ROad **S**afety **ATT**ributes exchange infrastructure in **E**urope

D5.4
Aggregated test report including detailed test reports

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Abstract:

The objective of the validation of the ROSATTE data chain is to test and document the efficacy of the exchange infrastructure and the tools developed in the project for the aggregation of cross border geographic data and integration in data users' applications. Five test areas have been identified. Within these areas local and national road administrations will update relevant safety attributes for a test period of three months, the source data will be propagated through the infrastructure and aggregated into the target databases of data users.

This document presents the final test results of the ROSATTE project validation including the test method, detailed test reports as well as an analysis of the validity of the tools and infrastructure developed in the project.

Keyword list: Map Data Exchange, Location Referencing, Validation, Data quality, Quality management, Test sites

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4. ROSATTE, deliverable D3.1 Specification of data exchange methods, 2009.
5. ROSATTE, deliverable D5.1 Test and validation plan, 2010.
6. ROSATTE, deliverable D5.2 Report on data quality management concept, 2010.
7. ROSATTE, deliverable D6 Organisational aspects and expected benefits, 2010.

Executive summary

The document at hand presents the applied methodology and the results of the ROSATTE test and validation activities.

At the beginning, the document describes how the test and validation methodology that was defined in the test and validation plan D5.1 is applied in ROSATTE. Details about the format of the provided data and the practical workflow at the different test sites are given. The data evaluation and comparison is described with the help of some practical examples using figures with map details. Also some exceptional cases are presented to show the limitations of the assessment approach.

The main part with the validation results is divided into two parts. The first part presents the results of the test site-independent validation. It is based on the requirements defined at the beginning of the project, and mainly focuses on the general project developments such as the ROSATTE exchange data format specifications. It can be shown that the project has achieved all relevant requirements.

In the second part, the results of the topological and geometrical assessment are given. As they are gained from the evaluation of the test datasets provided by the test sites and integrated by the two map providers, the results are also specific for each test site-map provider combination. This section mainly contains the numerical results followed by a detailed analysis by the respective test site responsible. It can be shown that the success criteria that were also set-up in the project test and validation plan can be partly met. It became quite clear, that the location referencing necessary for the geometrical referencing of the ROSATTE safety feature attributes is the major key for a successful data exchange.

The document ends with some suggestions for improvement and final conclusions. It is shown that the project successfully developed an exchange infrastructure for road safety attributes. This infrastructure was successfully implemented at five test sites across Europe. As the location referencing and especially its practical implementation is the key for a successful and quality assured exchange of road safety attributes, the experiences gained during the practical work in ROSATTE should be used to further improve the implementations and with that increase the achieved success rate and reliability.

1 Introduction

1.1 ROSATTE Contractual References

ROSATTE is a STREP submitted for the call FP7-ICT-2007-1. The acronym stands *for ROad SAfety ATTributes exchange infrastructure in Europe.* The Grant Agreement number is 213467 and project duration is 36 months, effective from 01 January 2008 until 31 December 2010 (after the contract amendment in March 2010). The agreement is with the European Commission, DG INFSO.

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1.2 Project Objectives

The ROSATTE project intends to develop the enabling infrastructure and supporting tools that will ensure European access to road safety attributes including incremental updates. This infrastructure will facilitate administrative internal functions as well as supply of data to third parties e.g. for safety relevant services.

The **overall objectives** of the project are 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

1.3 Key issues / Project scope

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.

For data users, the reality today is however a rather complex landscape of multiple data providers, multiple formats, varying availability and quality of data and long delays between data updates. Road authorities and infrastructure operators are usually at the beginning of the information chain, being responsible for the physical implementation, equipment and maintenance of roads.

The major problem is how to ensure timely and easy access to road information owned and maintained by thousands of road authorities. In addition mechanisms are 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. With respect to a future continuous delivery and integration of updates of road attribute data, road authorities that provide such updates will be 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 will be responsible for correct interpretation of the received data, and correct inclusion in their digital map databases. For certain safety critical attributes, an independent certification body may be created that will be responsible for surveillance of the methods and procedures used.

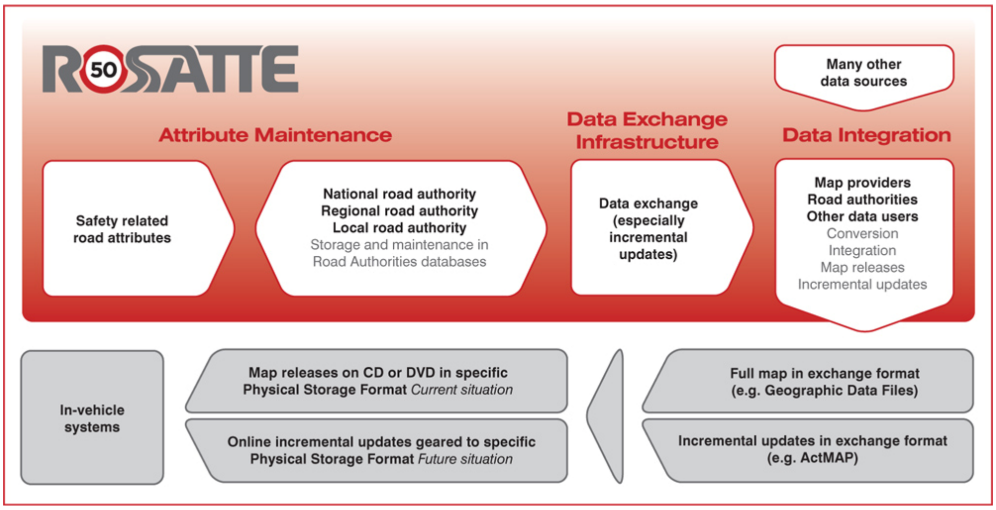


Figure 1: The scope of ROSATTE [1]

1.4 Purpose of the document

The objective of the validation of the ROSATTE data chain is to test and document the efficacy of the exchange infrastructure and the tools developed in the project for the aggregation of cross border geographic data and integration in data users' applications. Five test areas have been identified. Within these areas local and national road administrations will update relevant safety attributes for a test period of three months, the source data will be propagated through the infrastructure and aggregated into the target databases of data users.

At the end of the project, an aggregated test report is indispensable. This document provides an overall view on the results obtained during the data verification and validation phase. The document gives an insight into the validation methodology, the tests conducted and the data used for validation. The essential part of the document is composed of detailed test sites reports. For each test site, an own chapter is assigned and provides the results of detailed analysis of the delivered data. The workflow, the verification and validation approach of map provider and road authority requirements is described for each test site and includes checklists and diverse tables.

1.5 Structure of the document

Apart from the introduction chapter the document contains following subdivisions:

Chapter 2 - Assessment fundamentals

The chapter deals with the methodology and procedures that were applied for validation and testing purposes. In addition, a more detailed description on data and information which were used ultimately for validation is given. The test sites and map provider verification and validation efforts as well as their specific test data formats are also presented. This way they are presenting a unique compilation of all test site peculiarities.

Chapter 3 – General assessment results

This chapter presents the results of the overall project validation. The functional requirements as well as road authority and map provider requirements were assessed for the whole project at once. Also most of the non-functional requirement could be assessed for all test sites.

Chapter 4 – Test site specific assessment results

Several test sites were participating in the project and made their data available for the validation phase. Each section of this chapter presents the results of the most important and most critical verification parameters "Completeness of an integrated dataset", "Topological correctness" and "Geometric accuracy".

Chapter 5 – Final conclusions and prospects

The last chapter of this document sums up all the results and draws the final conclusions in the overall project context. It contains both the local authorities' as well as the map providers' view on the results.

2 Assessment fundamentals

This chapter describes the assessment methodology that was applied for the validation of the ROSATTE project results. It is also described, in what form the test site and map providers provided their data for validation. At last, some examples from the practical validation process are given to describe the applied methodology and difficulties that occurred at this.

2.1 Applied test and validation methodology

The test and validation methodology used within ROSATTE is given in deliverable D5.1 test and validation plan [4]. The assessment must be based on the requirements that were defined at the beginning of the project.

The most important key points concerning the fundamentals on methodology of validation and the definition of the shape file format for the ROSATTE project are presented hereinafter.

First and foremost validation was done by using shape files. Local Authorities (LA) have submitted shape files containing two important entries: safety features (safety attribute layer) and the underlying road network (network layer). Map providers (MP) have submitted shape files with the integrated safety features (safety attribute layer) and also their underlying road network (network layer).

The evaluation is performed using ArcGIS Software and is done manually. The automation could not be fully introduced, because each case requires an individual assessment and decisions or judgments based on experience and several other factors which are hardly to generalize. However the possibility for partly automated evaluation comparing new integration results with the bounding box of a reference object was suggested by partners. For more effective use this may require further investigation.

2.1.1 Inspection of the methods and tools at the test sites

The project's functional requirements, map provider requirements and road authority requirements can be assessed by inspecting the methods and tools developed at the test sites. This inspection was conducted using a checklist based on the assessment definitions in D5.1, sections 3.1.1, 3.2.1 and 3.2.2. The results of this inspection can be found in chapter 3 in the document at hand.

2.1.2 Analysis and comparison of the processed data

According to section 4.2 in the test and validation plan D5.1, all 5 project test sites have generated road safety feature updates according to a defined schema. These updates have then been provided to the two map providers via the developed ROSATTE data exchange infrastructure. The map providers have interpreted and integrated the received updates into their databases. For validation purposes, both the public authority at the test site and the map providers have generated ESRI shape files of their datasets to document the status of the road safety feature updates at the respective processing step. These shape files have been compared at the University of Stuttgart, which has acted as an independent validation body within the project. The detailed data format used by the test sites and map providers is described in section 2.2 of the present document.

The comparison of the datasets produced at the local and map provider level is based on quantified indicators that are derived from the project's non-functional requirements and

defined in section 3.1.2 of D5.1. Figure 2 provides an overview of the requirements and their respective indicators.

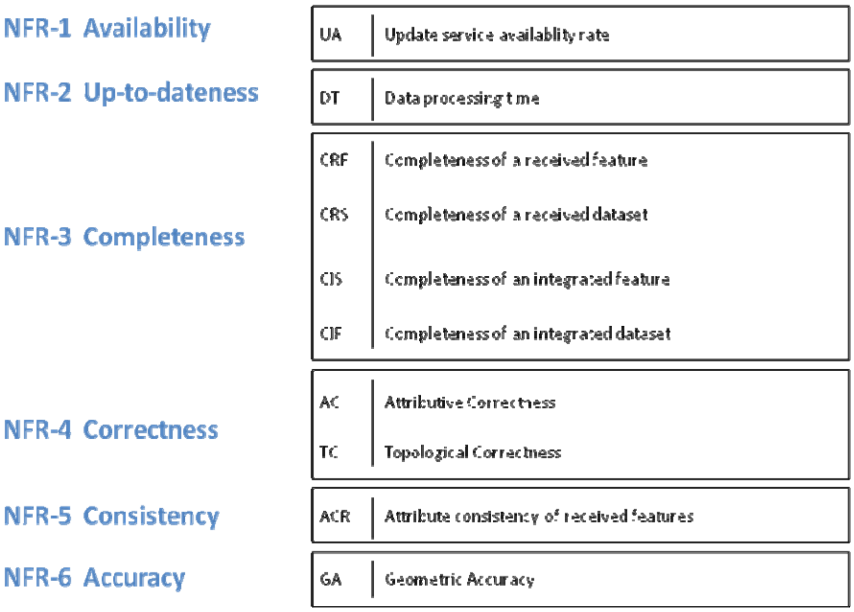


Figure 2 - Non-functional requirements and derived assessment indicators

2.2 Information and data used for validation

This section describes the information, data and data formats that have been provided by the partners and used for validation. Having the data formats and specifics of each test site and map provider in mind, the result chapters are much easier to be understood.

For the documentation of the status of the road safety feature updates processed along the ROSATTE exchange infrastructure, partners were asked to provide ESRI shape files. According to section 4.2.3.1 of D5.1, one shape file containing the actual ROSATTE features and another one containing the underlying road network should be provided. In order to achieve a common data format, the shape file attribute structure given in Table 1 was proposed.

However, due to their internal data structure and other organizational restrictions, the test sites delivered data that was very close to the specifications. The map provider shape files were very much consistent with the ROSATTE data exchange format since they just kept the data format that they received from the local authorities. In comparison to the map providers' datasets, it appeared that the local authorities generated their validation shape files prior the generation of the ROSATTE update datasets. As it can be seen from the following sections, the test sites could not always provide shape files that contain all required attributes. In any case, the naming of the attributes was always specific to the test sites, which was not very helpful for the validation and comparison of the different files.

The detailed test site data formats are described in the following.

Table 1: Shape file data format

Shape file type	Attributes
Network Layer	Street name
	Functional road class
	Form of way (u.a. Multiple Carriage way)
	Direction of traffic flow
	Country, State, County, City, …
	Build-up-areas, water, greens,… (for visualization only, not absolutely necessary)
Safety Feature Layer	Timestamp (acc. ISO 19103, e.g. 1998-09-18; 18:30:59) LA: time of database entry MP: time of integration
	SafetyFeatureID = ProviderID + ID
	SafetyFeatureTypeCode
	SafetyFeaturePropertyValue
	SafetyFeaturePropertyTypeCode
	Valid from/to
	ConditionSet
	Direction Linear features: Direction information can be derived from Shape-geometry (Order of points) Point features: tangent on the respective link (has to be provided as an shape file attribute since this information cannot be extracted from the shape file geometry)

2.3 Assessment set up and workflow at the test sites

This section describes the individual assessment workflow for each test site. It also gives details about the format, content and coverage of the data provided from the test sites for validation.

2.3.1 Test site ASFA

The road safety features for the ASFA test site were provided as ESRI Shape files. Details about the contained attributes are shown in Table 2. Due to the internal database structure, the expected data format could not be provided. However, the given format was sufficient for the validation.

Within the ASFA test site, two motorway companies, namely AREA and Cofiroute provided simulated road safety attribute update data for validation. AREA provided 48 updates (line features) in total consisting of 28 inserts, 11 modifications and 9 deletes. The features are located on the French motorways A43 and A48. Cofiroute provided 38 updates (line features), thereof 18 inserts, 10 modifies and 10 deletes. All Cofiroute features are located on the French motorway A10.

The AREA road database is based on a TeleAtlas map. Therefore the TeleAtlas AGORA online encoder service could be used to retrieve AGORA codes for the road safety update features.

Table 2: ASFA safety feature shape file data format

Attribute	Description
Date	Date of creation
Action	UpdateType (Add / Modify / Remove)
id_troncon	Identifier
id_exploit	
id_segment	
pk_dep	Station start
pk_fin	Station end
id_vitesse	Speed limit code (proprietary)
cause	
observation	
flag_carte	
agorastr	
id_ta	
x	
y	
xy_deb	WGS 84 coordinates start
xy_fin	WGS 84 coordinates end

2.3.2 Test site BALI

The BALI test site reused the already existing road database and its corresponding management and exporting tools from the BALI project. This setup allows creating full database exports only, instead of incremental updates. For the data processing this is not a big problem, besides a significant growth of file size and required storage for these full database outputs. The only drawback was that the map providers and also the validation team had to search for and extract the changed road safety features (the updates) from the provided full database outputs.

The BALI database is based on a French road map. For location referencing, an AGORA dialect was used, since not all of the AGORA rules were implemented during the BALI project. After some testing and investigations, TeleAtlas was finally able to parse the relevant information and make use of the BALI data. Navteq was not able to interpret the proprietary BALI data format

For validation purposes, the BALI test site performed and provided 62 simulated road safety features, thereof 32 insertions, 20 modifications and 10 deletes on urban and inter-urban roads as well as on motorways. Due to the inability to provide road safety feature updates, the test site provided 6 full database outputs, to document the performed changes to the database.

However, not the requested ESRI shape files, but only a textual description of the changed features could be provided for validation. Therefore, not the full validation methodology could be applied on the BALI data. The feature locations were given as Department, City, and Road name together with a map screenshot generated with the BALI database tool. Object identifiers or WGS84 coordinates could not be provided, unfortunately. With this address information only, it was very hard to find the respective integration result in the TeleAtlas shape files.

2.3.3 Test site Bavaria

The Bavarian test site has provided 100 newly inserted road safety features for validation. From these 100 features, 45 were modified and 20 were deleted afterwards.

Originally, the Bavarian test site started providing AGORA location referencing codes using the Navteq online encoding service. After having problems, with the produced AGORA codes, it was decided to develop an OpenLR encoder and use OpenLR location referencing codes. Since Navteq does not support OpenLR, only TeleAtlas integration results are available for the Bavarian test site.

Table 3: Test site Bavaria safety feature shape file format

Attributes	Description
ID	SafetyFeatureID
PROVIDER	Provider ID
INSTALLED	Road sign installed [true/false]
MEMO	Free text comments
TIME_INTEG	Timestamp of traffic regulation
TIME_ENTRY	Timestamp of database entry
SF_TYPE	SafetyFeatureTypeCode
PROP_TYPE	SafetyFeaturePropertyTypeCode
PROP_VAL	SafetyFeaturePropertyValue
C_TIM_FROM	Begin of ValidityPeriod
C_TIM_TO	End of ValidityPeriod
C_TIM_TYPE	TimeCondition Type Code
C_WEA_TYPE	WeatherCondition

C_VEH_TYPE	VehicleCondition
GEOM_AGO	AGORA location referencing code
GEOM_BIDIR	Geometry bidirectional flag

2.3.4 Test site Flanders

The Flanders test site was the only one that provided point features only. This was because the Flemish Road Authority maintains a road sign database and the ROSATTE road safety feature updates were derived from that. The Flemish road database is based on a Navteq map, so that the Navteq online AGORA encoder could be used to generate AGORA location referencing codes for all provided updates. The Flanders test site provided 56 updates in total, thereof 51 inserts of new road safety features and 5 modifications. The updates were provided as shape files for validation, the detailed data format can be found in Table 4.

Table 4: Flanders safety feature shape file format

Attribute	Description
X	Local coordinates
Y	Local coordinates
LA	
MP	Timestamp of database output
SafetyFeat	Feature Identifier
SafetyFe_1	SafetyFeatureTypeCode
SafetyFe_2	WarningSignType / SafetyFeaturePropertyValue (depending on SafetyFe_3)
SafetyFe_3	Warning Sign / Speed limit
ValidFrom	
ValidTo	
ConditionS	Conditions
Direction	Azimuth [rad]
UpdateInfo	UpdateType (Add / Modify / Remove)

2.3.5 Test site Sweden / Norway

The Swedish / Norwegian test site provided 133 road safety feature updates for Sweden and 99 for Norway. Besides an initial full database output, these features were provided in 4 sets of updates. Since the same road database maintenance tool was used, the output data for both countries has the same format. Both road databases are based on proprietary

road maps. They use a proprietary AGORA encoder that provides the location codes in an XML format.

For the validation, shape files containing all update features were provided. The safety feature shape files contained a great number of attributes from which only a view where really used. That was mainly because not only the inserted or changed features were contained in the dataset. Also the outdated features as well as other surrounding features or parts of features were exported from the database. The dataset also contained separate features for each driving direction which itself doubles the number of features in the database. Unfortunately, this led to a situation where the feature identifiers were not unique any more. Many of the objects mentioned before came with the same ID. Big efforts needed to be taken to identify the objects that really were of interest (meaning the features that represent the new / changed situation after the ROSATTE updating process). Table 5 presents the shape file format. Since quite a lot of attributes were contained in the files, the table contains only a selection of the most important attributes that were really used for the validation.

Table 5: Test site Sweden/Norway safety feature shape file format

Attributes	Description
OID_	Feature Identifier
FROM_DATE	Valid from
TO_DATE	Valid to
Safet_19_3	SafetyFeatureSource
Safet_19_4	SafetyFeatureType
Safet_19_1	SafetyFeaturePropertyTypeCode
Strin_19_1	SafetyFeaturePropertyValue for speed limits
Warni_19_1	PropertyValue for warning signs (WarningSignType)
begin_time	Begin of time condition
lengt_1_12	Duration of time condition
DIRECTION	Direction flag
CHANGE_TYP	UpdateType (Add / Modify / Remove)

2.3.6 Test site London

The London test site provided 102 update features. 20 of them where modified and 21 where deleted afterwards. However, since only the speed limit values have been modified, only the 102 inserted objects were considered for the geometry validation. Since Transport for London derived all features from their speed limit database, no warning sign features were provided. All features are located in the Borough of Islington. Table 6 shows a selection of the most important shape file attributes that were used for validation.

Table 6: Test site London safety feature shape file format

Attributes	Description
DESCRIPT0	Road type
ROADNAME	Road name
LATESTREAS	UpdateType (Add / Modify / Remove)
LIMIT	Speed limit value
LIMIT2	Speed limit value after modification (where applicable)
MI_PRINX	Internal feature ID
MD5_HASH	ROSATTE feature ID

2.4 Assessment set up and workflow at the map providers

This section gives details about the format and content of the data provided by the map providers.

2.4.1 TeleAtlas

TeleAtlas provided validation shape files for all test sites since they are able to decode and integrate both AGORA and OpenLR location reference codes. Table 7 shows the detailed data format.

Table 7: TeleAtlas safety feature shape file format

Attributes	Description
DATASET_ID	Public authority dataset ID
PROVIDER_ID	Feature ID
PROVIDER_NA	Provider name
FEATURE_SOU	Feature source
UPDATE_INFO	UpdateType (Add / Modify / Remove)
VALID_FROM	Start of validity period
VALID_TO	End of validity period
FEATURE_TYP	Feature Type
UOM	Unit
VALUE	SafetyFeaturePropertyValue
VALUE_TYPE	Value type (speed limit or warning sign)
WARNING_SIG	Warning sign type
ALIGNED	Direction information (aligned or not aligned with road link direction)
CONDITIONS	Conditions

2.4.2 Navteq

Navteq was able to decode and integrate road safety features provided with an AGORA location reference code. Therefore for the London and BALI test site, no integration results are available. Table 8 shows the detailed Navteq shape file format.

Table 8: Navteq safety feature shape file format

Attributes	Description
sFId	Feature ID
providerID	Provider ID
name	Feature ID
base64St	
lengthSeco	
measure	SafetyFeaturePropertyValue
negate	
operator	
propertyVa	
source	SafetyFeatureSource
timeDomain	
type	SafetyFeaturePropertyTypeCode
updateType	UpdateType (Add / Modify / Remove)
validFrom	Begin of ValidityPeriod
validTo	End of ValidityPeriod
vehicleTyp	VehicleCondition
warningSig	WarningSignType
isDlr1Loc	

2.5 Practical considerations on the Data validation workflow

2.5.1 General

The public authority shape files for some test sites were created before the ROSATTE road safety feature were created in the ROSATTE data store using proprietary database tools. The map providers, however, could only provide those features for validation purposes that were contained in the official ROSATTE exchange data format. Therefore, sometimes feature attributes were not consistent between the public authority and map provider validation shape files (especially direction, conditions)

2.5.2 Geometrical and topological validation

For practical reasons, the initially made definitions of the attributes topological correctness and geometric accuracy had to be better adapted to the experienced realities. New and more precise definitions were needed to be able to accurately perform the validation. The definitions listed in Table 9 were concluded and finally agreed by all the partners for the sake of testing and validation.

Table 9: Adapted parameter definition of two important features

Parameter	General definition according to D5.1	Proposed definition for testing and validation
Topological correctness	Integration result needs to (1) Follow same route as original (2) start- and endpoints must exactly match topological correct correspondence in map providers' map (e.g. if the original location starts at an intersection, the integration results must also start at the corresponding intersection in the map provider map. Any deviation from this intersection point, regardless of the distance, will lead to an incorrect location)	Integration result needs to (1) Follow same route as original (2) Has the same direction as original (3) Start- and endpoints need to **lie** on the topological correct link (does not matter where exactly on that link)
Geometric accuracy	The original public authority location points are **projected** on the map provider network to reduce the influence of map deviations on the measurement results. These points are referred to as **reference points** in the following. The following distances are measured (1) Reference point (e.g. start of linear location) to integration result (startpoint) (2) Reference point to topological correct point in the map provider map (e.g. intersection)	(1) Identify reference location in MP map - At intersections: same distance from intersection point to location point in both maps - Apart from intersections: project original point on LA map onto MP map (2) Measure distance between reference location and integration result in MP map (3) Distance is to be judged according to application requirements

Based on these refined definitions, the geometrical and topological assessment was conducted for all test datasets that were provided by both the local authorities at the test sites and the two map providers. In the following, the practical application of the accuracy and correctness definitions mentioned before are explained with the help of some real examples from the validation:

2.5.2.1 *Topological Correctness*

Two accessible and comprehensible criteria can be used to illustrate the quality of the road safety feature update data in ROSATTE: (1) topological correctness and (2) geometrical accuracy.

The topological correctness focuses on the proper assignment within the meaning of mapping correctly or combination of corresponding elements with each other. Let the assumed elements even be substantially far-off from the actual destination (the position), but the connection between the elements corresponds to the input requirement, so is the topology assumed to be correct, and the geometric inadequacy is being completely neglected. As result topological correctness represents itself as independent from the geometrical comparison between maps and judges instead on the state of the network.

In other words, only the position of the start and end-points of the road safety feature relative to topological reference-points, such as e.g. intersections, is taking into consideration and being evaluated. The integrated updates provided by the map providers have to match exactly the same topologically position as the original updates in the public authority network. The validation establishes whether this assumption is accurate or if significant differences occurred during processing of the data.

Examples of the proceedings are presented below. Figure 3 shows the color annotation legend that is used for all the example map sections.

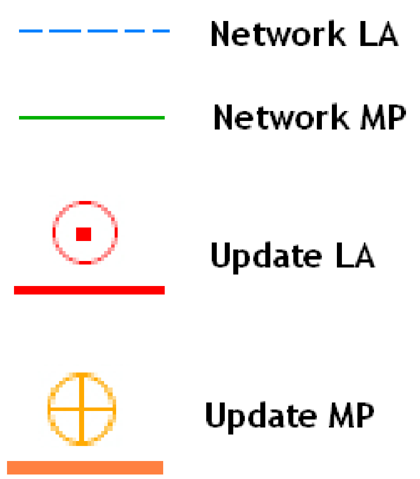


Figure 3: Color annotation legend

Example 1:

In this example, a road safety feature was inserted in the public authority map starting and ending directly at the two intersection points (indicated in red). As can be seen from Figure 4, there is a geometrical difference of 7.2m between the respective intersection points in the public authority map (dashed blue) and map provider map (solid green). The integrated update, however, ends at the topologically correct location in the map provider network, which in this case is the intersection. So obviously, the used location referencing algorithm has accounted for the map deviations correctly and the integration result can be considered topologically correct.

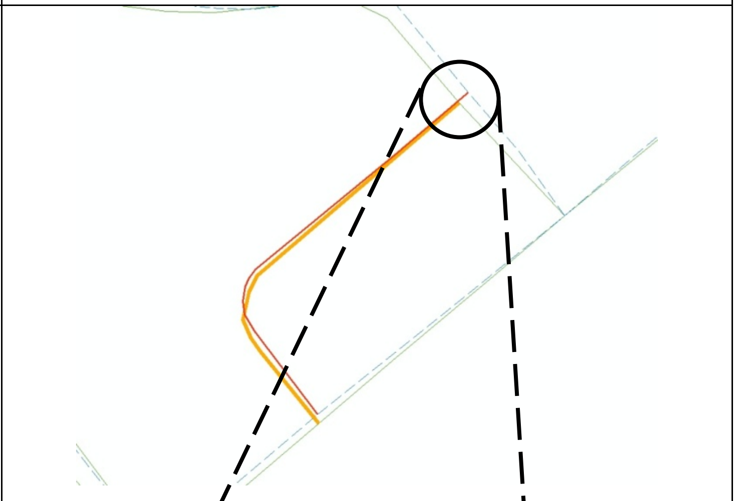
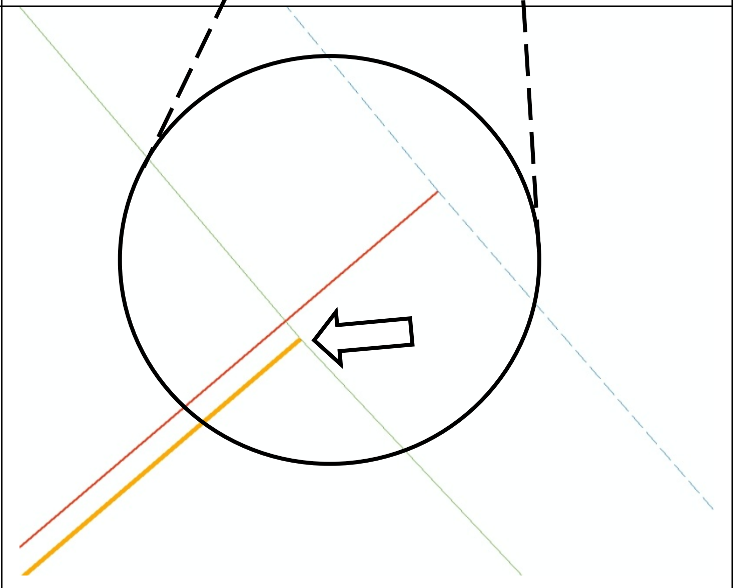
Testsite	SWE – Update 4
Rosatte ID	{77d311ae-ed09-48d3-a756-f6d78ece9d95}
Map section	
Map detail	

Figure 4: Topological Correctness Example 1

Example 2:

In this example, the intersection points in the public authority map (dashed blue) and the map provider map (solid green) only deviate by 1.4m. The original road safety feature at the public authority was inserted until the intersection (red line). However, the map provider's integration result road safety feature update does not reach the intersection (orange line). Therefore the integration in this case is considered topologically not correct. So it can be seen from this example that even in situations where the maps show good consistence, the location referencing algorithms not necessarily succeed with the correct decoding.

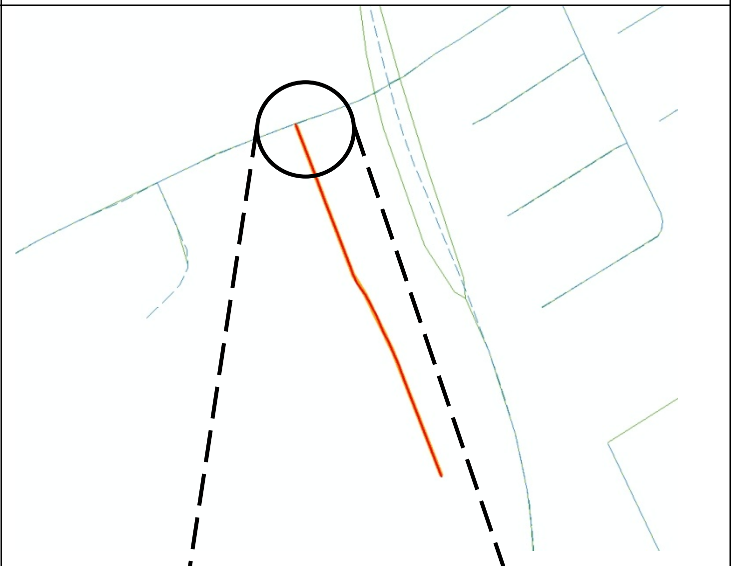
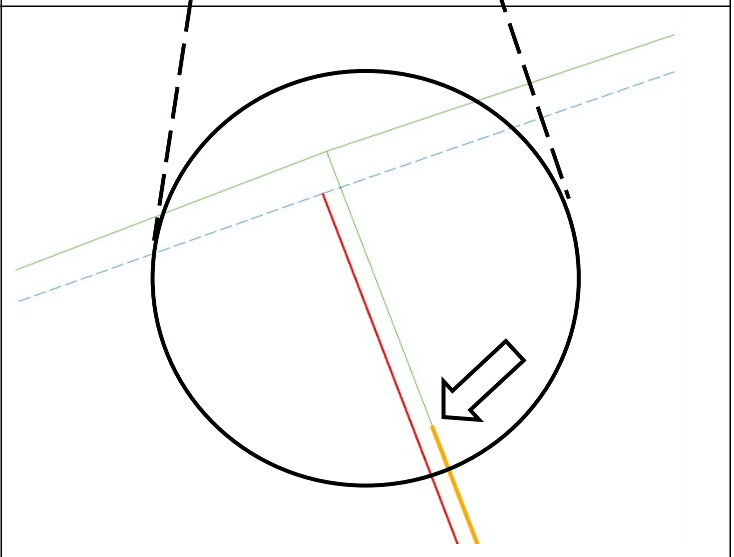
Testsite	SWE – Update 1
Rosatte ID	{46259b6f-e311-4b6b-8f79-676e4648e94f}
Map section	
Map detail	

Figure 5: Topological Correctness Example 2

Example 3:

In this example, the map provider integrated road safety feature (red line) is about 30m “shorter” at both ends compared to the originally inserted feature at the public authority (orange line). Despite this inaccuracy, the integration result is considered topologically correct, since there is no other topological information (e.g. intersections) in the direct vicinity of the road safety feature. Such problems mostly occur on motorways.

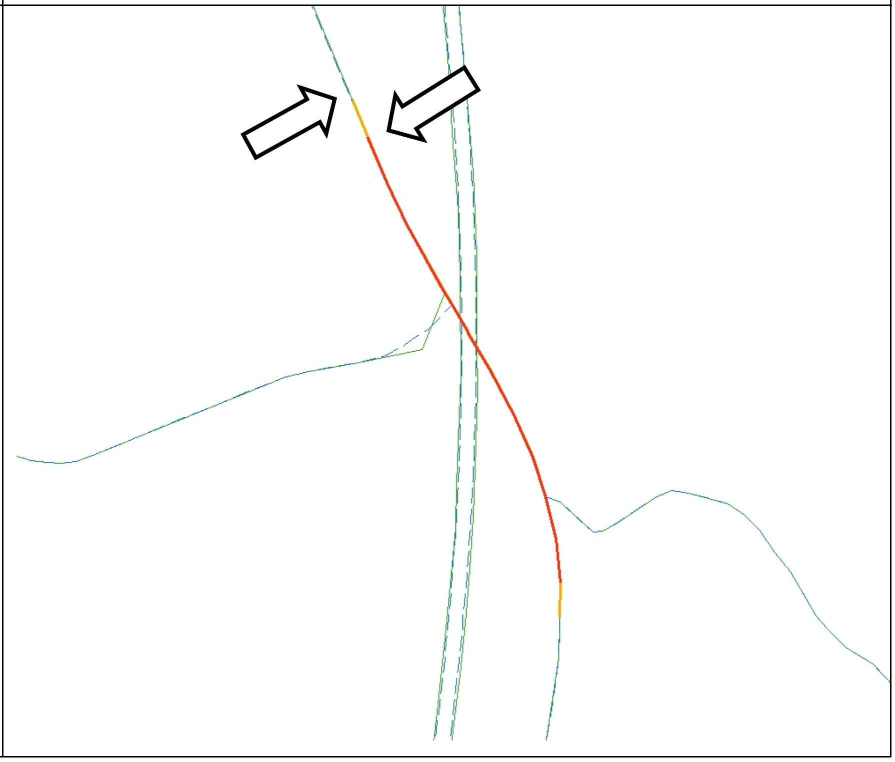
Testsite	SWE – Update 2
Rosatte ID	{de5f7579-14b6-4219-bac6-2f67262179d2}
Map section	

Figure 6: Topological Correctness Example 3

Example 4:

The lower red line indicates the public authority safety feature which has a significant distance from the next intersection point in the local road network (indicated by the black arrow). As can be seen from the map in Figure 7, by a "lucky" accident, the map provider intersection point (green line) is really close to the start point of the original local road safety feature. Thus the feature resulting from the map provider integration (orange line) directly starts at the intersection in the map provider network. However, according to the definition of the topological correctness, it should have started with the same distance from the intersection as in the public authority network as approximately indicated by the red arrow. Therefore, the feature is considered topologically incorrect although it starts really close to the original public authority feature.

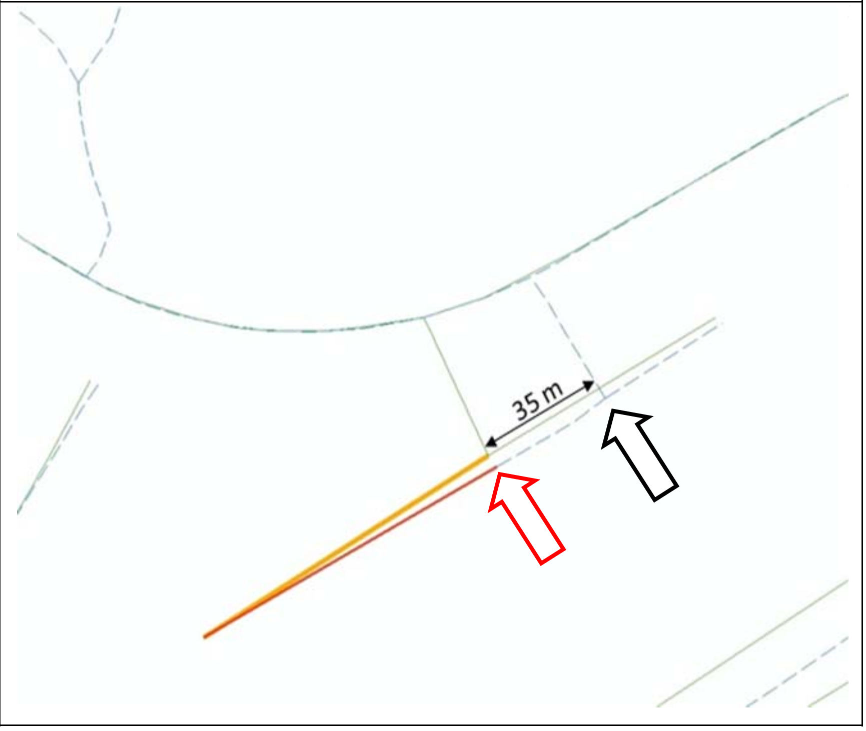
Testsite	SWE – Update 3
Rosatte ID	{458db0fe-1919-473f-a061-e96fde7f9d2f}
Map section	

Figure 7: Topological Correctness Example 5

2.5.2.2 Geometrical Accuracy

The second attribute which is essential in efforts to establish a conclusive validation is the geometrical accuracy. In the process of validation only the integrated updates within the map-provider network are being considered.

Following the definition in Table 9, the geometrical accuracy is the distance between the integrated update end and the topologically correct reference point (see Figure 8). This definition allows an unambiguous description of different situations presented here.

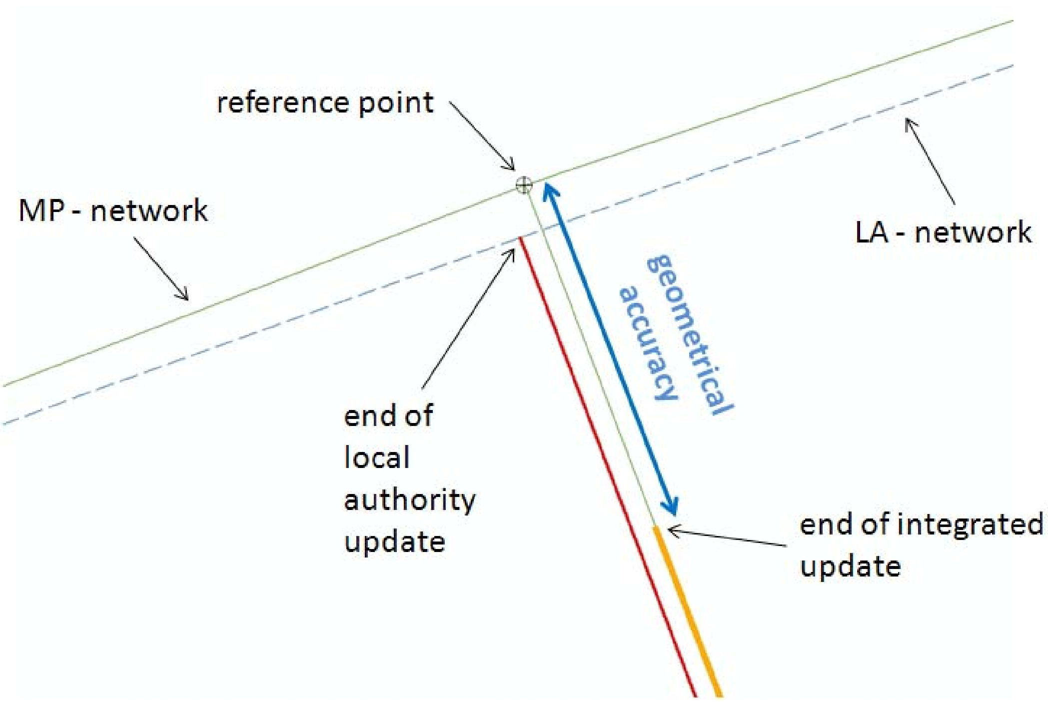


Figure 8: Terms used in the validation

One interesting question in this context is the definition of the so-called reference point. Two cases can be distinguished. In a first case, the road safety feature is located close to a topologically unique location (in most cases this would be an intersection). Then the reference point has the same distance to this unique topological location in the map provider network, as the road safety feature has in the public authority map. In the situation shown in Figure 8, the red public authority feature starts directly from the northern intersection and goes southwards. Therefore the corresponding reference point will be put onto the corresponding intersection point in the map provider network. Then the measure for the geometrical accuracy is the distance from the reference point to the beginning of the integrated road safety feature, indicated by the orange line.

In the second case, there is no topological unique location in the vicinity of the start- or end point of the safety feature as shown in Figure 9. Then the start- or endpoint of the safety feature in the public authority network is projected orthogonally to the map provider network to determine the location of the reference point. The measure for the geometrical accuracy again is then the distance from the reference point to the start- or endpoint of the integrated road safety feature.

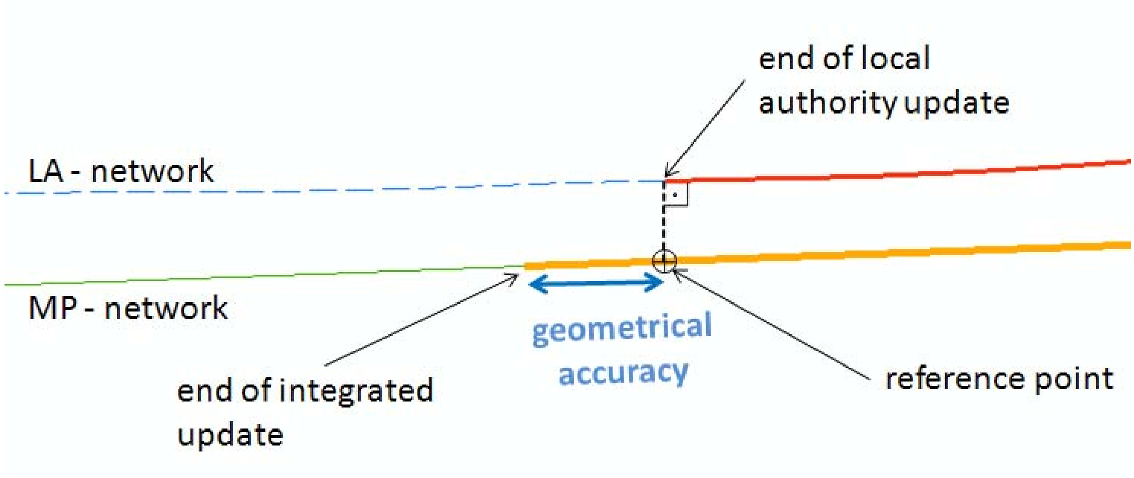


Figure 9: Illustration of the “rectangular” principle

Example 5:

The road safety feature treated in this example was already presented in example 2 (Figure 5) in connection with topological correctness. The integration result did not reach the intersection and is topologically not correct. However, the geometrical accuracy parameter as defined above was determined as 1.4 m, which is quite satisfactory.

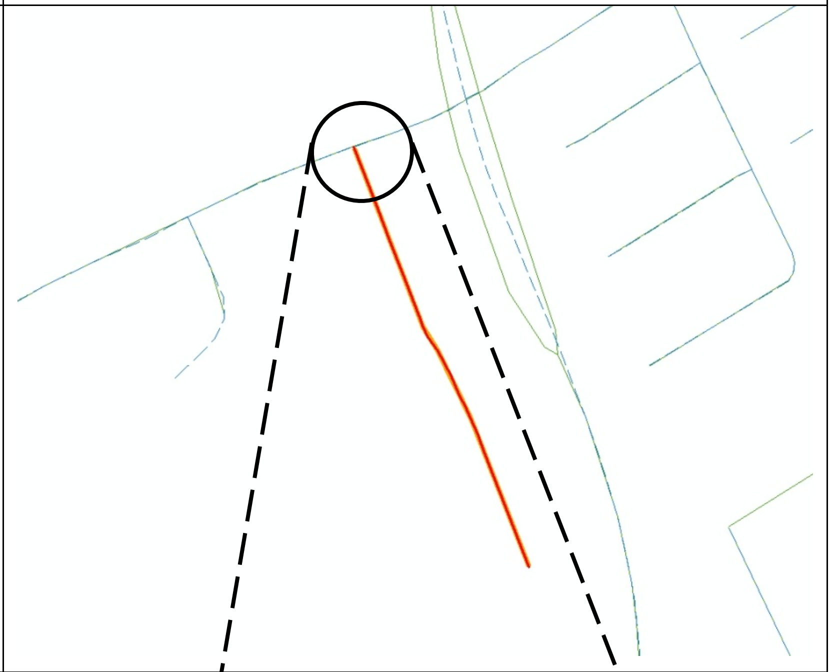
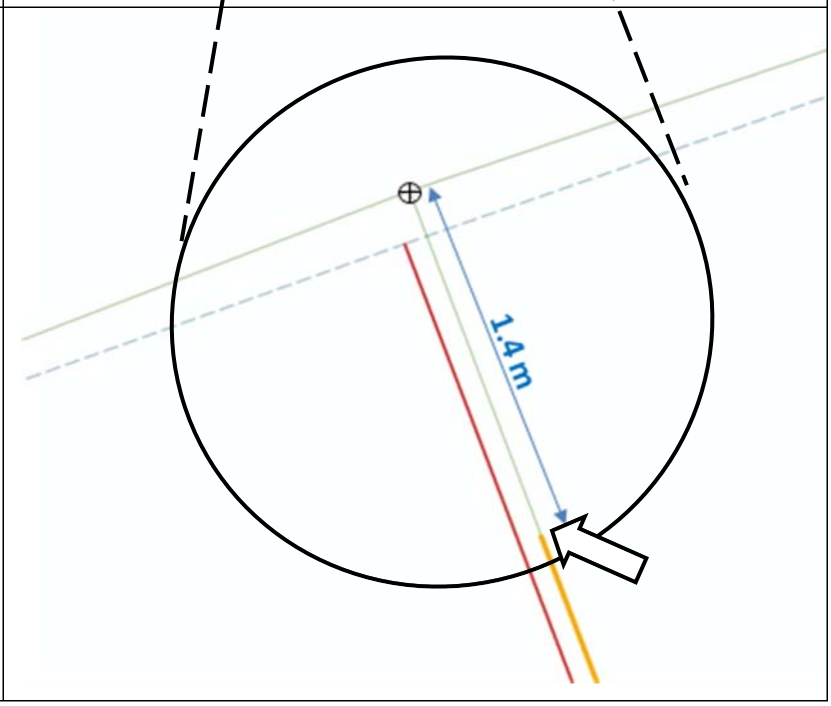
Testsite	SWE – Update 1
Rosatte ID	{46259b6f-e311-4b6b-8f79-676e4648e94f}
Screenshot 1	
Screenshot 2	

Figure 10: Geometrical Accuracy Example 7

2.5.2.3 Map Deviations

Within the project, all partners that are involved in the exchange of road safety feature update data may use digital road maps from different map vendors and/or of different version within their databases. To overcome the problem of exchanging features between these different maps, so-called location referencing algorithms like AGORA or OpenLR are used in ROSATTE. For the validation of the ROSATTE results, however, the problem of deviating sender and receiver map remains. During the practical validation of the test data, some cases which were tough to handle arose. Two of them are exemplarily shown in the following.

Example 6:

In some cases, roads that were present in the public authority map were not contained in the map provider's maps. Should the public authority in such a case have inserted a road safety feature, the location referencing decoder may have problems to find the proper safety feature location in the receiving map. Figure 11 shows such a case. The public authority road safety feature (red line) ends directly at an intersection with the road heading north (dashed blue line). This road, however, is missing in the map provider map. Therefore, the location referencing decoder put the end of that feature somewhere aside the intersection (orange line). To get the reference point for validation, the end point of the public authority feature was orthogonally projected onto the MP-network. In this particular case, the integration result was considered topologically correct.

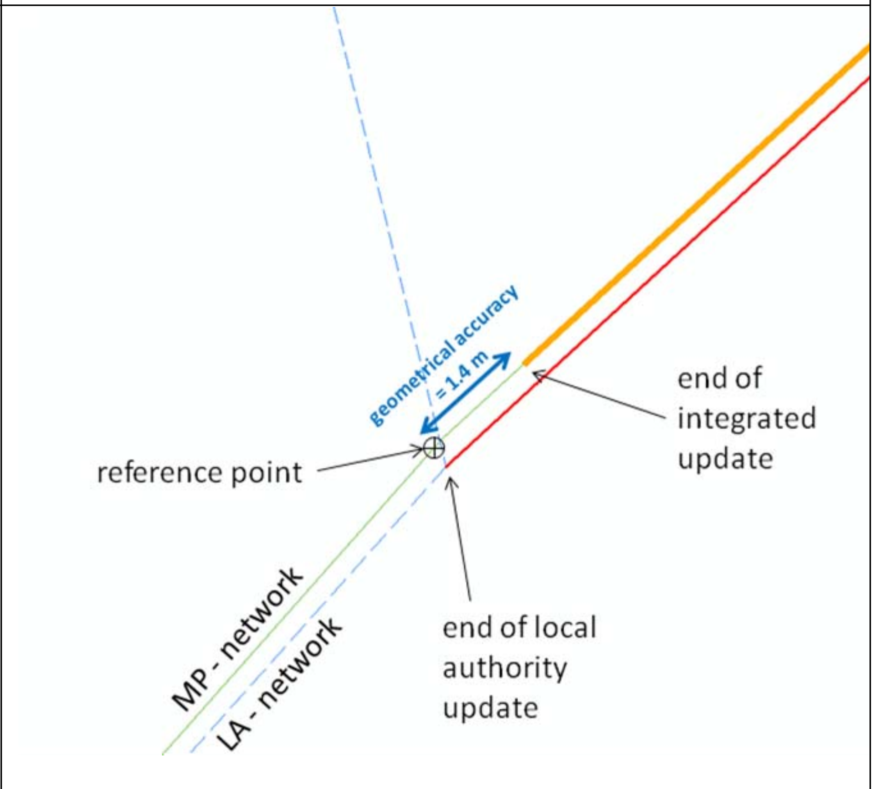
Testsite	SWE – Update 1
Rosatte ID	{cdbef6bb-3503-439f-9c2b-3a4db57cb492}
Screenshot	

Figure 11: Map Deviations Example 8

Example 7:

In this example the complete north-eastern branch of the main road is missing in the map-provider road network. Figure 12 in this area only shows the public authority roads in dashed blue. The red line indicates the road safety feature update that was inserted by the public authority in this area. Since there was no directly corresponding road in the decoding map, the update was integrated on the link that was next to the actual position as indicated by the orange line (see arrow). Because updates like this one are very hard to evaluate, they were not considered for the calculation of the final results of validation.

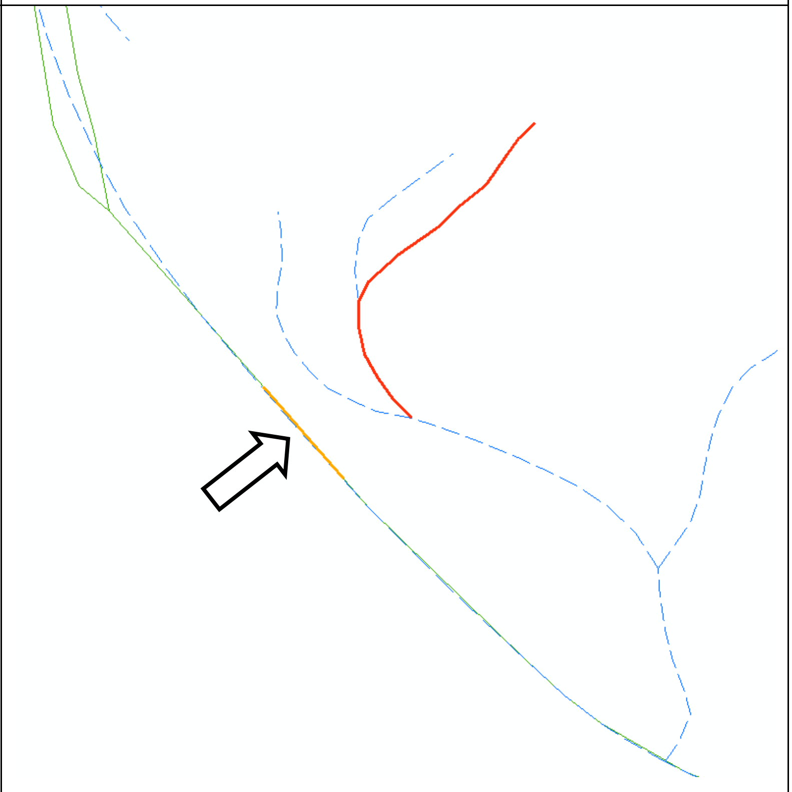
Testsite	SWE – Update 2
Rosatte ID	{0cf316b3-24a3-4041-b333-39e2e3b3545f}
Screenshot	

Figure 12: Map Deviations Example 9

2.5.3 *Attribute comparison and analysis*

According to the ROSATTE test and validation plan [10], not only the geometry of the integration results has to be evaluated but also their respective attributes. For that purpose, the attribute status of each tested road safety feature was compared between the public authority dataset and the result from the integration at the map providers. The attribute information has been taken from the shape files' dbf tables that were provided for validation as mentioned in section 2.3.

Since quite an amount of data needed to be evaluated, an automated evaluation process was aspired. The general functionality of the developed tool can be seen from Figure 13.

After specifying the two attribute tables to be compared, an attribute matching table will be loaded. This is necessary to account for the different attribute naming and format used in the different test sites as mentioned in section 2.2. Since in some test sites even a proprietary attribute value coding was used, also this had to be accounted for in the tool. Once this attribute matching is concluded, all attributes are internally available in the standard ROSATTE format and can be compared.

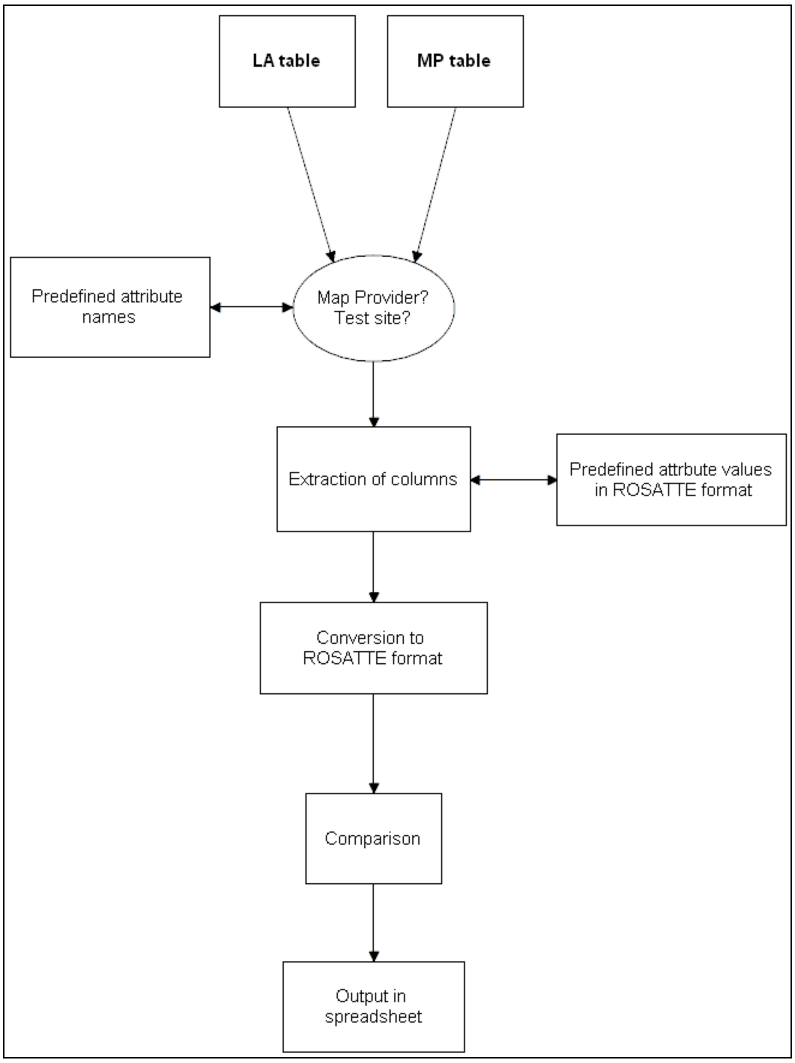


Figure 13: Harmonization of LA and MP shape files

The comparison itself works based on the process shown in the flow process chart in Figure 14. It can detect features that have not been integrated at the map providers as well as feature attributes that differ between data supply and data integration. At the end an output table is produced containing results for each feature listed in the shape file.

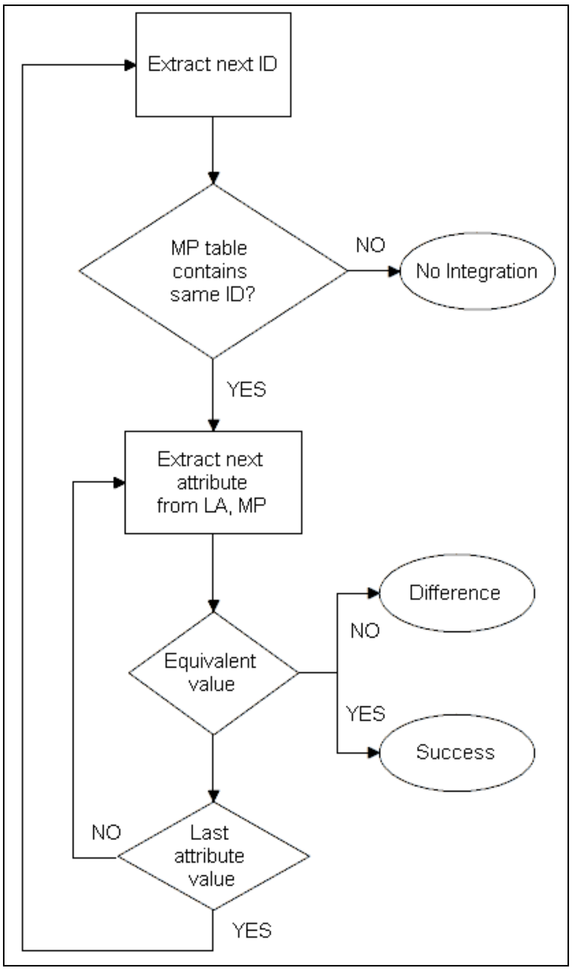


Figure 14: Flow chart of the comparison process

2.6 Success criteria

In order to be able to judge the validation results described in this document, section 3.3 of the project test and validation plan D5.1 [4] defined a list of possible applications of the data provided by ROSATTE. From these applications and their requirements on their base data, a table with so-called success-criteria derived. Table 10 shows the resulting success criteria. It can be seen, that 4 classes or levels of quality were defined.

Table 10 - General success criteria overview [4]

Parameters	Entry level	1* (information application)	2* (warning application)	3* (control appl.)
Update Availability	>80%	>90%	>95%	>99%
Up-to-dateness	3 months	Month-week	1 day	1 hour
Completeness	>80%	>90%	>95%	>99%
Completeness of a received feature	>80%	>90%	>95%	>99%
Completeness of a received dataset	>80%	>90%	>95%	>99%
Completeness of a integrated feature	>80%	>90%	>95%	>99%
Completeness of a integrated dataset	>80%	>90%	>95%	>99%
Attributive Correctness	>80%	>90%	>95%	>99%
Topological Correctness	>80%	>90%	>95%	>99%
Attributive consistency	>80%	>90%	>95%	>99%
Geometric accuracy	50m	20m	10m	5m

3 General assessment results

This chapter gives an overview of the final assessment status of the different test sites and presents the results of the test site independent assessment.

3.1 Final assessment status overview

This section presents the final test site validation status. Table 11 shows the data, that has been exchanged between the test sites and the map providers and the respective validation status.

The complete and detailed test results will then be presented in the following sections as well as in chapter 4.

Table 11: current assessment status overview

Test site / Map Providers	TeleAtlas	Navteq
ASFA (AREA)	Data integration completed, validation data available. Validation completed.	Available integration results are based on an outdated test dataset. Validation completed.
ASFA Cofiroute	Data integration completed, validation data available. Validation completed.	Available integration results are based on an outdated test dataset. Validation completed.
BALI	Data integration of proprietary test site data completed. No test site shape files available, therefore no detailed assessment possible. See section 4.2 for BALI test site qualitative assessment.	NT does not support the proprietary data format used by the test site.
Bavaria	Data integration completed, validation data available. Validation completed.	NT does not support OpenLR location referencing. AGORA-based locations are used for validation
Flanders	Data integration completed, validation data available. Validation completed.	Data integration completed, validation data available. Validation completed.
Sweden /	Data integration completed, validation data available. Validation completed.	Data integration completed, validation data available. Validation completed.

Norway	Data integration completed, validation data available. Validation completed.	Data integration completed, validation data available. Validation completed.
London	Data integration completed, validation data available. Validation completed.	NT does not support OpenLR location referencing. Therefore present test site data cannot be processed by NT.

3.2 Verification of functional requirements

This section presents the results of the functional requirements verification at the test site. Table 12 shows the results in detail, it is based on the definitions in D5.1 test and validation plan [5].

Table 12: Functional requirements verification results

ID	Requirement name	Assessment Method	Checklist YES	Checklist NO	Comments
FR-2	Standardized access Data Services and their use shall be specified.	Check by inspection: • Is the data exchange specification available and maintained?	X	○	The project deliverable on specificaitons of the data exchange methods D3.1 [4] specifies the data exchange services.
		• Are service descriptors (WSDL, XSD) available and maintained?	X	○	Deliverable D3.1 also specifies the service descriptors (XSDs).

ID	Requirement name	Assessment Method	Checklist		Comments
			YES	NO	
FR-3	Data subscription Guidelines specifying how to subscribe to road safety attributes in the ROSATTE exchange infrastructure shall be provided.	Check by inspection: • If a standardized access method is available and implemented at each test site and on the map integrator side	X	○	Standardized access methods are specified in D3.1 [4]. All test sites (except BALI) and map providers implemented a simplified version. Discovery services were not implemented since they need to be developed anyway in the context of INSPIRE by all member states and therefore all public authorities. So in the project, new update datasets were made available by the test sites (except BALI) according to the D3.1 format specifications on webservers, from where the map providers could access and download them. The BALI test site provided its data manually.
FR-4	Specification of Quality management procedures Guidelines specifying how to quality assure received road safety attributes shall be specified.	Check by inspection: • Is there a quality management procedure?	X	○	Quality management procedures have been specified in D5.2 and validated in D5.3.

ID	Requirement name	Assessment Method	Checklist YES	Checklist NO	Comments
FR-5	Incremental updates The ROSATTE infrastructure shall provide both incremental updates and full updates of road safety attributes.	Check by inspection: • Whether test sites have been able to supply both full and incremental updates by using the ROSATTE infrastructure	X	○	All test sites were able to provide a full initial data supply using the standard ROSATTE data format according to D3.1. All test sites (except BALI) were able to extract changes in their databases automatically and from that provide incremental updates according to D3.1.
FR-6	Unambiguous location referencing (LR) The road safety attributes provided through the ROSATTE infrastructure shall be structured to enable unambiguous decoding and interpretation of the referenced locations. Different locating methods allowed.	Test if the location referencing method used leads to reliable decoding [YES: LR works sufficiently] [NO: LR does not work] See detailed test report	X	○	The test sites used either AGORA or OpenLR location referencing algorithms. From the results of the validation of non-functional requirements (see chapter 3) can be seen that, where the map providers supported the respective location referencing method, finally good results could be achieved. Since ROSATTE is the first project which implemented and used these location referencing methods at such a scale, big development efforts as well as an intensive testing was necessary to achieve the present status and results. However, the current status of the location referencing might not be sufficient and not reliable enough to meet high-level requirements. See also the detailed project requirements from Table 10.

ID	Requirement name	Assessment Method	Checklist YES	Checklist NO	Comments
FR-7	Data Store initiation The project shall provide guidelines for Data Store design and initiation.	Check by inspection: • Check if data store initiation guidelines are available.	X	○	Data store initiation guidelines are provided in D2.1 [2].
FR-8	Data import The project shall define guidelines for import of road safety attributes and road network data. If suitable import tools are non-existent, new tools shall be developed.	Check by inspection: • Whether guidelines exist.	X	○	D2.1 [2] provides such guidelines.
		• Whether import tools exist.	X	○	Import tools exist at the test sites, since they are a prerequisite for the data store initiation (road network data) and its maintenance (road safety features).

ID	Requirement name	Assessment Method	Checklist YES	Checklist NO	Comments
FR-9	Workflow support The project shall produce a specification of tools and guidelines for integrating data maintenance with legal workflow.	Check by inspection: • Whether tools have been specified and guidelines provided for integrating data maintenance with legal workflow.	X	○	The legal workflow at the European countries is quite different due to the different legal and administrative systems in the different countries. The advantage of the methods developed within ROSATTE actually is the big independence from legal or organizational structures at the local administrations. In D2.2 [3] the test sites exemplarily document their individual implementations. It can be seen that new or changed road safety features can be gained from very different existing procedures at local road authorities. Organizational experiences gained during the project duration are also documented in D6 [7].
FR-10	Presentation and maintenance tools The project shall develop specifications of how to present and maintain the road safety attributes. If existing tools are not suitable, new tools shall be developed.	Check by inspection: • Whether specifications for presentation and maintenance of road safety features have been developed	○	○	The presentation and maintenance of the road safety features at the local authorities is specific to the used database management system. Also the way the data maintenance is integrated into the respective organizational procedures is very different among different countries or states. Therefore it was decided within the project not to develop such specifications.
		• Whether suitable tools have been either identified or developed	X	○	All test sites either used already existing tools (e.g. SWE-NOR) or developed new data acquisition and maintenance tools (e.g. Bavaria, ASFA).

ID	Requirement name	Assessment Method	Checklist YES	Checklist NO	Comments
FR-11	Feedback loop A feedback channel from information providers back to enacting authorities shall be provided.	Check by inspection: • If a feedback channel has been included into the ROSATTE framework	X	○	The feedback loop is contained in the ROSATTE format specifications in D3.1. Map providers provide feedback about the data integration results. However, these feedbacks are not automatically processed by the local authorities since this was not in focus of the project. This might be a topic for further developments in this field.
FR-12	Integration tools Tools to integrate road safety attributes into existing information providers systems shall be developed if existing tools does not provide the satisfactory functionality.	Check by inspection: • If existing tools with sufficient functionality for integration of road safety attributes have been identified or otherwise have been developed	X	○	The map providers improved existing integration tools so that they were able to retrieve and integrate the ROSATTE update information provided by the test sites. The data integration step was mainly governed by the location referencing decoding. The latter step was validated using the topological correctness and the accuracy parameter of the non-functional requirement, see results in chapter 4.
FR-13	Flexible type definitions	Check by inspection: • Whether the type definitions are flexible to allow for future extensions and modifications	X	○	The type definitions from D3.1 are developed for road signs with focus on speed limits and warning signs. However, the data format is not limited to that. The given structure can easily be extended should a specific road sign be missing. Due to the XML structure of the data format, also new feature classes (e.g. traffic lights) can easily be added to the present structure.

3.3 Validation of map provider requirements

This section presents the results of the map provider requirements validation at the test site. Table 13 shows the results in detail, it is based on the definitions in D5.1 test and validation plan [5].

Table 13: Map provider requirements validation results

ID	Requirements name	Assessment method	Checklist		Comments
			YES	NO	
UR-3	Unified access: Map providers need a unified way of access and retrieval of road safety attribute data across Europe.	Check by inspection: • If map providers can access and retrieve road safety attribute data in a unified way across Europe.	X	○	During the validation activities it became evident, that both map providers are able to access and retrieve the data that was provided by the different project test sites across Europe. TeleAtlas implemented a fully automatic process of data retrieval, download and integration as well as provision of feedback on integration status of the updates. Navteq downloaded the data manually and then started an automated process of data integration and provision of feedback about the implementation status of the processed features.
UR-4	Data updates: Map providers need both initial supply and incremental updates of road network safety attributes, expressed according to one unified data model. Updates can be initiated by change	Check by inspection: • If initial supply is supported by the ROSATTE interface.	X	○	The data format specification in D3.1 does not explicitly foresee a possibility to exchange initial datasets. However, the test sites have proved that it is possible to exchange initial datasets using the insert operation of the standard ROSATTE exchange format.
		• If incremental updates are supported by	X	○	The ROSATTE format specification in D3.1 support incremental updates.

ID	Requirements name	Assessment method	Checklist YES	Checklist NO	Comments
	notifications from road authorities.	the ROSATTE interface. • If change notifications are supported by the ROSATTE interface.	X	○	The ROSATTE format specification in D3.1 supports both PUSH and PULL data exchange scenarios. The PUSH scenario contains change notifications since the local road operator actively notifies the service (map) provider about new updates and provides the respective update data. PULL in this context means that the map providers themselves ask for new updates on their own basis. So ROSATTE provides a big flexibility.
UR-6	Quality: Map providers need quality assured data to integrate into their own databases in order to ensure the quality of the end user products	Check by inspection whether quality metadata are provided with delivered data sets	○	X	Quality-related metadata elements have been defined in D3.1. The metadata-related experiences gained during the project together with some implementation guidelines are documented in D6. Since the implementation and in particular the testing of the core functionality was quite intense, the metadata part of the specification was not implemented.
		Check by inspection whether data providers follow defined quality management procedures	○	X	ROSATTE has no influence on the quality of the data provided by the local authorities or road operators. The project, however, provided quality management guidelines in D5.2. Moreover the defined quality metadata elements enable the data providers to document the quality of the provided data so that finally the map provider have good information about the quality of the data received via the ROSATTE infrastructure.

3.4 Validation of road authority requirements

This section presents the results of the road authority requirements validation at the test site. Table 14 shows the results in detail, it is based on the definitions in D5.1 test and validation plan [5].

Table 14: Road authority requirements validation results

ID	Requirements name	Assessment method	Checklist		Comments
			YES	NO	
UR-10	Data presentation and maintenance: Enacting authorities, data store operators and road network managers need tools for data presentation and maintenance.	Check whether attributes can be viewed in the data store (preferable in a map view) • See Implementation documentation in D2.2 (Could also be considered outside immediate validation objectives)	X	○	Presentation of the data at local level was not considered as a central project responsibility and therefore this was not part of the common specifications. The test sites could decide according to their local needs, organizational structures and legal regulations whether they have and / or will present the data already at the local datastore level. Some of the test sites (e.g. ASFA, Bavaria) can use their web-based data acquisition tools also for a map presentation of the road safety feature updates. However, the maintenance of the local data is vitally important for ROSATTE. Due to the big divergence of the locally used databases and tools as well as the diversity of legal frameworks from which the ROSATTE road safety attributes are gained from, the detailed design of the local maintenance tools was not subject of the ROSATTE specifications. On the contrary, ROSATTE only requires the road safety feature update data to be provided in the agreed data format and does not care from which tools, databases or legal processes the data comes from. Data maintenance tools at the local test sites were either already available or they have been developed and implemented by the test sites. In some cases, existing tools needed to be extended / further developed. This was necessary to provide road safety features for the final validation.

ID	Requirements name	Assessment method	Checklist YES	Checklist NO	Comments
UR-11	Data publishing, both for the ROSATTE infrastructure, and for public websites: Data store operators need a data publishing mechanism which is flexible and easy to adapt.	• Check whether supply to ROSATTE interface is available (implicit to any automatic data transfer to information providers)	X	○	All test sites (except BALI [is that correct???]) implemented data publishing services to provide their road safety feature update data to the map providers. These services were used and tested during the project validation that is also part of the document at hand.
		• Check whether other publishing mechanism (safety feature maps) are in place	X	○	This requirement does not reflect the major concern of the ROSATTE infrastructure as it only asks whether test sites provide their data not only via the ROSATTE data exchange but also via publicly available interfaces, e.g. web portals. However, some of the test sites (e.g. Bavaria or BALI) have developed such publishing portals.
UR-13	User feedback: Data store operators, road network managers and enacting authorities need feedback from users to improve quality.	• Check whether feedback interface of information providers is implemented and accessible	X	○	Both map providers implemented a feedback service, so that the implementation status is available for each integrated road safety feature.
		• Collect (written) feedback from public authorities in the test sites if feedback is considered useful	X	○	The use of the map provider feedback information by the local authories was not mandatory in ROSATTE. However, it became a very useful instrument for the authorities to check the integration status of their test data and enabled them to act accordingly, e.g. check location referencing encoder in case the decoding failed with a certain error code.

UR-14	INSPIRE conformance: INSPIRE has become a directive, and conformance is a requirement for data owners.	Ask independent expert involved in Inspire to review ROSATTE exchange specifications: • Check whether technologies used conform with INSPIRE.	☒	○	The ROSATTE data exchange format described in D3.1 is fully conform with INSPIRE. The document lists the INSPIRE requirements and recommendations that are valid for ROSATTE.
		• Check whether published data can be used according to INSPIRE specifications.	○	○	The ROSATTE format specifications in D3.1 correspond with INSPIRE. However, the publication and discovery services etc. have not been implemented within ROSATTE. Therefore, these services could not be checked during the validation.
		• In case INSPIRE specifications are not clear enough, clarify check if ROSATTE contradicts INSPIRE stipulations	☒	○	ROSATTE specifications are seen to be clear enough.
UR-15	Existing work and standards: To protect investments, ensure acceptance, and save time and effort, work should build on existing work and standards.	This step was undertaken during the ROSATTE exchange specification phase: • check by inspection (external review) if selection of technologies in D3.1 build up on external work and standards	☒	○	All technologies used in D3.1 build up or are even taken from existing standards.

UR-16	Quality management: Data store operator, enacting authorities, road network managers need quality management in order to guarantee the provision of quality assured data.	• Initiate review by test sites, whether ROSATTE requirements on metadata can be met by their data maintenance operations Could also be considered outside immediate validation objectives on data exchange (Quality management does not influence quality of exchange mechanisms, but that of the exchanged data)	○	○	ROSATTE metadata part was not implemented due the concentration of implementation and testing resources on the core functionality of ROSATTE. However, D6 contains metadata recommendations and guidelines to be used and implemented at a later stage.

3.5 Verification of non-functional requirements

This section presents the results of the verification of non-functional requirements using the verification parameters defined in D5.1 test and validation plan [5].

3.5.1 NFR-1: Availability

3.5.1.1 Update service availability rate (UA)

This parameter describes how often the services requested by the Map Providers respond. The rate is evaluated as a mean value for every Public authority-Map Provider combination.

Evaluation procedure

Map Providers count the total number of update service requests and the number of successful replies. Rate is computed as percentage of performance.

Results

During the actual testing phase with intensive data exchange between the local authorities at the test sites and the map providers, it turned out that the Update service availability is always fulfilled once the sending and receiving sides have implemented the ROSATTE data exchange specifications and approved that compatible settings are used. In this context it has to be mentioned and taken into account that not fully automatic discovery and download services were implemented in ROSATTE but more or less manual or semi-automatic processes. This practically means that the local authorities have made available new update datasets on their web services. The map providers then were notified manually for the new data. TeleAtlas in fact had set up an automatic process that checked all test sites for newly available data. However, this process was checked manually since it was known whether new data was available or not. NAVTEQ downloaded the test site datasets on demand *and started an automated process for decoding and integration afterwards*.

Because of this special situation, the numerical evaluation of the Update service availability was not carried out.

3.5.2 NFR-2: Up-to-dateness (Validity)

3.5.2.1 Data Processing Time (DT)

This parameter describes for every Public authority-Map Provider the mean time that is needed to process a road safety feature update from the first database input to the final integration into the map providers' databases.

Evaluation procedure

Local authorities store the timestamp T_{LA} when a new road safety feature update has been entered into their database. Map providers will also record the timestamp T_{MP} when they have integrated the respective update.

Results

During the validation period with its intensive data exchange between the local authorities and the test sites, it appeared that the technical data processing of the road safety feature data has only very little influence on the total data processing time. The data processing time mainly is determined by the update cycles at the public authority as

providing side and the map providers as receiving side of the data. Test sites that provided test data on a regular basis (e.g. Bavaria) set up automated processes to regularly generate ROSATTE updates from their internal databases, e.g. once per day resp. night. On the other side, the map providers' set-up processes to check the test site servers for new data on a regular basis, e.g. TeleAtlas checked the test sites once per day or even once per hour.

3.5.3 NFR-3: Completeness

3.5.3.1 Completeness of a received Road Safety Feature (CRF)

This parameter describes whether a Road Safety Feature received by the map providers contains all mandatory attributes according to the specification.

Evaluation procedure

USTUTT compares the attribute tables of each update feature from the local authorities' and map providers' shape files whether all expected attributes are filled in. If at least one mandatory attribute is missing, the complete update feature is regarded as not complete.

Results

During the practical validation, it became clear, that the safety feature shape files provided by the map providers represent the final integration status of the features. Therefore, there was no differentiation between CRF and CIF. So please refer to the CIF results in the next section.

3.5.3.2 Completeness of an integrated Road Safety Feature (CIF)

This parameter determines the rate to which the integrated updates are complete (i.e. all mandatory feature attributes are present)

Evaluation procedure

All integrated features have to be checked, whether they are complete or not. If at least one mandatory feature attribute is not present, the complete feature is considered not complete.

See the detailed test procedure, described in section 2.5.3.

Results

The detailed analysis of the test datasets has shown that normally all attributes of the road safety features can be exchanged without any problems. The map providers could also receive and interpret all feature attributes delivered in the ROSATTE data format. However, in some cases, the test sites could not provide all feature attributes mentioned in the ROSATTE data format description since they were just not available at the respective local authorities.

3.5.3.3 Completeness of a received Road Safety Feature Dataset (CRS)

This parameter determines whether the map providers receive all expected elements of a Road Safety Feature update dataset.

Evaluation procedure

The number of updates that are entered into the public authority database within the respective test period is documented in the respective shape file to be provided by the respective public authority. The map providers will retrieve the updates for the same period. The number of received updates can be derived from the feedback message log since for every received update, whether it could be integrated or not, a corresponding feedback message will be created and send out.

Results

During the validation period, did not report any problems concerning the incompleteness of the received datasets. No loss of data could be detected during the exchange between local authorities and map providers.

3.5.3.4 Completeness of a integrated Road Safety Feature Dataset (CIS)

This parameter determines the number of updates that could be integrated into the map provider's database.

Evaluation procedure

The number of updates that are entered into the public authority database within the respective test period is documented in the respective shape file to be provided by the respective public authority. The number of integrated features at the map providers can be determined from the map provider's evaluation shape file.

Results

Please refer to the detailed assessment results for the individual test sites in sections 4.1 to 4.6.

3.5.4 NFR-4: Correctness

3.5.4.1 Attributive Correctness (AC)

This parameter describes whether or not the attributes of the Road Safety Features integrated by the map providers correspond with the attributes that have been inserted by the local authorities.

Evaluation procedure

Compare individual entries in the attribute tables at local authorities and map providers. If at least one attribute per feature does not coincide between the two attribute tables, then the whole feature is considered not correct.

See the detailed test procedure, described in section 2.5.3.

Results

The attribute tables of the test datasets that were provided by local authorities and map providers were compared. As for the completeness of the road safety features (CRF/CIF), no random errors could be detected. However, due to the different attribute structure and modelling in the local and map provider databases, also the attributes were modelled differently. And in this respect, some systematic errors could be detected. For example, for some test sites the *UpdateType* attribute was not evaluated correctly at first (both *Add*

and *Modify* operations were interpreted as insertions of new features). However, most of these issues could be fixed as they occurred during the development process.

3.5.4.2 Topological Correctness (TC)

This parameter describes whether the topological course of the linear road safety feature after the integration corresponds with the original one that was entered into the public authority's database.

Evaluation procedure

The topological course of the linear feature in both shape files has to be compared. Therefore the corresponding feature course has to be identified in the receiving map. It has to be checked whether the integrated feature follows this course and has the same direction. Deviations in the start- or endpoint are not considered here, they are treated by the parameter "Start- / Endpoint geometric accuracy (GA)".

In case the two routes deviate from each other, this certain feature is considered topologically not correct.

Remark:
If the topological deviation is caused by significant map deviations between the sending and receiving road network, the topological correctness will not evaluated for this feature. Since the feature locations in two different road networks have to be compared, this step is done by manual inspection and analysis.

Results

Please refer to the detailed assessment results for the individual test sites in sections 4.1 to 4.6.

3.5.5 NFR-5: Consistency

Describes whether the attributes of the received road safety features correspond with the data format specification.

Evaluation procedure

Compare attribute format with data specification and compute ratio number of consistent updates / total number of received updates.

See the detailed test procedure, described in section 2.5.3.

Results

In general, the safety feature's attributes were consistent with the format specification. During the detailed analysis, however, some systematic problems were detected. Some test sites, for example, used certain codes to describe the speed limits in spite of using the speed limit value directly. Using the corresponding format description, the map providers were able to integrate this information correctly. A bit more difficult was the correct coding of road safety feature conditions. It seemed to be difficult for the test sites to implement the condition information as described in D3.1. This appeared not a general problem with the ROSATTE format description but may be due to the fact that the test sites have this information available in quite different formats. Different interpretations were seen and the map providers sometimes had difficulties to interpret and integrate the condition information.

3.5.6 NFR-6: Accuracy

3.5.6.1 Start- / Endpoint geometric accuracy (GA)

This parameter describes the geometrical deviations of the start-/endpoint of a linear Road Safety Feature or of a point feature, respectively, between the public authority and the map provider road network.

The parameter should be independent from possible map deviations. However, this is not always possible to the full extend, so it is tried to account for map deviations as much as possible.

Evaluation procedure

In a first step, the "original" location from the public authority network has to be mapped onto the map provider network. This mapped location is referred to as the "reference" location in the following, and has to be differentiated for two situations:

- *At intersections:*
  Reference location in the map provider network has the same distance from the intersection point as the original location in the public authority map.
- *Apart from intersections:*
  Reference location point is achieved by orthogonal projection of original location point from public authority network onto map provider network

Then the reference location point (which represents the original location in the public authority network) and the location integration result are available in the same map provider road network and can be compared with each other. This comparison is done by just measuring the distance between these two points.

Results

Please refer to the detailed assessment results for the individual test sites in sections 4.1 to 4.6.

4 Test site specific assessment results

This chapter presents the numerical validation results the non-functional requirement parameters “topological correctness” and “geometrical accuracy” for each of the test sites. The results are based on the validation of the ESRI shape files provided by the local test site authorities as well as the map providers as explained in section 2 in detail. The results are given separately for each map provider. After the presentation of the numerical results, the reader can find individual summaries of the results and the drawn conclusions from each test site.

4.1 Test site ASFA

4.1.1 Verification results TeleAtlas

Table 15: Geometry validation results for ASFA-AREA in case of TA

		all categ.	
	Total number of features considered for validation	**49**	**100.0%**
	integrated features	**30**	**61.2%**
	Topologically correct features	**30**	**61.2%**
geometry	mean distance [m] reference point to integrated point	**171**	
geometry	features with accuracy worse than 50 m	**18**	**36.7%**
geometry	features within accuracy tolerance of 50 m	**1**	**2.0%**
geometry	features within accuracy tolerance of 20 m	**1**	**2.0%**
geometry	features within accuracy tolerance of 10 m	**0**	**0.0%**
geometry	features within accuracy tolerance of 5 m	**10**	**20.4%**
	overall correct integrated features (with accuracy better than 50 m)	**12**	**24.5%**

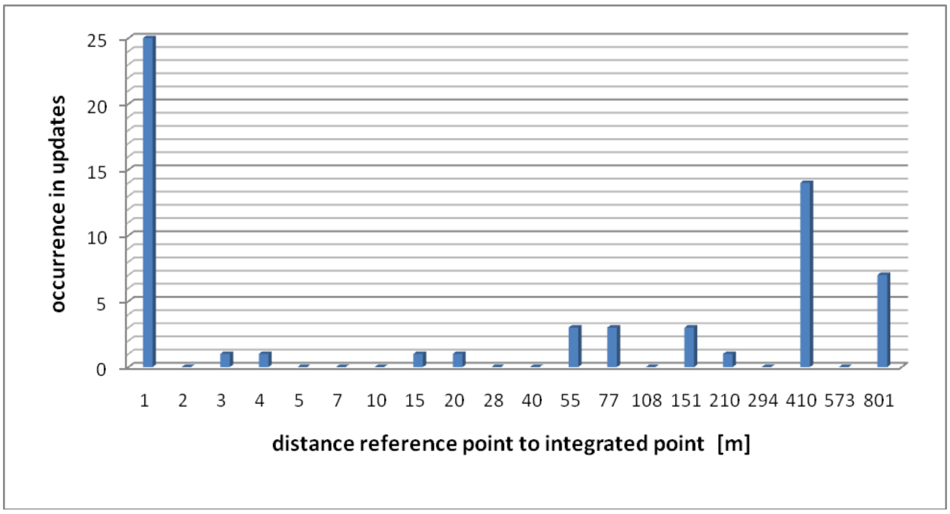


Figure 15: Diagram of the conducted geometry integration for ASFA-AREA (TA)

Table 16: Geometry validation results for ASFA-Cofiroute in case of TA

		all categ.	
	Total number of features considered for validation	**41**	**100.0%**
	integrated features	**36**	**87.8%**
	Topologically correct features	**36**	**87.8%**
geometry	mean distance [m] reference point to integrated point	**183**	
	features with accuracy worse than 50 m	**17**	**41.5%**
	features within accuracy tolerance of 50 m	**2**	**4.9%**
	features within accuracy tolerance of 20 m	**1**	**2.4%**
	features within accuracy tolerance of 10 m	**0**	**0.0%**
	features within accuracy tolerance of 5 m	**16**	**39.0%**
	overall correct integrated features (with accuracy better than 50 m)	**19**	**46.3%**

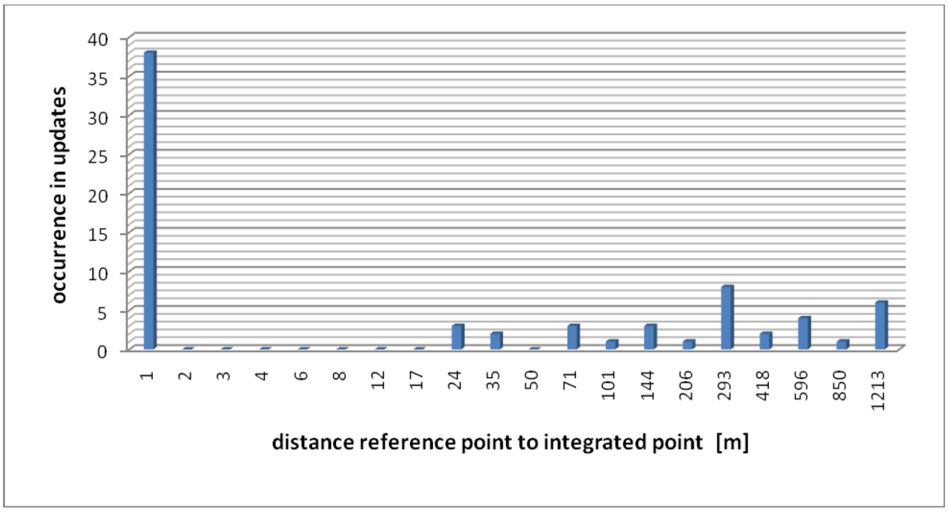


Figure 16: Diagram of the conducted geometry integration for ASFA-Cofiroute (TA)

4.1.2 Verification results Navteq

Table 17: Geometry validation results for ASFA-AREA in case of NT

		all categ.	
geometry	Total number of features considered for validation	**49**	**100,0%**
	integrated features	**29**	**59,2%**
	Topologically correct features	**28**	**57,1%**
	mean distance [m] reference point to integrated point	**781**	
	features with accuracy worse than 50 m	**21**	**42,9%**
	features within accuracy tolerance of 50 m	**0**	**0,0%**
	features within accuracy tolerance of 20 m	**1**	**2,0%**
	features within accuracy tolerance of 10 m	**0**	**0,0%**
	features within accuracy tolerance of 5 m	**7**	**14,3%**
	overall correct integrated features (with accuracy better than 50 m)	**8**	**16,3%**

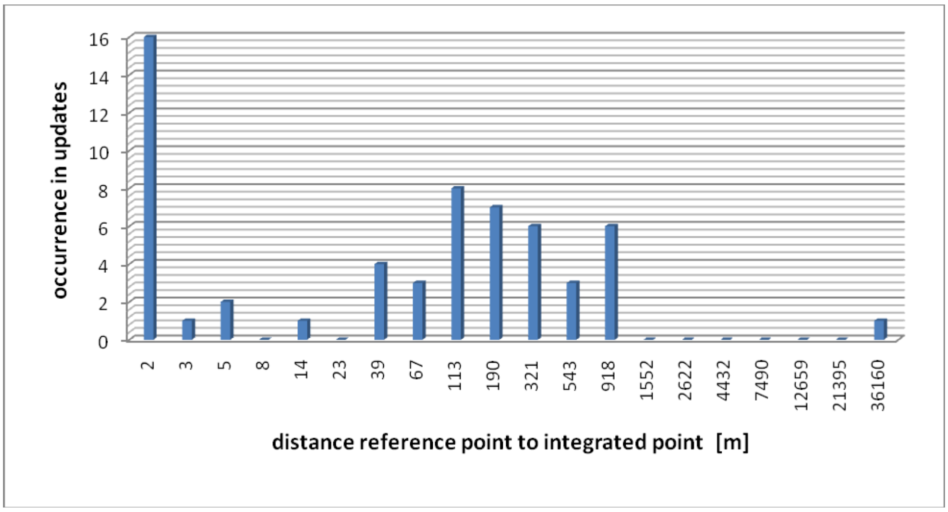


Figure 17: Diagram of the conducted geometry integration for ASFA-AREA (NT)

Table 18: Geometry validation results for ASFA-Cofiroute in case of NT

		all categ.	
geometry	Total number of features considered for validation	**41**	**100,0%**
	integrated features	**23**	**56,1%**
	Topologically correct features	**23**	**56,1%**
	mean distance [m] reference point to integrated point	**181**	
	features with accuracy worse than 50 m	**12**	**29,3%**
	features within accuracy tolerance of 50 m	**2**	**4,9%**
	features within accuracy tolerance of 20 m	**0**	**0,0%**
	features within accuracy tolerance of 10 m	**0**	**0,0%**
	features within accuracy tolerance of 5 m	**9**	**22,0%**
	overall correct integrated features (with accuracy better than 50 m)	**11**	**26,8%**

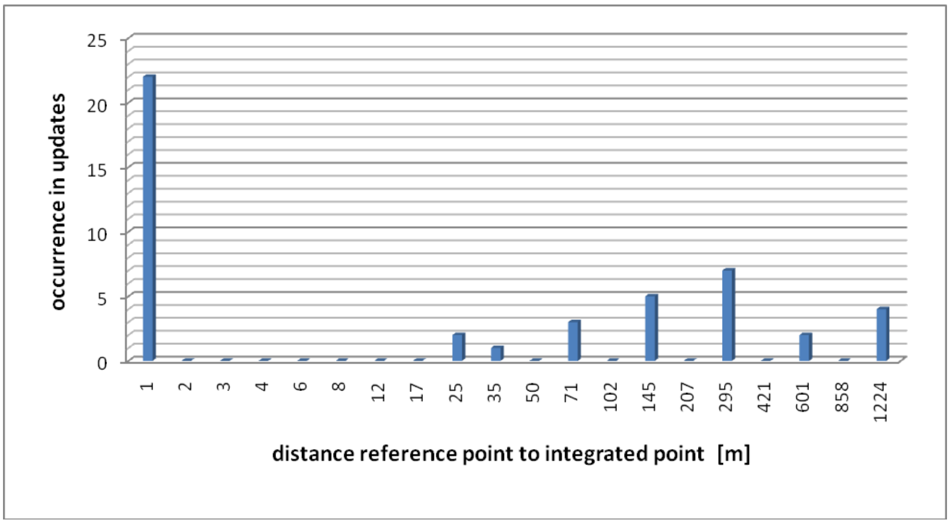


Figure 18: Diagram of the conducted geometry integration for ASFA-Cofiroute (NT)

4.1.3 Analysis of test site results and conclusions

The major problem at ASFA test site was a malfunction of an internal technical tool used to produce test site shapefiles. This malfunction caused the (x,y) location to be wrong and therefore the mean distance between reference points and integrated points was extremely high. After this problem was detected, the datasets were re-produced with correct locations.

This can be seen in the Navteq results, which were calculated only with the first datasets (with the wrong locations) due to lack of time. When comparing these results with the TeleAtlas ones, which used datasets with recalculated locations, one can see that the mean distance between reference points and integrated points has been greatly improved in the process, even though it remains somewhat high. The reason this mean distance

remains superior to 100 meters for a large number of attributes is not totally clear but we suspect that the malfunction was actually not entirely fixed. As motorway operators, we consider that a 50 m accuracy is widely acceptable as it represents a very short travel time for the driver (1s). As these results show a percentage really lower than 80% in the range of 50 m accuracy, this is going to be a good objective on which we will work.

Another issue is that a certain number of attributes (around 25% in total) could not be decoded at all. This could be due to some information missing in the datasets or to technical problems when creating the attributes' IDs, but this could not be explained really conclusively. Some more research would need to be done on this topic.

Finally, there is a sizeable part of the ASFA test site that does not appear in this deliverable: it is the part that dealt with temporary and dynamic speed limits. Due to the various technical problems encountered, it was not possible to produce workable datasets with these data and they are therefore not part of the validation process. However, the frequency with which they are used for motorway management makes it clear that this kind of data has to be taken into account when dealing with incremental updates. This also raises the question of the update frequency (set at once a day for the tests), as it was observed that many of these variable speed limits last less that one day and so they are outdated before the map providers get them. The management of temporary and dynamic safety attributes will represent the next challenge in the process of updating the related databases.

4.2 Test site BALI

As already explained in section 2.3.2, the BALI test site provided test data that did not fully correspond to the ROSATTE xml data format defined in D3.1. TeleAtlas was able to parse the BALI dataset and extract some relevant parts. However, it could not be guaranteed that all location referencing information was available or could be extracted in order to get reliable and accurate results. Still some issues remained. As the integration result from TeleAtlas was analyzed, it turned out that the BALI speed limit features in many cases were segmented and divided into several parts. Each part was then integrated independently from the others. It could not be clarified whether this already happened on the public authority side or at the TeleAtlas data parser / decoder / integration process. As no feature identifiers could be supplied by the public authority, no direct connection between the features on the public authority map copies and the segments in the TeleAtlas integration result could be established.

An assessment of the results was rather difficult, the standard evaluation procedure, however, could not be used. It can be said, that the location referencing worked in principle. But since the locations were split up in ten or more parts, it was very likely that the integration of one of these ten parts either failed completely or that the topological/geometrical requirements were not met.

At the end, the open location referencing issues remained unsolved. However, with some efforts, it seems conceivable to overcome these problems in the future.

The fact that the test site was not able to create incremental updates, however, seems to be more critical in this context. The question remains, how the final data users (e.g. the map makers) could make use of full database updates if the test site cannot name the created updates in the full export dataset, e.g. by unique identifiers. The validation showed that it can be rather complicated to assign the integrated features with their original ones.

4.2.1 Verification results TeleAtlas

Since there are numerical results, a typical example for the BALI dataset and its integration result is given in this section. Figure 19 shows an inserted speed limit of 70km/h indicated by the blue line in the middle. From the figure, it can be assumed that the blue line corresponds to one continuous feature, however this cannot be judged definitely.

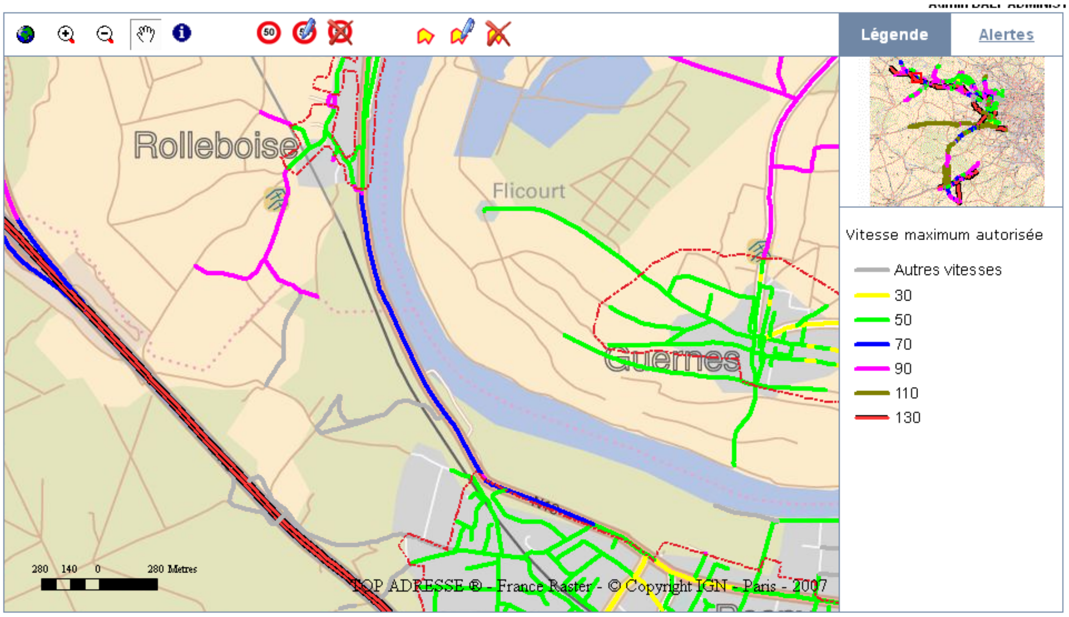


Figure 19: BALI feature v3-10

Figure 20 shows the corresponding TeleAtlas integration result. It can be seen that only parts of the original location could have been reconstructed. All the segments were found as individual parts in the TeleAtlas database. It was not fully clear, why and at what stage the feature became segmented. As it also could be seen, some parts of the locations were integrated not as a line feature, but as point features. That may indicate that the proprietary BALI location referencing that of course was AGORA based but not completely followed the AGORA rules could not be understood correctly.

Figure 20: TeleAtlas integration result of BALI feature v3-10

4.2.2 Verification results Navteq

Please note that Navteq was not able to decode the BALI location referencing. Therefore no results can be presented here.

4.3 Test site Bavaria

4.3.1 Verification results TeleAtlas

Table 19: Geometry validation results for test site Bavaria (TA)

		all categ.	
	Total number of features considered for validation	**149**	**100.0%**
	integrated features	**136**	**91.3%**
	Topologically correct features	**116**	**77.9%**
geometry	mean distance [m] reference point to integrated point	**49.3**	
geometry	features with accuracy worse than 50 m	**26**	**17.4%**
geometry	features within accuracy tolerance of 50 m	**27**	**18.1%**
geometry	features within accuracy tolerance of 20 m	**21**	**14.1%**
geometry	features within accuracy tolerance of 10 m	**24**	**16.1%**
geometry	features within accuracy tolerance of 5 m	**38**	**25.5%**
	overall correct integrated features (with accuracy better than 50 m)	**103**	**69.1%**

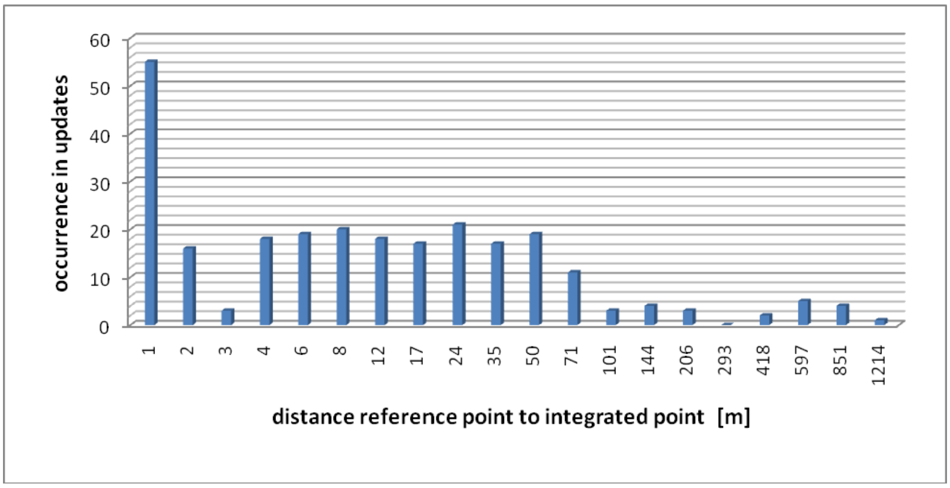


Figure 21: Diagram of the conducted geometry integration for Bavaria (TA)

4.3.2 Verification results Navteq

It has to be noted that the Navteq verification results presented in this section are based on a set of test site locations that was created using AGORA location referencing. As explained in section 4.3.3 in more detail, the test site later changed to OpenLR location referencing for different reasons. However, Navteq does not support OpenLR and therefore could not integrate the latest test site data. Therefore, the dataset used for the Navteq analysis has only preliminary character and does not reflect the final status of the test site's work. However, despite big efforts both on local test site and Navteq side, the issues could not finally be solved. A much deeper analysis would have been necessary to identify and resolve the remaining issues that led to partly unsatisfying results in the AGORA encoding and decoding processes at the Bavarian test site.

Table 20: Geometry validation results for test site Bavaria (NT)

		all categ.	
	Total number of features considered for validation	**22**	**100.0%**
	integrated features	**21**	**95.5%**
	Topologically correct features	**14**	**63.6%**
geometry	mean distance [m] reference point to integrated point	**114**	
geometry	features with accuracy worse than 50 m	**6**	**27.3%**
geometry	features within accuracy tolerance of 50 m	**1**	**4.5%**
geometry	features within accuracy tolerance of 20 m	**0**	**0.0%**
geometry	features within accuracy tolerance of 10 m	**2**	**9.1%**
geometry	features within accuracy tolerance of 5 m	**12**	**54.5%**
	overall correct integrated features (with accuracy better than 50 m)	**11**	**50.0%**

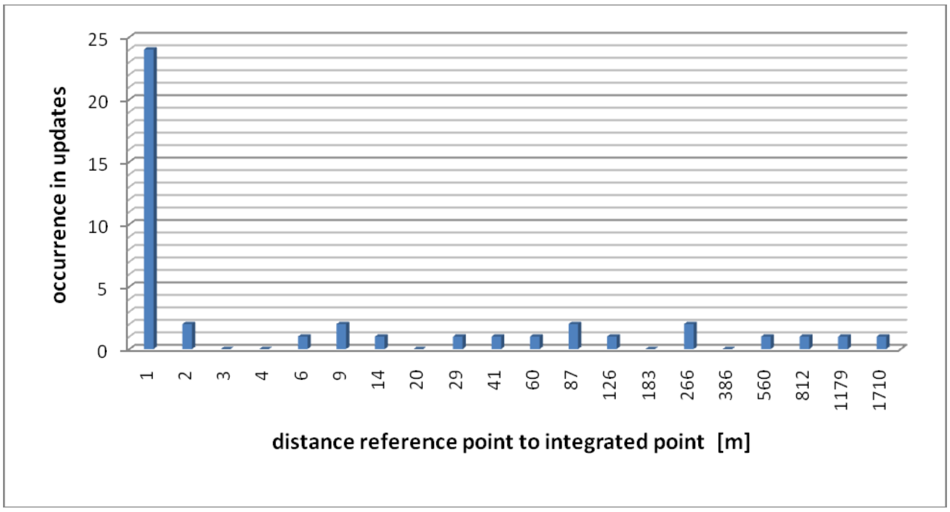


Figure 22: Diagram of the conducted geometry integration for Bavaria (NT)

4.3.3 Analysis of test site results and conclusions

Testsite Bavaria has a modified Navteq map (so called INTREST map) as underlying referencing map basis. For map independent reference transfer, initially a remote service for AGORA-encoding offered by Navteq was used. The available AGORA-encoders/decoder implementations proved limited in their capabilities. When results especially for a transfer to the TeleAtlas map turned out to be poor, a test site specific, own OpenLR encoding mechanism was implemented. OpenLR could only be used for map transfer to TeleAtlas, since Navteq did not support OpenLR in the project.

Chapter 4.3.1 presents the results for the transfer of data to TeleAtlas using OpenLR. Of the whole sample, about 13 features could not be integrated at all. About half of these are due to ill-defined test features (zones instead of linear features) or due to limited consistency checks during editing, which lead to inconsistent capturing of features. Such errors can be avoided with increasing sophistication of the editing tools and data transfer mechanisms.

Especially for motorway but also for urban and rural areas, there are a number of features with geometric deviations of several hundred meters. This could not be explained conclusively. Since the OpenLR encoding/decoding was not verified elsewhere, it is not excluded, that there is still errors in the implementation on the encoding or decoding side. Overall, this drastic deviation is visible for about 12 features, which thereby fail the integration. The mean distance of close to 50m across the whole sample, is thereby significantly flawed and lifted upwards. Without these 12 features, the average geometric deviation reduces to about 20m, which is in the range of differences between the source and target map. Excluding those features which are either not correctly captured as well as those with extreme geographic deviations, the rate of correctly integrated features rises to 85%. Not surprisingly, the integration rate for urban areas is lower than for rural areas and motorways.

Due to the undetermined reason for the strong geometric deviation of certain features, the whole evaluation is biased. Unfortunately, the analysis could not be further pursued to fully understand the behaviour encountered. Nevertheless, OpenLR appears to be a promising option for map independent transfer of safety related attributes contingent that the implementation used is fully checked and proven.

Chapter 4.3.2 presents results of data transfer to Navteq using (remote) AGORA-encoding. With 50% final success rate the results are surprisingly low and disappointing – in particular in view of the fact, that source and target map are similar (Navteq or Navteq derived) and that encoder/decoder both come from the same source (Navteq). This is certainly to be attributed to the fact, that the encoder/decoder offered by Navteq has not reached a mature level, rather it appears to implement only a subset of AGORA rules. No conclusive results can therefore be given.

4.4 Test site Flanders

4.4.1 Verification results TeleAtlas

Table 21: Geometry validation results for test site Flanders (TA)

		all categ.	
	Total number of features considered for validation	**56**	**100.0%**
	integrated features	**47**	**83.9%**
	Topologically correct features	**39**	**69.6%**
geometry	mean distance [m] reference point to integrated point	**2.57**	
geometry	features with accuracy worse than 50 m	**4**	**8.5%**
geometry	features within accuracy tolerance of 50 m	**0**	**0.0%**
geometry	features within accuracy tolerance of 20 m	**3**	**6.4%**
geometry	features within accuracy tolerance of 10 m	**5**	**10.6%**
geometry	features within accuracy tolerance of 5 m	**35**	**74.5%**
	overall correct integrated features (with accuracy better than 50 m)	**39**	**83.0%**

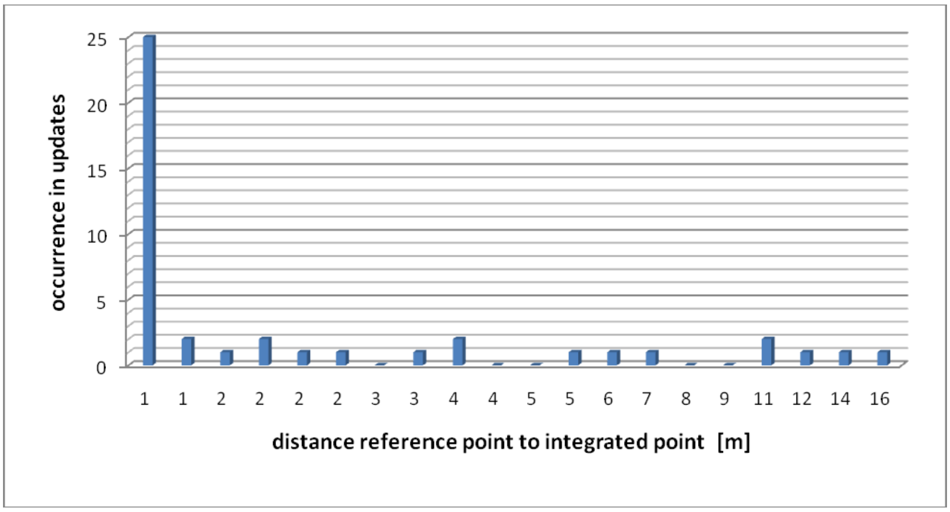


Figure 23: Diagram of the conducted geometry integration for test site Flanders (TA)

4.4.2 Verification results Navteq

Table 22: Geometry validation results for test site Flanders (NT)

		all categ.	
	Total number of features considered for validation	**56**	**100.0%**
	integrated features	**50**	**89.3%**
	Topologically correct features	**30**	**53.6%**
geometry	mean distance [m] reference point to integrated point	**2.09**	
geometry	features with accuracy worse than 50 m	**20**	**40.0%**
geometry	features within accuracy tolerance of 50 m	**0**	**0.0%**
geometry	features within accuracy tolerance of 20 m	**1**	**2.0%**
geometry	features within accuracy tolerance of 10 m	**2**	**4.0%**
geometry	features within accuracy tolerance of 5 m	**27**	**54.0%**
	overall correct integrated features (with accuracy better than 50 m)	**30**	**60.0%**

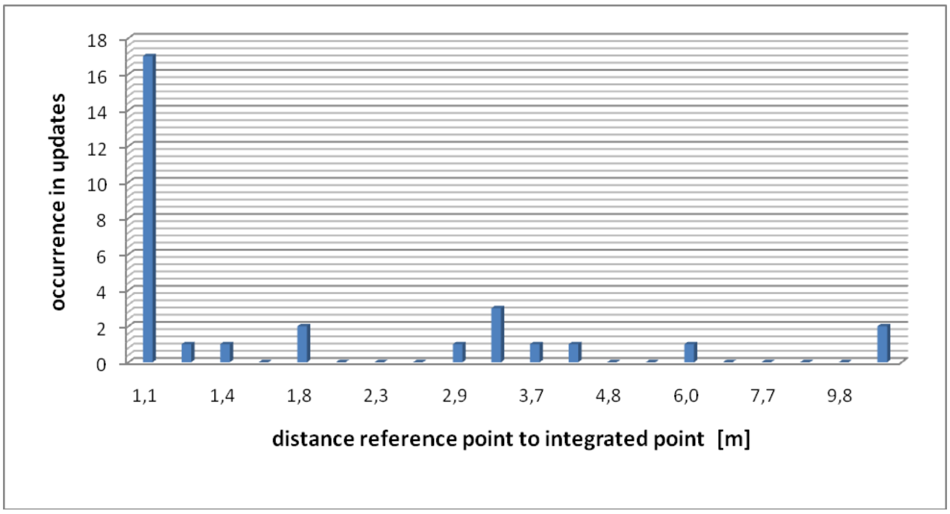


Figure 24: Diagram of the conducted geometry integration for test site Flanders (NT)

4.4.3 Analysis of test site results and conclusions

In the Flanders test site, a successful data chain was established between the Flemish government traffic sign data base and the map makers Navteq and TeleAtlas.

Most of the problems in the Flanders test site were encountered when making the ROSATTE xml extraction. All these encountered problems were and will be taken into account for optimizing the extraction tool of Flanders.

In order to solve some other encountered problems, a modification (mainly extension) of the ROSATTE specification is needed and the traffic sign database of Flanders also needs

some modifications. E.g. zone road signs of the type ZCxx (zones with a prohibition xxx) are for the moment not described in the ROSATTE specification (except the speed limit zone signs).

The Flanders test site also experienced a lot of problems when implementing the Navteq encoding service. The main cause of these problems was that the traffic sign database of Flanders used a different version of Navstreets as the version used in the Navteq encoding service. The Navteq encoding service is always based on the Q2 or Q4 version of Navstreets. Within the Flemish government, the Q3 version of Navstreets is always used. In order to solve this incompatibility, Flanders implemented the Q4 version of Navstreets for the test site area.

4.5 Test site Sweden/Norway

4.5.1 Verification results TeleAtlas

Table 23: Geometry validation results for test site Norway - TA

		all categ.	
	Total number of features considered for validation	**117**	**100.0%**
	integrated features	**92**	**78.6%**
	Topologically correct features	**73**	**62.4%**
Geometry	mean distance [m] reference point to integrated point	**8.61**	
Geometry	features with accuracy worse than 50 m	**17**	**18.5%**
Geometry	features within accuracy tolerance of 50 m	**1**	**1.1%**
Geometry	features within accuracy tolerance of 20 m	**1**	**1.1%**
Geometry	features within accuracy tolerance of 10 m	**1**	**1.1%**
Geometry	features within accuracy tolerance of 5 m	**72**	**78.3%**
	overall correct integrated features (with accuracy better than 50 m)	**71**	**77.2%**

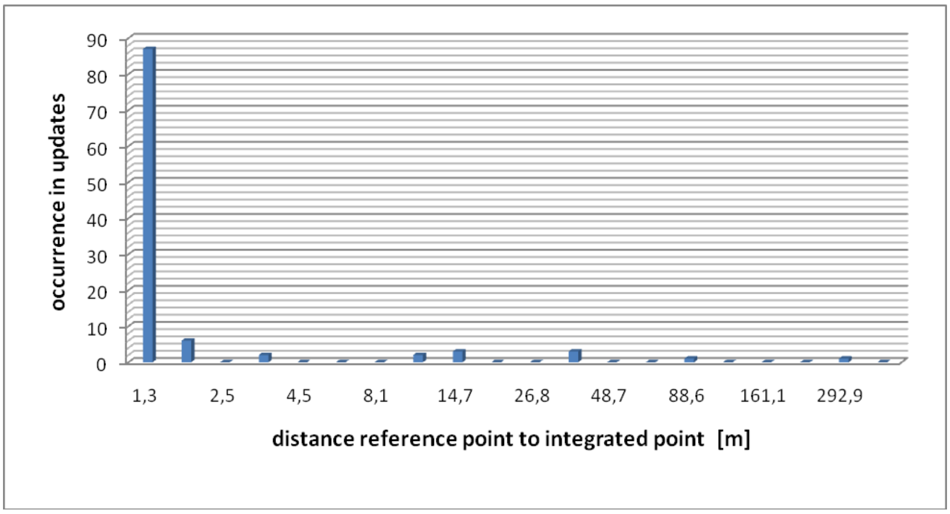


Figure 25: Diagram of the conducted geometry integration (Norway TA)

Table 24: Geometry validation results for test site Sweden - TA

		all categ.	
	Total number of features considered for validation	**162**	**100.0%**
	integrated features	**134**	**82.7%**
	Topologically correct features	**89**	**54.9%**
geometry	mean distance [m] reference point to integrated point	**16.9**	
geometry	features with accuracy worse than 50 m	**14**	**10.4%**
geometry	features within accuracy tolerance of 50 m	**8**	**6.0%**
geometry	features within accuracy tolerance of 20 m	**8**	**6.0%**
geometry	features within accuracy tolerance of 10 m	**15**	**11.2%**
geometry	features within accuracy tolerance of 5 m	**89**	**66.4%**
	overall correct integrated features (with accuracy better than 50 m)	**85**	**63.4%**

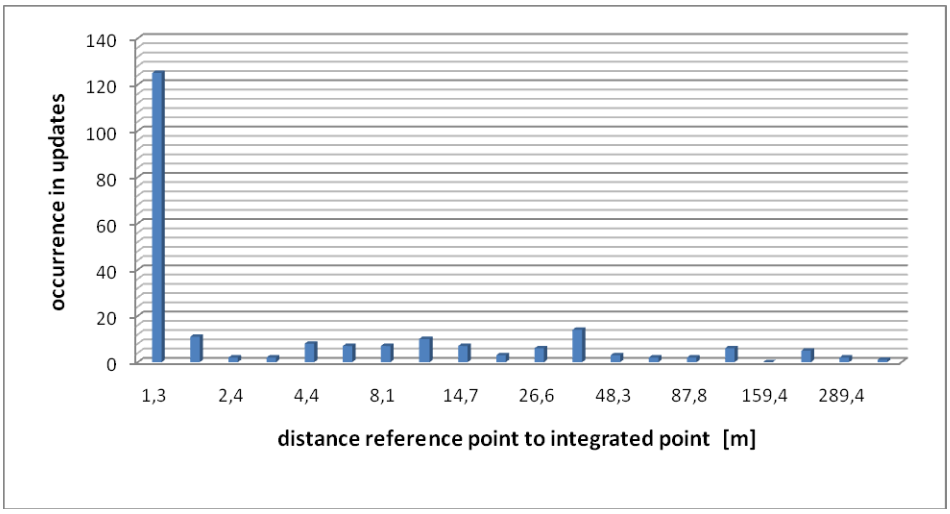


Figure 26: Diagram of the conducted geometry integration (Sweden TA)

4.5.2 Verification results Navteq

Table 25: Geometry validation results for test site Norway - NT

		all categ.	
	Total number of features considered for validation	**117**	**100.0%**
	integrated features	**114**	**97.4%**
	Topologically correct features	**22**	**18.8%**
geometry	mean distance [m] reference point to integrated point	**17.7**	
geometry	features with accuracy worse than 50 m	**97**	**85.1%**
geometry	features within accuracy tolerance of 50 m	**2**	**1.8%**
geometry	features within accuracy tolerance of 20 m	**0**	**0.0%**
geometry	features within accuracy tolerance of 10 m	**0**	**0.0%**
geometry	features within accuracy tolerance of 5 m	**15**	**13.2%**
	overall correct integrated features (with accuracy better than 50 m)	**16**	**14.0%**

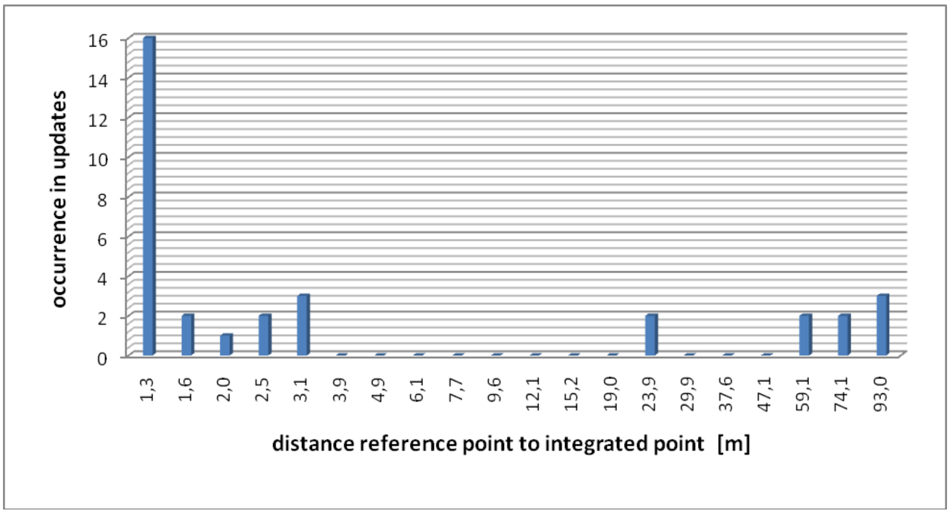


Figure 27: Diagram of the conducted geometry integration (Norway NT)

Table 26: Geometry validation results for test site Sweden - NT

		all categ.	
	Total number of features considered for validation	**162**	**100.0%**
	integrated features	**156**	**96.3%**
	Topologically correct features	**45**	**27.8%**
geometry	mean distance [m] reference point to integrated point	**7.91**	
geometry	features with accuracy worse than 50 m	**12**	**7.7%**
geometry	features within accuracy tolerance of 50 m	**5**	**3.2%**
geometry	features within accuracy tolerance of 20 m	**11**	**7.1%**
geometry	features within accuracy tolerance of 10 m	**17**	**10.9%**
geometry	features within accuracy tolerance of 5 m	**111**	**71.2%**
	overall correct integrated features (with accuracy better than 50 m)	**44**	**28.2%**

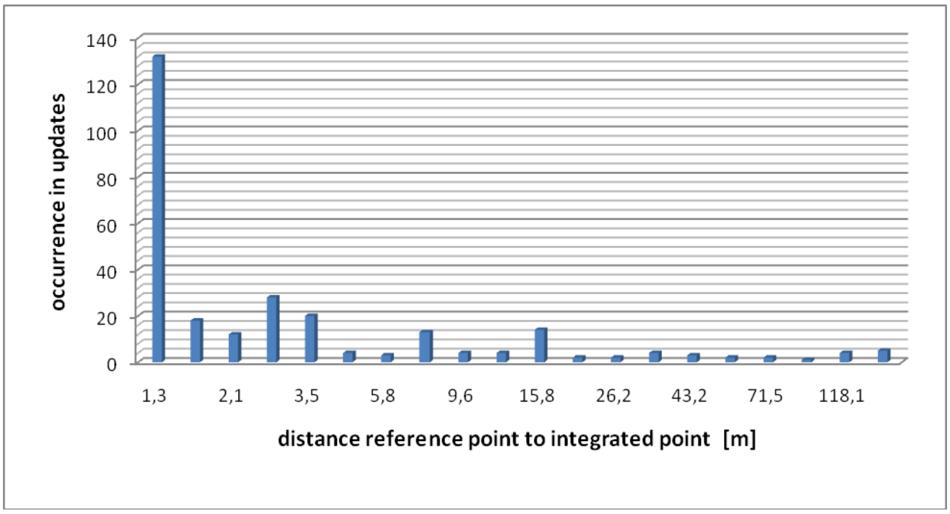


Figure 28: Diagram of the conducted geometry integration (Sweden NT)

4.5.3 Analysis of test site results and conclusions

In this section, the involved test site partners will analyse the developments at the test site as well as the assessment results.

4.5.3.1 Establishing a data store

In Sweden and Norway we have databases and tools since before, but these were developed before ROSATTE and INSPIRE.

Quality parameters are available in our databases. These parameters are based on the ISO-standards also used as a base in ROSATTE. It will be necessary for all Public Authorities to harmonize the quality descriptions towards the ISO-standards.

Mapping of our own attributes towards Agora-C required attributes is necessary and not always easy. The mapping result is dependent on how harmonized the data from the authorities are with the map provider data. Sometimes we do not have the required underlying data to do the mapping in a proper way.

At the authorities we have had data in different databases, some more similar to the ROSATTE structure and some differs more from ROSATTE. Of course it is more difficult with the latter. A recommendation to newcomers is to look at the ROSATTE structure and requirements before specifying the internal databases.

4.5.3.2 Data exchange methods

It is recommended to use a validated encoder (AGORA-C). Concerning OpenLR, as it is open source it might be easier to take open code that is validated by other users.

The AGORA-C implementations seem to be immature. Perhaps this is a result of AGORA-C being quite complicated. The implementations do not work in the same way at different sites. To be able to use it in a production line some more work is needed to harmonize the implementations.

OpenLR validation is of course also needed to harmonize the OpenLR implementations, but in this case a platform is available by the open source consortium.

REST-service is an easy way to publish the data.

Discovery service is not tested in ROSATTE, but will be necessary if ROSATTE should be successful in the long run.

4.5.3.3 Result of integration at Map Providers

In general the integration at a map provider works quite well, although no deep analysis has been carried out concerning the alignment to all defined quality parameters.

As the specifications of the databases and the digital road network differs e.g. concerning generalizations, we will always get some problems and errors. If we harmonize the road networks in the long run, a better result will be reached.

The requirements from the Map Providers and the rules to use for integration are not elaborated enough, which means that a Public Authority can do a lot more than what we have done to really satisfy requirements from the Map Providers and that would make the integration at Map Providers easier. The validation figures above are the result of a first test of the data chain from Public Authorities to Map Providers, which means that there is a large potential for improvements.

We do not think that the Map Providers use the available information in an optimal way to really make the integration best possible. The result from the Norwegian part of the test site differs a lot after integration at Tele Atlas respectively at NAVTEQ. This indicates differences in the Agora-C implementations at the two Map Providers. The different results can’t be explained only by differences in geometrical representation of the road network.

The implementations were not totally validated within the timeframe of the project. Bugs might still exist and some effort to correct them would definitely enhance the result.

More time for dialog between Map Providers and Public Authorities is needed to optimize the implementations at both sides.

4.5.3.4 Feedback

ROSATTE has not reached the level where feedback can be used to assist in correcting errors and enhancing the data provision from the Public authorities.

4.6 Test site London

4.6.1 Verification results TeleAtlas

Table 27: Geometry validation results for TfL in case of TA

		all categ.	
	Total number of features considered for validation	**102**	**100.0%**
	integrated features	**89**	**87.3%**
	Topologically correct features	**72**	**70.6%**
geometry	mean distance [m] reference point to integrated point	**3.84**	
geometry	features with accuracy worse than 50 m	**1**	**1.1%**
geometry	features within accuracy tolerance of 50 m	**5**	**5.6%**
geometry	features within accuracy tolerance of 20 m	**5**	**5.6%**
geometry	features within accuracy tolerance of 10 m	**6**	**6.7%**
geometry	features within accuracy tolerance of 5 m	**72**	**80.9%**
	overall correct integrated features (with accuracy better than 50 m)	**72**	**80.9%**

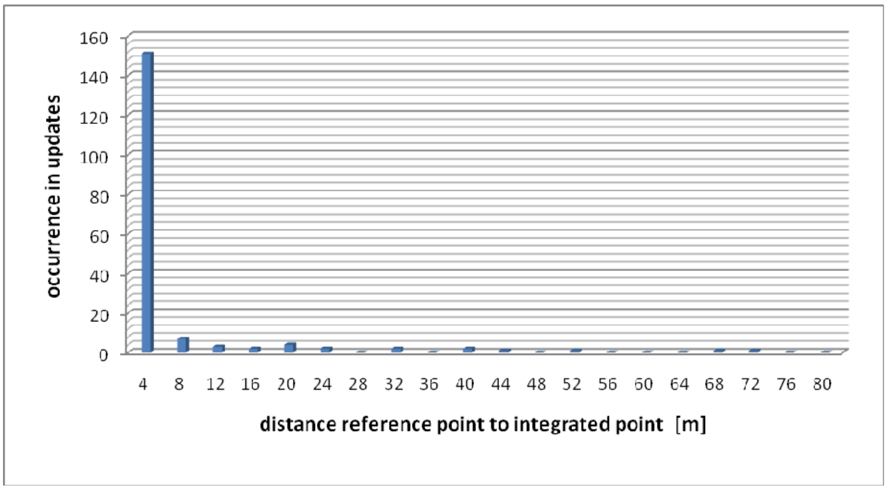


Figure 29: Diagram of the conducted geometry integration for test site London (TA)

4.6.2 Verification results Navteq

Please note: For the London test site no Navteq results are available. Navteq does not support OpenLR location referencing, that is used by the London test site.

4.6.3 Analysis of test site results and conclusions

The results achieved for the London test site using OpenLR seem promising. OpenLR is a relatively new technology and this was the first time the TfL developer had ever created an application of this type. Due to time and resource constraints the encoder was never completely finished (i.e. packaged with a GUI), however it is firmly believe that further improvements to accuracy would be possible if development of the encoder was resumed.

The main discrepancies seem to come from the subtle difference between the OS ITN map, that was used at the public authority and the TeleAtlas map.

There were a number of reasons for this, primarily:

1. The OpenLR en/decoder web-service only allows to en/decode publicly accessible roads. In some cases roads that are called 'private' in Ordnance Survey, are in fact public access roads in Tele Atlas, and vice versa. Even though we assign these roads a speed limit, they do not get encoded/decoded properly.

   For example, "Rowstock Gardens" (London Borough of Islington) is shown as publicly accessible on the Ordnance Survey data, but as a private road in the TA map, so it will be extracted and always fail to decode

2. Discrepancies between the maps (OS and TA) mean that some roads in Ordnance Survey do not exist in Tele Atlas, and vice versa.
3. The London Digital Speed Limit map initially did not specify the difference between one-way and two-way roads. As part of OpenLR, the en/decoder needs to know which roads are one-way roads, and what the direction of flow is. We have subsequently included an 'orientation' field in our map which stipulates the direction of flow of one-way roads through either a '+' or '-' sign. Already included in the attribute data is 'start node' and 'end node'. The 'orientation' field determines whether direction of flow is from start to end node (i.e. +) or from the end to start node (i.e. -).
4. Another issue was that Ordnance Survey and Tele Atlas do not store Functional Road Class (FRC) in the same way (OS = DescTerm; TA = FRCA). Table 28 highlights the differences (OS on left; TA on right). FRC is an important aspect in the OpenLR en/decoder. What was found was that even with the FRC "mappings" there are still discrepancies between OS and TA values.

Table 28: Test site London functional road class differences

DescTerm (Ordnance Survey)	FRCA (TeleAtlas)	
Motorway	Motorways	1
A road	Other Major Roads	3
B Road	Local Connecting Roads	5.1
Alley		
Local street	Local roads of Minor Importance	7
Minor road	Local Roads	6
Pedestrianised street	Other Roads	8
Private road – Publicly accessible	Local Roads of Minor Importance	7
Private road – Restricted access	Local Roads of Minor Importance	7
Private road – Restricted access and ‘Name’ is empty	Local Roads of Minor Importance	7

One other important consideration and limitation in the London Test Site, was the use of Ordnance Survey mapping. Ordnance Survey currently has very strict and limiting derived data rules on their map products. As the London Digital Speed Limit map is based on the Ordnance Survey ITN2 layer, it considered derived data, and hence OS essentially own the map. This means TfL cannot provide the data to anyone who would use it for commercial gain, and anyone with whom the data is shared, would need to be a contractor of TfL or would need to procure an Ordnance Survey license.

This, naturally, seriously constrains the ability to share and make publicly available the speed limit data from the London Test Site. For the purposes of ROSATTE the data will be assessed, but not used. Thus, although given current Ordnance Survey IPR laws the actual sharing of TfL’s data is not possible, we can still test the theory behind it. There are hints that OS might relax their derived data laws, so hopefully in the future this problem may fall away.

Not being able to use the results in the Navteq map was a concern. However, ideally, in the future Navteq may support OpenLR, or some other way of conversion may be found.

As a test site we are satisfied with the results as a proof of concept and as the ROSATTE project moves beyond the exploratory/test phase, we hope to invest in developing and improving our OpenLR encoder and thereby improving the accuracy.

5 Final conclusions and prospects

At first, it can be said that good and intensive cooperation between all partners was a key factor for the successful execution of the validation. Regular consultation and exchange of experiences between the local authorities as providers of the test data, the map providers as the project-internal customers and data integrators and the University of Stuttgart as the institution carrying out the validation with success to all the test data was especially important during the development phase. Quite a lot of errors and quality lacks could be identified and the performance of the complete system could be improved significantly.

Incremental updates are a challenge when it comes to ensure the rapid dissemination and quality of the data. The detected map deviations, topologically incorrectness or data incompleteness point to specific implementation problems, mainly in used location referencing approaches. Internal procedures, both at the sending and the receiving side, must be matched with the standardized exchange format. On the whole all test sites were able to provide a full initial data supply and most of them could extract changes in their databases automatically to provide incremental updates. They were made available by the test sites on web servers. The map providers in turn could access and download them from there.

Due to the fact that all involved parties are located in different countries and have to follow to a variety of legal and administrative laws and guidelines one of the biggest advantages of the ROSATTE project excelled clearly: the independence of such structures focusing on more local matters. Cooperation across national boundaries has been achieved through standardization and adaptation of homogeneous procedures. However, because of the different approaches to integrate data maintenance into the respective procedures, ROSATTE gone without additional specification in this regard showing more flexibility where it is reasonable.

The map providers delivered feedback information about their data integration results. However, this particular issue was not in the main scope of the current project. Feedback integration by local authorities is advisable for further development.

Within ROSATTE both AGORA and OpenLR location referencing algorithms were used. In both cases satisfactory results could be obtained. The validation of non-functional requirements seems to confirm this conclusion but also makes clear that for superior requirements these methods might be not effective enough. Surely a field which might be of further interest to pursue at the proper time.

Within the validation, the two non-functional parameters "geometrical accuracy" and "topological correctness" played a central role. From the success criteria in section 2.6 can be seen, that the relocation of the road safety features in the receiving (map provider) map should achieve a geometrical accuracy of less than 50m. From the validation results can be seen that this requirement cannot finally be demonstrated in all test sites.

The second important parameter, topological correctness, was firstly introduced in ROSATTE. It was important to assess not only whether the road safety objects follow the same route as their original, but also whether they are on the right side of the road or whether they were correctly integrated in the context of intersections (nodes) in the receiving map. It could be shown that also here, some problems remain. From the algorithms

However, as can be seen from the test sites' validation result analysis, the level of implementation of the available algorithms still can be improved. Secondly, the location referencing algorithms themselves need to be further assessed and improved using the

results and experiences gained with their extensive use in ROSATTE as well as the defined validation methodology and parameters.

5.1 Public Authorities' perspective

As an overall conclusion we note that the results of the work at the various test sites from the Public Authority (PA) perspective have been successful.

A number of possible improvements have been identified during the testing process - some have been addressed but there is still considerable scope to further improve the results when exchanging incremental updates. By analyzing and fixing the remaining "typical errors" we believe that the results could be significantly improved.

Further feedback directly from Map Providers (MP) to Public Authorities (PA) between each delivery round of changed data, in the testing process, would have probably been an advantage to "tune" the procedures at both the PA and MP side.

There are also still possibilities to "fine tune" encoding/decoding when it comes to location referencing.

Harmonization - both data definitions and quality parameters – is an important issue at the PA side to facilitate a smoother exchange of data.

Experience gathered in the test work is also a valuable input to the authorities who are intending to establish "ROSATTE services" in their operational service.

There is great potential in an established ROSATTE infrastructure since it with no doubt could be useful for data exchange of other road attributes than just safety related data.

PA's has expectations that the results from the ROSATTE project will be useful to address the requirement on authorities to comply to EU-directives such as INSPIRE, ITS Directive etc

5.2 Map Providers' perspective

From the map providers' point of view, it is very important that with the ROSATTE exchange infrastructure, road safety attributes from different European road authorities could have been successfully retrieved and integrated using a standardised methodology and data format. This achievement can simplify the map maintenance process in place and help reducing costs and effort to source updated data from public authorities. The data available from these road authorities is regarded especially valuable since it can be retrieved directly from its origin. The data is therefore assumed to have a good level of quality and it can be exchanged quite fast.

It could also be shown that also the road authorities have great interests to provide their data to the commercial map makers in order to have the latest changes present in the maps so that the end-user applications can rely on the information available in the maps. This will finally help to increase the acceptance of such applications, e.g. advanced driver assistance systems but also and more important to decrease the number of road casualties and increase the road safety across Europe.

The validation of the ROSATTE results showed that the developed exchange format and infrastructure works properly and road safety features can be exchanged almost in real-time. However, the success criteria for potential applications could only be met partially so far. The prototypical implementations, and especially those of the location referencing methods, need to be improved further to finally be able to use them for concrete end-user applications. From the experiences gained in ROSATTE it seems to be quite realistic that such improvements are possible since the developments in ROSATTE achieved good

progress. Only the limited resources and time within the project were seen as limiting factors to further improvements.

In the perspective, the scope of the exchange infrastructure developed in ROSATTE could even be widened. The methods and tools may not only be used for the exchange of road safety attributes, but also for all other kinds of publicly available data that needs to be able to be integrated in European-wide commercial road maps.