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Quality of Service

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1 Introduction

1.1 Prerequisites and Overall objective

In eMaPS there is a budget for external consultancy services available, totalling 100.000 €. One of the tasks identified for the consultancy budget is the task of assessing Quality of Service requirements in eMaPS. One of the main showstopper related to the data quality is the fact that there are no requirements set by the end-users for the different types of data.

ROSATTE has set a series of data requirements based on expert reflections and on previous literature and projects. The ITS Action Plan is proposing a table with some criteria of up-to-dateness. eMaPS should reflect this, and formulate clearly what are the needs according to the data quality model set by ROSATTE (which is derived from EUROROADS): ADASIS and more particularly the OEMs in the forum/project could be the ones who can issue clear data quality requirements.

1.2 Objectives of this study

This study consists of two consecutive tasks that are described in detail in the following.

A. Suggest parameters to define the level of quality needed for

1. Data used for "signaling" – provided data being used as a signaling system to verify the user's own data (further on referred to as "signaling data level")
2. Data used as "source data" – provided data being used as the sole source of data for the user (further on referred to as "source data level")

The suggested parameters and their values and requirements should be based on the ROSATTE deliverable D6 "Organizational aspects and expected benefits" [1]. In this deliverable a guideline for the further implantation of the ROSATTE quality framework was proposed in the chapter 6.3. "Guidelines on metadata to be provided by Public Authorities".

This guideline can be used as a basis, but has to be simplified especially by leaving out parameters that require sophisticated computing or acquisition of reference data (especially regarding the quality parameter "accuracy"). The evaluation of those complex quality parameters can be done e.g. by receiving feedback from the data users and does not have to be done by the data provider.

The data quality requirements for the distinction between these two data provision levels can be based on table 4 of ROSATTE deliverable D6 [1] or an updated version of it. They have to be checked and updated in close cooperation with the data providers involved in eMaPS or ROSATTE.

It has to be evaluated, if it makes sense to give an overall quality value or to distinguish between different feature types.

B. Propose a checklist for declaration of service quality.

The checklist can be a practical way for new data providers to declare the quality of their data, based on the parameters defined in A. This checklist should be simple to use, e.g. using drop-down menus or checkboxes in an Excel-sheet. It should give the data provider an evaluation, if his data can be used for "signaling" or as source data.

2 Background

In the following chapter the knowledge background of this study is presented. Different documents and interviews with experts have been used as basis.

2.1 ROSATTE

The ROSATTE project developed an infrastructure that will ensure European access to road safety attributes including incremental updates.

The overall objectives of the project were to:

1. Facilitate access to, exchange and maintain European-wide core road safety spatial data from national/regional/local sources by standard procedures
2. Enable multi-level aggregation and update of European-wide safety map data
3. Assess the technical and organizational feasibility of this infrastructure

Accurate and up-to-date safety related road network attributes are particularly important for efficient road operation and administration, and for safe driving along the European road network.

The major problem was how to ensure timely and easy access to road information owned and maintained by thousands of road authorities. In addition mechanisms were needed to enhance the quality of the available data in terms of accuracy, correctness and up-to-datedness, and to enable multi-level (local/national/European) aggregation of the data.

For a continuous delivery and integration of updates of road attribute data, road authorities that provide such updates are responsible for the timeliness delivery (within an agreed time period after the change of the attribute on the road), and for the correctness and positional accuracy of the data.

Data integrators on their side are responsible for correct interpretation of the received data, and correct inclusion in their digital map databases. The overall scope of ROSATTE is visualized in Fig. 1.

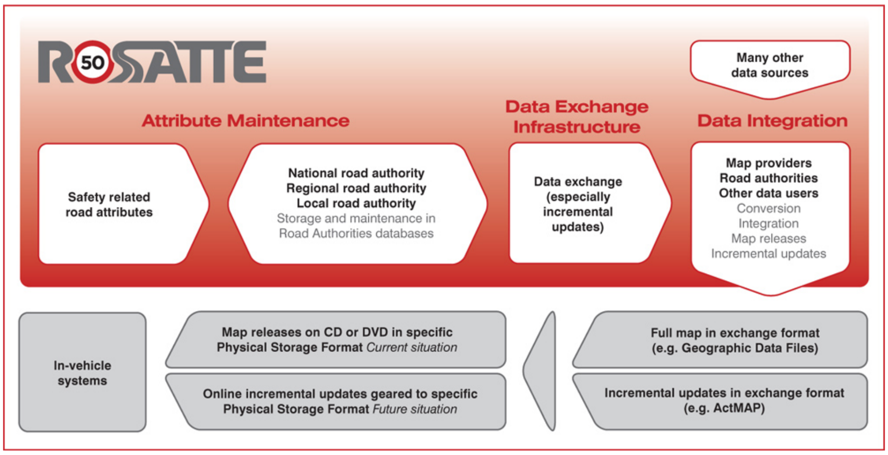

Fig. 1 The scope of ROSATTE

2.1.1 Test and Validation

The ROSATTE Test and Validation Plan [2] describes the assessment of the system and user requirements. Evaluation methods were proposed for the requirements, including validation indicators. The test and validation plan contains general guidelines to be applied as well as a compilation of test procedures and suitable evaluation methods. It also includes answers on how the test procedures should be carried out and the supported attributes.

From the beginning it was taken into particular account that a quality management concept has to apply for the entire data chain. Within this a number of quality parameters were defined (see Table 1).

Table 1: ROSATTE Quality elements and derived sub-elements [2]

Quality elements	**Quality sub-elements**
Availability	Update service availability rate
Up-to-dateness	Data processing time
Completeness	Completeness of a received feature
	Completeness of a received dataset
	Completeness of an integrated feature
	Completeness of an integrated dataset
Correctness	Attributive Correctness
	Topological Correctness
Consistency	Attributive Consistency of received features
Accuracy	Geometric Accuracy

The main focus was to assess the quality development of the ROSATTE data chain and not to describe the quality of the data sources . Therefore the ROSATTE quality parameters and their definitions have to be adapted within this study so that they can be used to describe the quality of a data source. .

2.1.2 D6 – Organizational aspects and expected benefits

In this document [1] the experiences from development and testing of the ROSATTE data chain are summarized. It is structured in a way, that other countries not participating in ROSATTE can use it as guidelines or best practice example to implement a similar data exchange infrastructure. As the ROSATTE Implementation Platform is actually a follow-up of the work done in ROSATTE, the D6 document is also an important basis for the work in this study.

Section 6.3 of the document at hand states “Guidelines on metadata to be provided by Public (Road) Authorities”. The description of the quality of service is also part of the metadata to be provided for each data source in a sense of INSPIRE. Data sources in ROSATTE or the ROSATTE Implementation Platform, respectively, are the responsible Public Road Authorities in the respective Member States. The document structures the metadata elements in three groups, namely

- “Data source information”,
- “Data source process description”, and
- “Quality of provided data”.

The suggested metadata elements are shown in the following Table 2:

Table 2: Road Authority metadata elements suggested in ROSATTE

Metadata group	Metadata element
Data source information	Coverage
	Completeness
	Correctness
Data source process description	Used data acquisition method
	Used update intervals
	Used location referencing technique
Quality of provided data	Geometric Accuracy
	Up-to-dateness

For these quality parameters, a set of requirements was derived reflecting different levels of ability of providing such road information. The so-called entry-level was foreseen for countries just having started to provide ROSATTE compliant data. See Table 3 for details.

Table 3: Levels of service suggested in ROSATTE

Parameters	Entry level	1*	2*	3*
Coverage	Only Motorways and/or major roads	Motorways and main roads	Full network without residential streets	Full road network
Completeness	>80%	>90%	>95%	>99%
Correctness	>80%	>90%	>95%	>99%
Geometric accuracy	50m	20m	10m	5m
Up-to-dateness	3 months	Month-week	1 day	1 hour
Used location referencing technique, incl. details of used implementation	Provision of WGS84 coordinates with additional location information (e.g. road class, name, …)		Provision of standardised and accepted location referencing code that enables accurate and reliable exchange of location information	

Based on these suggested levels of service, the quality parameters of this study have been derived.

2.2 INSPIRE

INSPIRE, the “Infrastructure for Spatial Information in the European Community”, was published as directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007. The main scopes of this directive focus on spatial data held by or on behalf of public authorities and to the use of spatial data by public authorities in the performance of their public tasks [3].

The planned information flow of INSPIRE is visualized in Fig. 2. On the left the different data sources are shown together with the use of the national spatial data infrastructures. In the middle part the requirement of the standardisation and harmonization can be derived. The directive focuses, besides some general provisions, on metadata, the interoperability of spatial data sets and services and network services. This structure is comparable to the ROSATTE structure.

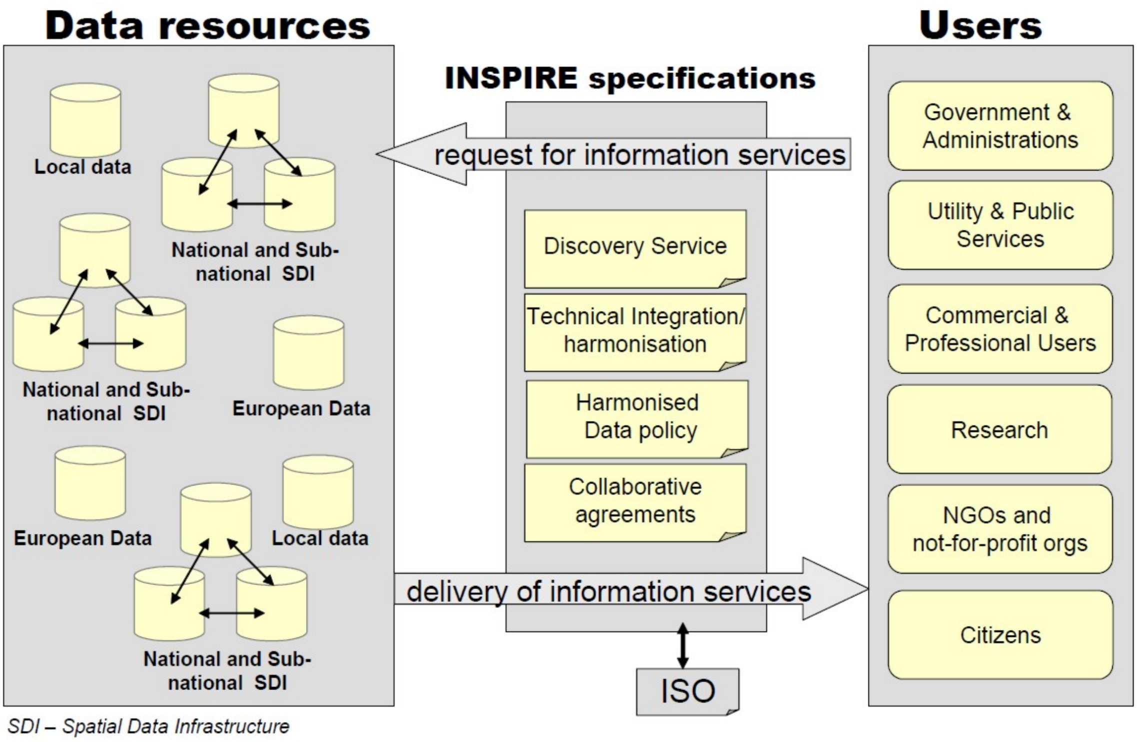

Fig. 2: INSPIRE Information Flow [3]

For the further realization of INSPIRE implementation rules are adopted by the European Commission for a number of different areas. The INSPIRE directive structures the area of discourse in so-called themes. The themes are listed in the annexes of the directive. The "Transport Networks" theme is mentioned in annex I which makes it a high priority for implementation. The INSPIRE Thematic Working Group on Transport Networks developed data specifications for this theme. Inside these specifications also quality elements and data quality sub-elements were defined. However, for the determination of these elements reference information is required. Therefore they cannot be used for the purpose of quality self-declaration which is in focus of this study.

2.3 ITS Action Plan

The ITS Action Plan [4] and in the following the ITS Directive [5] demand optimization of the collection and provision of road data. Moreover the Action Plan and the Directive asked for the definition of procedures for ensuring the availability of accurate public data for digital maps and their timely updating through cooperation between the relevant public bodies and digital map providers, taking into account the results and recommendations of the eSafety Digital Maps Working Group.

The technical framework was described within the ROSATTE project. Also the quality of the framework was defined in ROSATTE. In the course of the realization of the ROSATTE Implementation Platform, this study aims in defining quality elements for the data sources providing their data using the ROSATTE specifications.

The EC DG Mobility and Transport commissioned a study named "Availability of Public Data for Digital Maps"on action 1.3 of the ITS Action Plan [6] that should propose the minimum road data requirements and possible procedures for the publication of public road data within the EU. This study [6] approved that the quality systems of ROSATTE and INSPIRE are complementary. It recommends a clear definition of quality levels per road data type and per application area. It also mentions the difficulties considering the differences in development of the road data value chains in the different Member States. It is also suggests to develop a clear and objective method to describe the level of quality of road data sets of specific data types [6]. The two level approach assigned in this eMaPS study can be a first step towards these recommendations mentioned in [6].

2.4 Input from external experts

During a meeting with a representative of the ADASIS forum representing a group of car manufacturers such as Daimler, Ford, Opel and others (further on referred to as OEMs) the OEMs' view on quality requirements for ROSATTE data has been discussed intensively. As in the study mentioned above [6], it was the intention, to get some application-related quality requirements on digital map data from the OEMs. From those requirements, a list of quality parameters and respective thresholds should then be derived afterwards.

During the meeting, however, it became immediately clear that the OEMs do not see themselves as being mandated to issue any quality requirements on digital map data. It was rather referred to the general process for the derivation of product requirements between OEMs and map providers. That also involves the interest of the map vendors to keep their internal data specifications confidential, mainly with respect to their competitors. According to the OEMs' depiction, the map vendors derive their product specifications for newly data products from the individual OEM requirements. These OEM requirements have been communicated on a confidential basis before. Once the map vendors receive significant needs for new data content and decide to extend their product portfolio, the OEMs have to accept the product specifications made by the map vendors.

In this situation, for the study authors it was not possible to get substantial input regarding quality requirements for digital map data from neither map vendors nor car manufacturers.

Despite the car manufacturers, also the road authorities' view should be considered within this study. During a conference call with a road authority that was involved in ROSATTE, the derived quality model was discussed. The authority representative provided valuable feedback and suggestions for improvement with respect to individual quality parameters. Further, during the conference call, suggested European studies and projects (e.g. Quantis, EasyWay) were investigated and taken into account.

3 Derived levels of service quality for eMaPS data

3.1 Quality of Service Levels

The main aim of this study is to enable the data providers to declare the quality level of their provided data. The procedure for the declaration should be in a practical and easy way. As result the data providers can determine the quality level of their provided data by using a simple check list. In the assignment of the study, two levels for the provided data were suggested: The "Signaling Data Level" and the "Source Data Level". From our opinion, a third level should be integrated for the case, if a minimum data quality is not reached. This third quality level gives the data users more information about the quality of the provided data. So the quality level will differentiated between

- "Minimum Signaling Data Level not reached",
- "Signaling Data Level" ,and
- "Source Data Level".

For a better understanding, all three levels will be explained in the following sub-chapters.

3.1.1 Minimum Signaling Data Level not reached

This level represents the data for which the minimum quality requirements of "Signaling Data Level" cannot be reached. That means, the offered data, for example, has big gaps regarding the coverage of the road network for which the data provider is responsible.

3.1.2 Signaling Data Level

With the second level of quality, the data can be used for signaling. This means the provided data can be used to verify the user's (i.e. map provider's) own data. The data has to be checked before integration in the users' data base. "Signaling Data Level" has lower quality requirements than "Source Data Level". For example signaling level data cannot be used for safety relevant applications in driver assistance systems because of possible inconsistency of parts of the data. The minimum requirements of this level are based on Table 3 and will be further elaborated in chapter 3.2.

3.1.3 Source Data Level

The data which was indentified with high quality level is the so called "Source Data Level". Here the provided data can be used as the sole source of data for the user (i.e. map provider). This data level has very high quality requirements on with respect to e.g. measurement accuracy, completeness of the responsible network, or up-to-dateness. The minimum requirements of this level are also based on Table 3 and will be elaborated in more detail in chapter 3.2.

Detailed information about the identified quality parameters will be given in the following chapter.

3.2 Quality parameters

As mentioned before, one of the main topics of this study is to enable data providers to declare the quality of the provided data on their own and in a practical and easy way. The data types which will be provided can be for example road network, traffic signs, or speed limits. For each of these data types a declaration regarding the quality of the provided data can be assigned. This is especially necessary if the different data types, for example, show lacks in completeness. A quality model which integrates all different data types would be too complex for the given task. For this reason the different data types have to be considered separately.

Furthermore, the declaration of the quality should be based on a comprehensible procedure and on quality parameters which do not depend on any reference data. To realize the named demands with an easy quality model, the following quality parameters were selected:

- Completeness
- Used data acquisition method
- Up-to-dateness
- Used location referencing method
- Quality Checks
- Digital data flow

These quality parameters will be described below. The descriptions include a rationale why they are used and definitions of the quality parameter values.

- **Completeness**
  One of the most important information for data users is, how complete the provided data set is with respect to the reality. The named quality parameter shows how good the data of the responsible road network is already acquired from the respective road authority. This quality parameter is based on the results of ROSATTE (c.f. Table 3). The value is given in percent and will be computed using the following equation with respect to the responsible road network:

$$Completeness = \frac{Number\ of\ data\ elements\ already\ acquired}{Complete\ number\ of\ data\ elements} \cdot 100[\%] \qquad (3\text{-}1)$$

- **Used data acquisition method (w.r.t. position)**
  The next important information is the location accuracy of the acquired data elements. Since no reference data for computation of the accuracy is available, the accuracy of the data element has to be derived from the used data acquisition method respectively the used sensor. That means, the acquisition method has to reflect the worst position accuracy of all acquired dataset elements. The following table shows the assumed accuracy with respect to the used acquisition method. It must be considered here, that the mentioned accuracy values are assumed exemplarily and have to be checked or validated for each individual implementation.

Table 4: Acquisition Method with respect to according accuracy

Acquisition Method		**Accuracy [m]**
Position based on local measurements		
(1)	GNSS (code-measurement)	10
(2)	Mileage (accuracy depends on interpolation between mileage posts, e.g. by measurement tape, hand-odometer, estimation)	5
(3)	Manual indication of position in a map (e.g. city map, cadastral map, …) followed by a digitization using a GIS	>50[1]
(4)	Referenced on spatial objects (e.g. buildings), measured with tape	5
Position taken from legal order		
(5)	Address	50
(6)	Position indicated in a site map	20
(7)	Position defined w.r.t. local road network (e.g. intersections)	>50

- **Up-to-dateness [days]**
  Some driving assistance systems, like for example Intelligent Speed Adaption, use speed information from digital road maps. For these applications, up-to-dateness information is very important to get an idea about the reliability of the used map data. According to [1], the up-to-dateness describes the degree of adherence of geographic data to the time changing universe of discourse. This is depending on the dynamic of reality and the rate of change. The parameter describes the period starting when the traffic sign/regulation becomes valid until the update is available in data provider's data store (c.f. Table 3).
  The used values are:
  (1) < 1 day
  (2) 1 day - 3 month
  (3) > 3 month

- **Used location referencing method**
  In order to update road network databases automatically, different location referencing methods are used. Doing so, the referencing method also plays a very important role. On-the-fly reference procedures based on AGORA-C [7] and OpenLR™ [8] are currently used. Both procedures were tested in ROSATTE [9] and they both delivered good results. The following parameter values were used for computation of the levels:
  (1) AGORA-C
  (2) OpenLR™
  (3) Coordinate-based:
  Coordinates of objects were used for location referencing.
  (4) Mileage-based
  Mileage information of objects were used for location referencing.
  (5) Others

[1] This accuracy depends on the scale of the used map and the accuracy of manual indication. Here the worst case is assumed.

- **Quality Checks**
  Quality checks seem to be reasonable to raise the reliability of the offered map data. This quality parameter contains information about the implemented quality check routines at the respective data provider. As a first approach, a list with three possible quality check methods are proposed to be selected. The combination of different quality check methods is also possible. Furthermore the option "no data check" is available. The list below shows the different options and gives a short description:
  (1) Data Base Synchronization:
  A second data source will be used to check the new data acquired.
  (2) Field Inspection:
  The new data acquired will be checked on site in reality.
  (3) Plausibility Check:
  The new data acquired will be checked if the data makes sense with respect to the location. For Example a zebra crossing on a motorway does not make sense. This could be checked during the data input.
  (4) A combination of at least two of the named checks
  (5) No Check
- **Continuous digital data flow implemented**
  Continuous digital data flow will lead to consistent and fast data exchange and reduces gross errors (e.g. type errors) dramatically compared to analogue data maintenance still used in many road authorities. For this reason this quality parameter provides information if a complete digital data flow is used or not. The available values are:
  (1) Yes
  (2) No

3.3 Implementation of the Quality Parameters

In this chapter the implementation of the quality parameters defined in chapter 3.2 in the demanded checklist is described. . The mathematical background for the computation of the respective quality levels will also be given.

3.3.1 Minimum values and computation of quality level

To get a better understanding of how the computation of the respective quality level will be done, a closer look on the implementation will be given in this subchapter. The necessary model enhancements, the minimum values for each level, and the equations for the computation of each level will be shown below.

First of all two new parameters "Q-Level Check" and "Q-Parameter"will be defined for the computation of the respective level:

Q-Level Check: This value checks if the minimum criteria for "Signaling Data Level" for the respective quality parameter arefulfilled or not. For the later computation of the level state, all values of the different parameters must fulfill the minimum criteria for "Signaling Data Level". If this is not the case the "Signaling Data Level" cannot be reached.
The Q-Level Check C_i becomes "1" if the minimum value is reached for "Signaling Data Level". If the minimum value is not reached C_i becomes "0".
→ $C_i \in [0,1]$

Q-Parameter: This value describes the reached level of each quality parameter. If “Signaling Data Level” is reached, Q-Parameter P_i becomes “1” and if “Source Data Level” is reached, Q-Parameter P_i becomes “2”. If all quality parameters have reached “Source Data Level” the provided data becomes also “Source Data Level” state. The default value is “1”.
→ $P_i \in [1,2]$

In Table 5 the quality values, the minimum values for each level and the respective Q-Level Check and Q-Parameter will be shown. The value domain shows the possible values for each quality parameter. Each value has a number which can also be found in the columns of the respective level.

For example: If the used data acquisition method is GNSS, the respective number is (1). GNSS has the accuracy to reach “Signaling Data Level”. So (1) is represented in the column “Signaling Data Level” and the row “Used data acquisition method”.

Table 5: Minimum values of quality parameters

Parameter	Value domain	Minimum of Signaling Level not reached $C_i = 0$	Signaling Data Level Requirements $P_i = 1; C_i = 1$	Source Data Level Requirements $P_i = 2; C_i = 1$	Q-Level Check $C_i \in [0,1]$	Q-Parameter $P_i \in [1,2]$
Completeness	% of responsible road network (1) >95% (2) 80% -95% (3) <80%	(3)	(2)	(1)	C_C	P_C
Used data acquisition method (w.r.t. position)	Position based on local measurements: (1) GNSS (code-measurement) (2) Mileage (accuracy depends on interpolation between mileage posts, e.g. by measurement tape, hand-odometer, estimation) (3) Manual indication of position in a map (e.g. city map, cadastral map, …) followed by a digitization using a GIS (4) Referenced on spatial objects (e.g. buildings), measured with tape Position taken from legal order (5) Address (6) Position indicated in a site map (7) Position defined w.r.t. local road network (e.g. intersections)	(3)[>50m] (7)[>50m]	(1) [10 m] (6) [20 m] (5) [50 m] (<= 50 m)	(2) [5 m] (4) [5 m] (< 10 m)	C_{DA}	P_{DA}
Up-to-dateness	Average/Days after physical installation: (1) < 1 day (2) 3 month – 1 day (3) > 3 month	(3)	(2)	(1)	C_{Up}	P_{Up}
Used location referencing method	(1) AGORA (2) OpenLR™ (3) Coordinate-based (4) Mileage-based (5) Others	(5)	(3) (4)	(1) (2)	C_{LR}	P_{LR}
Quality Checks	(1) Data Base Synchronization (2) Field Inspection (3) Plausibility Check (4) Two or more of named checks (5) No Check	(5)	(1) (2) (3)	(4)	C_{QC}	P_{QC}
Digital data flow	(1) Yes (2) No	-	(2)	(1)	C_{DF}	P_{DF}

In a first general approach, all parameters are considered to have the same weight. Like mentioned before, if one of the “Q-Level Check” values is zero, “Signaling Data Level” cannot be reached. As the only exception, “digital data flow” will be disregarded, because a lot of data acquisition procedures still work in an analogue way. So this value is only considered for the decision if “Source Data Level” is reached or not.

To decide which level is reached, an overall quality parameter L_I has to be computed. L_I combines all inputs of the quality parameters "Q-Level Check" and "Q-Parameter "in one value. The computation of L_I will be done as follows:

$$L_I = \prod_{i=1}^{n} C_i \cdot \sum_{j=1}^{m} P_i = C_C \cdot C_{DA} \cdot C_{Up} \cdot C_{LR} \cdot C_{QC} \cdot \left(P_C + P_{DA} + P_{Up} + P_{LR} + P_{QC} + P_{DF}\right) \qquad (3\text{-}2)$$

The respective level arises from the result of L_I (status quo):

$L_I = 12 \rightarrow$ Source Data Level
$0 < L_I < 12 \rightarrow$ Signaling Data Level
$L_I = 0 \rightarrow$ Minimum Signaling Data Level not reached (3-3)

The following example demonstrates the computation of L_I:

Table 6: Example for computation of level

Parameter	Value	Q-Level Check	Q-Parameter
Completeness	(3) 80% - 95%	$C_C = 1$	$P_C = 1$
Used data acquisition method	(1) GNSS	$C_{DA} = 1$	$P_{DA} = 1$
Up-to-dateness	(1) < 1day	$C_{Up} = 1$	$P_{Up} = 2$
Used location referencing method	(3) Coordinate based	$C_{LR} = 1$	$P_{LR} = 1$
Quality Management / Quality Checks / Assurance implemented	(2) Field Inspection	$C_{QC} = 1$	$P_{QC} = 1$
Continuous digital data flow implemented	(2) No		$P_{DF} = 1$

The values from Table 6 inserted in (3-2)

$$L_I = 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot (1 + 1 + 2 + 1 + 1 + 1) = 7$$

According to (3-3), the reached level is "Signaling Data Level".

Further examples can be found in chapter 3.3.2. If some of the parameters should have a bigger influence on the computatioin of the quality level, the weight of these parameters can be increased. For this purpose, the values for the decision of the respective level have to be adjusted. Within this study it was asked to derive a general and non-application related approach. Therefore, the investigation stops at this point. Further investigations could be focused on the derivation of specific and application related weighting of the parameters.

3.3.2 Handling of the check list

One of the objectives in this study was to implement the identified quality parameters in an Excel sheet. With this Excel sheet the data provider should be able to evaluate his own data. The Excel sheet should be realized like a check list with drop down menus. With these drop down menus the provider can choose the value which represents the quality of his provided data. As result the provider should have a feedback if his provided data has reached the minimum requirements for "Signaling Data level" or "Source Data Level".

Figure 6 shows the implemented drop down menus in Excel. The realization was done with Excel 2010. The operator can choose one value for each quality parameter. If the provider has different data bases with different accuracy levels or different quality checks, his choice must be oriented to the data with the lowest quality value. With each change of a value, the overall quality parameter L_I will be computed again and the result will be shown at the bottom. The handling is more or less self-explanatory.

	A	B
1	**Parameter**	**Value (make your choice)**
2		
3	Completeness	>90 %
4	Data Acquisition (lowest acc.)	< 80% 80 % - 95% >90 %
5	Up-to-dateness	< 1 day
6	Location referencing method	OpenLR
7	Quality Management	two of named checks
8	Continuous digital data flow	Yes
9		
10		
11	**Level**	**Source Data Level**

Figure 1: Scroll down menu

3.3.3 Examples

For a better understanding how the excel sheet works, in this chapter three examples will be given. The three examples show the screen of the excel file with the chosen quality parameter values, the result and how the level was computed.

3.3.3.1 Example 1

In this example the "Signaling Data Level" will not be reached because one of the parameters does not fulfill the minimum requirements. In this case the accuracy of the data acquisition method is below 50 m. As result no level will be reached.

1	**Parameter**	**Value (make your choice)**
2		
3	Completeness	80 % - 95%
4	Data Acquisition (lowest acc.)	Local road network [> 50m]
5	Up-to-dateness	< 1 day
6	Location referencing method	OpenLR
7	Quality Management	two of named checks
8	Continuous digital data flow	No
9		
10		
11	**Level**	**Minimum Signaling Level not reached**

Figure 2: Example 1 – Minimum Signaling Data Level not reached

The quantitative values behind the quality parameter are shown in Table 7.

Table 7: Example 1 - Values of quality parameters

Parameter	Q-Level Check	Q-Parameter
Completeness	$C_C = 1$	$P_C = 1$
Used data acquisition method	$C_{DA} = 0$	$P_{DA} = 1$
Up-to-dateness	$C_{Up} = 1$	$P_{Up} = 2$
Used location referencing method	$C_{LR} = 1$	$P_{LR} = 2$
Quality Checks	$C_{QC} = 1$	$P_{QC} = 2$
digital data flow		$P_{DF} = 1$

The computation of the overall quality parameter L_I will be carried out with (3-2):

$$L_I = \prod_{i=1}^{n} C_i \cdot \sum_{j=1}^{m} P_i = C_C \cdot C_{DA} \cdot C_{Up} \cdot C_{LR} \cdot C_{QC} \cdot \left(P_C + P_{DA} + P_{Up} + P_{LR} + P_{QC} + P_{DF}\right)$$

$$= 1 \cdot 0 \cdot 1 \cdot 1 \cdot 1 \cdot (1 + 1 + 2 + 2 + 2 + 1) = 0$$

According to (3-3) the decision is : “Minimum Signaling Data Level not reached”

3.3.3.2 Example 2

In this example the “Signaling Data Level” will be reached because all of the parameters fulfill at least the minimum requirements.

1	**Parameter**	**Value (make your choice)**
2		
3	Completeness	>90 %
4	Data Acquisition (lowest acc.)	Referenced on spatial objects [5 m]
5	Up-to-dateness	< 1 day
6	Location referencing method	OpenLR
7	Quality Management	two of named checks
8	Continuous digital data flow	No
9		
10		
11	**Level**	**Signaling Data Level**

Figure 3: Example 2 – “Signaling Data Level” is reached

The quantitative values behind the quality parameter are shown in Table 8.

Table 8: Example 2 - Values of quality parameters

Parameter	Q-Level Check	Q-Parameter
Completeness	$C_C = 1$	$P_C = 1$
Used data acquisition method	$C_{DA} = 1$	$P_{DA} = 2$
Up-to-dateness	$C_{Up} = 1$	$P_{Up} = 1$
Used location referencing method	$C_{LR} = 1$	$P_{LR} = 1$
Quality Checks	$C_{QC} = 1$	$P_{QC} = 1$
digital data flow		$P_{DF} = 1$

The computation of the overall quality parameter L_I will be carried out with (3-2):

$$L_I = \prod_{i=1}^{n} C_i \cdot \sum_{j=1}^{m} P_i = C_C \cdot C_{DA} \cdot C_{Up} \cdot C_{LR} \cdot C_{QC} \cdot (P_C + P_{DA} + P_{Up} + P_{LR} + P_{QC} + P_{DF})$$

$$= 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot (1 + 2 + 1 + 1 + 1 + 1) = 7$$

According to (3-3) the decision is : “Signaling Data Level”

3.3.3.3 Example 3

In this example the “Source Data Level” will be reached because all of the parameters fulfill respective requirements.

1	**Parameter**	**Value (make your choice)**
2		
3	Completeness	>90 %
4	Data Acquisition (lowest acc.)	Referenced on spatial objects [5 m]
5	Up-to-dateness	< 1 day
6	Location referencing method	AGORA
7	Quality Management	two of named checks
8	Continuous digital data flow	Yes
9		
10		
11	**Level**	**Source Data Level**

Figure 4: Example 2 – “Source Data Level” is reached

The quantitative values behind the quality parameter are shown in Table 9.

Table 9: Example 2 - Values of quality parameters

Parameter	Q-Level Check	Q-Parameter
Completeness	$C_C = 1$	$P_C = 2$
Used data acquisition method	$C_{DA} = 1$	$P_{DA} = 2$
Up-to-dateness	$C_{Up} = 1$	$P_{Up} = 2$
Used location referencing method	$C_{LR} = 1$	$P_{LR} = 2$
Quality Checks	$C_{QC} = 1$	$P_{QC} = 2$
digital data flow		$P_{DF} = 2$

The computation of the overall quality parameter L_I will be carried out with (3-2):

$$L_I = \prod_{i=1}^{n} C_i \cdot \sum_{j=1}^{m} P_i = C_C \cdot C_{DA} \cdot C_{Up} \cdot C_{LR} \cdot C_{QC} \cdot (P_C + P_{DA} + P_{Up} + P_{LR} + P_{QC} + P_{DF})$$

$$= 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot (2 + 2 + 2 + 2 + 2 + 2) = 12$$

According to (3-3) the decision is : “Source Data Level”

4 Conclusions

The goal of the eMaPS support action is to contribute to the establishment of the ROSATTE implementation platform which is a first step towards the implementation of priority action 1.2 and 1.3 of the ITS directive. Within eMaPS the study "Quality of Service" at hand was commissioned.

This study should suggest parameters to distinguish "signaling data level" and "source data level". Also a checklist should be delivered for an easy determination of quality of service. For this in a first step, the current EU legislation and the present projects and their results have been reviewed within this study. Especially the relevance of the INSPIRE Directive, the ITS Action Plan, and ITS Directive with respect to this quality of service study has been assessed.

Furthermore the ADASIS forum representing a group of car manufacturers and some road authorities were consulted during the development of the quality model.

Within this study an easy-to-use quality model and classification schema road data was developed. Six quality parameters were identified to describe the quality of the data without using any reference data. The computation of the quality level by using these six quality parameters results in three levels of service: Minimum requirements not reached, "Signaling Data Level" reached or "Source Data Level" reached. If only two levels are required, "minimum requirements not reached" could be disregarded. This would only change the procedure marginally.

Due to the required easy general classification approach, a specification of quality parameters for different data classes in the quality model was not realized (e.g. completeness for each road class). The derived quality model, however, can be applied to different road classes or datasets by just assigning different threshold values to the individual quality parameters. For an application-oriented quality description (as suggested in [6]), additional quality parameters have to be added to the model, where necessary.

Furthermore, it could also be shown that the developed procedure could be implemented in an Excel sheet. The operator can choose the respective value for each quality parameter for his respective dataset using drop down menus. The resulting level of service is directly computed and visualized. The Excel sheet is self-explanatory and can be used without almost any prerequisites. .

In Summary it could be said, that in all objectives of the study could be realized. Further investigations could be focused on the individual weighting of quality parameters and their adaption for different applications or use-cases. However, that would require the clear definition of such use-cases with corresponding requirements.

5 References

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A. Appendix

A.1 Realization

In this chapter a short description will be given, how the Excel file was realized and how the sheets are organized. Like it was mentioned before the Excel file is realized with Excel 2010.

In the realized excel file two excel sheets are used. In the first sheet the values for the drop down menus are stored (cf. Figure 5). For the later on use of the excel file we suggest to make this sheet invisible and lock it by a password.

	A	B	C	D	E	F
1	Correctness	Used data aquisition	Up-to-dateness	Referencing method	Quality Check	Digital Data Flow
2						
3						
4	< 80%	GPS [10 m]	> 3 month	AGORA	Data Base Synchronization	Yes
5	80 % - 95%	Mileage [5 m]	3 month - 1 day	OpenLR	Field inspection	No
6	>90 %	Manual Indication [20 m]	< 1 day	coordinate-based	Plausibility Check	
7		Referenced on spatial objects [5 m]		mileage-based	two of named checks	
8		Adress [20 m]		others	no check	
9		Position indicated in site map [20 m]				
10		Local road network [> 50m]				
11		no value				
12						

Quality Parameter (locked) | Level Computation

Figure 5: Excel sheet with quality parameters

The second sheet includes the check list and the algorithm for the computation of the quality level. With the check list the provider has the possibility to make a choice of one value for each quality parameter (c.f. Figure 6).

1	**Parameter**	**Value (make your choice)**
2		
3	Completeness	< 80% (< 80% / 80 % - 95% / >90 %)
4	Data Acquisition (lowest acc.)	
5	Up-to-dateness	< 1 day
6	Location referencing method	OpenLR

Figure 6: Scroll down window

The values in the check boxes will be represented by numerical values in the columns C and D. They are important for the computation of the overall quality parameter shown in the chapter 3.3.1.

	A	B	C	D
1	**Parameter**	**Value (make your choice)**		
2				
3	Completeness	>90 %	1	2
4	Data Acquisition (lowest acc.)	Referenced on spatial objects [5 m]	1	2
5	Up-to-dateness	< 1 day	1	2
6	Location referencing method	OpenLR	1	2
7	Quality Management	two of named checks	1	2
8	Continuous digital data flow	Yes	1	2
9			1	12
10				
11	**Level**	**Source Data Level**		

Quality Parameters (locked) | Level Computation

Figure 7: Excel sheet for computation of quality level

For the final excel sheet we also suggest to hide the columns C and D. In doing so, the excel sheet should also be locked by a password to avoid data manipulation by the providers.

Together with the report it will be offered two kinds of excel sheets. The first one is completely unlocked (Level_Computation_Final_unlocked.xlsx). The second one is locked by password (Level_Computation_Final_locked.xlsx). This is the Excel file which the data provider should use. The password for unlocking is “emaps”.