ROSATTE

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

D2.1 - Conceptual specification of how to establish a data store

Version Number: 1.00
Produced by: Triona AB and PTV
Due Date: 31/12/2008
Release Date: 3/3/2009

ROSATTE is co-financed by the European Commission – DG INFSO
Contract Number: 213467

Programme Name	7th Framework Programme – Specific Programme Cooperation – Theme 3 "Information and Communication Technologies"
Grant Agreement Number:	213467
Project acronym:	ROSATTE
Project name:	ROad Safety ATTributes exchange infrastructure in Europe
Project start and end:	January 2008 – June 2010 (30 months)
EC Project Officer:	Mrs. Elina Holmberg
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Dissemination level[1]:	Public

Title of document:	Specification of how to establish a data store
Work package:	WP2
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Abstract: The document specifies, on a conceptual level, how to establish and maintain a data store that complies with ROSATTE requirements

Keyword list: Safety attributes, ADAS, digital maps, data exchange, database, data store, public/private cooperation

[1] This is either: Public, restricted to other programme participants, restricted to a group specified by the consortium, confidential

Document Control Sheet

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Work area: 2

Document title: Conceptual specification of how to establish a data store

Version history:

Version number	Date	Main author	Summary of changes
0.1	06/08 2008	Lars W	Created first outline
0.2	25/08 2008	Peo S	Updated outline and added new parts
0.3	05/09 2008	Peo S	Updated after conf call with Timo
0.35	15/09 2008	Peo S	Updated before WP2 workshop
0.4	10/10 2008	Peo S	Updated after WP2 Workshop and further discussions
0.5	13/11 2008	Peo S	Updated after the meeting in Veldhoven and after received input from all test sites
0.6	1/12 2008	Peo S	Updated after internal review and the meeting in Brussels.
0.7	2/12 2008	Peo S	Update of Glossary and References
0.8	4/12 2008	Peo S	Minor updates before sending it to peer reviewers
0.95	16/2 2009	Peo S / Michael L	Updates after input from peer reviewers
1.0	3/3 2009	Peo S / Michael L	Small updates after input from SRA

Approval:

	Name	Date
Prepared	Per-Olof Svensk/Michael Landwehr	03/03/2009
Reviewed		
Authorized		

Circulation:

Recipient	Date of submission
ROSATTE Consortium	
EC	

Executive Summary

This report presents the result of ROSATTE WP2.1. It specifies, on a conceptual level, how to establish and maintain a data store that complies with ROSATTE requirements.

The methodology used in this report is essentially the same as was used in the ROSATTE requirements and overall architecture deliverable, ref[11]. The requirements and recommendations for establishing and maintaining a data store come from identified use cases, process-, information- and component viewpoints. Finally a chapter with guidelines is provided. The aim with the guidelines is to give practical help to organisations/road authorities regardless of their pre-conditions.

The aim with the identified use cases is to, on a conceptual level; cover the majority of the activities that are necessary to perform for an organisation aiming to establish a ROSATTE compliant data store. Not all use cases are relevant for all European countries/regions.

Most of the requirements in ROSATTE deal with the actual exchange of data between an organisations/road authority gathering basic road data and an information provider for example Navteq or Tele Atlas. These exchange specifications, rules etc. are defined in D3.1.

The document does not specify any fully harmonized solution for road authorities. Although by following the recommendations in the document it will be easier for road authorities to exchange data according to the ROSATTE exchange specifications.

Most of the necessary tasks are expressed as recommendations not actual requirements, depending on the difference in pre-conditions and the number of different ways to establish the data store. Chapter 7 provides a summary of requirements and recommendations applicable for Road Authorities and other organisations establishing a ROSATTE data store.

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Glossary

Table 1 – Glossary and Abbreviations

Term	Definition
ADAS	Advanced Driver Assistance System
AGORA	European project which developed on-the-fly referencing method. The method is now available in different versions (ISO, Agora-C)
ASFA	French Motorway Companies Association
CEN	European Commission for Standardisation
Component	A component is the whole or part of a software system, seen from the outside as one unit.
Dataset	A dataset is an identifiable collection of data.
DG INFSO	General Directorate for Information Society and Media
GDF	European standard used to describe and transfer road networks and road-related data. See ref [20]
GML	Geographic Markup Language
GPS	Global Positioning System
INSPIRE	Infrastructure for Spatial Information In the European Community initiative, www.ec-gis.org/inspire/
INTREST	System for handling road network and attributes, used in Bavaria
Interface	An interface is a gateway to the functionality that a component exposes to other components or external systems.
User	A user is an external entity (person, organization, system) interacting with the system.
Use case	A use case is a series of interactions with the system to perform one unit of work. Can also be defined as a high-level function initiated by a user.
Role	A role is an area of responsibility. One user has one or more roles. One role can be shared by many users.
Metadata	Metadata is data about data, information making it possible to discover available data types and structures, quality parameters, geographic coverage etc., without reading the actual datasets.
NPRA	Norwegian Public Road Administration
OBB	Bavarian Department of Highways and Bridges
OGC	Open Geospatial Consortium - international industry consortium developing publicly available interface specifications, see www.opengeospatial.org/ogc
RM-ODP	Reference Model - Open Distributed Processing, ISO-standard ref [17]
Service	A service is a software system running on its own, not relying on user input, used by external components.

Term	Definition
Spatial data	Spatial data is data pertaining to the location and spatial dimensions of geographical entities.
SRA	Swedish Road Administration
STREP	Small or medium-scale focused research project
TNE	Transport Network Engine – System for handling road network and attributes, used in Sweden and Norway
UML	Unified Modeling Language. Includes a set of graphical notation techniques called UML models, see www.uml.org
WFS	Web Feature Services - Interface standard from OGC that defines a standard interface for specifying requests for retrieving geographic features, ref [21]. See www.opengeospatial.org/standards/wfs
VIB	VerkehrsInformationsagentur Bayern – Public-Private Organisation in Bavaria operating a system for handling road network and attributes.
WMS	Web Map Services – Interface standard from OGC that provides a simple HTTP interface for requesting geo-registered map images, ref [23]. See http://www.opengeospatial.org/standards/wms

Fundamental definitions

Table 2 – Definitions of fundamental expressions that are used in the document

Term	Definition
(Legal) Traffic regulation	Legal order established by an enacting authority, which regulates the use and equipment of roads e.g. with regards to speed, overtaking ban, traffic lights etc. at a specific location. It often leads to the installation of *traffic signs* at this location. The traffic regulation may cover a point along the road (e.g. pedestrian crossing), a linear location (speed limit along the road from location A to B) or an area location (30km/hour zone, i.e. a set of streets in an area)
Traffic sign	Signs (e.g. speed limit signs) which are put up by road maintenance operators as a manifestation of a traffic regulation for driver information. Traffic signs, by their nature are point objects. To describe a line or an area regulation, several traffic signs may be put up for clarity of information to the drivers. Traffic signs data are often maintained as a part of separate data bases by road maintenance authorities in order to more efficiently manage road (side) equipment. While for certain signs, the content is close in meaning to the corresponding 'safety attribute', transformation is needed to create a safety attribute together with a correct location description. E.g. several traffic signs (repeated speed limit signs) may need to be analysed to define the location/extent of the corresponding safety attribute (speed restriction for several kilometers along a road).
Field survey	Capturing of information by on site road inspection. Measurements/recording of road features including traffic signs etc. on the roads in a specific area or for a specific road level. Field surveys can be done as (repeated) total surveys of areas (full supply) or more ad hoc surveys from small areas. Field surveys may be useful for safety attribute data bases e.g. when creating an initial data set on safety attributes or to support quality mechanisms by providing reference data on safety attributes, which come from other sources.
Road network database	Digital description of road network including certain attributes. There is different ways to describe a road network by data objects. In this document we mean the representation of roads by their geometry (holding a direct location description) and topology using segments and nodes to describe road sections and junctions. In order to be useful as a basis for on-the fly referencing methods, a road network databases has to include certain structures and attributes (called 'location referencing attributes' in this document) required for all road network databases between which on-the-fly references shall be exchanged.

Term	Definition
Safety Attribute	Feature/attribute in a digital road database which describes the content of a traffic regulation. To be useful, each safety attribute along a road must be paired by the description of its location. The location may be a point, a linear or an area location. To describe the location of a safety features/attributes it can be 'attached' to the road network by (logical) reference to the road database objects in order to clarify their location. Alternatively, a direct location description by coordinates is often used (geo-reference). Its details (as well as the location information) may be directly derived from a traffic regulation (or it could hold a reference to the regulation at its origin). Alternatively, its details (and location information) may be captured by field survey, or from databases including traffic signs.
Location referencing	Location referencing describes a method to describe a location of an object in a digital database. Direct Location referencing uses a description of a location by geo-references (i.e. a description in reference to a geodetic reference system, e.g. latitude and longitude coordinates in WGS84). In the document, geo-references are often used synonymous to direct location references. Indirect location referencing describes a location by its logical reference to other objects (e.g. road segments, or nodes) in a digital database, which themselves hold direct (geo-)references for describing their location. In our case these other objects are those of the road network database (segments, nodes). Indirect references to the road network will also be called 'network reference' in the document. Indirect location references can usually only be interpreted in connection to the specific database objects, which they point to (logical reference). If location references shall be independent of one database, there exist two main ways: • "[It] can be implemented by pre-coding often used locations, as is done in RDS-TMC. The location codes and related additional information are stored in so-called location tables. Advantage is the conciseness of the code; disadvantage the limited amount of addressable locations." (From the AGORA Specification [19]). These predefined and coded locations need to be integrated in each network database, between such location references shall be transferred. • On-the-fly location referencing, which is another method to identify a location independently from a specific instance of a geographic information database. A location known in ones own geographic information set (as indirect location reference) is transformed by an encoding mechanism (using certain rules) into a location code, which can be decoded in reference to another geographic information set (as indirect location reference). The location code contains direct location referencing information (usually geo-references to point locations) as well as typical features/classifications of the (indirectly referenced) data base objects (e.g. classification of a road segment, street names or the like), which are common to all databases. The location referencing method used creates requirements for the source and the target geographic information set with regards to structure and content.

Term	Definition
Linear Referencing	The Linear Reference System (LRS, also called Linear Referencing System) is a reference system in which features are localised by a measure along a linear element. Each feature is localised by either a point known as a "milepoint" or a linear event ("segment"). The system is designed so that if a segment of a route is changed only those milepoints on the changed segment need to be updated. (from Wikipedia). ISO 19148 is an upcoming standard on LRS. In the above classification, LRS is an indirect location referencing technique, which –in the case of a road network – uses 'routes' (a directed chain of segments) as 'aggregated' linear objects, in reference to which a linear location is described either by distance measures (from km 115 to km 120 in reference to the start point at km 0) or percentages (from 55% to 58% of the route length).
AGORA	AGORA [19] is one on-the-fly location referencing method, which is made reference to throughout this document. AGORA requires a digital network description that includes (1) geometric road information, (2) which has a topology to allow routing functions and (3) which contains certain road attributes, such as 'form of way' and 'functional road class'. AGORA was initially developed in an EU funded research project and has evolved into an ISO standard.
Full supply of data	Supply of data with exhaustive comprehensive coverage. A full supply of data is needed when 'initialising' a database, i.e. filling it comprehensively with the data in question. A full supply of data may be established in regular intervals, i.e. asynchronously of data changes. It then replaces the previous data set. The up-to-dateness of the database is only given at moments, where a (new) full supply is available. Road network data are an example of data that could be updated by full supplies in regular intervals.
Incremental supply of data	Method for regularly updating a database as soon as changes occur in data. The up-to-dateness of the database is continuously maintained. Incremental updates can be provided either through record update events or by comparing different database states. In the case of record update events it is necessary to store information that describes when a safety object is added, modified or deleted. The other option is to send updates as batches of increments created from a process comparing the latest version of a dataset to a previous one.

1. Introduction

1.1 Objectives of WP2

The objectives of WP2 are:

- To enable the road authorities to access and to maintain safety related data for supply to data users' side (map providers, road authorities, third parties…) in a way, that is efficient and easy to adapt to road authorities' internal processes and workflows.
- To learn from existing implementations and to create examples for replication, how data access and maintenance on the road authority side can be efficiently managed.
- To establish quality management in data capturing, maintenance and delivery compliant with ROSATTE requirements;
- To provide reference implementations for the demonstration of data access and maintenance in the respective test beds

1.2 Purpose of Document

This document defines a conceptual specification for a road data maintenance and delivery system serving as a role model for road authorities and test sites in respect of user needs and requirements established in Task 1.2.

The purpose of the document is to give help, recommendations and guidelines for road authorities and other organisations gathering basic road data, to establish and maintain a data store from where safety attributes can be provided according to the ROSATTE infrastructure. Different pre-conditions at different road authorities and different situations regarding availability of the safety attributes are taken into account. Existing processes and existing workflow on the road authority side shall be supported.

The purpose of the document is not to suggest and specify a fully harmonized solution for road authorities and try to overcome the diversity on their side. Although by following the recommendations in the document it will be easier for road authorities to exchange data according to the ROSATTE infrastructure defined in D3.1.

1.3 Structure of Document

This document consists of the following sections:

- A short introduction describing the methodology.
- Description of how to establish a data store based on:
  - Functional Viewpoint
  - Process Viewpoint
  - Information Viewpoint
  - Component Viewpoint
- A summary of Requirements and Recommendations
- Examples of planned implementations at test sites
- Practical guidelines for establishing and maintaining a data store

1.4 ROSATTE Contractual References

ROSATTE is a STREP submitted for the call FP7-ICT-2007-1. It stands *for ROad SAfety ATTributes exchange infrastructure in Europe*.

The Grant Agreement number is 213467 and project duration is 30 months, effective from 01 January 2008 until 30 June 2010. It is a contract with the European Commission, DG INFSO.

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1.5 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 maintenance of a European-wide core road safety spatial dataset 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 organisational feasibility of this infrastructure

2. Methodology

The methodology used in the document is essentially the same as was used in the ROSATTE requirements and overall architecture deliverable, ref[11]. The document primarily deals with the overall use case "Maintain attributes" defined in ref[11] and refines that description in a more detailed way. The methodology is the same as in the overall architecture, i.e. UML and RM-ODP ref[17].

As in the requirements and overall architecture document, the used viewpoints are *Functional viewpoint, Process viewpoint, Information viewpoint* and *Component viewpoint* and each viewpoint describes its particular perspective of the overall use case "Maintain attributes". More information on these viewpoints can be found in D1.2 ref[11]. This is what we consider as conceptual specification, which allows potential data providers to operate efficient data maintenance as well as ROSATTE compliant data supply to third parties.

The requirements and recommendations for a data store from where safety attributes can be provided will come from the use cases, process-, information- and component viewpoints.

To find a conceptual specification that fits as many road authorities as possible, interviews have been carried out both with test site actors within ROSATTE and with external stakeholders.

As the situation concerning road data in European countries is very different, Road Authorities must be able to work in different ways to establish and maintain their data source. Different aspects of pre-conditions at different Road Authorities are taken into account when the different viewpoints are described.

To comply with ROSATTE, the data store can be established and constituted in a few different ways; this is described in section 5.

The definitions in this document will serve as basis for technical specification of tools and demonstrators within ROSATTE and also as a template for future implementations.

Methodologies used in the document also include guidelines applicable for most road authorities taken into account the different pre-conditions at different authorities, in order for them to be able to implement a system that is compliant with the recommendations.

3. Functional viewpoint

3.1 Introduction and Scope

In ROSATTE deliverable D1.2, ref[11], the following high level use cases were defined:

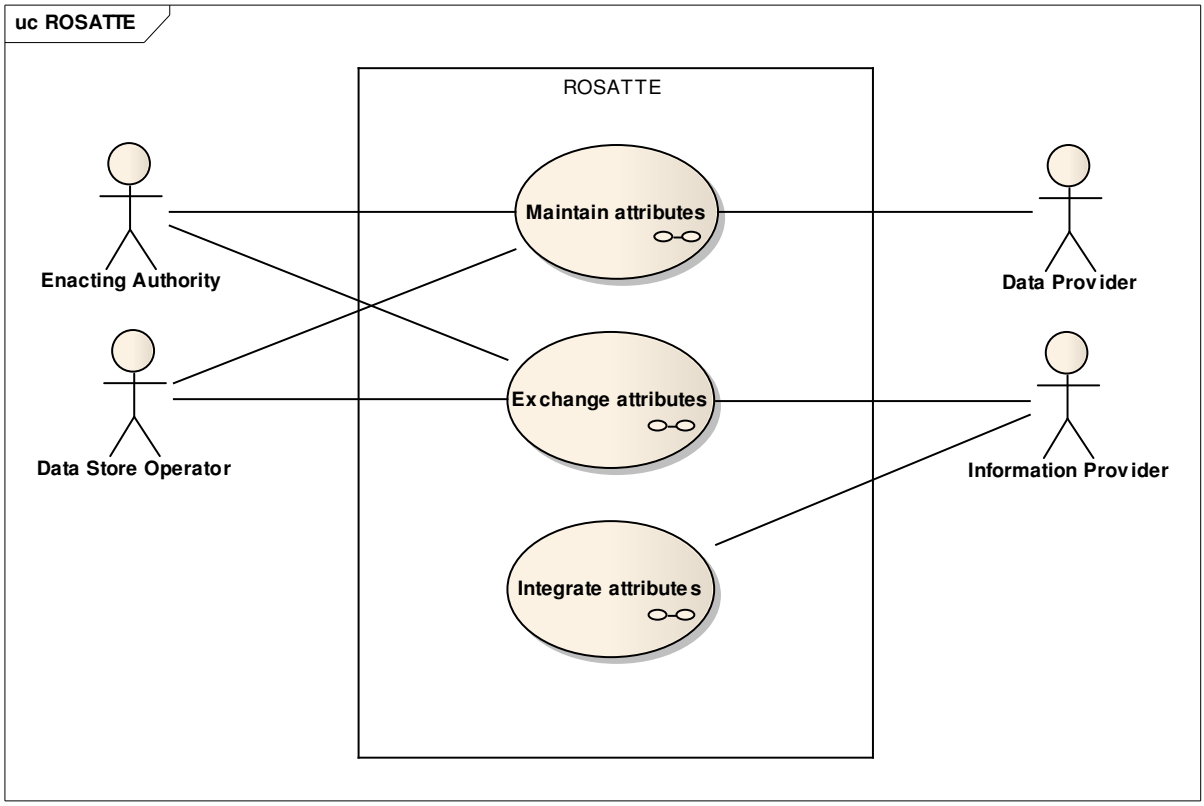

Figure 1 – Top level Use Case

This document focuses on the "Maintain attributes" use case and the associated roles (*Enacting authority, Data store Operator* and *Data provider*). Maintain attributes is mainly about keeping Data Store up to date. The use cases 'exchange attributes' and 'integrate attributes' are dealt with in separate deliverables (D3.1 and D4.1 respectively).

The description of the use case "Maintain attributes" are further detailed in this document.

3.2 Users and roles

The first definitions of relevant users and roles, and the connection between them, were done in ROSATTE deliverable D1.2 ref[11]. In the table below, the definitions made are developed further: some new Users and Roles are defined, some may be further elaborated or entirely changed.

Table 3 - Users and roles

Roles		Users	Comments Examples
Name	**Definition**		
Enacting Authority	Responsible for establishing (legal) traffic regulations The Enacting Authority can be responsible for editing and providing data to a data store, depending on the organization of responsibilities at the site. The EA can also be responsible for other sources of data like a traffic sign database.	Road authority or entity in charge of supervising the regulation of the road network	SRA in Sweden or OBB in Bavaria, municipalities, districts, state, police
Road Network Manager	Responsible for correct maintenance of traffic signs on the road network. He might initiate a request for regulations or may be initiating field surveys. The RNM (on an executing entity charged by him) can be responsible for editing and providing data to a ROSATTE data store, depending on the organization of responsibilities at the site.	Road authority or entity in charge of maintaining traffic signs on the road network	Municipalities, Motorway company in France, SRA in Sweden, OBB in Bavaria, districts, state, police *(Role essentially outside the scope of ROSATTE)*
Road network data Provider	Supplier of basic data to the ROSATTE Data Store Operator. The base data supplied include all data except for the safety attribute itself) e.g. digital road network, attributes necessary for location referencing etc.	Map provider, road authority or other organization.	Navteq, Tele Atlas, NPRA, land surveys, municipalities, others.
Field Surveyor	Entity carrying out field surveys for gathering of road data including those related to safety attributes from traffic signs on the road. He may be responsible for editing and providing data to a data store, depending on the organization of responsibilities at the site, e.g. in the context of an initial supply of safety attributes.	Private companies, road authorities, etc.	*(Role outside the scope of ROSATTE)*

Roles		Users	Comments Examples
Name	**Definition**		
(Local) Data Store Operator	Responsible for initiating and operating a Data Store in a specific region or for a specific network level. He is responsible for editing and entering data in the data store either by himself, e.g. as a service for the enacting authority or the road network manager (or others) in the region[2], or by supervising other partners in their own data entry activities. Responsible for delivering data to the central ROSATTE data store, if several data stores exist.	Road authority or other organization in charge of a data store that provides data to the ROSATTE data store.	Municipalities, Motorway company in France, SRA in Sweden, districts, state, police
ROSATTE Data Store Operator	Responsible for initiating and operating the central ROSATTE Data Store, which integrates data from all data stores in its constituency. The (central) ROSATTE data store operator can also include all roles of a local data store operator. He operates the service to deliver data to third parties (information providers) via the ROSATTE interface.	Road authority or other organization in charge of the central ROSATTE data store Also responsible for establishing suitable metadata for its data store and for providing these to the Metadata store operator	SRA in Sweden, OBB in Bavaria Autoroutes trafic in France
Metadata Operator	Responsible for handling Metadata and operating the Discovery Service.	Road authority or other organization in charge of the service that provides data to Information Providers.	INSPIRE requires public authorities to take on this role. Metadata operation on ROSATTE (road safety attributes) would then be one topic within a number of INSPIRE topics (roads, in general, environment, water…)
Information Provider	Responsible for the integration of Safety Attributes with other data and provision of it to Service Providers	Map Provider	Navteq, Tele Atlas Receives data in ROSATTE-format *(Role outside the scope of this document)*

[2] E.g. by offering a service where faxed information on new traffic regulations received from local authorities are entered in to the data store.

3.3 Entities

In addition to users and their roles, a few additional entities are defined.

Table 4 - Entities

Entity		Description
Name	**Definition**	
(Local) Data Store	Data store with road safety attributes in a specific region or for a specific network level. Source of data to the central ROSATTE Data Store.	Local, regional databases etc. Optional, exists if a distributed organization is used. Note: Depending on the decentralization of the data store organization, there may be several data stores for each region/network level. Alternatively, no local data stores exist, rather all operations are done centrally in the ROSATTE data store.
ROSATTE Data Store	Data store with road safety attributes for all network levels and sub-regions in one region. It integrates information from local data stores and also allows direct entries in the ROSATTE data store (e.g. for one specific network level) The ROSATTE data store also offers the ROSATTE service to information providers	The central database that stores data compiled from one or several other databases. The central ROSATTE data store may be on the level of a region, a state or a country. It only should include all safety attributes from all network levels in its constituency. Note: it may be the only data store, depending on the centralization of the organization, i.e. no local data store exists.
Meta data service	Discovery and metadata service for ROSATTE data	Should be integrated with other INSPIRE metadata services.

3.4 Use Cases

3.4.1 Identified Use Cases

Maintain attributes concerns the initiation of the ROSATTE Data Store, the data import, the maintenance of attributes, and the quality management of road safety attributes up until the point where they are provided according to the ROSATTE-format. In addition, reception of feedback is a part of this use case scenario. The figure below is a development of the Use Case view identified in the ROSATTE deliverable D1.2, ref[11]. Based on input from test sites and participating organizations a number of new Use cases are identified as can be seen in the figure below.

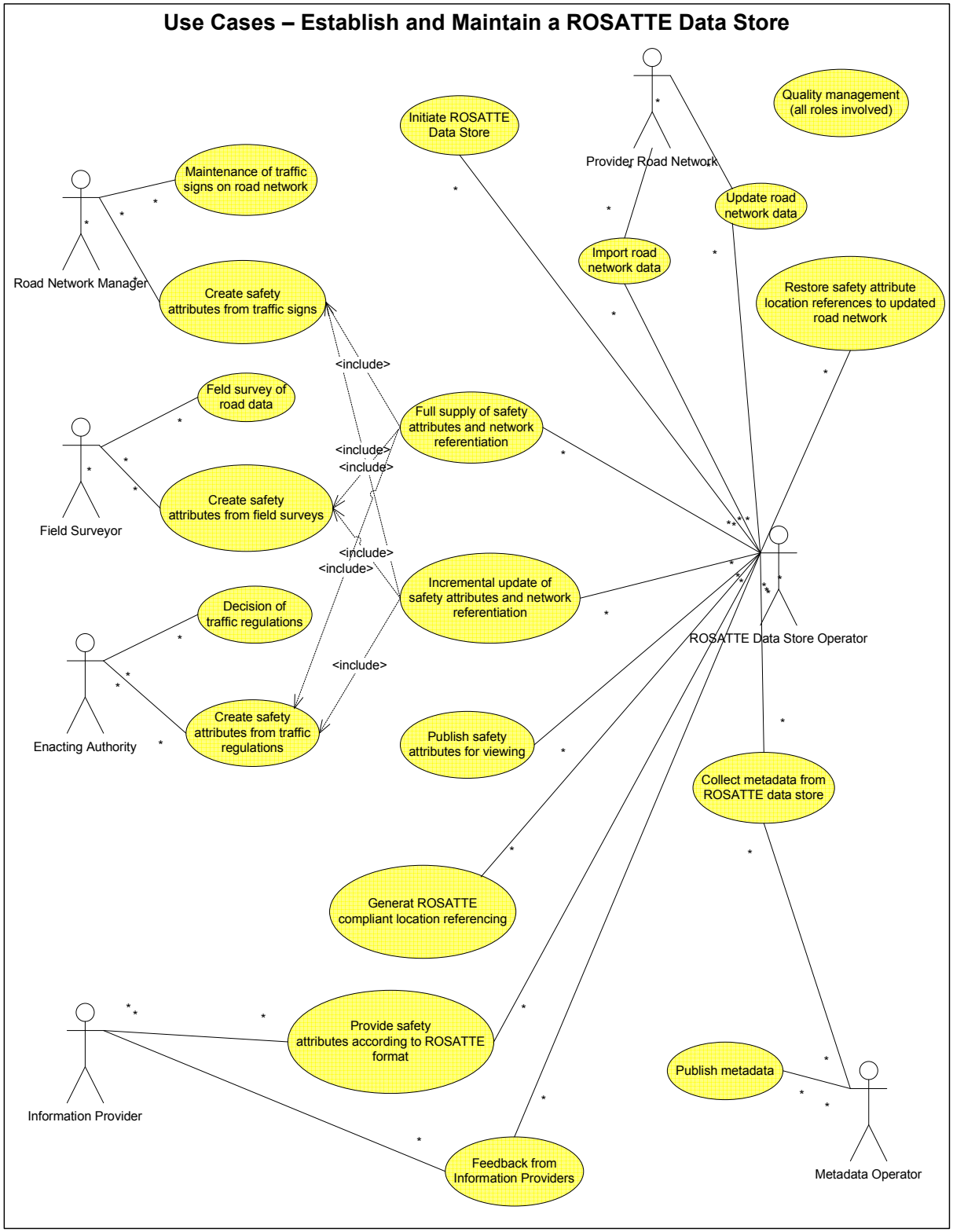

Figure 2 – Use cases in "Maintain attributes"

In the table below each Use case is defined and described. Not all use cases are relevant for all countries and regions in Europe.

Table 5 - Use cases in "Maintain attributes"

Name	Description	Roles involved
Decision of traffic regulations	The enacting authority proclaims new traffic regulation.	Enacting authority
Maintenance of traffic signs on road network	The Road Network Manager initiates the physical installation and maintenance of road equipment, traffic signs etc. on the road network, e.g. due to new traffic regulation.	Road Network Manager
Field survey of road data	Road data including those related to safety attributes are gathered from field surveys.	Field Surveyor, road network manager
Initiate ROSATTE Data Store	The initiation includes operations such as initiate hardware and software structures necessary to store attributes and to communicate with the other ROSATTE components.	ROSATTE Data Store Operator
Import road network data	Digital road network and other necessary data (as those road features/attributes, which are required by ROSATTE location referencing method (AGORA) are imported from road network Data Provider.	Local Data Store Operator or ROSATTE Data Store Operator, Provider Road network
Full supply of safety attributes and network references	Filling of the data store with a full coverage of safety attributes and their location information. This is done initially when a ROSATTE data store is set up. A full supply at regular intervals (where all old information is replaced) is also conceivable, but is not considered a normal workflow. Full supply of data typically includes automated imports and transformation of safety related content (traffic signs, field survey…) from external sources Depending on the situation it may include the use cases • create safety attribute and network reference from field survey data • create safety attribute and network reference from traffic sign database • create safety attributes from other sources, e.g. manual notes on analog maps my also be used (not explicitly modeled as use case here!) The use of traffic regulation documentation for an full/initial supply is principally possible if a traffic regulation data base exists (alternate workflow)	Local Data Store Operator or ROSATTE Data Store Operator, Enacting authority or Field surveyor or Provider Road network
Incremental update of safety attributes and network references	Stepwise update of specific safety attributes and locations in the data store when as soon as changes occur in the real world. Update operations include insert, modify or delete. Usually this includes the use case • create safety attributes from traffic regulation (though this is considered not very practicable for full supply) Incremental updates from traffic sign databases or field survey data may also be used (alternate flow).	Local Data Store Operator or ROSATTE Data Store Operator, Enacting authority or Field surveyor or Provider Road network

Create safety attributes and network references from field survey data	Safety attributes are extracted from field survey data and entered to the ROSATTE data store. Details of the safety attribute are defined and introduced in the database. The network reference of the safety attribute is created to describe the location. The use of field survey data will require specific rules and transformations for converting the source data into safety attribute data and proper network references (instead of geo-references). The use case may also include 'graphical editing of safety attributes' as an alternate workflow	Local Data Store Operator or ROSATTE Data Store Operator, Field Surveyor
Create safety attributes and network references from traffic signs	Safety attributes are extracted from a traffic signs data base and entered to the ROSATTE data store. Details of the safety attribute are defined and introduced in the database. The network reference of the safety attribute is created to describe the location. The use of traffic sign data will require specific rules and transformations for converting the source data into safety attribute data and proper network references (Usually a number of point objects (representing traffic signs, described by a coordinate pair geo-reference) need to be transformed into a linear location which describes the total geographic extent of the safety attribute). This linear location needs to be expressed as indirect reference to the road network. The use case may also include graphical editing of safety attributes as an alternate workflow	Local Data Store Operator or ROSATTE Data Store Operator, Road Network Manager
Create safety attributes and network references from traffic regulations	Safety attributes are imported extracted from traffic regulation documents and entered to the ROSATTE data store. Details of the safety attribute are defined and introduced in the database. The network reference of the safety attribute is created to describe the location. The use of traffic regulations will require some rules to determine the content of safety attribute data and proper network references. It is done either during the establishment of the content of the regulation (actor: enacting authority) or once a regulation has been passed/enacted (actor: enacting authority or data store operator). In this case the content of the regulation has to be accessible to the data store operator. This creation of safety attributes is considered the preferred way to provide incremental updates for safety attributes in the data store. It is usually done by manual editing of data in the data store e.g. via a graphical interface. (main workflow)	Local Data Store Operator or ROSATTE Data Store Operator, Enacting authority

Generate ROSATTE compliant Location referencing	An on-the-fly location (AGORA) reference is generated for a safety attribute in the ROSATTE data store. This is done using an on-the-fly location referencing (AGORA) encoder, which uses the digital road network (including specific location referencing attributes) of the ROSATTE data store to create a map-independent location reference. The location reference may be generated when a safety attribute is entered/edited and permanently stored in the database. Alternatively this may be done later-on once the safety attribute shall be exchanged via the ROSATTE data exchange.	Local Data Store Operator or ROSATTE Data Store Operator
Update road network and location referencing attributes	The digital road network and the location referencing attributes must be updated continuously to represent the changes in the real road network. This can be done by a full update of the network in longer (regular) intervals or by incremental update of the road network depending on the supplier of the road network data.	Local Data Store Operator or ROSATTE Data Store Operator, Provider Road network,
Restore safety attribute location references to updated road network	When the digital road network has been updated, references of safety attributes to the road network in the data store which have been altered by the road network data changes, need to be restored (re-'attached') to fit to the updated road network data. This can be done using different techniques, which are not described here.	Local Data Store Operator or ROSATTE Data Store Operator
Feedback from information providers	Information providers may provide feedback concerning success and quality of road safety attribute from their integration of the safety attributes in their road data bases. The feedback must be received and conflicts arising from this feedback need to be handled. The ROSATTE Data Store Operator receives the feedback and should send it further on to Enacting Authorities and to local Data Store operators when such exist. In absence of Local Data Store operators he may correct errors in the data store directly.	ROSATTE Data Service Operator, ROSATTE Data Store Operator, , Enacting authority, information provider
Publish road safety attributes for viewing	Road safety attributes of the data store are made available for public or authorized viewing e.g. on a website.	ROSATTE Data Store Operator
Provide data according to ROSATTE exchange mechanism	The Safety attributes are formatted and transferred according to the ROSATTE exchange format and exchange methods to the information provider.	ROSATTE Data Service Operator, information provider
Collect metadata from ROSATTE data store	Metadata like quality characteristics are established and updated.	ROSATTE Data store operator, Metadata operator
Publish metadata	Metadata are made available for the Discovery Service. Notification is generated and sent to the Data Service.	Metadata Operator, Discovery Service

Quality management	This use case is included in all import and editing operations at all levels	All roles

4. Process viewpoint

4.1 Introduction and Scope

The process view in this document is a further refinement of the process viewpoint Maintain attributes, defined and initially described in D1.2, ref[11]. It also elaborates on the use cases presented in the previous chapter. While the use cases define the functionalities and what roles are responsible for them, the process view describes a sequential order of these functionalities together with the relevant information elements flowing between the functionalities.

The process view is drawn as a UML activity diagram and uses a pragmatic approach where we in addition to the regular control flow also use the object flow to illustrate information elements communicated between the functionalities.

4.2 Process description

The ROSATTE Data Store is initiated (hardware and software arrangements as well as management procedures). Digital road network and specific attributes needed for location referencing are imported to the ROSATTE data store. This data needs to be regularly updated to represent the current state of the road network.

An initial supply of safety attributes is then operated into the data store as the bases for future incremental updates.

It is typical assumed that an initial supply of safety attributes is made from field survey data, separate traffic sign databases or other locally available data (e.g. analog maps). Such data needs to be transformed into the information model of the safety attribute, in particular with regards to the location description.

Such a data set of safety attributes can then be updated by an exchange of data within an area (field survey data, traffic sign data) or by an incremental update preferable from newly issued or changed traffic regulations. Also here, a transformation of the content in the regulation into the information model of the data store is necessary.

A traffic regulation is decided by an enacting authority and a road network operator does the actual physical installation and maintenance of traffic signs on the roads.

In both cases (initial supply and update), the process may be partly automated and partly requiring manual work of editing personnel.

In both cases safety attributes are stored into the database and a (indirect) reference to the digital road network in the data store is created, to describe the location in the road network. Typically linear referencing techniques are used to attach the safety attribute to the digital road network. In addition, geo-coordinates may also directly be stored with the safety attribute, but such a direct description of the location is not sufficient to create an on-the-fly location reference later-on.

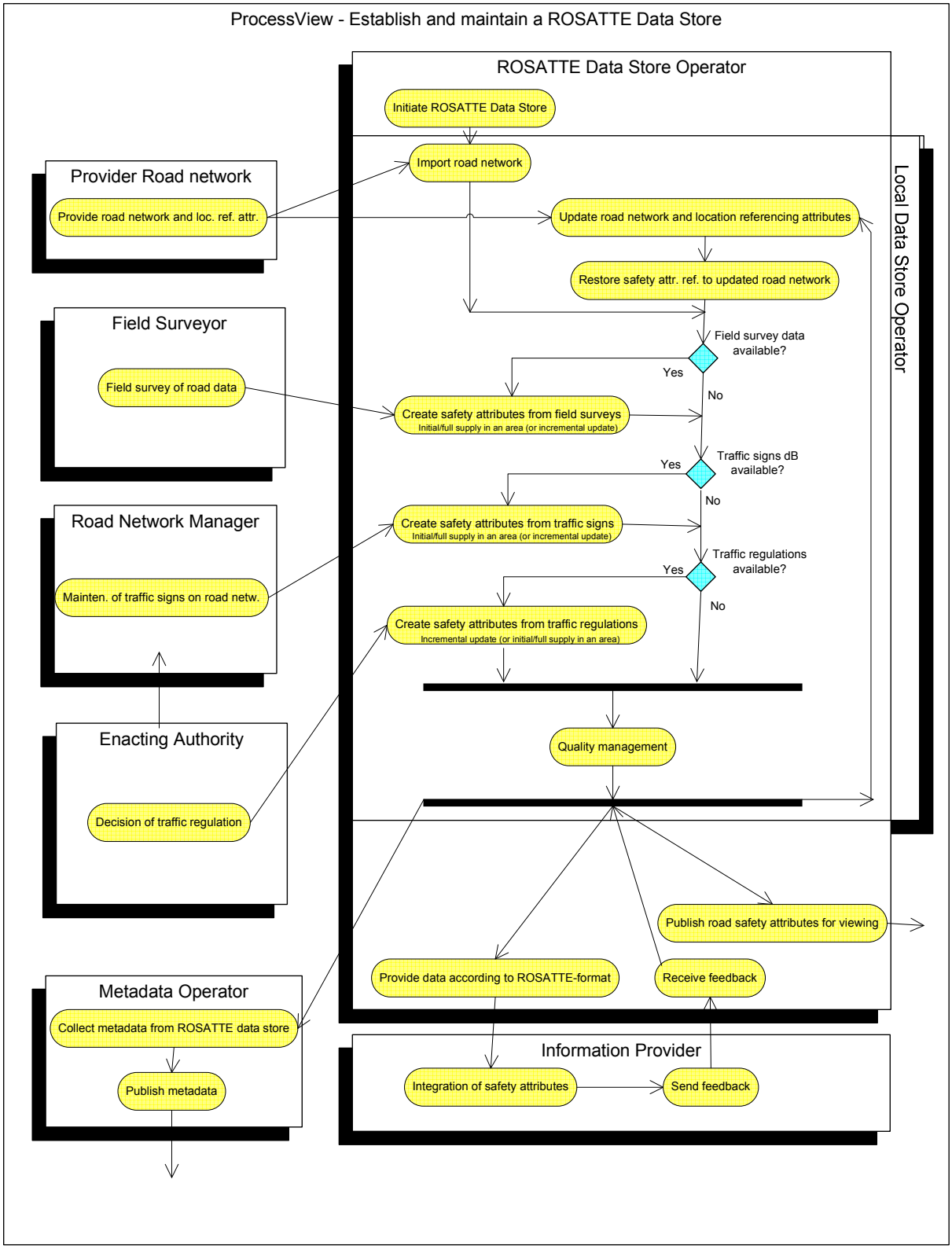

Figure 3 – Process Maintain attributes

Once the safety attribute is 'attached' to the network, a location reference code can be created from the location in the road network provided that it contains sufficient attributes for this location referencing method. This is done by using an on-the-fly location

referencing (AGORA)-encoder. This encoding may be done once the safety attribute is entered and the location code may be stored or alternatively the encoding may be done, once the data shall be exchanged.

Note that the ROSATTE data store may consist of a hierarchy of data store. E.g. local data store with limited regional coverage and a central data store, which integrates all data from the local stores. In such a scheme, the compilation of data from local data stores in the central store may happen incrementally with similar mechanisms as used for ROSATTE data exchange to third parties. Functionality for incremental updates is crucial to be able to maintain the ROSATTE data store.

Once the safety attributes are part of the ROSATTE data store, they can be viewed or edited if needed for internal or quality management purposes.

Secondly they can be made available for third parties either for viewing (publish for viewing) or for actual delivery of data for further use in other data bases, (provided to Information providers via the ROSATTE exchange infrastructure).

In parallel, meta data on the safety attributes need to be gathered and made available to the metadata services, to allow other potential information provider to discover the ROSATTE service as a data resource.

Information providers integrate the safety attributes exchanged into their database. In case of errors, inconsistencies or conflicts, they may provide feedback to the data store operator, which handles the feedback and might send it further on to its suppliers of data.

All the above operations are highly dependent on proper quality management procedures to ensure that the data has sufficient quality.

5. Information viewpoint

In the Information viewpoint, important aspects concerning data are evaluated along with the definitions of conceptual data models. Specifications of different safety attributes are not done in this document; it is specified in D3.1.

The conceptual data model of the data store holding the safety attributes should be as close as possible to the conceptual data model for ROSATTE data exchange. The closer the two sides are, the less transformation is needed and the less problems with quality will arise with the data exchanged. The following description uses therefore the concepts in D3.1 for data exchange and extends them to describe the preferred way to store data in the data store that makes it possible to export data to the ROSATTE data exchange format with a minimal transformation effort. This conceptual data model is **not** in itself a description of the ROSATTE data exchange format.

Figure 4 gives an overview of the elements which are part of a data store.

The importance of a digital road network and how to deal with location referencing are discussed in chapter 5.1 and 5.2. This is reflected in the conceptual model of Location Referencing below.

The data store has to include the information about the safety attributes describing the current situation along a road which will be valuable for the driver.

The data store also has to contain mechanisms to create changes which are then exchanged as incremental updates with partners.

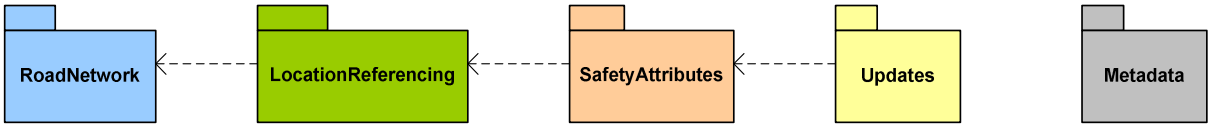

Figure 4 - An overview of packages to be modelled in the data store

5.1 Road Network

5.1.1 Overview

The road network in the ROSATTE data store is a means to describe the location of a safety attribute by attaching it to the network through indirect (usually linear) referencing (see below). With this, it becomes possible to generate on-the-fly location references, which can be shared with other (conceptionally similar) road networks. Depending on the on-the-fly location referencing method used, specific requirements arise for the network description.

Stable identities for network-elements in the ROSATTE Data store, are necessary, especially if the road network needs to be regularly updated, to limit the work for reconstructing the logical references to the updated road network.

The basic standard for modelling digital road networks is defined by ISO TC211 and the standard is called ISO 19133 Location based services , tracking and navigation, ref.21. The location referencing method used in ROSATTE uses some concepts of GDF, which then

would need to be introduced in a network description according to ISO 19133. The GDF-standard is called ISO14825 and it is defined by ISO TC 204, ref.20.

5.1.2 Conceptual data model

Indirect referencing of safety attributes using linear references requires a digital road network consisting of road-links and road-nodes. Routes consisting of a number of road-links can also be defined. Both geometry and topology are necessary and have to be modelled.

If the same digital road network is used in the ROSATTE Data Store as at the Information Provider, common linkIDs could be used when providing respectively receiving safety attributes. This will only rarely be the case.

In the case of AGORA, which is the preferred on-the-fly location referencing method in ROSATTE, the digital road network database needs to contain geometry and topology of the road segments. This is needed to allow shortest path algorithms (routing) to be performed in the network. In the case of AGORA, also the description of road segments by their 'form of way' and 'functional road class' is mandatory. If the data base used does not contain such information a priory, it needs to be added. The definition of these two attributes comes from the GDF standard.

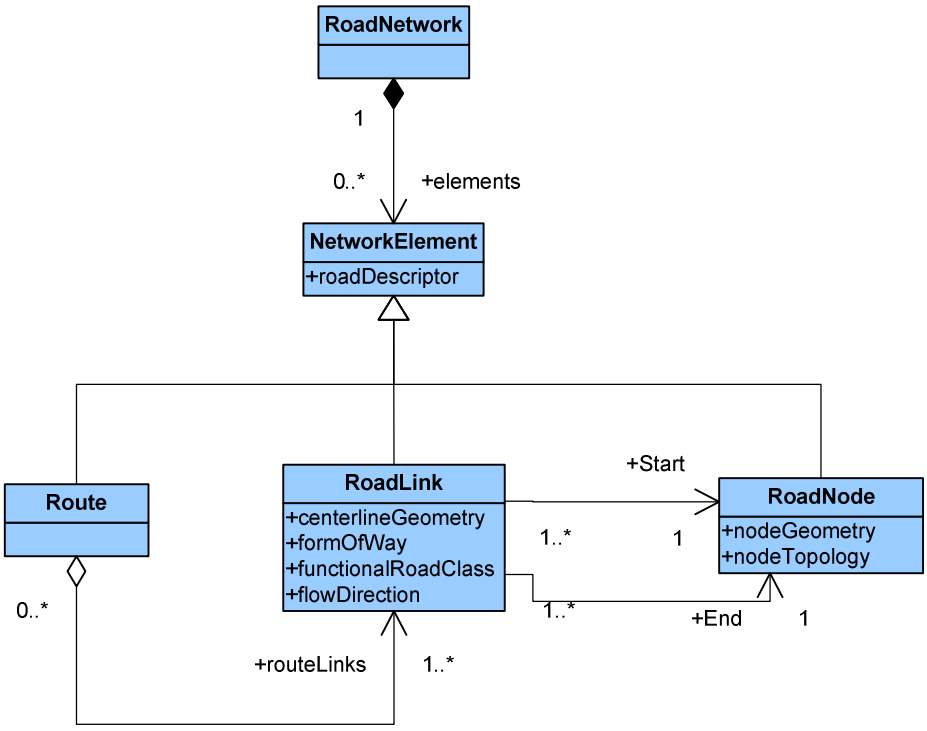

Figure 5 - Conceptual model of Road Network

The structure sketched here provides the basic concept in a very simplified way. Links are connected by nodes. Routes are a (sorted) composition of (connected) links, which may be used as a means for linear referencing. For more detail on the information model of the road network please refer to the standards ISO 19133, ISO14825 and the specifications in EuroRoads [ref.15], which also provides a good entrance to the subject.

5.2 Location references

5.2.1 Overview

In a data store, basically two methods of referencing are possible:

- Indirect referencing towards a digital road network (e.g. linear referencing). Through this indirect reference the geographical position and other local features at the location can be deducted from the underlying digital road network.
- Direct geographical referencing of the safety attributes, which means that position (coordinates) and other features at the location are directly stored with the safety attribute itself. These data (position and additional features) could be identified from on-site field survey and inspection or deduced using a mapping service, but usually would not require storing a digital road network together with the safety attributes in the data store.

With the requirement to be able to transfer locations to other road networks, a simple direct geographical referencing approach (position + some attributes such as heading and street name) appears not to be sufficient but a more complex location referencing technique is needed.

In the past years different approaches have been trialled to overcome this problem and to create such a 'complex' location references transferable between network databases. The AGORA approach ref[19] and ref[18], which appears the most promising, relies amongst others on a set of surrounding positions, which are identified according to a set of rules in a digital road network, as well as additional features of the road network at these positions. These positions and attributes then enable the reconstruction of the location in other road network databases.

In the source data store, it is therefore assumed that locations are stored as indirect location references. For transfer, these are transformed into a complex (direct) location reference (AGORA reference code), which is then again decoded into an indirect location reference on the receiving side (information provider).

As a result, compliance with ROSATTE leads to the general recommendation that in the ROSATTE data store indirect referencing to a road network (i.e. linear references) is used. Then, a location reference encoder can be used which uses the digital road network in place. The encoding is an automated process which can take place any time, independent of data maintenance. The generated location reference code may not be needed to be stored in the local data store since it can be (re-)generated any time from the indirect (linear) reference and the respective road network.

When using indirect location references in the data store, the geometry for the safety attributes is taken from the road network. Despite of that, when available it could be a good idea to store the original geometry of a point attribute and the original geometry of the startingpoint and endingpoint of a line attribute. "Original geometry" can be available if the geometry of the attribute is measured in a field survey independent of the road geometry.

Yet, **if direct referencing is still preferred** for position storage in the ROSATTE data store , an on-the fly location reference code could be generated by using an external service. Providing the location of an attribute unambiguously to this service requires manual intervention, e.g. positioning on a graphical map interface provided by this service. In return, the service could then generate and return a location reference code which is

stored in the local data store as attribute to the road safety attribute. This alternate workflow is not described in further detail in this document and not recommended further.

5.2.2 *Conceptual data model*

Indirect location referencing means a data store where safety attributes are referenced to a road network objects, e.g. by linear referencing. The light-blue part of the model describes this. The measure-value(s) defines where on a network-element the instance of the safety attribute starts and ends.

Using direct location referencing in a data store, implies that safety attributes are stored as geographical objects and all direct location referencing information (geo-references, i.e. the step-points of a polyline) are stored together with the safety information. The light-green part of the model describes this. In the case of direct referencing, location referencing attributes like road number, functional road class, etc. have to be stored together with the safety attributes as a complement to the actual geometry (coordinate-pair). Instead of storing separate location referencing attributes an Agora-string (according to the specification in D3.1) can be derived and stored together with the geometry. This is not considered a recommended practice and is not described in further detail here.

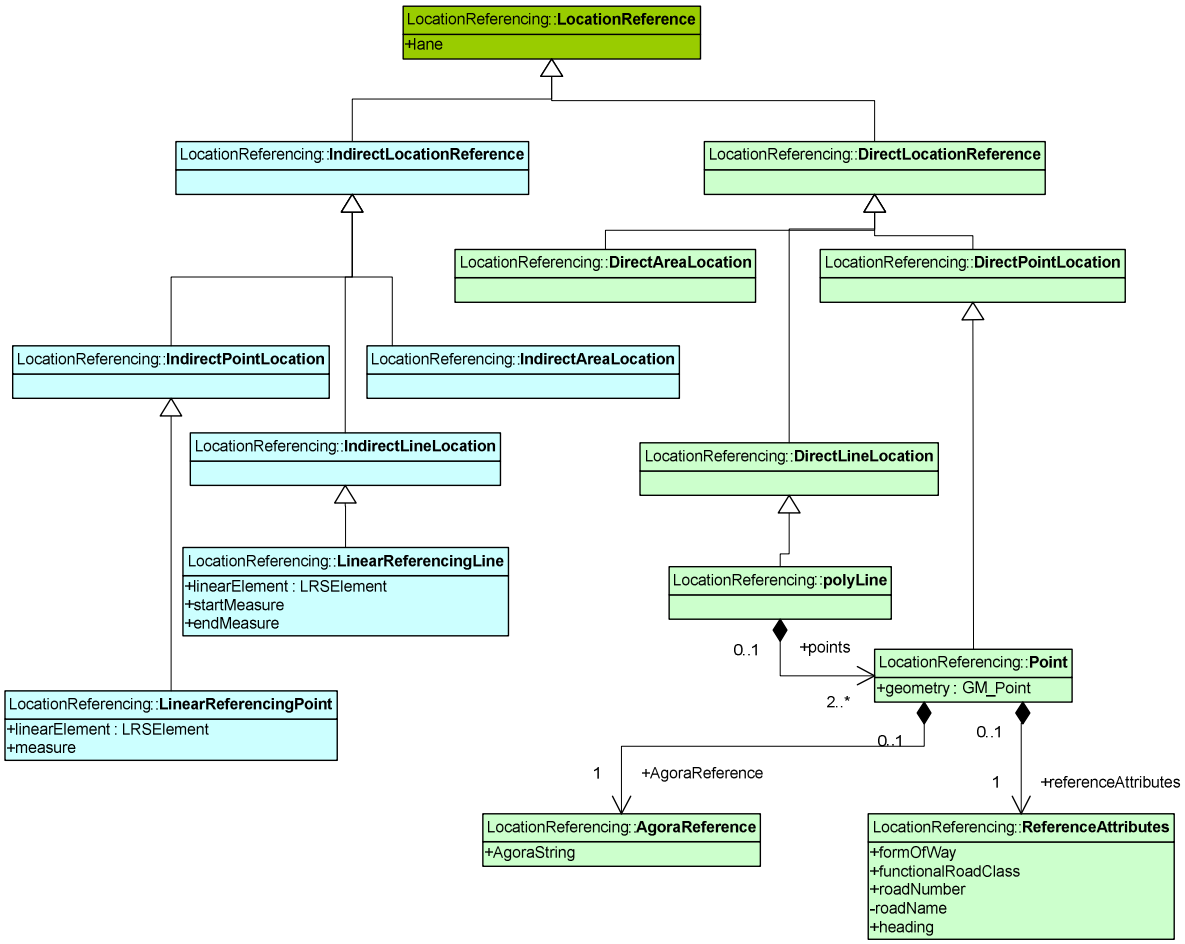

Figure 6 - Conceptual model of Location Referencing

5.3 Safety attribute

5.3.1 Overview

Below is a table with safety attributes identified as interesting for in-vehicle ADAS-applications.

Table 6 - Safety attributes for in-vehicle ADAS applications

Safety Attributes	Example of ADAS application	Change frequency
Speed limit	Speed alert	Very high (7-9% / year)
Traffic signs	Enhanced navigation (e.g. truck)	High
Lane information (number, width, divider, connectivity)	Lane keeping assistance, Lane departure warning, Curve warning	Medium
Traffic lights	Intersection assistance	Medium
Crossings (pedestrian, tram)	Enhanced navigation Vulnerable road-users protection	Medium
Toll barriers, motorway junctions, tunnel access	Obstacles / change of lighting / speed limit / inter-vehicle distance management	Very low (new road or reshaping)
Gradient (slope)	Curve warning Fuel consumption assistance (car and truck)	Very low (new road or reshaping)
Transverse gradient (banking)	Roll-over warning system (truck) Curve warning	Low (new road or reshaping)

Source: ROSATTE annex 1, 2007 ref[9], slightly different than a table defined in Maps and ADAS ref[13]

From the list of safety attributes described in Table 4, it was agreed by data providers (mainly road authorities as data owners) and data users (map providers, vehicle industry and road authorities) that this project needs to address the attributes with the highest priority market demand and focus on a limited number of safety attributes characterized by a high change frequency:

- Speed limits
- Other traffic regulations and signs relevant to road safety.

The focus in test sites will be on these attributes, but some other attributes like Traffic lights and Crossings might also be provided from some ROSATTE test sites.

The intention is of course to establish exchange format's which are flexible enough to enable the provision of a number of other kinds of attributes, although that will not be tested in ROSATTE test sites.

More precise definitions of a specified number of safety attributes can be found in D3.1.

Source for a safety attribute in the data store can be:

- Legal traffic regulations *and/or*
- Field survey of actual road conditions
- A traffic signs data base.

As seen in the conceptual data model below, type of speed limit, validity, vehicle, driver, weather condition, etc. are interesting parameters for speed limits. For temporary speed limits start- and expire-time are necessary.

5.3.2 Conceptual data model

Examples of safety attributes are shown in Figure 7.

The validity of a safety attribute can be a rather complex description of the time-periods, (months, weekdays, hours, etc.) of when a specific instance of a Safety Attribute is valid.

Legal traffic regulations are both implicit (e.g. 50 km/h in all urban areas where no other regulation overrides it) and explicit (a regulation for a specific part of a road). Explicit traffic regulations are sign posted on the roads, although the location of the sign post and the location of the regulation might differ depending on for example where it is practical to actually set up a sign post. Sign posts often repeat information shown on other sign posts. When storing information relevant for safety, there is no need to store all sign posts.

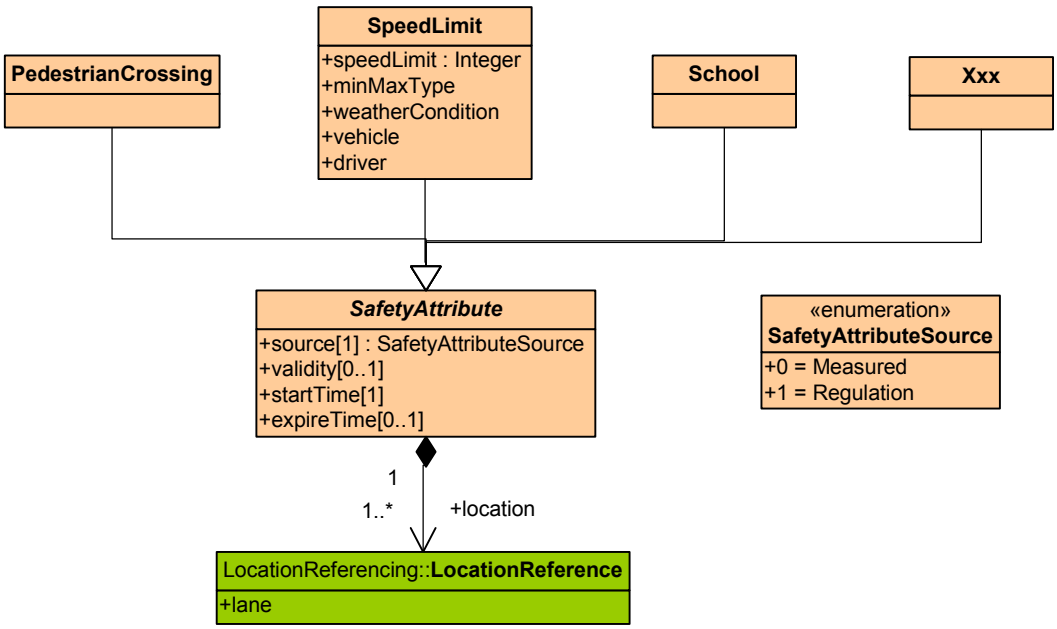

Figure 7 - Conceptual model of safety attributes including some examples

5.4 Update information

5.4.1 Overview

Incremental updates can be provided either through record update events or by comparing different database states. In the case of record update events it is necessary to store information that describes when a safety object is added, modified or deleted. The other option is to send updates as batches of increments created from a process comparing the latest version of a dataset to a previous one.
A full supply of safety attributes as initial supply to an information provider who has no such data at all, is also handled via this concept. All objects, which initially exist before

the updating starts, can be modeled as a large number of 'inserts'. Hence no different exchange mechanism/format is foreseen for full supply.

5.4.2 Conceptual data model

The model below describes the situation with record update events. A transaction with a timestamp defines when every safety object is added, modified or deleted in the ROSATTE Data Store.

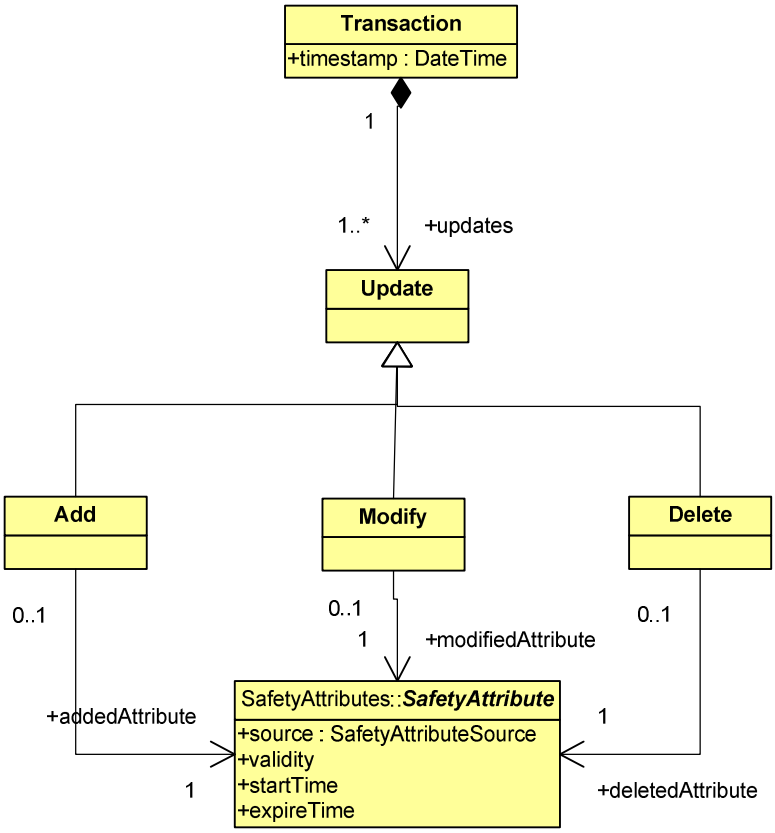

Figure 8 - Conceptual model of Update information

5.5 Metadata

Metadata describes the actual content of the data store and the characteristics of the content. This includes e.g. spatial, temporal and thematic extents of the content.
Quality parameters like Availability, up-to-dateness, completeness, consistency, correctness and accuracy are a part of metadata (definitions and descriptions of these parameters will follow in other deliverables).

6. Component viewpoint

6.1 Introduction and Scope

This viewpoint focuses on typical components and techniques that constitute the attribute maintenance system.

Components described in this view include:

- Databases
- Interfaces
- Applications/tools
- Services

6.2 Component description

6.2.1 Overview

Figure 9 describes a general component view.

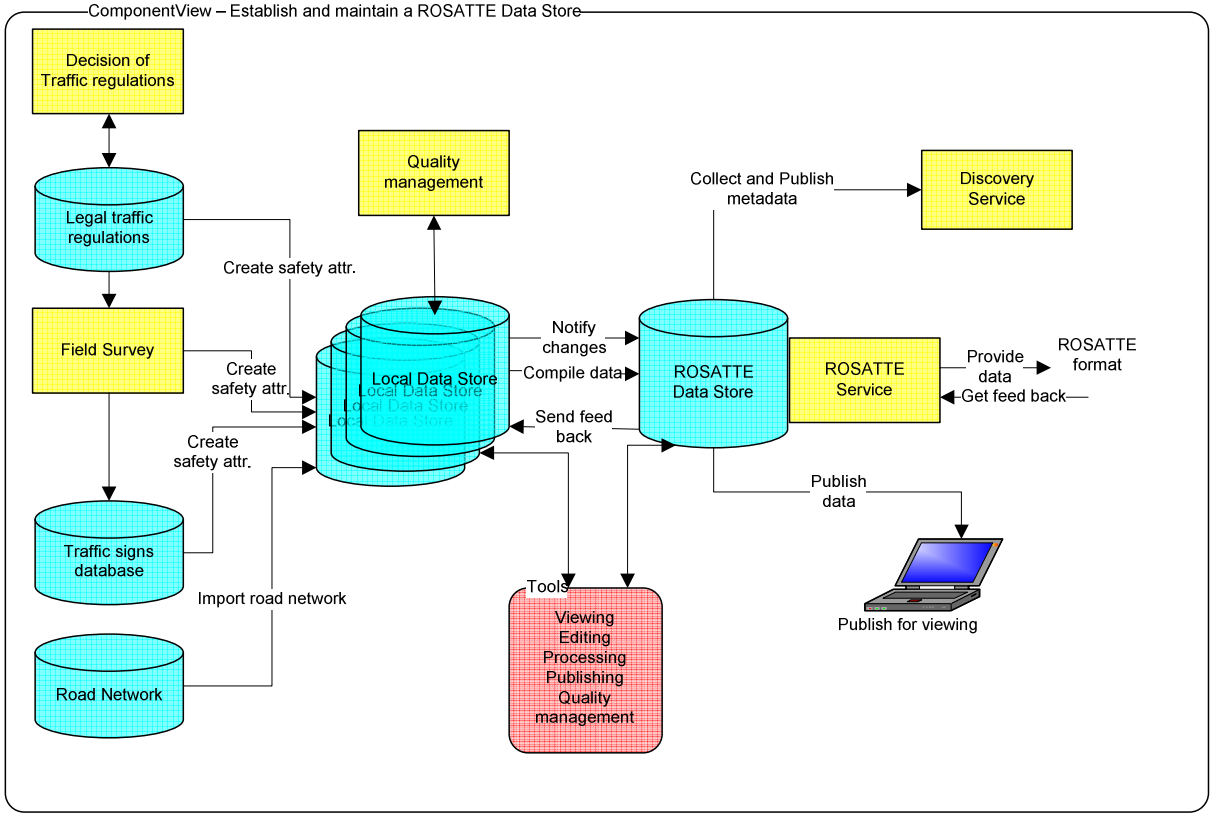

Figure 9 - General Component view

6.2.2 Components and interfaces available to local data stores or to the ROSATTE data store

Some of these components, but not necessarily all of them, should be available to the data store operators:

- Databases from where a digital road network and location referencing attributes can be loaded. It is recommended to store temporal data or change logs to make incremental updates of the road network possible.
- Files with field survey-data. Initial supply of data to a data store is often done from field survey data. Field surveys can be done as repeating full surveys of areas or more ad hoc surveys from small areas. Import of field survey measurements usually means a full exchange of data along the measured roads, although a comparison with existing data in the data store could be valuable before choosing newly measured data and deleting old data. Incremental updates from field survey data are less probable.
- Databases with traffic signs. Initial supply of data to a data store can be done from a traffic signs database. Updates from a traffic signs database probably means full exchange of data in an area. Incremental updates are less probable.
- Traffic regulations - local, regional, national depending on the current situation. Traffic regulations can be extremely complex. They have to be stored in a way that enables creation of safety attributes as incremental updates from them. A full supply of data from traffic regulations is less probable.

6.2.3 Local data stores, the ROSATTE data store and the interface between them

Local data stores are optional, but usually present with an interface between local data stores and the ROSATTE data store to enable incremental updates. ISO-standards are recommended for the interfaces. Incremental updates should be possible or alternatively a process comparing the states at two datasets is needed to extract the updates.

An alternative solution would be to totally omit the local data stores and instead operate one central ROSATTE data store where local operators (enacting authority, road network manager, field surveyors) can access data for viewing, editing and maintenance.

6.2.4 The ROSATTE data store and the ROSATTE service

Generation of data for the ROSATTE service can be seen as an internal activity in the ROSATTE data store. It involves the transformation of data in the data store into the information model and exchange format of the ROSATTE exchange. In case of updates to be transferred, ‘history’ information on the safety attributes, change logs or comparison of data base versions can be used to generate the relevant data for transfer.

7. Summary of Requirements and Recommendations

7.1 Introduction

Overall system requirements are defined in D1.2. These are divided into functional requirements, non-functional requirements (quality requirements) and context requirements. These requirements are not repeated in this document, although most of them are relevant for an organisation establishing a ROSATTE data store. In any case some of these requirements are the base for the following requirements and recommendations.

7.2 Requirements

Requirements put on an organisation establishing a ROSATTE data store:

- Functionality to receive and store safety attributes in the ROSATTE data store.
- The safety attributes should describe the information regarding road conditions valid at point locations and along segments of the road. (Can be created from traffic regulations, traffic signs databases or field surveys.)
- Store necessary data and establish mechanisms to be able to provide both full supply/total exchange of data and incremental updates from the ROSATTE Service according to the requirements defined in D3.1.
- Establish unambiguous location referencing that enables the safety attributes to be transferred from one digital road network to another digital road network. It should be possible to generate direct (on-the-fly) location referencing, which is required by the ROSATTE exchange format.
- Functionality for handling feed back from Information Providers.
- Define metadata describing the safety attributes in the ROSATTE data store.
- Declare the following quality parameters in metadata (definitions and descriptions of these parameters will follow in other deliverables):
    - Availability
    - Up-to-dateness
    - Completeness
    - Consistency
    - Correctness
    - Accuracy
- Conformance with European law concerning the INSPIRE directive.

7.3 Recommendations

Recommendations for an organisation establishing a ROSATTE data store:

- Use a conceptual data model which is in line with or can be mapped to the conceptual model provided in this document in order to reach the required functionality.
- Specify quality management procedures to be used at all steps in the data chain.
- When available, use traffic regulation as the source for the safety attributes.
- As far as possible updates of safety attributes should be initiated by the enacting authority responsible for defining traffic regulations.
- Reference the safety attributes towards a digital road network, i.e use indirect (linear) location referencing in the data store.
- Use unique IDs for attributes to allow for incremental updates (add, modify, delete) along the data chain from the different local data stores to the ROSATTE data store.
- Model attributes representing the status of a segment along the road e.g. speed limit as line objects in the data store.

- The data model and tools at the ROSATTE data store should be flexible enough to allow for adding and handling additional safety attributes defined after the initiation of the ROSATTE data store.
- Use tools in the ROSATTE data store to be able to view and edit the safety attributes.
- Use tools in the ROSATTE data store to be able to publish safety attributes for viewing on websites etc.

8. Examples from planned Implementations at test sites

8.1 Swedish Road Administration

8.1.1 Process View

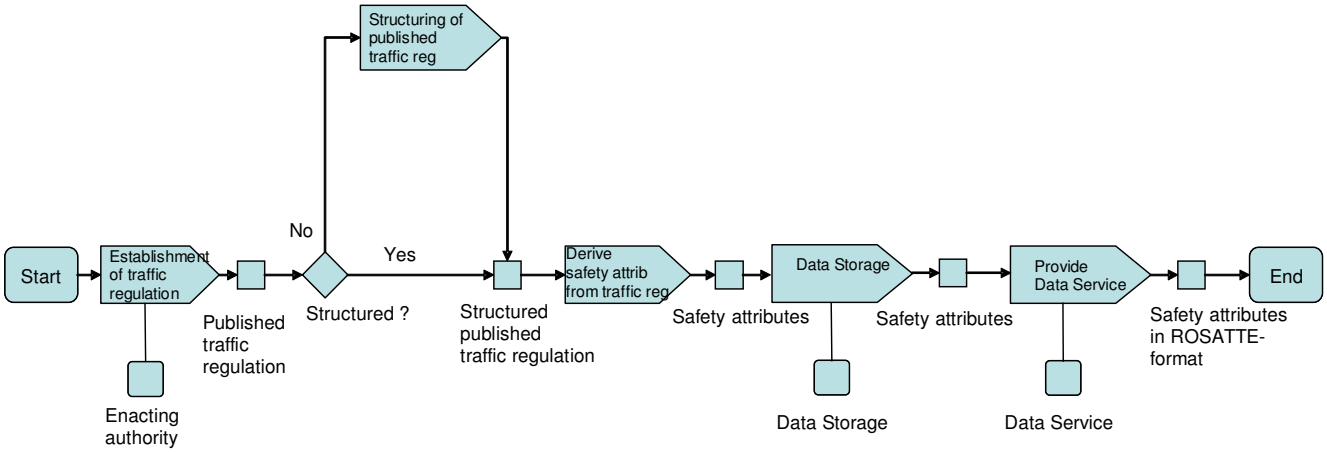

Figure 10 – Process view from Swedish Road Administration

8.1.2 Component View

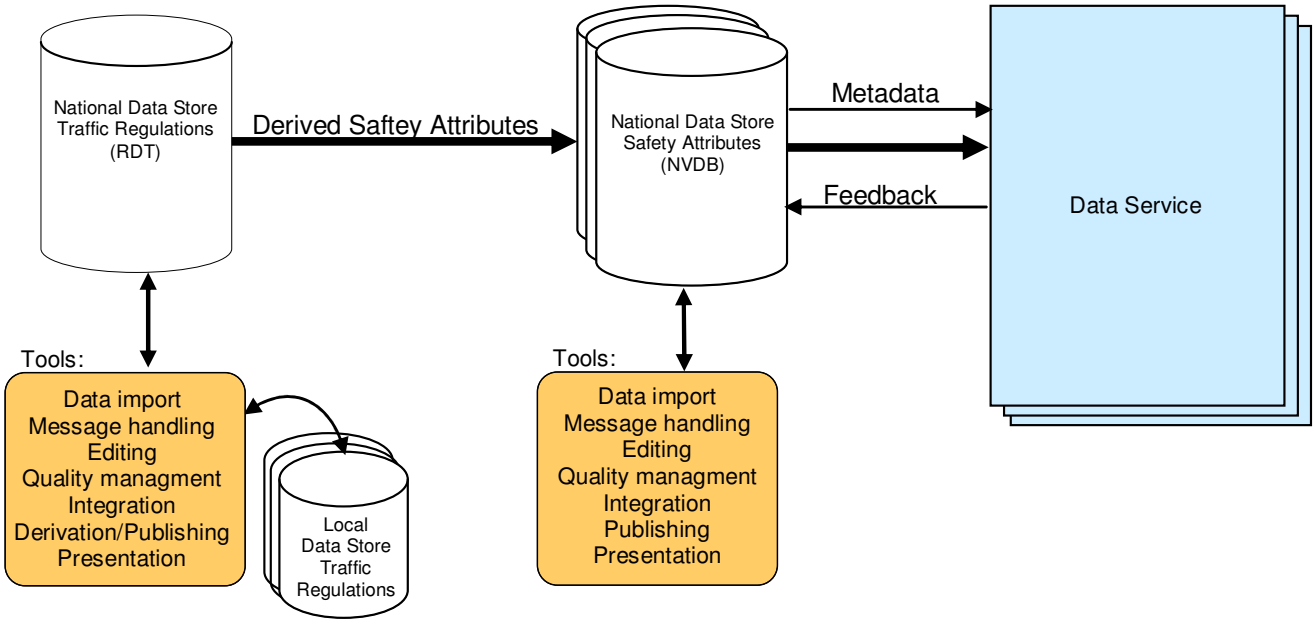

Figure 11 – Component view from Swedish Road Administration

8.2 Bavarian Board of Building

8.2.1 Process View

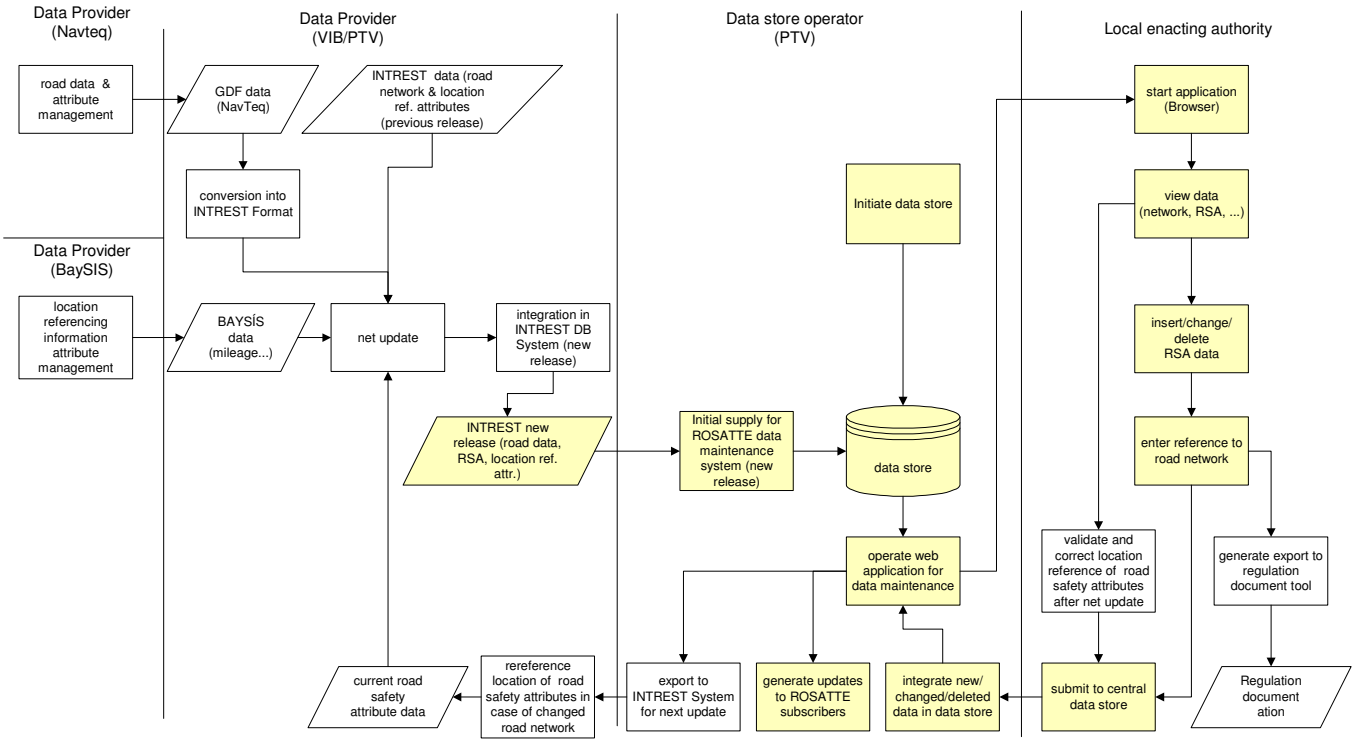

Figure 12 – Process view from the Bavarian test site

In TS Bavaria, the INTREST System operated by a public private partnership (Verkehrsinformationsagentur Bayern, VIB) has the role of a data provider and provides the road network data to the ROSATTE data store operator. VIB itself integrates road network data from a commercial data provider in regular intervals in the map update process with other data which are continuously maintained in the INTREST System by decentralised data maintenance partners (e.g. public transport data, bicycle and pedestrian roads etc.).
This map update process results in releases of the so-called 'INTREST map', which contains commercial map data blended with locally maintained data. Data layers from these releases are used in different applications and services (e.g. traffic management applications of the motorway authorities, intermodal traffic information services, etc.), including the ROSATTE data store operation. With the start of the ROSATTE data store operation, the data content of is therefore initially filled from an INTREST release with the road network and speed limit.

This central data store is used by the ROSATTE web application. Enacting authorities can use the web interface for viewing and editing speed limit objects in the central ROSATTE data store. The data entry on the web interface is made during the establishment of the regulation documentation and the graphical representation of the edited speed limit can be exported and used for documentation purposes in the regulation documentation. With the data entry on the web interface the referencing to the INTREST road network is established as a linear reference (chain) which is stored in the ROSATTE data store after the editing session (submission).

A separate application operating on the ROSATTE data store regularly extracts updates from it, converts them and supplies to information providers according to the ROSATTE

exchange specification. In regular intervals the speed limits data layer are fed back to and integrated in the main INTREST database for map update. Once a new map release is made, it is imported into the ROSATTE data store.

8.2.2 Component View

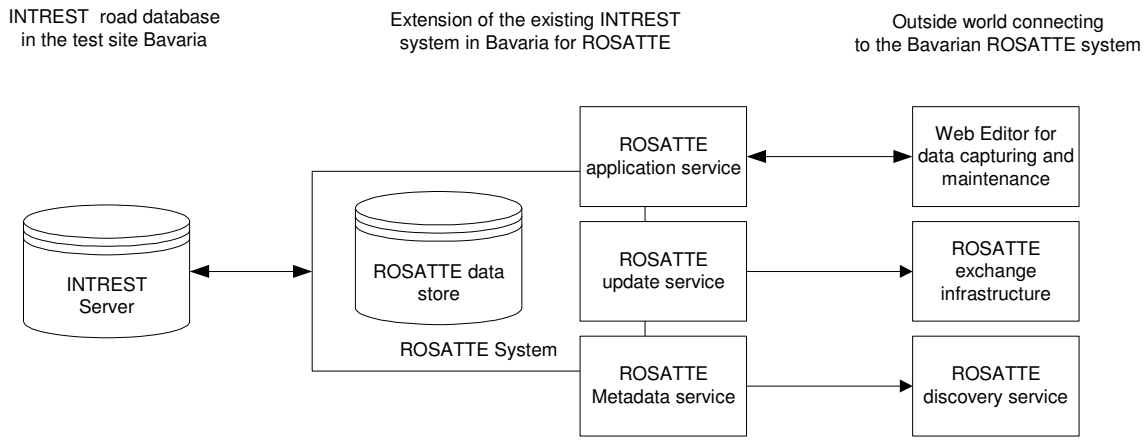

Figure 13 – Component view from the Bavarian test site

8.3 Flanders

8.3.1 Process View

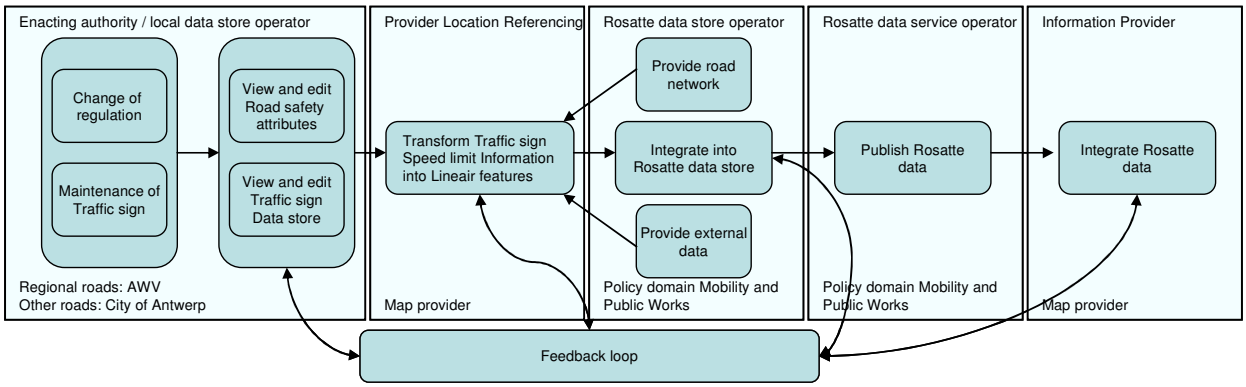

Figure 14 – Process views from test site Flanders

8.4 ASFA

8.4.1 Process View

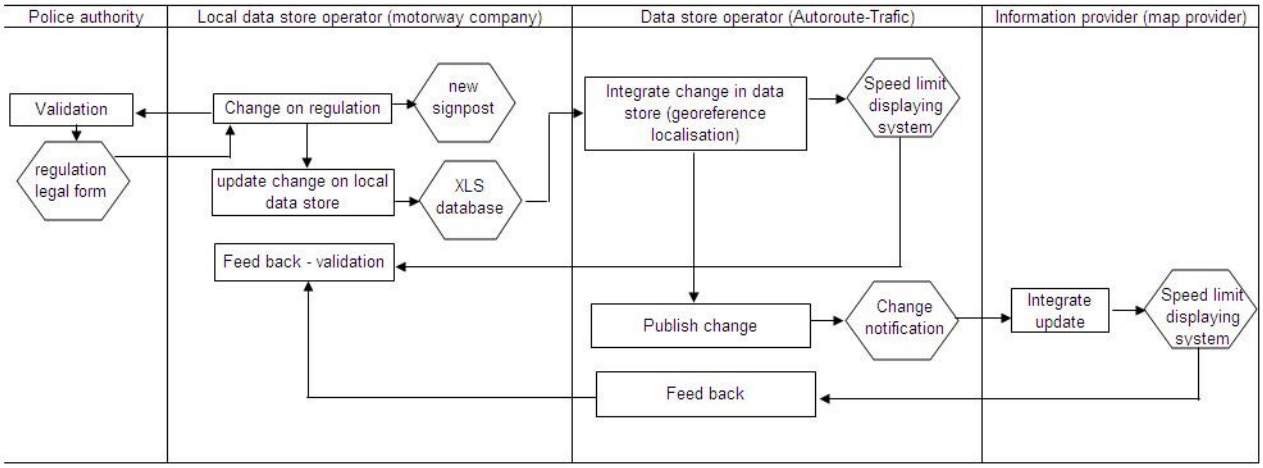

Figure 15 – Process views from ASFA test site

In the ASFA test site, static and temporary (and dynamic) speed limits are managed differently:

- Static speed limits: At the road network operator side, these data are stored in a database (XLS files). The whole database is delivered to the data store operator at a periodic basis.
- Temporary speed limits: At the road network operator side, these data are integrated into the network management system. They are delivered to the data store operator dynamically through an XML feed. The feed is automatically refreshed when there is an update (insert, update, delete).

Both data types are delivered to Autoroutes Trafic who is the data store operator in ASFA organisation. Autoroutes Trafic process these data which come with referent points to translate them in linear locations. The processed data are stored in a spatial database.
Autoroutes Trafic will set up a set of web services to publish the safety attributes database to map providers. Error reporting and quality assessment will be done all along the chain.

8.4.2 Component View

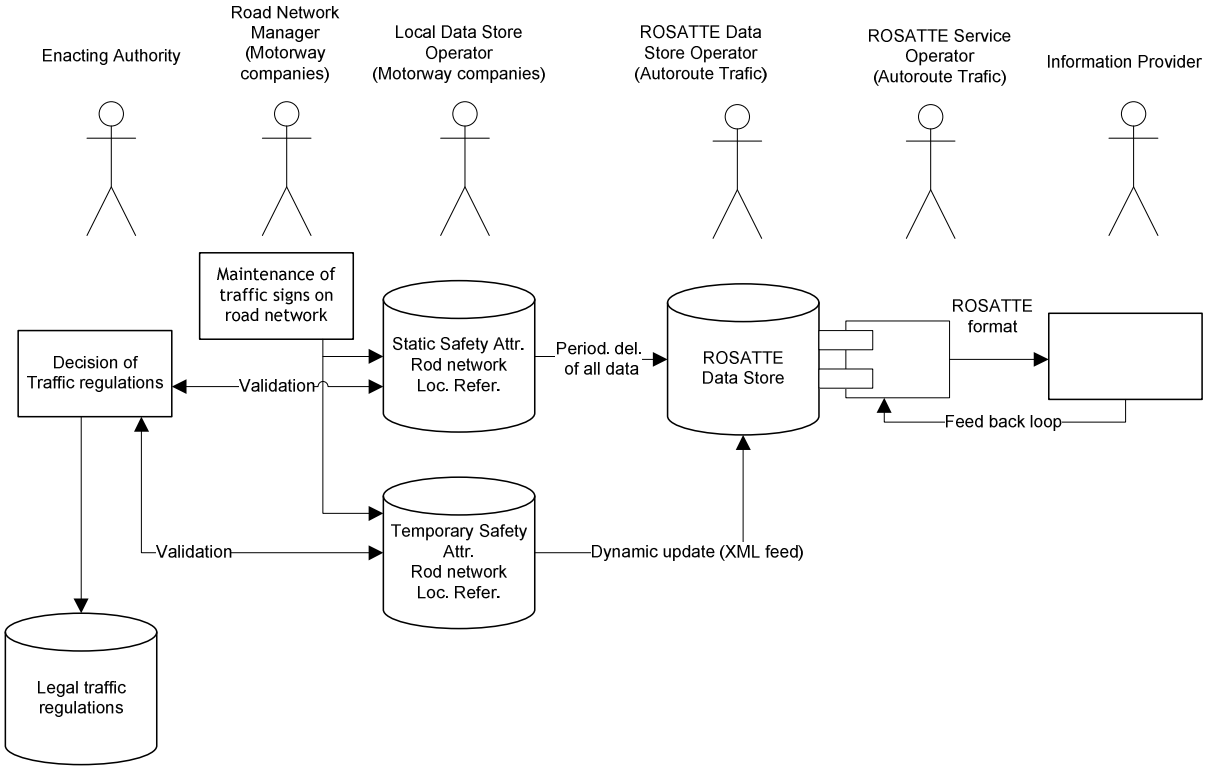

Figure 16 – Component view from ASFA test site

Create and maintain a spatial repository:

- Collect data from French private motorway operators
  - Static speed limits database
  - Temporary speed limits XML feed
- Process data to convert referent points to linear locations
- Store data in a Spatial database (PostGres/PosGis)
- Create tools for an easier maintenance of the data
- set up a data feedback process

Publish the data:

Data are delivered through a set of Web Services. Basic actions are:

- request an initial delivery (full database)
- request the last data update timestamp
- request the updated data sets
- notify errors found in the delivery

9. Guidelines for establishing and maintaining a data store

9.1 Background

Reading the ROSATTE deliverable "D1.1 State of the art" ref[10], it is obvious that the situation concerning road data in European countries is varied. This means that, road authorities and other organisations should be able to work in different ways to establish and maintain their data source. The actor establishing a ROSATTE Data store can be a public or a private road authority or another organisation responsible for providing data to Information Providers.

In the planning of the ROSATTE-project, the situation concerning availability of safety attributes, were described as levels of maturity using these levels:

- Paper documents and archives
- Electronic spread sheets
- GIS-platforms as part of map data
- Business systems that are not integrated
- National/regional integrated databases

In the guidelines we have chosen not to use levels of maturity. Instead the guidelines are a set of recommendations on what to do and how to work to be able to provide safety attributes complying with the ROSATTE specification. The aim is to give a practical help to road authorities regardless of their pre-conditions.

As a start it is recommended to study the viewpoints and requirements above and based on the current situation, try to identify what is applicable for your organisation when trying to comply with ROSATTE.

It should once again be highlighted that this is no guidelines for aligning to a fully harmonized solution between road authorities. Although by following the guidelines it will be easier to exchange data according to the ROSATTE infrastructure defined in D3.1.

9.2 Overview

These aspects are considered

- Availability of safety attributes
- Availability of digital road network and location referencing attributes
- Compile attributes from local, regional and national authorities (source, media, etc.)
- Conduct a field survey
- Location referencing (Indirect (linear) Referencing, Direct geographical Referencing)
- Storing the attributes
- Techniques for compiling data
- Quality aspects
- Updating process
- Receiving feed back from Information Provider
- Publish data
- Tools
- Organisational aspects

9.3 Availability of safety attributes

Safety attributes that are of interest to map providers are defined and prioritized in ROSATTE D3.1. Actions to take:

- Find out all implicit legal traffic regulations on all levels.
- Do a survey to find out which attributes are available on a local, regional and national level.
- Identify the source for all these attributes on local, regional and national levels. Is the source legal traffic regulations or field surveys (directly or via a traffic signs database)?
- Identify the owner of the attributes.
- Talk to the owners and find out if they are willing to provide their attributes and if they are willing to take part in the work to provide them.
- Identify the media on which these attributes are stores, (paper documents, excel sheets, GIS-databases, etc.).

If it is possible and practical to compile safety attributes from local, regional and national organisations then do the actions described in 9.5 below.

If some safety attributes of required quality are missing it is assumed that it will not be possible to compile attributes from local, regional and national organisations, a dedicated field survey may be the only solution, see 9.6 below.

9.4 Availability of digital road network and location referencing attributes

To be able to reference its data, it is highly recommended to use a digital road network. The road network can originate from:

- Several local, regional and national road networks can be aggregated to one road network base underlying to the ROSATTE data store. To compile a road network in this way the actions are the same as described in first in 9.2 above and then 9.5 below.
- External sources i.e. from Navteq, Tele Atlas or land survey organisations.

Many road authorities and road organisations use road networks from commercial map makers. This makes it easy to directly benefit from a nationwide road network for the location referencing of the safety attributes.

It is assumed that attributes necessary for location referencing are attached to the digital road network as basic attributes. Attributes necessary for location referencing are defined and prioritized in D3.1.

If a road network and location referencing attributes of required quality is missing and it is assumed that it will not be possible to compile it from internal or external sources, a field survey may be the only solution, see 9.6 below.

In principle, it may be possible to store safety attributes only with direct location referencing without an explicit reference to a road network, although at some stage a functionality using a digital road network is needed to generate the location referencing required for ROSATTE exchange.

9.5 Compile safety attributes from local, regional and national authorities

9.5.1 Source

The source for safety attributes at local, regional and national organisations can be either

- Legal traffic regulations *and/or*
- Field survey of actual road conditions (can be expressed on sign posts). They may come from dedicated field surveys but could also be data gathered and maintained from infrastructure management operations.

If the source is legal traffic regulations these specific actions have to be taken:

- Legal traffic regulations can overlap each other, which mean that an important issue is to calculate the actual valid value of the safety attribute on every segment of the road network.
- Establish common agreed rules for how to derive safety attributes from traffic regulations.

If the source is field surveys, these specific actions have to be taken:

- Establish common agreed definitions of the attributes and the quality parameters for the attributes.

The original source for safety attributes created from a traffic signs database are usually field surveys.

9.5.2 Media

The work to do for compiling safety attributes from local, regional and national organisations is highly dependent on the media on which the attributes are stored.

For safety attributes only available on papers, excel-sheets, etc. do this:

- Find out if how to convert the data to a format more suitable for automatic provision of the data.
- If the effort to do so is too extensive, the only solution might be to start from the beginning with field surveys.

For safety attributes available as geographical objects do this:

- Compile data as described in this document and allow for real location referencing of the attributes at some stage of the data chain. As earlier in the data chain as better.

For safety attributes available as attributes referenced to a road network do this:

- Compile data as described in this document using incremental updates.

9.6 Conducting a field survey

To establish a data store based on measured traffic signs, field surveys are of course necessary. How to organise a field survey will not be described in this document. Some remarks to have in mind are:

- Make a specification – mandatory for surveying companies to comply with
- Set quality requirements on the attributes.
- Decide from the beginning how to update the data set once the initial data set is established. Are field surveys within some intervals planned for updating the attributes, or are other processes (e.g. maintenance of new attributes from regulation) foreseen?

- Be sure to store parameters from the field survey that allows for incremental updates along the data chain local data store – ROSATTE data store – ROSATTE service.
- Be sure to store parameters that allows for tracing the origin of all safety attributes.

9.7 Location referencing

As defined in 5.2 the data store can in principle be constituted either as a road database with all safety attributes indirect (linear) referenced to a digital road network or as a geographical database without an explicit reference of the safety attributes to a digital road network, i.e direct referencing of the safety attributes.

9.7.1 Indirect (linear) referencing

Advantages:

- Geometric description of all safety attributes can be derived from the same road network.
- Better quality of ROSATTE location referencing, (since no matching to an otherwise separate road network is needed for generating the final attachment to the information provider's map).
- Usable for many functions within and without an organisation/authority.

Disadvantages:

- It requires advanced methods to keep a fully indirect (linear) referenced system up-to-date.

9.7.2 Direct geographical referencing

Advantages:

- The safety attributes are independent of each other carrying their own geometry.
- Attributes with one single value valid for large areas, can be stored as polygons.

Disadvantages:

- Storing the geometry for each attribute means that the same geometry is stored as many times as you have attributes in the data store.
- Storing only coordinates for location referencing means very low success rate when attaching the safety attributes to a road network at the Information Provider.
- To derive the location referencing attributes that increase the success rate, a digital road network is needed at some stage of the data chain. This means that indirect (linear) referencing could have been used anyway.
- So far it is not clear whether a geographical reference really can meet the quality requirements when transferring safety attributes from one digital road network to another.

Regardless of what location referencing method is used, to comply with ROSATTE it is necessary to generate the on-the-fly location reference defined in D3.1 when providing data from the ROSATTE service.

9.8 Storing the attributes

In a road database with indirect (linear) referencing, the safety attributes can be stored as point objects referenced to the road network or line objects referenced to the road network.

In a database with only geographical referencing, the safety attributes can be stored as points, lines and polygons.

Regardless of the location referencing method in the data store, the safety attributes will be referenced to a road network at the Information Provider. A polygon as the geometrical description means that the attribute value is valid on all road segments within the polygon. The translation from the polygon description to the road segment has to be done either at the ROSATTE Data store or the Information Provider side.

Speed limit is an example of an attribute that is valid on a specific segment of a road or street, starting in one point and ending in another point. Some other attributes like railway crossing can be considered as valid only in a specific point. Attributes only valid in a point should of course be stored as point-attributes in the data store. Attributes valid on a specific stretch of the road/street can also be modelled as point-attributes with the location of the point in the location where the specific value starts and implicitly ends at a point where another specific value starts. Although this is possible, it is recommended to store line safety attributes as line objects. If line attributes are gathered as points try to convert them to line-objects in the ROSATTE data store.

It is strongly recommended to store the implicit value of safety attributes in the data store, in order to reach as complete coverage as possible for the stored attributes, which makes it easier for a receiver to handle the data.

9.9 Techniques for compiling data

To compile data from local authorities, regional authorities and different national authorities to one data store, a number of different techniques can be used.

9.9.1 File transfer

Data can be transferred from a local data store to the ROSATTE data store by file transfer in an agreed (standardized) format. This is the most common way to do it today.

9.9.2 Using a common database

All data providers can have access to and responsibility for their data in a centralized common database (the ROSATTE data store).

9.9.3 Using services

All data providers can provide their data through web services. In the world of geographical data, WFS (Web Feature Services) is a usable standard for this. WFS is defined in INSPIRE ref[4].
This means that the ROSATTE data store is a virtual data store. It is a portal from where safety attributes in local databases can be reached and provided out to the ROSATTE service.

9.9.4 Coordination between different levels

Organisations on different levels have to agree on who is responsible for what.

- Where are the geographical boundaries between the different authorities?
- Who can publish data?

9.10 Quality aspects

Quality management is essential in all processes.

It is necessary to se quality parameters on all attributes.

- Availability – see above
- Up-to-dateness – updating process (incremental) or new survey with certain intervals.
- Completeness – decide which road network and set a goal for completeness
- Consistency – values according to metadata, etc.
- Correctness
- Accuracy

A meta-database is mandatory.

9.11 Updating process

It is very important to establish a process for updating the attributes from the sources all the way to the data store. Updates depend to a large extent on work processes and interfaces between different systems should allow for incremental updates. To enable incremental updates start-time should be set for all safety attributes. When expire-time is known it should also be set.

As described in section 4.2 the incremental updating process can be established either through record update events or by comparing different database states.

Full exchange of data within a specified area can also be considered as an update of the data store, although it is not an incremental update and it is not the recommended method.

9.12 Receiving feed back from Information Provider

Routines and tools for handling feed back should be established by the actor running the ROSATTE data service and the ROSATTE data store. Feed back should be pushed back along the data chain to the source of the reported feed back.

More information on how to handle feed back will be provided in the document after the test beds have carried out testing.

9.13 Publish data

To publish data from the ROSATTE data store to the ROSATTE service can be seen as an internal activity if the same actor (for instance a road authority) operates these two roles. If not, the interface will work in the same way as the interface between local data operators and the ROSATTE data operator. Incremental updates should be possible.

Metadata should be published to the Discovery Service.

9.14 Tools

Tools are for example necessary for:

- services to provide data
- field surveys
- referencing attributes to a road network.

Referencing attributes to a road network could be a web tool where the user can point at the road network to locate start- and end- location for specific attributes. If the road network in the web tool has location referencing attributes attached to it, the safety attributes will be referenced to it in a useful way.

As the need for tools is very specific for each country/region/test site etc. no more elaborated description of tools will be done in this document.

9.15 Organisational aspects

Organisational aspects are very important; however most of these issues are described in D6.1. For example to make incremental updates possible, organisational aspects are of high importance.

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