a "direct line-of-sight" distance between the actual position and the one indicated to the observer on the map*	< 500m	< 100m	< 10m	*100%*
	Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles Data entities: Geographic position of entry, Opening hours, Conditions for use, Type of fuel	*Accuracy of entry positions for each reported refuelling station, compared to the actual position of the entry. It is measured on the ground as a "direct line-of-sight" distance between the actual position and the one indicated to the observer on the map.*	< 500m	< 100m	< 10m	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Location accuracy						
	Bike sharing stations Data entity: Geographic position of entry, Opening hours, Conditions for use	*Accuracy of entry positions for each provided station, compared to the actual position of the entry. It is measured on the ground as a "direct line-of-sight" distance between the actual position and the one indicated to the observer on the map.*	< 500m	< 100m	< 10m	*100%*
	Car-sharing stations Data entity: Geographic position of entry, Opening hours, Conditions for use	*Accuracy of entry positions for each provided station, compared to the actual position of the entry. It is measured on the ground as a "direct line-of-sight" distance between the actual position and the one indicated to the observer on the map.*	< 500m	< 100m	< 10m	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★

Note: $\bar{e}$ (Mean value of positional uncertainties) is calculated as follows:

For a number of points (N), the measured positions are given as x_{mi} and y_{mi} coordinates. A corresponding set of coordinates x_{ti} and y_{ti} are considered to represent the true positions.

The errors are calculated as: $e_i = \sqrt{(x_{mi} - x_{ti})^2 + (y_{mi} - y_{ti})^2}$ *. The mean positional uncertainties of the positions are calculated as:* $\bar{e} = \frac{1}{N}\sum_{i=1}^{N} e_i$.

(Based on quality definitions for INSPIRE: "D2.8.I.7 Data Specification on Transport Networks – Technical Guidelines", see chapter 7.17/page 137). $\bar{e}$ *is not expressed in meters, it is just a number. Values are guessed, expert knowledge is needed.*

In the table below an example of how $\bar{e}$ *would be calculated for a cycle network is shown. It is only for demonstration purposes (although the coordinates used are real) and it does not imply an imposed methodology.*

Coordinates of the nodes in the map of the cycle network		Ground truth coordinates of the nodes		e_i
x	y	x	y	
23.887946	47.938894	23.594258	48.018636	$e_1 = \sqrt{(23.887946 - 23.594258)^2 + (47.938894 - 48.018636)^2} = 0.304$
25.963302	48.027105	28.858459	47.017882	$e_2 = \sqrt{(25.963302 - 28.858459)^2 + (48.027105 - 47.017882)^2} = 3.066$
23.704649	47.999682	27.797712	47.19429	$e_3 = \sqrt{(23.704649 - 27.797712)^2 + (47.999682 - 47.19429)^2} = 4.172$
23.880876	47.964484	26.003682	43.856301	$e_4 = \sqrt{(23.880876 - 26.003682)^2 + (47.964484 - 43.856301)^2} = 4.624$
$\bar{e} = \frac{1}{4}(e_1 + e_2 + e_3 + e_4) = 3.042$				

Note: For Connection links, link accuracy can be considered as particularly relevant, and $\bar{e}$ *may not be the best measure as it is an average across all data. In cases like these a proportional measure could be more relevant i.e. for shorter distances the accuracy is more important. Topological distance accuracy between the position and adjacent interchange locations may be considered as a measure.*

Note: For Network Topology and lines, 'Compass card direction' in practise is an important specific GIS attribute to consider.

Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).

Table 12: Initial Target Values for MMTIS Level of Quality Criterion 'Error rate'

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Error rate	Connection links where interchanges may be made, default transfer times between modes at interchanges Data entity: Geographic position, Transfer time, Physical path, Link length	*Percentage of links for which at least one data entity has a wrong value out of the total links*	10%	5%	1%	*100%*
	Network topology and routes /lines (topology)s Data entity: GIS attributes, Line shapes	*Percentage of routes and lines for which at least one data entity has a wrong value out of the total routes and lines*	10%	5%	1%	*100%*
	Timetables Data entity: Arrival and departure time at each stop	*Percentage of lines for which at least one data entity has a wrong value out of the total lines*	10%	<5%	<1%	*100%*
	Planned interchanges between guaranteed scheduled services Data entity: Geographic position, Transfer time	*Percentage of interchanges for which at least one data entity has a wrong value out of the total interchanges*	15%	8%	5%	*100%*
	Road network Data entity: GIS attributes including road class, turning restrictions, headroom, driving restrictions, speed limits, presence of ferries in network (non-toll/toll including tariffs)	*Percentage of links for which at least one data entity has a wrong value out of the total links*	20%	10%	5%	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Error rate	Cycle network (segregated cycle lanes, on-road shared with vehicles, on-path shared with pedestrians) Data entity: GIS attributes including type of path, direction, possibly also safety coefficient (as present in e.g. OpenStreetMap), presence of ferries in network (non-toll/toll including tariffs)	*Percentage of links for which at least one data entity has a wrong value out of the total links*	20%	10%	5%	*100%*
	Park & Ride stops Data entity: Geographic position of entry, Opening hours, Available PT lines, Conditions for use, Occupancy	*Percentage of the values for a service which are different from the ground truth, related to data entities "Opening hours"," Occupancy" and "Conditions for use"*	10%	5%	1%	~~*100%*~~
	Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles Data entities: Geographic position of entry, Opening hours, Conditions for use, Type of fuel	*Percentage of the values for a service which are different from the ground truth, related to data entities "Opening hours", "Conditions for use", "Type of fuel"*	10%	5%	1%	~~*100%*~~
	Disruptions (all modes) Data entity: Type, Vehicle/line/connection, Effect, Duration, GIS attributes of closed locations, stops, segments, etc.	*Average of errors for data entities type, vehicle/line/connection and duration. For type and vehicle/line/connection the error is either 0% or 100%*	20%	<10%	<5%	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Error rate	Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) Data entity: Delay time, Cancelled lines, Cancelled stops, Real-time/actual vehicle positions	*Percentage of lines or stops for which at least one data entity has a wrong value out of the total lines or stops*	15%	<10%	<5%	*100%*
	Future predicted road link travel times Data entity: Travel time	*Error of the predicted travel time, as compared to the real/ground-truth time, as an average deviation for all reported road links*	20%	10%	5%	*100%*
	Bike sharing stations Data entity: Geographic position of entry, Opening hours, Conditions for use	*Percentage of the values for a service which are different from the ground truth, related to data entities "Opening hours" and "Conditions for use"*	10%	<5%	<1%	*100%*
	Car-sharing stations Data entity: Geographic position of entry, Opening hours, Conditions for use	*Percentage of the values for a service which are different from the ground truth, related to data entities "Opening hours" and "Conditions for use"*	10%	<5%	<1%	*100%*

Note: Instead of defining CRITICAL and NON-CRITICAL data entities, we've assumed all data entities mentioned in the Delegated Regulation's Annex are equally important and should be error free to the same extent at each quality level.

Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).

Table 13: Initial Target Values for MMTIS Level of Quality Criterion 'Event coverage'

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Event coverage	Disruptions (all modes) Data entity: Type, Vehicle/line/connection, Effect, Duration, GIS attributes of closed locations, stops, segments, etc.	*Percentage of disruptions published with respect to all occurring disruptions on the concerned network per year; percentage of disruptions for which effect or duration are reported*	Best effort	95%	99%	*100%*
	Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) Data entity: Delay time, Cancelled lines, Cancelled stops, Real-time/actual vehicle positions	*Percentage of real time status updates published with respect to all established entities to report on within the concerned network per reporting period.*	Best effort	95%	99%	*100%*

Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).

Table 14: Initial Target Values for MMTIS Level of Quality Criterion 'Report coverage'

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Report coverage	Timetables Data entity: Arrival and departure time at each stop	*The percentage of timetables which were updated out of the total time-tables for which changes occurred since the previous update period*	Best effort	90%	99%	*100%*
	Road network Data entity: GIS attributes including road class, turning restrictions, headroom, driving restrictions, speed limits, presence of ferries in network (non-toll/toll including tariffs)	*The percentage of instances or data entities which were updated out of the total data entities for which changes occurred since the previous update period*	Best effort	90%	97%	*100%*
	Park & Ride stops Data entity: Geographic position of entry, Opening hours, Available PT lines, Conditions for use, Occupancy	*Percentage of the Park & Ride stops for which either data entities "Opening hours", "Conditions for use" or "Occupancy" were updated out of the total park & ride stops for which changes occurred in these data entities since the previous update period*	Best effort	90%	97%	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Report coverage	Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles Data entity: Geographic position of entry, Opening hours, Conditions for use, Type of fuel	*Percentage of the refuelling stations for which either data entities "Opening hours", "Conditions for use" or "Type of fuel" were updated out of the total refuelling stations for which changes occurred in these data entities since the previous update period*	Best effort	90%	97%	*100%*
	Disruptions (all modes) Data entity: Type, Vehicle/line/connection, Effect, Duration, GIS attributes of closed locations, stops, segments, etc.	*Percentage of disruptions for which updates were published with respect to all published disruptions per year*	Best effort	90%	97%	*100%*
	Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) Data entity: Delay time, Cancelled lines, Cancelled stops, Real-time/actual vehicle positions	*The percentage of instances or data entities which were updated out of the total data entities for which changes occurred since the previous update period*	Best effort	90%	97%	*100%*
	Future predicted road link travel times Data entity: Travel time	*Percentage of published travel times for which updates are provided*	Best effort	90%	97%	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion: Report coverage	Bike sharing stations Data entity: Geographic position of entry, Opening hours, Conditions for use	*Percentage of the bike sharing stations for which either data entities "Opening hours" or "Conditions for use" were updated out of the total bike sharing stations for which changes occurred in these data entities since the previous update period*	Best effort	90%	97%	*100%*
	Car-sharing stations Data entity: Geographic position of entry, Opening hours, Conditions for use	*Percentage of the car sharing stations for which either data entities "Opening hours" or "Conditions for use" were updated out of the total car sharing stations for which changes occurred in these data entities since the previous update period*	Best effort	90%	99%	*100%*
Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).						

Table 15: Initial Target Values for MMTIS Level of Quality Criterion 'Completeness of data'

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS Criterion Completeness of data	Connection links where interchanges may be made, default transfer times between modes at interchanges Data entity: Geographic position, Transfer time, Physical path, Link length	*The percentage of data entities within instances in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	100% (all)	100% (all)	100% (all)	*100%*
	Network topology and routes /lines (topology)s Data entity: GIS attributes, Line shapes	*The percentage of data entities within instances in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	100% (all)	100% (all)	100% (all)	*100%*
	Timetables Data entity: Arrival and departure time at each stop	*The percentage of data entities within instances in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	100% (all)	100% (all)	100% (all)	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS (Criterion Completeness of data)	Road network Data entity: GIS attributes including road class, turning restrictions, headroom, driving restrictions, speed limits, presence of ferries in network (non-toll/toll including tariffs)	*The percentage of data entities within instances in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	50% (at least ½)	80% (at least 4/5)	100% (all)	*100%*
	Cycle network (segregated cycle lanes, on-road shared with vehicles, on-path shared with pedestrians) Data entity: GIS attributes including type of path, direction, possibly also safety coefficient (as present in e.g. OpenStreetMap), presence of ferries in network (non-toll/toll including tariffs)	*The percentage of data entities within instances in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	50% (at least ½)	80% (at least 4/5)	100% (all)	*100%*
	Park & Ride stops Data entity: Geographic position of entry, Opening hours, Available PT lines, Conditions for use, Occupancy	*The percentage of data entities for stops in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	50% (at least ½)	80% (at least 4/5)	100% (all)	*100%*
	Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles Data entities: Geographic position of entry, Opening hours, Conditions for use, Type of fuel	*The percentage of data entities within instances in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	50% (at least ½)	80% (at least 4/5)	100% (all)	*100%*

	Data types	Interpretation	★ (Basic)	★★ (Enhanced)	★★★ (Advanced)	★★★★
MMTIS (Criterion Completeness of data)	Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) Data entity: Delay time, Cancelled lines, Cancelled stops, Real-time/actual vehicle positions	*The percentage of data entities within instances in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	50% (at least ½)	80% (at least 4/5)	100% (all)	*100%*
	Bike sharing stations Data entity: Geographic position of entry, Opening hours, Conditions for use	*The percentage of data entities for stations in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	50% (at least ½)	80% (at least 4/5)	100% (all)	*100%*
	Car-sharing stations Data entity: Geographic position of entry, Opening hours, Conditions for use	*The percentage of data entities for stations in the service provision for which values are provided out of the total data entities for which quality criteria have been defined*	80% (at least 4/5)	90% (at least 9/10)	100% (all)	*100%*

Note: With regard to Connection link, the following alternative approach may be considered: Basic: physical path is not required, Enhanced/Advanced: physical path required. But also weighting (i.e. is this a preferred interchange), opening times (restricted access, exits) and accessibility (i.e. completely accessible, wheelchair accessible may be relevant data entities, if not covered elsewhere)

Note: With regard to Timetables, and generally, we propose 100% for all quality levels in the case of services that contain two or less data entities.

Note: 'Occupancy' (e.g. for Park & Ride stops), although it may be considered real-time status information, is specified in the Delegated Regulation's Annex as a data entity for the separate service(s).

Note: With regard to Bike sharing stations, suggestions were made to add total number of stands. Besides that, the following alternative approach may be considered: Basic: ALL geographic positions, Enhanced: Basis PLUS either opening hours OR conditions for use, Advanced: ALL data entities

4. Quality assessment methods

4.1. Descriptions of quality assessment methods

The quality assessment methods in this chapter have been derived in part from the 'Quality package for safety related and real-time traffic information services' (version 1.06, 29-08-2017). They will in some cases apply mainly to the services Disruptions (all modes), Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes) and Future predicted road link travel times, in as far as they concern the road network.

Quality assurance and assessment in MMTIS beyond that are often still non-existent in many member states and in other instances still not fully mature. Further validation and development efforts, with stakeholders in the field, are required. For this, the methods listed in the following sub-chapters may be considered as a reference for possible, adapted assessment methods.

In choosing assessment methods, it is important to consider, for MMTIS in comparison to RTTI and SRTI, the total amount of information/data to be collected for the proposed matrix of data entities/services and quality requirements and also the complexity of the complete proposed framework. In order to prepare and implement the complete quality package, we have chosen to focus, at this stage, on pragmatic methods, the effort for which in terms of measuring and reporting quality will be proportionate to the benefits.

4.1.1. METHOD 1: CONTINUOUS MONITORING OF EQUIPMENT PERFORMANCE AND AVAILABILITY

Method description

The method is intended for continuous monitoring of the functioning of existing detector networks. It may also been applied to detectors monitoring occupancy and/or availability at park & ride stops, bike sharing stations and car sharing stations, as well as to e.g. public transport vehicle transponder equipment. The aim is to get timely alerts of the malfunctioning equipment in order to fix or replace it. The monitoring process may be automated or be performed by a human user. The monitoring of equipment performance may include:

- Verifying the availability of the data the equipment is supposed to produce.
- Checking of consistency between the data values measured by the same equipment.

- Comparison of the measured data to other equipment in adjacent or to the same geographical area and
- Monitoring of error messages and alerts generated by the equipment.

The methods used to detect failures are more or less specific for the type of equipment. The detection of faults in inductive loops has been discussed in a literature review published in 2008 (Lu 2008), and the topic has been analysed further in a study report published in 2010 (Lu et al. 2010). The following checks for errors in loop data are mentioned in (Chen et al. 2003):

- The number of samples in a day with zero occupancy must be less than certain threshold
- The number of samples in a day with occupancy more than zero and flow equal to zero must be less than certain threshold
- The number of samples in a day that have occupancy greater than a certain value must be less than a certain threshold
- The entropy of occupancy samples must be greater than a certain threshold

Loop detector faults and possible detection methods have been summarised in Lu et al. (2010, Table 4.1; ref. 'Quality package for safety related and real-time traffic information services').

Data requirements

The method requires access to real-time data generated by the equipment, referring to its monitoring and possible error messages or alerts. Some tests also require data which can be used for testing the data under analysis. In addition to the application layer, access to lower layers of data transmission may be needed for example when monitoring the status of the data link between roadside equipment and back-office system.

Applicability

Quality assurance

The method is used for quality assurance. It is used for following-up the monitoring systems deployed by the TCC.

Parts covered value chain

This method could be used in the different phases. It is mainly used in the content detection phase (Figure 6), but it could also be used in the Content processing and Service provision phase.

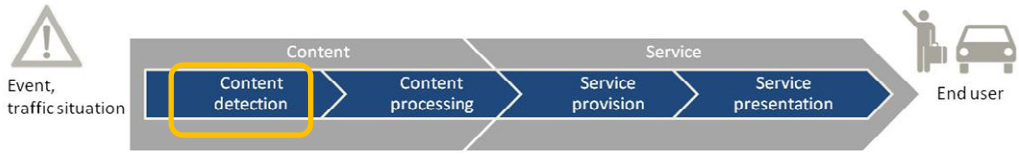


Figure 6: Parts of value chain covered by the method – Continuous monitoring of equipment performance and availability

Type of service aspect / service equipment

This method could be used to monitor different types of equipment. It is not only focused on monitoring systems - loops, public transport vehicle transponders, parking sensors (also visual) etc. - but also other equipment involved in the ITS service provision chain (for example VMS).

Covered criteria

Criteria that can be assessed are: Availability, Error Rate, Event coverage, Report coverage and Completeness of data.

Usage

Objective

This method could be used to determine the quality assessment of service, but it could also be used as an acceptance test (for example if the installed system has a minimum percentage of availability)

Stage of the process

This method is used during operation to assess if the system or the service responds as expected. It could be used as an acceptance test to assess the system.

Rate of use

It could be used in the three rates of use. Usually it is used on single or individual spots when the system is just installed or when some deviations in the monitoring data are detected.

Parts covered value chain

This method could be used in the different phases. It is mainly used in the content detection phase, but it could also be used in the content processing and service provision phase.

Type of service aspect / service equipment

This method could be used to monitor different types of equipment. It is not only focused on monitoring systems (loops, meteorological stations,…) but also other equipment involved in the ITS service provision chain (for example VMS).

Covered criteria

Criteria that can be assessed are: Availability, Error rate, Event coverage, Report coverage and Completeness of data.

Table 16: Usage – Continuous monitoring of equipment performance and availability

<table>
<tr><td colspan="8">Method 1: Continuous monitoring of equipment performance and availability</td></tr>
<tr><td colspan="8">Usage</td></tr>
<tr><td colspan="2" rowspan="2">Objective</td><td colspan="4">Stage of the process</td><td colspan="2" rowspan="2">Rate of use / needs for usage</td></tr>
<tr><td></td><td>used</td><td>useful</td><td>not useful</td></tr>
<tr><td>Assessment of service</td><td>✓</td><td>acceptance test</td><td>☐</td><td>☐</td><td>✓</td><td>Single / spot check in case of problems</td><td>☐</td></tr>
<tr><td>Acceptance testing</td><td>✓</td><td>operation</td><td>✓</td><td>☐</td><td>☐</td><td>Periodic</td><td>monthly or more frequently</td></tr>
<tr><td>Feasibility / testing new procedure / algorithm</td><td>✓</td><td>problem</td><td>✓</td><td>☐</td><td>☐</td><td>Continuous use</td><td>✓</td></tr>
<tr><td>Internal quality control / monitoring</td><td>✓</td><td>diagnosis</td><td>✓</td><td>☐</td><td>☐</td><td>Needed special equipment</td><td>software running in the back office</td></tr>
<tr><td colspan="6" rowspan="2"></td><td>Needed special knowledge</td><td>specifications of equipment</td></tr>
<tr><td>Expected cost</td><td></td></tr>
<tr><td colspan="8">Remarks:</td></tr>
</table>

Table 17: Applicability – Continuous monitoring of equipment performance and availability

Method 1: Continuous monitoring of equipment performance and availability								
Applicability								
Assessment / assurance		Part value chain		Type of service (equipment)		Quality criteria		Type of result
Assurance	✓	Content detection	✓	Equipment	✓	Geographical coverage	☐	*Choose an item.*
Assessment	☐	Content processing	☐	e.g. monitoring of loop detectors or road weather stations		Availability	✓	objective
						Timeliness start	☐	
Event / status		Service provision	☐	Process	☐	Reporting period	☐	*Choose an item.*
				If yes, give description.		Timeliness update	✓	results do encompass criteria
						Latency	☐	
Event	✓	Service presentation	☐			Location accuracy	☐	
Status	✓					Reporting accuracy	✓	quantitative
Offline / online						Classification correctness	☐	
Offline	✓					Event coverage	✓	quantitative
Online	✓					Report coverage	☐	
Remarks								

4.1.2. METHOD 2: MANUAL VERIFICATION OF ENTITIES, EVENTS OR CONDITIONS

Method (short name) and short description

Manual verification of events or conditions based on current actual reality.

Method description

The manual verification focuses on correctness of reported entity or event occurrence or reported conditions. It is mainly used for verification of manually reported entities, events or conditions.

Relevant questions are: Does an entity event occur (at the reported location)? Is the reported type and dimension of entity, event or condition correct? Is the reported location of entity, event or condition correct?

Used methods to check information against the actual reality depend on personal and technical equipment. If CCTV cameras do exist at e.g. the respective car park, public transport stop or car or bike sharing station, these can be used for manual verification. Otherwise this can be done by field inspection and desk research.

In Germany, for instance, the road traffic police verifies reported safety-relevant events or conditions by road inspection in line with danger prevention.

In France, for instance, part of the contracts between public transport authorities and the transport providers – even resulting in financial bonuses/maluses – is the monitoring of e.g. punctuality and the existence and accuracy of the information provided to the public (e.g. time tables and stops in the network). The private companies must provide the data (they collect them themselves by doing the surveys internally, by way of e.g. field inspections and data research, or hire independent institutes. To ensure the objectiveness of the data provided, the public transport authority also randomly commissions double-checks to second independent institutes.

Applicability

Quality assurance / assessment

The method is mostly used for quality assurance to correct or delete wrong messages about actual reported entities and vents by responsible operators.

Event / status

The method is practicable for status as well as event information.

Offline / online

The described method is practicable as an offline and online process.

Parts covered value chain

The applicability of manual verification is shown in the following diagram (Figure 7).

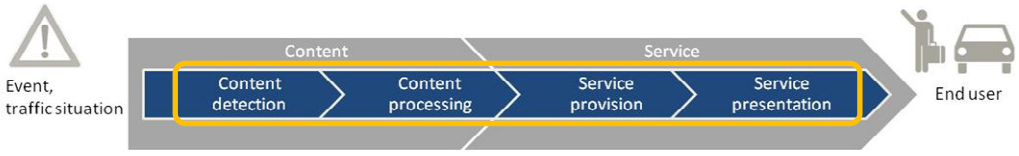


Figure 7: Parts of value chain covered by the method – Manual verification of events and conditions.

Manual verification can be used in all phases for quality assurance. It is mainly used to verify the quality in the content processing phase to avoid providing wrong information based on manual detection.

Type of service aspect / service equipment

Manual verification can be based on CCTV cameras. Furthermore field inspection at the reported location is applicable.

Covered criteria

Criteria that can be assessed are: Timeliness (focused on time for verification), Location accuracy, Disruptions, Real-time status information, Error rate and Completeness of data.

Results related to the criteria

The results of manual verification are:

- Qualitative (yes or no answering questions mentioned above),
- Objective (result is independent from the verifying human operator),
- Direct (positive or negative verification identifies correct or wrong messages) and
- Encompass criteria (by decreasing of location accuracy the error rate increases).

Usage

Objective

Manual verification is mainly used for internal quality control. Other objectives can be addressed as well.

What stage of the process

Manual verification is used during operation to assess whether current reported events or conditions are correct or not. The method is based on the actual reality.

What rate of use

Manual verification is used as quality assurance method continuously depending of the presence of relevant entities or occurrence of relevant events. Entities and events reported separately by many independent sources or entities and events with low impact may cause lower importance of manual verification. Spot checks in case of problems are another use case of this method.

Manual verification of entities and events is used by road operators, transport authorities, public transport operators and traffic reporting offices to ensure the correctness of manually detected events and reported entities.

References

Gerlach, J., Seipel, S., Leven, J.: Falschfahrten auf Autobahnen. Final report, 2012.

Table 18: Usage – Manual verification of events and conditions

Method 2: Manual verification of events or conditions							
Usage							
Objective		Stage of the process				Rate of use / needs for usage	
			used	useful	not useful		
Assessment of service	✓	acceptance test	☐	☐	☐	Single / spot check in case of problems	✓
Acceptance testing	✓	operation	✓	✓	☐	Periodic	Periodic and not periodic
Feasibility / testing new procedure / algorithm	✓	problem	✓	✓	☐	Continuous use	✓
Internal quality control / monitoring	✓	diagnosis	✓	✓	☐	Needed special equipment	Possibly CCTV cameras
						Needed special knowledge	basic
						Expected cost	?
Remarks:							

Table 19: Applicability – Manual verification of events and conditions.

<table>
<tr><td colspan="10">Method 2: Manual verification of events or conditions</td></tr>
<tr><td colspan="10">Applicability</td></tr>
<tr><td colspan="2">Assessment / assurance</td><td colspan="2">Part value chain</td><td colspan="2">Type of service (equipment)</td><td colspan="2">Quality criteria</td><td>Type of result</td></tr>
<tr><td>Assurance</td><td>☐</td><td>Content detection</td><td>✓</td><td>Equipment</td><td>✓</td><td>Geographical coverage</td><td>☐</td><td>qualitative</td></tr>
<tr><td>Assessment</td><td>✓</td><td>Content processing</td><td>✓</td><td colspan="2" rowspan="2">If yes, give description.</td><td>Availability</td><td>✓</td><td rowspan="2">objective</td></tr>
<tr><td colspan="2" rowspan="3">Event / status</td><td rowspan="3">Service provision</td><td rowspan="3">✓</td><td>Timeliness start</td><td>✓</td></tr>
<tr><td>Process</td><td>✓</td><td>Reporting period</td><td>☐</td><td>direct</td></tr>
<tr><td colspan="2">If yes, give description.</td><td>Timeliness update</td><td>✓</td><td rowspan="2">results do encompass criteria</td></tr>
<tr><td>Event</td><td>✓</td><td rowspan="2">Service presentation</td><td rowspan="2">✓</td><td></td><td></td><td>Latency</td><td>☐</td></tr>
<tr><td>Status</td><td>☐</td><td colspan="2"></td><td>Location accuracy</td><td>✓</td><td></td></tr>
<tr><td colspan="2">Offline / online</td><td></td><td></td><td colspan="2"></td><td>Reporting accuracy</td><td>☐</td><td></td></tr>
<tr><td>Offline</td><td>✓</td><td></td><td></td><td colspan="2"></td><td>Classification correctness</td><td>✓</td><td></td></tr>
<tr><td>Online</td><td>✓</td><td></td><td></td><td colspan="2"></td><td>Event coverage</td><td>☐</td><td></td></tr>
<tr><td>Remarks</td><td colspan="9"></td></tr>
</table>

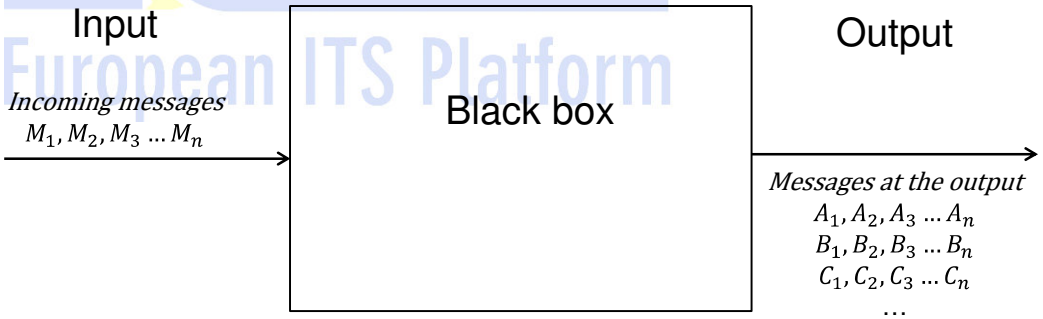
4.1.3. METHOD 3: MONITORING OF DATA COMPLETENESS AND LATENCY

Method description

The objective of the automated monitoring of latency is to monitor the processing times of information in for instance traffic information centre (TIC) or traffic management centre (TMC). It may also be implemented for other purposes, such as in car parkings or public transport control centers. Automated monitoring of latency is typically implemented with software that automatically registers the time stamps of incoming/outgoing information related to a certain event within an organisation. This allows statistical analysis of the performance of the operator in the processing of the event and message provision.

The analysis can be divided into the following steps

1. Define the messages to be analysed and the part of service chain to be covered and treat it as a black box (Figure 7)
2. Describe the relation between messages at the input and messages at the output. The relation may be from one to one, from many to one, or from one to many. In the latter case, one has to define which of the messages at the output is chosen for analysis.
3. An automated system calculates the time difference between messages observed at the output and the corresponding messages at the input (Figure 7).
4. Aggregated key performance indicators are calculated and statistical analysis can be performed for the observed latencies of individual messages.



Latency l for message n which appears at the output: $l_n = t_{A_n} - t_{M_n}$

(note: message M at the input generates messages A, B and C;
messages of type A selected for analysis)

Figure 7: Latency for message which appears at the output of the system to be analysed

Data requirements

The method requires an unambiguous relation between the messages at the input and output of the system to be analysed. The simplest case is the one to one relationship between input and output messages. Cases in which there is either one input message related to many output messages or many input messages related to one output message are more complex and require careful analysis. In these cases, there has to be objective criteria to determine which of the messages will be analysed.

The messages must also have reliable timestamp that is attached to a message when it enters or exits the system. This means that the software creating the input and output timestamps must be either using the same system clock or that the clocks used to create input and output timestamps must be either synchronised to each other or to a common external time reference.

EXAMPLE – APPLICATION OF THE METHOD IN THE NETHERLANDS

Method (short name) and short description

Monthly report

Short description

Every month the monthly report (factsheet) is generated which describes the availability, actuality and the overall score per data provider.

Availability:

The amount of traffic data of each data provider has available in the historical database with distinction in lane, location and minute. The percentage is calculated relatively to the total amount of expected traffic data:

- The total amount of expected traffic data is determined by the amount of minutes in one month, the amount of active locations during this month and the number of lanes per location. When locations are activated or deactivated during this month then they are not available during the inactive period.
- There is a distinction in available traffic data between error messages and usable traffic data.

Actuality:

The time difference between the moment that a traffic data is available for publication in the central NDW system and the end of the measure minute.

- The actuality norm for the data providers is 55 seconds. Besides this period the central system needs 20 seconds to for staging the message. The actuality

measured in the monthly report is 75 seconds. This is the content segment of the value chain.

- The actuality is only determined for the available traffic data. If only 1 part is delivered then the actuality is 100%.

Overall score:

This gives an indication of the overall performance of each data provider for the delivery of actual traffic data. The overall score is determined by multiplying the availability and the actuality.

In the monthly report the result of each data provider for these indicators is presented and accommodated with an explanation.

Applicability

Quality assurance / assessment

Quality assurance / assessment

Event / status

At this moment, the monthly report only focusses on status traffic data. Event information is also provided by NDW but not yet monitored in the monthly report.

Offline / online

The method can easily be applied offline.

Parts covered value chain

In the Netherlands, the whole value chain of NDW (content segment) is examined for status services, like flow and travel times (Figure 8). The focus is on the completeness not the content.

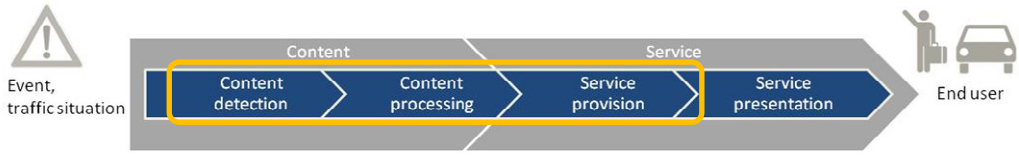


Figure 8: Parts of value chain covered by the method – Monitoring of data completeness and latency

Type of service aspect / service equipment

The monthly report can be used for all types of equipment and processes. At this moment, the monthly report is only used for the delivery of status reports, but this is also possible for event reports. Starting point is the time stamp of every report.

Covered criteria

Criteria that can be assessed are: Availability, timeliness start, reporting period, timeliness update, latency and classification correctness.

Results related to the criteria:

- Quantitative
- Objective
- Direct
- Results do encompass criteria.

Usage

Objective

The monthly report is used for assessment of service and internal quality control and monitoring.

What stage of the process

The monthly report is used to monitor the delivery of reports during operation. Besides, it can be used to identify problems and diagnose them.

What rate of use

The report is presented monthly to the data providers and the partners of NDW. The monitoring of the value chain is a continuous process.

Experiences and actual use

At this moment (Q4 2014) a process is started to improve the quality of the monthly report. In the current situation, the whole NDW value chain is monitored in total. Therefor is it difficult to improve the process because the value chain is divided into segments and for example the delay can be in only one segment.

References

NDW, Factsheet kwaliteit verkeersgegevens juli 2014

Table 20: Usage – Monitoring of data completeness and latency

Method 5: Monitoring of data completeness and latency							
Usage							
Objective		Stage of the process				Rate of use / needs for usage	
			used	useful	not useful		
Assessment of service	✓	acceptance test	☐	☐	☐	Single / spot check in case of problems	☐
Acceptance testing	☐	operation	✓	✓	☐	Periodic	monthly
Feasibility / testing new procedure / algorithm	☐	problem	✓	✓	☐	Continuous use	✓
Internal quality control / monitoring	✓	diagnosis	✓	✓	☐	Needed special equipment	
						Needed special knowledge	
						Expected cost	
Remarks: Monitoring is continuous, reporting is done in NL on a monthly basis							

Table 21: Applicability – Monitoring of data completeness and latency

Method 5: Monitoring of data completeness and latency								
Applicability								
Assessment / assurance		Part value chain		Type of service (equipment)		Quality criteria		Type of result
Assurance	✓	Content detection	✓	Equipment	✓	Geographical coverage	☐	quantitative
Assessment	✓	Content processing	✓	*If yes, give description.*		Availability	✓	objective
						Timeliness start	✓	
Event / status		Service provision	✓	Process	✓	Reporting period	✓	direct
				If yes, give description.		Timeliness update	✓	results do encompass criteria
						Latency	✓	
Event	✓	Service presentation	☐			Location accuracy	☐	
Status	✓					Reporting accuracy	☐	
Offline / online						Classification correctness	✓	
Offline	✓					Event coverage	☐	
Online	☐					Report coverage	☐	
Remark	In NL, atj NDW the whole value chain is examined (for status services, i.e. travel times) as an assessment.. method Completeness = Focused on quantity of reports/reporting location (not content in status report)							

4.1.4. METHOD 4: MONITORING OF TIMELINESS AND DATA COMPLETENESS

Method description

The objective of this method is the automated monitoring of timeliness and data completeness information in the Central Access Point (CAP). It may also be implemented for other purposes. Automated monitoring of timeliness is typically implemented with software that automatically registers the time stamps of incoming/outgoing information related to a certain event within an organisation. This allows statistical analysis of the performance of the operator in the processing of the event and message provision.

The analysis can be divided into the following steps

1. Define the messages to be analysed and the part of service chain to be covered.

2. Describe the relation between messages at the input and messages at the output. Part of this are e.g. service requirements. The relation may be from one to one,

from many to one, or from one to many. In the latter case, one has to define which of the messages at the output is chosen for analysis.

3. An automated system calculates the timeliness of messages observed at the output.

4. Aggregated key performance indicators are calculated and statistical analysis can be performed for the observed timeliness or completeness of individual messages.

Data requirements

Although for part of the messages monitored a system of manually triggered messages (see later examples) is conceivable, this is prone to human error. Therefore, to monitor any system that covers the whole value chain, it is desirable for equipment (e.g. vehicle transponder or sensor based) to be in place that automatically generates triggers and messages.

Furthermore, this method, too, requires an unambiguous relation between the messages at the input and output of the system to be analysed. The simplest case is the one to one relationship between input and output messages. Cases in which there is either one input message related to many output messages or many input messages related to one output message are more complex and require careful analysis. In these cases, there has to be objective criteria to determine which of the messages will be analysed.

The messages must also have reliable timestamp that is attached to a message when it enters or exits the system. This means that the software creating the input and output timestamps must be either using the same system clock or that the clocks used to create input and output timestamps must be either synchronised to each other or to a common external time reference.

EXAMPLE – APPLICATION OF THE METHOD IN THE NETHERLANDS

Method (short name) and short description

Monthly report (ref. Annex 3: Example of KPI benchmark on basic quality requirements for (source) data provisioning by concession holders in the Netherlands)

Method description

Every month the monthly report (KPI benchmark) is generated which describes the availability, timeliness and completeness per operator/data provider. These operators are public transport concession holders and scores are determined based on both legal and concession requirements.

New stops:

New stops that become operational at the start of a new timetable, are requested no later than 2 months before the date of entry. This provides stop managers with the opportunity to collect and make available the physical and accessibility features of the stops in time.

Correction of coordinates:

The Concession holder as Main transport registers the coordinates of stops in the Central Stops File with an accuracy of 10 meters and a wind-rose orientation with a maximum deviation of 22.5 degrees.

Timetable data:

- The timetable data, provided via the appropriate standard interface, is 100% complete and corresponds with the timetable as published by the Concession holder through the different customary channels (such as the internet, timetable modification sheets, press releases etc.).
- The Concession holder is required at all times to provide the basis timetable that is valid at least 8 weeks in advance.
- Modifications to the basic timetable as a result of temporary (traffic) measures should be provided as soon as possible but no later than two work days before the planned date of entry.
- At the request of Concessionaire bridges will be included in the route definition and the planned driving times/passing times in the appropriate standard interface.

Arrivals linked to departures:

- The appropriate standard interface is used to assign platforms to a trip (dynamic platform allocation). The interface contains the information concerning the circulation (=transition of trips) relevant for the selected nodes (StopPlaces/Stop Areas) where dynamic platform allocation) is relevant.

Current vehicle position and punctuality:

- The current vehicle position and punctuality per trip are provided in accordance with the appropriate interface (BISON KV6 definition version 8.1.2.0 or higher).
- In addition to the interface definition the RD-X en RD-Y coordinates are required to be included in the Arrival, Departure and OnStop messages.
  Norm: compliant Yes/No.
- An ‘Arrival message’ is required to be sent to the interface no later than 5 seconds after arrival at the stop.

Norm: compliant Yes/No.

- A 'Departure message' is sent in accordance with the norm. *(KPI report under construction)*
  Norm: out of x% van all stop passages the Departure message should be received no later than 5 seconds after departure.
- 'Lead time' is in accordance with the norm.
  Norm: In 98% of all cases a message should be offered to the NDOV and Data service providers within 10 seconds after the Trigger.
- 'Timeliness 1st message' is in accordance with the norm.
  Norm: No later than 2 minutes before a trip's planned departure time it should be reported if the trip will be executed according to plan (and the trip information is current) in no less than 93% of all executed trips. A first (KV6) interface message should be received at the planned departure time of a trip.
- Update frequency is in accordance with the norm. Norm: during trip execution an update message should be received in no less than 95% of all minutes.
- Trip registration is in accordance with the norm.
  Norm: Of all trips that are required, in accordance with the concession, to be executed with an Intelligent Vehicle System (on board computer with peripheral equipment for location positioning), a timely (KV6) interface message or 'cancelled trip message' (KV17) should be received in no less than 98% of all cases.
- Stops registrations are in accordance with the norm
  Norm: Of all tracked trips, for no less than 96% of all stop passages a timely (KV6) interface message or 'cancelled trip message' should be received.
- 'Initialisation' is in accordance with the norm.
  Norm: For no less than 98% of all trips executed with a vehicle tracking system, an INIT message should be received.

Changes to the service execution:

- Changes to the planned timetable, such as deviations, trip cancellations, that are not communicated via another appropriate interface, are provided through interface KV17.
  Norm: There is no separate norm for this requirement. The use of KV17 for trip cancellations (CANCEL) and redirected routes (SHORTEN) is part of the registered stops passages KPI.
- KV17 Timeliness is in accordance with the norm. *(KPI report under construction)*
  Norm: A message concerning a cancelled trip or cancelled stop passage is received before the scheduled departure trip time/stop passage in no less than x% of all cases.

- Changes are provided in accordance with the current version of the (KV17) interface definition at the start date of the concession implementation.

Products, Prices, Rates:

- Source data for the calculation of travelling on credit is required to be provided in accordance with the current version of the appropriate Product, Prices Rates interface at the entry day of the concession.
- Changes are provided in accordance with the most recent version of this interface.

  Completeness: For each journey between 2 stops on a trip, it should be possible to determine the price based on the source data. *(KPI report under construction)*

Applicability

Quality assurance / assessment

Quality assurance / assessment

Event / status

At this moment the monthly report still focusses on a limited amount of key performance indicators, but comprising both event and status oriented information.

Offline / online

The method can easily be applied offline.

Parts covered value chain

In the Netherlands the whole value chain of NDOV (content segment) is examined for status services, like actual operations and vehicle data (Figure 9). The focus is on the completeness not the content.

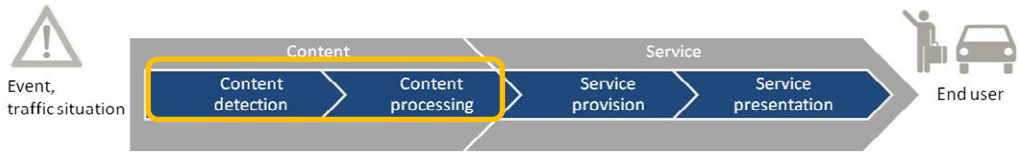


Figure 9: Parts of value chain covered by the method – Monitoring of timeliness and completeness.

Type of service aspect / service equipment

The monthly report can be used for all types of equipment and processes. At this moment the monthly report is used for the delivery of both event and status reports.

Covered criteria

Criteria that can be assessed are: Availability, Latency, Timeliness start, Reporting period, Timeliness update, Error rate, Event coverage and Data completeness

Results related to the criteria:

- Quantitative
- Objective
- Direct
- Results do encompass criteria.

Usage

Objective

The monthly report is used for assessment of service and external quality control and monitoring.

What stage of the process

The monthly report is used to monitor the operation and delivery of reports during operation. Besides it can be used to identify problems and diagnose them.

What rate of use

The report is presented monthly to the data providers and the partners of NDOV. The monitoring of the value chain is a continuous process.

Experiences and actual use

At this moment (Q4 2017) a process is ongoing to expand and improve the quality of the monthly report. In the current situation aspects of the whole NDOV value chain are monitored.

References

CROW-NDOV KPI rapportage May 2017

Table 22: Usage – Monitoring of data completeness and latency

Method 5: Monitoring of data completeness and latency							
Usage							
Objective		Stage of the process				Rate of use / needs for usage	
			used	useful	not useful		
Assessment of service	✓	acceptance test	☐	☐	☐	Single / spot check in case of problems	☐
Acceptance testing	☐	operation	✓	✓	☐	Periodic	monthly
Feasibility / testing new procedure / algorithm	☐	problem	✓	✓	☐	Continuous use	✓
Internal quality control / monitoring	✓	diagnosis	✓	✓	☐	Needed special equipment	✓
						Needed special knowledge	
						Expected cost	
Remarks: Monitoring is continuous, reporting is done in NL on a monthly basis							

Table 23: Applicability – Monitoring of data completeness and latency

Method 5: Monitoring of data completeness and latency								
Applicability								
Assessment / assurance		Part value chain		Type of service (equipment)		Quality criteria		Type of result
Assurance	✓	Content detection	✓	Equipment	✓	Geographical coverage	☐	quantitative
Assessment	✓	Content processing	✓	*If yes, give description.*		Availability	✓	objective
						Timeliness start	✓	
Event / status		Service provision	✓	Process	✓	Reporting period	✓	direct
				If yes, give description.		Timeliness update	✓	results do encompass criteria
						Latency	✓	
Event	✓	Service presentation	☐			Location accuracy	✓	
Status	✓					Reporting accuracy	☐	
Offline / online						Classification correctness	✓	
Offline	✓					Event coverage	✓	
Online	☐					Report coverage	☐	
Remark	In NL, at NDOV, parts of the whole value chain are examined (for status services, i.e. travel times) as an assessment.. method Completeness = Focused on quantity of reports/reporting location (not content in status report)							

4.1.5. METHOD 5: SURVEYS OF PERCEIVED QUALITY BY USERS

Method description

The aim of a user survey is to measure how the end users experience/perceive the travel information services. Data collection may be performed periodically (e.g. once a year).

The degree of satisfaction, the degree of relevance, the user needs, and the perceived quality are covered by the questionnaire. Many other questions are also asked. A web panel of a sufficient number of active users are asked to participate in a survey. The services which can be covered by the method are: web sites, mobile applications, RDS-TMC, and teletext.

Applicability

Quality assurance/assessment

The method is for Quality assessment.

Event/status

The method covers the services, which means both event and status information.

Offline/online

The method is an offline method.

Parts covered in value chain

All parts of the value chain are covered (Figure 10).

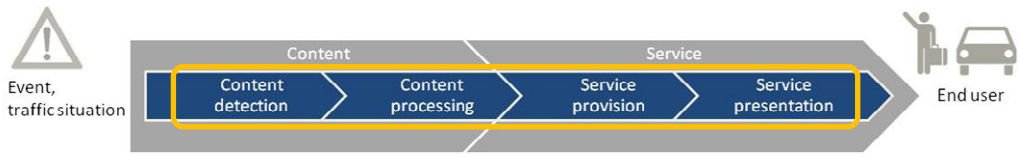


Figure 10: Parts of value chain covered by the method – Surveys of perceived quality by users

Type of service aspect / service equipment

User surveys can be used for all types of services.

Covered criteria

In principle, all criteria are covered by the quality perceived by the end users: Availability, timeliness and latency (in total), location accuracy, error rate and event coverage. The users often cannot distinguish between the system down (availability), a missed event (event coverage), wrong time table information or location, and a long timeliness or latency, if they observe an event in the public transport network, for which they have not received a message.

Results related to the criteria

The results related to the criteria are:

- Quantitative
- Subjective
- Indirect
- Results do not encompass criteria.

Usage

Objective

The objective is assessment of the services.

What stage of the process

The operation of the services is assessed.

What rate of use

The user surveys are performed once a year. The frequency of the surveys could be different. The surveys are done by commercial survey agencies. The costs per survey range from 10,000 € to 40,000 €.

Experiences and actual use

The mentioned surveys were used for the first time in 2012. In 2013, some improvements were observed.

EXAMPLE – APPLICATION OF THE METHOD IN DENMARK

A survey, very much as described, is carried out in Denmark (1,000 car users, each driving more than 8,000 km a year.

References

Slides shown at and distributed after the EIP meeting on 21 - 22 November 2013 in Brussels. Internal documents in Danish.

Table 24: Usage – Surveys of perceived quality by users

Method 8: Surveys of perceived quality by users							
Usage							
Objective		Stage of the process				Rate of use / needs for usage	
			used	useful	not useful		
Assessment of service	✓	acceptance test	☐	☐	☐	Single / spot check in case of problems	☐
Acceptance testing	☐	operation	✓	☐	☐	Periodic	yearly
Feasibility / testing new procedure / algorithm	☐	problem	☐	☐	☐	Continuous use	☐
Internal quality control / monitoring	✓	diagnosis	☐	☐	☐	Needed special equipment	
						Needed special knowledge	
						Expected cost	
Remarks:							

Table 25: Applicability – Surveys of perceived quality by users

Method 8: Surveys of perceived quality by users								
Applicability								
Assessment / assurance		Part value chain		Type of service (equipment)		Quality criteria		Type of result
Assurance	☐	Content detection	✓	Equipment	✓	Geographical coverage	☐	qualitative
Assessment	✓	Content processing	✓	*If yes, give description.*		Availability	✓	subjective
						Timeliness start	✓	
Event / status		Service provision	✓	Process	✓	Reporting period	☐	indirect
				If yes, give description.		Timeliness update	✓	results do not encompass criteria
						Latency	✓	
Event	✓	Service presentation	✓			Location accuracy	✓	
Status	✓					Reporting accuracy	☐	
Offline / online						Classification correctness	✓	
Offline	✓					Event coverage	✓	
Online	☐					Report coverage	☐	
Remarks								

4.1.6. METHOD 6: COLLECTION OF DIRECT USER FEEDBACK

Method description

Collection of direct user feedback means using different channels established by the service provider to collect feedback from the users regarding the quality of the service in question.

In quality assessment, collection of direct user feedback is a relatively easy way to get information how the actual users of the service experience the service quality. The feedback can be collected via social media (also an increasing information source for traffic and transport management agencies), telephone (requiring slightly more resources for registering the feedback) or smart phone app and webpage, where the feedback can be classified by the user and directed to the responsible parties.

Modern smart devices also offer capabilities for reporting many MMTIS-related situations (e.g. disruptions) in high precision and in real-time. With a certain penetration rate of this source, traveler feedback via smart phones – so-called 'Floating User Data', compare to 'Floating Car Data' – may be used as a 'reference data base' for data providers allowing for instance reference testing of data (ref. 'Quality package for safety related and real-time traffic information services', METHOD 3). User feedback is a very important method considering consumer information services (end user services), but can also be applied to b2b-type of services such as Content Access Point.

Applicability

Quality assurance / assessment

The method can be used as a part of the quality assurance process. If no other means of quality assurance are possible, at least this method should be used. The method provides only qualitative type of information which limits its use in systematical quality assessment.

Event / status

Method can be used for both types.

Offline / online

Method can be used in online analysis.

Parts covered in value chain

The coverage of the method in the ITS value chain is described in Figure 11.

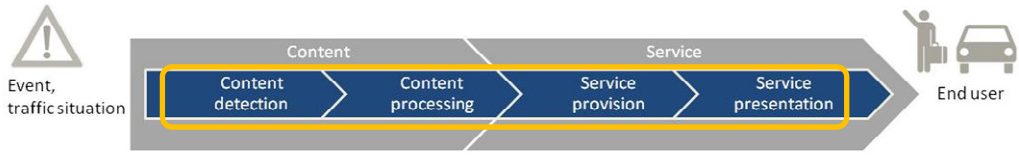


Figure 11: Parts of value chain covered by the method – Collection of direct user feedback

Type of service aspect / equipment

The method is best used in the evaluation of service as a whole from end users' perspective. The feedback, and the encountered problems, can however be traced to different phases in the value chain.

It is important to keep in mind that the method is also important for the quality assurance of services such as Content Access Point, even though the users are companies and organisations using the interface.

Covered criteria

The method can be used to collect information about availability, location accuracy, reporting accuracy and error rate.

The feedback could also concern the delay in the value chain, but timeliness cannot be separated from latency. Indications regarding poor event coverage can be achieved with this method.

Results related to the criteria

The collected feedback is in qualitative nature. Hence, if a lot of feedback is received concerning for example wrong travel times or wrong locations for incidents, this is a signal to make deeper quantitative analysis of the quality in the value chain. So the method does not directly measure the quality in terms of the defined attributes, but it collects (indirect) indications about the quality.

Feedback is always subjective.

Usage

Objective

Collection of direct user feedback is used for quality assessment of a running service. Because the method provides only qualitative information about the quality, it is not recommended as the only assessment method.

The method could also be used in the acceptance testing phase with a limited test group.

What stage of the process

The method is used in the operational phase of the service.

The method is also beneficial in the test phase of a new service. In this case, a test group of users is formed and their opinions are collected with the help of different channels.

What rate of use

The method is used continuously. Method does not require special expertise, but there are some minor costs related to the handling and analysis of the received feedback.

Experiences and actual use

Most services targeted for the end users are already using this assessment method. Possibility to leave user feedback is also part of a good customer experience, so the method is not only used as a means of quality assessment.

In a good practice of this method, the service provider explains the user for what purpose the feedback is collected, how it is processed, what is the processing time of the feedback, and whether the user will be provided with an answer from the service provider. In best practices, the user actually receives a personal answer including an explanation to what actions the feedback has/will lead to.

Hence, the use of the method requires person(s) who takes responsibility of the management of the feedback. The volume of users and the resulting amount of feedback defines the needed resources for this method.

A good practice to decrease the amount of unnecessary feedback is to set up a Questions & Answers page, where the most common feedback and the related answers are already addressed. Explanation about how the information is collected and what factors affect the quality of the information may be a good way to reduce the amount of (unnecessary) feedback.

The use of telephone in the collection is not recommended in case of end user services, because that would tie staff and requires more resources in the registration (typing in) of the feedback.

In case of b2b type of services such as Content Access Point, the amount of users is usually quite limited, and the feedback can be collected also via telephone as part of the customer service offered to the users of the service.

Table 26: Usage – Collection of direct user feedback

Method 9: Collection of direct user feedback							
Usage							
Objective		Stage of the process				Rate of use / needs for usage	
			used	useful	not useful		
Assessment of service	✓	acceptance test	☐	✓	☐	Single / spot check in case of problems	☐
Acceptance testing	☐	operation	☐	✓	☐	Periodic	
Feasibility / testing new procedure / algorithm	☐	problem	☐	☐	☐	Continuous use	✓
Internal quality control / monitoring	☐	diagnosis	☐	☐	☐	Needed special equipment	
						Needed special knowledge	
						Expected cost	minor
Remarks:							

Table 27: Applicability – Collection of direct user feedback

Method 9: Collection of direct user feedback								
Applicability								
Assessment / assurance		Part value chain		Type of service (equipment)		Quality criteria		Type of result
Assurance	✓	Content detection	✓	Equipment	✓	Geographical coverage	☐	qualitative
Assessment	☐	Content processing	✓	can indicate equipment faults		Availability	✓	subjective
						Timeliness start	☐	
Event / status		Service provision	✓	Process	✓	Reporting period	☐	direct
				can indicate process faults		Timeliness update	☐	results do encompass criteria
						Latency	☐	
Event	✓	Service presentation	✓			Location accuracy	✓	
Status	✓					Reporting accuracy	✓	
Offline / online						Classification correctness	✓	
Offline	☐					Event coverage	☐	
Online	✓					Report coverage	☐	
Remarks	Provides qualitative indication of the quality criteria							

4.1.7. METHOD 7: MONITORING OF SERVICE USE STATISTICS

Short description

Monitor amount of service use to assess effect of service content and quality by using counters of internet page visits, smartphone application downloads and use etc.

The method provides only indirect information of service quality, but is important as the main purpose of service quality is to provide benefit to the user of the service. The users will only use a service if it provides such benefit, and thereby service use statistics are essential for the service providers.

Applicability

Quality assurance / assessment

Applies to both.

Event / status

Applies to both.

Offline / online

Primarily offline

Parts covered value chain

The method covers service provision and presentation, but indirectly all parts of the value chain (Figure 12).

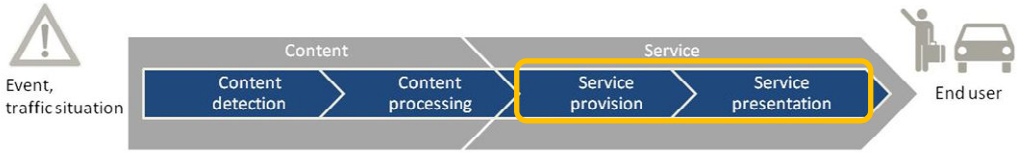


Figure 12: Parts of value chain covered by the method – Monitoring of service use statistics.

Type of service aspect / service equipment

Only the service as a whole, no possibility to differentiate between service aspects.

Covered criteria

Basically all as they all affect the whole service quality reflected in willingness to use service – it is very hard to establish link to availability, latency and timeliness criteria.

Results related to the criteria

- Quantitative / qualitative: qualitative for the criteria, but quantitative as such
- Objective / subjective: objective
- Direct / indirect: indirect
- Results do encompass criteria indirectly only

Usage

Objective

The objective is to assess the benefit and thereby quality to the users via monitoring how often and by how many the service is being used.

What stage of the process

Service operation, useful in both normal and abnormal situations of service operation.

What rate of use

Applicable to single/spot check, periodic, and continuous use

No special equipment is needed except for software solutions to provide usage counters at internet sites and pages, as well as willingness of application and app store providers to provide information of application download and use statistics.

The costs are expected to be very low.

Experiences and actual use

The practice is widely used globally.

Table 28: Usage – Monitoring of service use statistics

Method 10: Monitoring of service use statistics							
Usage							
Objective		Stage of the process				Rate of use / needs for usage	
			used	useful	not useful		
Assessment of service	✓	acceptance test	☐	☐	✓	Single / spot check in case of problems	✓
Acceptance testing	☐	operation	✓	✓	☐	Periodic	✓
Feasibility / testing new procedure / algorithm	☐	problem	☐	✓	☐	Continuous use	✓
Internal quality control / monitoring	☐	diagnosis	☐	☐	✓	Needed special equipment	
						Needed special knowledge	
						Expected cost	low
Remarks: Widely used for internet services and smartphone apps							

Table 29: Applicability – Monitoring of service use statistics

Method 10: Monitoring of service use statistics								
Applicability								
Assessment / assurance		Part value chain		Type of service (equipment)		Quality criteria		Type of result
Assurance	✓	Content detection	☐	Equipment	☐	Geographical coverage	✓	quantitative (but service quality indirect, qualitative)
Assessment	✓	Content processing	☐	can indirectly indicate equipment faults		Availability	☐	objective
						Timeliness start	☐	
Event / status		Service provision	✓	Process	✓	Reporting period	☐	in direct
				can indirectly indicate process faults		Timeliness update	☐	results do encompass criteria indirectly only
						Latency	☐	
Event	✓	Service presentation	✓			Location accuracy	✓	
Status	✓					Reporting accuracy	✓	
Offline / online						Classification correctness	✓	
Offline	✓					Event coverage	✓	
Online	✓					Report coverage	✓	
Remarks	Provides quantitative information essential to service provider but only indirect with regard to specific quality criteria							

4.2. Relevance and applicability of the assessment methods

The table below summarises the purposes for ´which the methods can be applied, the coverage of the methods in the RTTI value chain, their applicability to quality assurance or assessment, applicability to event or status oriented information and assessment of individual pieces or types of equipment or the service process.

Table 30: Summary on applicability of analysed quality assessment methods and practises

		Objective				Coverage of value chain				Assessment / assurance		Event / status		Type of service / equipment	
		Assessment of service	Acceptance testing	Feasibility / testing new procedure of algorithm	Internal quality control / monitoring	Content detection	Content processing	Service provision	Service presentation	Quality assurance	Quality assessment	Event	Status	Equipment	Process
1	Continuous monitoring of equipment performance and availability	X	X	X	X	X				X		X	X	X	
2	Manual verification of events or conditions	X	X	X	X	X	X	X	X		X	X		X	X
3	Monitoring of data completeness and latency	X			X	X	X	X		X	X	X	X	X	X
4	Monitoring of timeliness and data completeness	X	X		X	X	X	X		X	X	X	X	X	X
5	Surveys of perceived quality by users	X			X	X	X	X	X		X	X	X	X	X
6	Collection of direct user feedback	X				X	X	X	X	X		X	X	X	X
7	Monitoring of service use statistics	X						X	X	X	X	X	X		X

Mapping between the quality assessment methods and the elements of the quality criteria for MMTIS services is provided in Table 31. The table also indicates the types of results expected with the quality assessment methods.

Table 31: Results provided by analysed assessment methods. X means that the method can be used to address the criteria directly, and x means indirectly.

.		Quality criteria											Type of expected result					
		Geographical coverage	Availability	Timeliness start	Reporting period	Timeliness update	Latency	Location accuracy	Error rate	Event coverage	Report coverage	Completeness of data	Qualitative	Quantitative	Objective	Subjective	Direct	Results do encompass criteria
1	Continuous monitoring of equipment performance and availability		x			x				x				X	X			X
2	Manual verification of events or conditions			X		X		X	X				X		X		X	X
3	Monitoring of data completeness and latency		X	X	X	X			X			?		X	X		X	X
4	Monitoring of timeliness and data completeness		X	X	X	X	X		X	X		X		X	X		X	X
5	Surveys of perceived quality by users		x	x		x	x		x	x				X		X		
6	Collection of direct user feedback		X					X	X				X			X	X	X
7	Monitoring of service use statistics	x						x	x	x	x	?	(X)	X	X			

5. Summary and conclusions

Delegated Regulation (EU) No 2017/1926 contains some obligations to commonly describe and document the quality of services and underlying data in the field of Multimodal Travel Information Services (MMTIS).

EU EIP (and its antecessor projects) has previously developed frameworks how to commonly describe and document quality in the context of other Delegated Regulations, specifically for Real-time Traffic Information (RTTI) and Safety-related Traffic Information (SRTI) services. EU EIP is now about to introduce and discuss a similar framework for MMTIS.

Based on background from RTTI and SRTI activities, a first proposal on quality criteria and definitions for MMTIS has been elaborated EU EIP partners. This proposal includes:

- A set of quality criteria in the categories 'Level of Service" (describing the provision of data) and 'Level of Quality" (describing the data as such) → see chapter 2.3
- A mapping of relevant quality criteria to individual MMTIS services and data types → see chapter 2.4
- Quantitative quality requirements for individual MMTIS services (as initial target values), accompanied by "interpretation examples" → see chapter 3
- A set of proposed quality assessment methods → see chapter 4

The main lesson learned from the activities defining quality criteria and assessment methods is that quality assurance and assessment in MMTIS is far from established and mature, certainly when it comes to door-to-door travel chains. Hence, further validation, research, and development efforts are required. None of the quality requirements could be fully validated yet, although the evidence – also from RTTI and SRTI – suggests that the latency related requirements are likely of the correct overall magnitude. Pragmatic validation studies, also involving stakeholders, of the quality criteria for MMTIS will be carried out as the next task in the EU EIP 4.1.

Basically, the previous work for RTTI and SRTI indicated the value of having a European quality assurance and assessment framework, which facilitated a meaningful discussion of service quality in the EIP activities as well as in other platforms such as TISA. Similarly, there is a need to apply or set up such a framework also for multimodal travel and traffic information services – MMTIS – as well as other relevant European services in EU EIP.

The development of such a framework is now carried out by EU EIP 4.1. This is done in close cooperation with relevant stakeholders such as MMTIS service providers (as was the case with TISA members in the case of SRTI and RTTI). In the case of MMTIS many diverse stakeholders are concerned, sometimes organised in branch organisations.

First stakeholder insights on MMTIS quality dimensions have been already collected (e.g. during two dedicated workshops, see chapter 2.2). Based on those insights, light alterations and improvements have been made to the proposed quality criteria, requirements and methods.

During the recent validation phase, EU EIP 4.1 further fostered its interaction with relevant stakeholders for the following two reasons:

- to provide hands-on guidance on how to actually implement and use the proposed quality criteria, requirements and methods; and
- to gather feedback on the practicability and plausibility of the proposed quality criteria, requirements and methods.

An important lesson-learnt in this validation phase was that MMTIS Quality is quite a complex and evolving working field. This complexity can be explained by the Quality dimensions as understood by the public transport stakeholders, being a major data provider in MMTIS-NAPs. Expressed by the "Quality Iceberg" (see fig. 13), it becomes obvious that the visible part of data and service quality is a product of many underlying processes. Such underlying processes differ from organisation to organisation, and from data type and to data type, and are barely able to be harmonised in the form of a Quality Package.

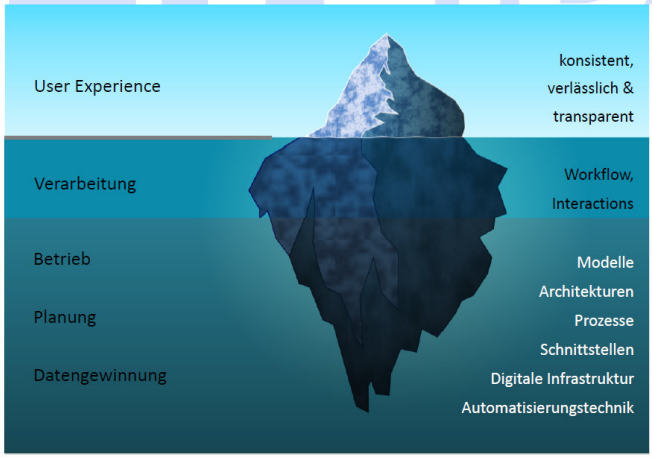


Figure 13: The "Quality Iceberg" in the context of MMTIS Quality (Source: VDV, Association of German Transport Companies)

Thus, any MMTIS Quality-related definitions cannot be determined in a complete and deep manner at this point of time. Consequently, this is document is not considered a formal guideline, but more an aid or source of information for interested stakeholders. Such stakeholders in particular include potential data providers for MMTIS-compatible

NAPs, who intend to describe the quality of their data offerings based on a harmonised framework.

As a recommendation for the on-going implementations of MMTIS-NAPs across Europe, Quality information about data offerings should be provided via a Metadata entry in the NAP portal (e.g. as an explicit Metadata field called “Quality information”). This way, a data provider will be able to describe the Quality for the data offering in a transparent manner. Also, any potential data providers should be encouraged to utilise that Metadata field and, when possible, relate the Quality descriptions to the definitions in this Quality Package.

As future work, e.g. for EU EIP follow-up projects, outstanding work is identified as follows:

- Enhancement of existing quality definitions, by improving usability and working towards full coverage of all data types of Delegated Regulation (EU) No 2017/1926,
- validation of quality definitions by checking them against test results in real-world operations,
- coverage of Quality aspects of the entire value chain of traveller information, including end-user perspective and
- identification of further MMTIS Quality requirements in relation to parallel, related contexts, such as Mobility-as-a-Service (MaaS).

Eventually, a more complete and more “obliging” state of MMTIS Quality definitions is envisioned at a later stage. Of course, any future activities in the definition and validation of MMTIS quality will require further, in-depth involvement of MMTIS stakeholders.

Annex 1: Relation between quality criteria and services

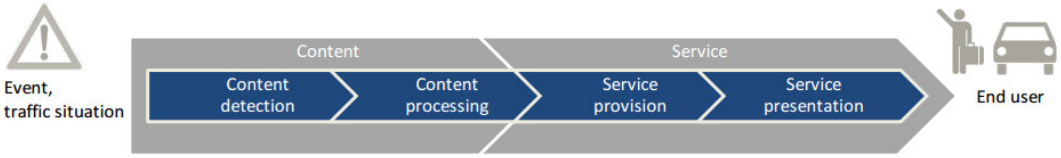
				Quality criteria										
Level of service	Service	Data type	Data entity	Geographic coverage	Availability	Timeliness (start)	Reporting period	Timeliness (update)	Latency (content side)	Location accuracy	Error rate	Event coverage	Report coverage	Completeness of data
1.1. Level of service 1	d) Trip plan computation – scheduled modes transport	I) Connection links where interchanges may be made, default transfer times between modes at interchanges	Geographic position	x	x					x	x			x
			Transfer time	x	x						x			x
1.1. Level of service 1	d) Trip plan computation – scheduled modes transport	II) Network topology and routes /lines (topology)s	GIS attributes	x	x					x	x			x
			Line shapes	x	x						x			x
1.1. Level of service 1	d) Trip plan computation – scheduled modes transport	IV) Timetables	Arrival and departure time at each stop	x	x						x		x	x
1.1. Level of service 1	d) Trip plan computation – scheduled modes transport	V) Planned interchanges between guaranteed scheduled services	Geographic position	x	x					x	x			
			Transfer time	x	x						x			
1.1. Level of service 1	e) Trip plan computation – road transport	I) Road network	GIS attributes including road class, turning restrictions, headroom, driving restrictions, speed limits, presence of ferries in network (non-toll/toll including tariffs)	x	x					x	x		x	x
1.1. Level of service 1	e) Trip plan computation – road transport	II) Cycle network (segregated cycle lanes, on-road shared with vehicles, on-path shared with pedestrians)	GIS attributes including type of path, direction, possibly also safety coefficient (as present in e.g. OpenStreetMap), presence of ferries in network (non-toll/toll including tariffs)	x	x					x	x			x
1.2 Level of service 2	f) Location search	I) Park & Ride stops	Geographic position of entry	x	x					x				x
			Opening hours	x	x						x		x	x
			Available PT lines	x	x									x
			Conditions for use	x	x						x		x	x
			Occupancy	x	x						x			x

				Quality criteria										
Level of service	Service	Data type	Data entity	Geographic coverage	Availability	Timeliness (start)	Reporting period	Timeliness (update)	Latency (content side)	Location accuracy	Error rate	Event coverage	Report coverage	Completeness of data
1.2 Level of service 2	f) Location search	IV) Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles	Geographic position of entry	x	x			x	x	x				x
			Opening hours	x	x			x	x		x		x	x
			Conditions for use	x	x			x	x		x		x	x
			Type of fuel	x	x			x	x		x		x	x
2.1 Level of service 1	a) Passing times, trip plans and auxiliary information	I) Disruptions (all modes)	Type	x	x	x		x	x		x	x	x	x
			Vehicle/line/connection	x	x	x		x	x		x	x	x	x
			Effect	x	x	x	x	x	x			x	x	x
			Duration	x	x	x	x	x	x		x	x	x	x
			GIS attributes of closed locations, stops, segments, etc.	x	x	x		x	x			x	x	x
2.1 Level of service 1	a) Passing times, trip plans and auxiliary information	II) Real-time status information - delays, cancellations, guaranteed connections monitoring (all modes)	Delay time	x	x	x	x	x	x		x	x	x	x
			Cancelled lines	x	x	x		x	x		x	x	x	x
			Cancelled stops	x	x	x		x	x		x	x	x	x
			Real-time/actual vehical positions	x	x	x		x	x		x	x	x	x
2.3 Level of service 3	e) Trip plans	I) Future predicted road link travel times	Travel time	x	x	x	x	x	x		x		x	
1.2 Level of service 2	f) Location search	II) Bike sharing stations	Geographic position of entry	x	x					x				x
			Opening hours	x	x						x		x	x
			Conditions for use	x	x						x		x	x
1.2 Level of service 2	f) Location search	III) Car-sharing stations	Geographic position of entry	x	x					x				x
			Opening hours	x	x						x		x	x
			Conditions for use	x	x						x		x	x

Annex 2: Value chains

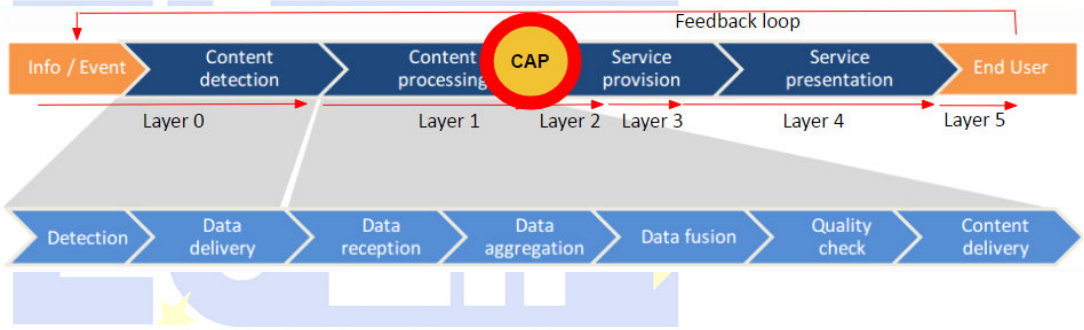
TISA definition of value chain

TISA has defined the terms and definitions for the traffic and travel information value chain. The value chain in the most simplified form is shown in the following figure:



At the highest level, two elements can be identified: Content and service. Content is referred to the observation of an incident or the measurement of a traffic condition, while service is referred to the transfer of the information and its maintenance.

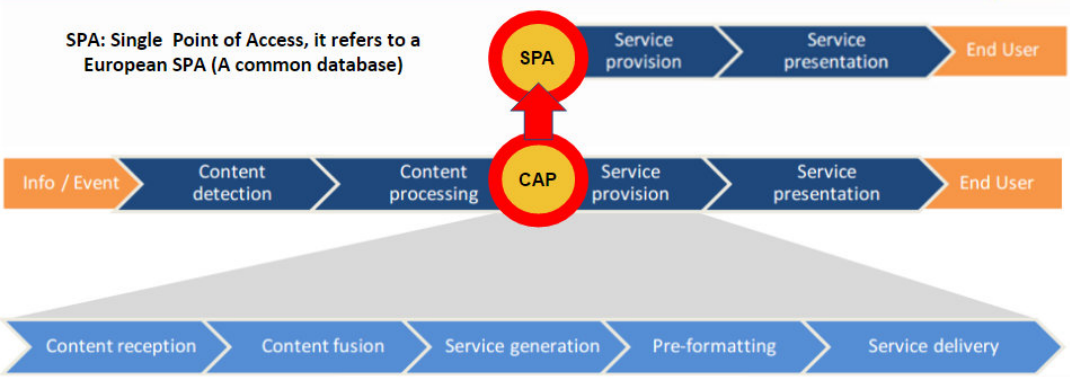
The Content segment expanded to show detailed functional sub-segments.



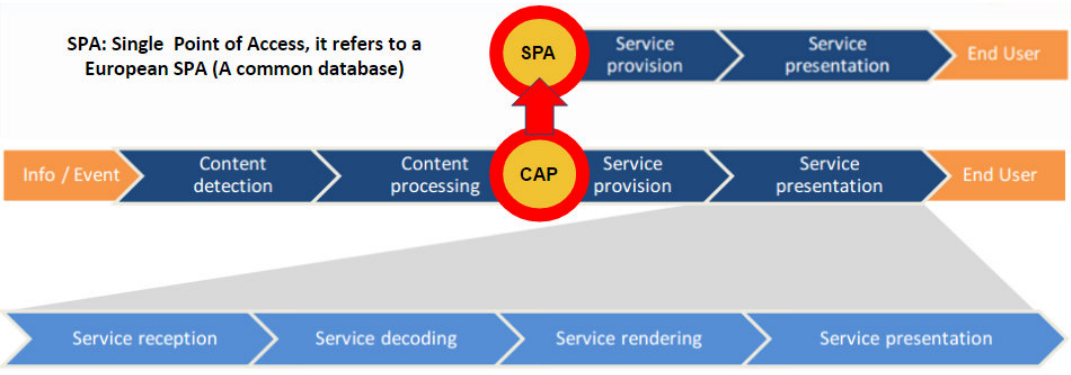
- DETECTION: The process of observing a measurement sample by means of technical equipment (detection could also involve human observation).
- DATA DELIVERY: The process of transferring the detected measurement sample from the measurement location to a central place.
- DATA RECEPTION: The process of collecting several measurement samples from the measurement locations at a central entity.
- DATA AGGREGATION: The process of gathering the received measurement samples in a repository.
- DATA FUSION: The process of combining raw data measurement samples from different means of detection into a representation of the traffic situation (traffic cameras, loop detectors, human observation...).
- QUALITY CHECK: The process of checking on measurement samples and the reconstructed traffic situation with the goal of removing erroneous samples.

- CONTENT DELIVERY: The process of transferring the content to a service provider, which will take care of the distribution of the content to the End Users.

The Service sub-segment expanded to show detailed functional sub-segments:



- CONTENT RECEPTION: The process of receiving content at the service provider (could be obtained from various content providers and through different communication channels).
- CONTENT FUSION: The process of combining the content from different content providers into a Service that can be consumed by the End User.
- SERVICE GENERATION: The process of improve the quality of the content such that it can be delivered to the End User (addition of meta information about the service area covered, type of content to be delivered...).
- PRE-FORMATTING: The process of "wrapping" the service in a way such that it can be transferred to the End User (data compression for reducing the required bandwidth for the transfer, packaging the content in smaller data containers…).
- SERVICE DELIVERY: The transportation of the service to the End User (radio, cellular phone, internet, apps...).



- SERVICE RECEPTION: The process of collecting the service at the End User device (FM or digital radio, mobile phones, personal computer...).
- SERVICE DECODING: The process of “unwrapping” the service from its packaging.
- SERVICE RENDERING: The process of preparing the content received as part of a service in a way that useful information can be presented to the End User (icon on a car navigation map, text message, audible announcement...).
- SERVICE PRESENTATION: The process of presenting the info or event to the End User, using whatever capabilities the End User device has to offer (graphical or alphanumeric display, loudspeaker...).

Annex 3: Example of KPI benchmark on basic quality requirements for (source) data provisioning by concession holders in the Netherlands

In the Netherlands, efforts over the past decade have resulted in a continuously developing KPI benchmark, define quality criteria and reporting. It is maintained by 'Nationale Data Openbaar Vervoer' (NDOV) – National Data Public Transport – the public transport information CAP in the Netherlands.

(CROW-)NDOV is a collaboration between 15 authorities which govern public transport in the Netherlands: 12 provinces, 2 metropole regions (bus, tram, metro, regional trains) and the Ministry of Infrastructure and the Environment (light rail, intercity trains). In the market, two data service providers make current PT data available to application service providers which in turn deliver current, diverse and accurate travel information to travellers via apps on smartphones or on DTIS screens at stops and stations. Within NDOV, public transport operators, public transport authorities and data service providers work together on the provisioning of public transport source data. Its beginnings, through the GOVI-project, date back to 2006.