ITS ACTION PLAN

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D7 –Final Report

Action 1.3 - Availability of Public Data for Digital Maps

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EUROPEAN COMMISSION
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MANAGEMENT SUMMARY

On 16 December 2008 the European Commission adopted the ITS Action Plan (COM (2008) 886) for road transport and interfaces with other modes. The Action Plan aims to accelerate and coordinate the deployment of Intelligent Transport Systems (ITS) in road transport. One of the key priority areas involves optimal use of road, traffic and travel data, the scope of this study falls within that priority area.

Action 1.3 of the ITS Action Plan aims to provide efficient access to publicly held road data for digital map providers. This document constitutes the final report of the study on Action 1.3, specifying the minimum road data requirements and possible procedures for the publication of public road data.

To achieve the study objectives and answer the key research questions, a wide range of aspects had to be assessed. A structured analysis was carried out assessing the current situation in Member States, technological developments, market developments, available standards and existing spatial data structures. Frequent consultations of stakeholders were held through interviews, an online survey, two workshops and additional consultations through e-mail, phone and face-to-face meetings. Possible deployment scenarios were developed and assessed in a cost-benefit analysis.

Based on the analysis, minimum requirements and possible procedures were described. These served as the basis for a series of recommendations.

These recommendations aim to create a framework for significantly improving the publishing of public road data for digital map providers to the benefit of both the public and private parties involved. The recommended solution provides quick wins, while allowing for a gradual expansion of content and road type coverage. By building on existing spatial data structures and standards, and opting for a stepwise roll-out, implementation and operational costs and risks are limited. It is believed that the recommended solution will gain the support of a wide range of public and private stakeholders involved in the road data value chain in Europe.

Key Recommendations

Rather than limiting the road data to a fixed set of attributes it is recommended to aim for the publication of all publicly held road data that either originates from public authorities, or that can only be sourced efficiently by public authorities.

Because in many Member States road data are not available in a structured format, it is recommended that content is provided on a step-by-step basis, starting with what is valuable and readily available, while allowing for a gradual inclusion of other content types. As a first step it is suggested that all Member States provide speed limit information for the complete TERN plus motorways in 2015.

Besides road attribute data, public road geometry data sets should also remain available to digital map providers as reference sources, in particular for road infrastructure changes.

Member States should define deployment plans for road data, identifying for each road type when a content class will be made available to digital map providers.

Map-agnostic location referencing methods are methods that can be used for location referencing on any map. Currently these perform sub-optimally, resulting in frequent map matching errors in an operational environment. AGORA-C is currently considered to be slightly better than OpenLR but is subject to commercial licensing requirements. It therefore is recommended to initially adopt AGORA-C as the map-agnostic location referencing method, but to promote the improvement of the license-free OpenLR or development of other map-agnostic license-free location referencing methods in parallel.

Road data changes are recommended to be published through case-by-case updates. Additional incremental and full data set updates should be encouraged but not be made mandatory at first. This limits the complexity of the data processing methods in the value chain significantly, reducing implementation risks for public authorities.

The study proposes a clear target definition of maximum update intervals for each road data type and recommends this to be adopted to ensure the road maps of digital map providers remain up-to-date.

How road data is collected, aggregated and published – the road data value chain - differs between Member States. In general the road data value chain involves public authorities on various levels of government, as well as various private parties. Because of the complexity and diversity of these value chains across Europe, the organisational approach of INSPIRE is recommended. How the road data value chain is organised is to be determined by each Member State on a national level. Road data do not necessarily have to be aggregated in a central national database, but a national register of road data sources should be published and maintained by Member States.

It is recommended that ROSATTE specifications for coding road data are adopted as an extension to the INSPIRE Transport Network Specifications, further referred to as the TN-ITS specifications.

Digital map providers can then find the different road data sources via the national INSPIRE registers, and can use the source through harmonised content coding based on the ROSATTE specifications, significantly lowering the overhead for both the digital map providers and the public authorities.

The recommended organisational framework combines INSPIRE and ROSATTE as follows. The Implementation Platform proposed by ROSATTE should serve as a forum to discuss, plan and support the implementation of the TN-ITS specifications by Member States and the Digital Map providers. It should also serve as a forum where future road data needs of the users of digital maps – private and public - can be discussed and anticipated, and where the development of coding methods and quality levels for new data types are initiated. The ROSATTE Implementation Platform will act as Spatial Data Interest Community on ITS (SDIC-ITS) within INSPIRE. This study defines a clear division of tasks between the two initiatives.

It is recommended the EC adopts specifications as part of the ITS Directive that require the adoption of the ROSATTE specifications as extension to the INSPIRE TN specifications, and requires Member States to comply with these specifications if they publish road data within the framework of the ITS Directive.

The EC is recommended to specify common access and re-use conditions as part of the INSPIRE Directive that apply to all road data publishing by public authorities in the EU. Member States and (semi) public sources within each Member State should be free to add or change conditions as

long as the common conditions are not violated. A first set of conditions has been compiled in this study.

Some technical and procedural aspects of the road data value chain need to be improved or further elaborated. It is therefore recommended the EC should support:

- The development of standards for coding new road data content classes
- The development of an objective optional method to classify data quality of road data sets of specific data types, based on the complementary work of INSPIRE and ROSATTE.
- The development and promotion of best practices and common tools, for the collection, aggregation and publication of road data by Member States with more developed value chains.

T A B L E O F C O N T E N T

1. Introduction

1.1. Background

An increasing number of ITS applications rely on the availability of accurate digital maps describing the road network geometry, topology and road attributes relevant to traffic.

Digital road maps were originally developed to meet the requirements of road authorities and the vehicle navigation market. As the sophistication of in-vehicle navigation systems increased, so did the amount of data that needed to be collected, stored and updated. Digital map providers increased the frequency of updates in all market segments.

The most recent developments in Advanced Driver Assistance Systems (ADAS) require more accurate and detailed digital map data. This applies in particular to safety critical support systems such as dangerous curve warnings and specific concepts for intelligent speed adaptation and intelligent cruise control. Digital map data contain information on road regulations and attributes that route planner and navigation devices use for planning and presenting driving instructions to car drivers. Driving instructions based on incomplete or incorrect road data have a detrimental effect on road safety, economy and environment. In addition, certain advanced information services would become feasible if specific road-related information would be generally available, e.g. the availability and conditions of use of on-street parking places. Road authorities manage the geometry of the road network, conditions that affect the availability of the road network, as well as traffic regulations. These are essential assets for the creation and maintenance of digital road maps. Timely incorporation of these changes in digital maps contributes to the safety of European motorists. Traffic regulations in particular tend to change frequently and therefore need to be monitored and processed continuously. Several public/private initiatives have devised methods for the publication of road map changes, and their incorporation into digital roadmaps, e.g. the eSafety (iMobility) Working Groups on Digital Maps, EuroRoadS, eMaPS, ROSATTE and INSPIRE.

INSPIRE will oblige public authorities to make their road data available according to the INSPIRE Implementing Rules from December 2012 for newly created datasets, and December 2017 for all other datasets. The

INSPIRE implementing rules however do not provide the means for the publication of the detailed road data required by more advanced ITS applications.

There is no generally accepted procedure for publishing detailed public road data for use in digital maps. Roads across Europe are managed by a wide range of organisation types, ranging from municipalities managing a small local network, to national road authorities managing thousands of kilometres of roads and motorways and to concessionaires operating motorways and vital tunnels and bridges.

Achieving an efficient system for the publication of road data is a technical and organisational challenge. It requires balancing the interests of the key stakeholders, and active and continued participation of private road operators as well as public authorities that manage road network data. It is essential that road data (stocks, updates and projects) are validated and made available to all players on a fair and equitable basis by all road operators, private and public, for all road types; rural, urban and inter-urban roads.

The European Commission can play an important role in making publicly held road geometry and attribute data available to digital map providers.

1.2. ITS Action Plan – Action 1.3

On 16 December 2008 the European Commission adopted the ITS Action Plan (COM (2008) 886) [1] for road transport and interfaces with other modes. One of the key priority areas involves optimal use of road, traffic and travel data.

The ITS Directive (Directive 2010/40/EU) [2], adopted on 7 July 2010, provides the legal framework for the deployment of the ITS Action Plan. Annex I of the Directive also defined the optimal use of road, traffic and travel data as priority I, and requests the EC to define the necessary requirements to make road, traffic and transport services data used for digital maps accurate and available, where possible, to digital map producers and service providers

The European Commission is planning to work in partnership with Member States and European road operators, service providers and industry to provide efficient, safe, and environmentally friendly intelligent transport systems which best serve the needs of the travellers, transport operators,

service providers, industry, and society at large. These systems will encourage travellers to make best use of the available modes and to support an integrated, sustainable transport system throughout Europe.

Many state-of-the-art ITS applications rely on accurate knowledge of both the characteristics of the road network and the applicable traffic regulations. Whilst in the past the bulk of this knowledge was provided by authorities, there is a trend towards the utilisation of commercial sources. Where road safety is at stake it is essential that public information is validated and made available to all players on a timely, fair and equitable basis, in view of ensuring safe and orderly management of traffic. This applies in particular, to road network data.

Action 1.3 of the ITS Action Plan aims to provide efficient access to publicly held road data for digital map providers. This document constitutes the final report of the study on Action 1.3.

1.3. Value Chain

The production of digital maps from road data involves a number of sequential activities. Together they form the *road data value chain* (Figure 1). The key processes are data collection, aggregation and publishing. These need to be supported by horizontal activities to optimise the working of the value chain, such as standardisation and quality management.

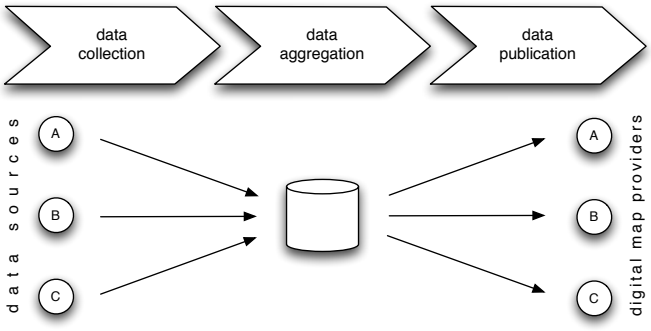


Figure 1 The road data value chain

In practice road data value chains are complex and interconnected networks with many players assuming one or multiple roles and responsibilities in the value chain.

1.4. Scope

The study's goal is to improve access to publicly held road data for digital map providers. The scope of the study is defined as follows:

Geographic coverage of the study is limited to the Member States of the European Union, taking into account Member States of the European Economic Area.

The study includes any type of publicly accessible roads, i.e. foot and cycle paths, and rail, air and water connections are considered outside the scope of this study.

The study considers data with the following properties;

- Any data describing the road geometry, topology, and any other characteristics relevant for the efficiency, safety and comfort of any type of road user.
- Static information, i.e. excluding dynamic and real-time information. Based on the EasyWay Traffic Information Clock [11] a definition of 'static' is adopted for road data that is not expected to change within one year. This means that regulatory speed limits and temporary speed limit changes for periods longer than a year (e.g. for longer lasting road works) are considered part of the scope. Temporary speed limits for periods shorter than a year are considered to be covered by Action 1.1 and 1.4 of the Action Plan and therefore considered out of scope (e.g. speed limit changes for short-term road works, and variable speed limits indicated by VMS and matrix signs).
- The study considers all road user types; private and commercial.
- Data on publicly accessible roads are considered part of the scope. These data can be owned by public authorities, private parties, and public private co-operations.
- Any findings and recommendations of the study will take into account the restrictions, rights and obligations of the European Commission and Member States as defined in the ITS Directive [2];
- The study takes into account the results and recommendations of the eSafety Digital Maps Working Group [3].
- The study focuses on what can be achieved within 10 years time.

1.5. Reading Guide

Chapter 1, this Chapter is the introduction and contains background, scope and a reading guide for the rest of this report.

Chapter 2 describes the study's methodology.

In Chapter 3 the results of the state-of-the-art study phase are summarised.

Chapter 4 presents the results from the specifications phase. It provides an overview of current and future map-based ITS applications, their minimum data requirements and procedural requirements.

Chapter 5 describes the potential role of public data in meeting the application requirements.

Chapter 6 describes currently available spatial data structures and how they can be best used to meet the minimum road data requirements and procedural requirements.

The costs-benefit-assessment of D4 [15] is summarised in Chapter 7.

Chapter 8 identifies the standardisation requirements for road data in the next 10 years.

Chapter 9 provides a synthesis of the findings of the previous chapters, presenting the recommendations for the minimum requirements and procedures for the disclosure of public road data.

Chapter 10, provides an assessment of the recommendations against the ITS Directive Principles, and the recommendations of the eSafety Digital Maps Working Group.

Chapter 11 contains the study conclusions.

Chapter 12 contains the management section. It relates the study achievements to the study objectives and key research questions.

All acronyms used in the document have been listed at the end of the main document. The acronym list is followed by the bibliography. Document references in the body text are indicated between square brackets (e.g. [1]). The number refers to the document number in the bibliography.

2. Methodology

2.1. Study Objectives and Key Research Questions

The objectives of the study on Action 1.3 of the ITS Action Plan have been defined as follows: definition of procedures for ensuring the availability of accurate public data for digital maps and their timely updating through cooperation between the relevant public bodies and digital map providers, taking into account the results and recommendations of the eSafety Digital Maps Working Group.

The specific objectives of the study are as follows [12]:

1. **Identify common minimum requirements of road data** for use in digital maps in the EU.

2. **Define procedures for ensuring a fair, simple and transparent access** of digital map providers **to these road data**, **identify common minimum requirements regarding timely update** of the digital maps by the digital map providers.

3. Estimate the **technical and standardisation needs**.

These objectives lead to the following key questions to be answered by the study [12]:

- What is the state-of-the-art concerning the practice of road data collection for digital maps in the Member States across the EU, which quality requirements exist related to public road data for digital maps in the Member States and their update and to which level are they applied in practice?
- What rules, procedures and methods are applied by digital map providers related to the timely updating of their digital maps?
- Which rules and procedures exist in the Member States for ensuring the availability of accurate public road data which are used in digital maps?

- How could a future system look like, ensuring the timely dissemination of the road data for digital map updates, taking also into account cost/benefit analysis considerations?

The terms of reference of this study [12] defined 'Procedures' to include at least:

- Minimum delay(s) regarding the update of public road data for the use in digital maps by Member States road authorities.
- Minimum delay(s) regarding the update of digital maps when new road data become available from Member States road authorities by the map provider.
- Possible optimal procedures of data exchange (stocks, updates, project data) between Member States road authorities and digital map providers, taking into account the existing or planned National and European Spatial Data Infrastructures.

To produce a workable, more complete framework for the future developments however, the Study Team considered it necessary to extend the definition of 'Procedures' to include service architecture, legal and organisational aspects, quality management procedures, update method, data aggregation level and access level, operational role of and policy options of the European Commission.

2.2. Workflow

To achieve the study objectives and answer the key research questions, a wide range of aspects had to be assessed. A methodology was elaborated to provide for an objective assessment of each aspect, and transparent propagation of analysis decisions. The diagram below presents the individual tasks and sub-tasks of the developed methodology as described in deliverable D1 – the Inception Report.

Phase A resulted in deliverable D2, a description of the current state-of-the-art of road data collection and publication in the EU and EEA Member States [4]. The results of phase A were presented at the first workshop in March 2011.

In Action B1 a technology roadmap was developed based on information from the state-of-the-art study. Applications that could be developed and

implemented based on the technology roadmap were identified and their specific requirements for public road data were described. For the selected applications, application requirements were described, including descriptions of the required content types (e.g. road geometry, speed limits, accident hotspots, etc.), required geographic and road type coverage, required accuracy and correctness of the data, as well as specific 'procedures'.

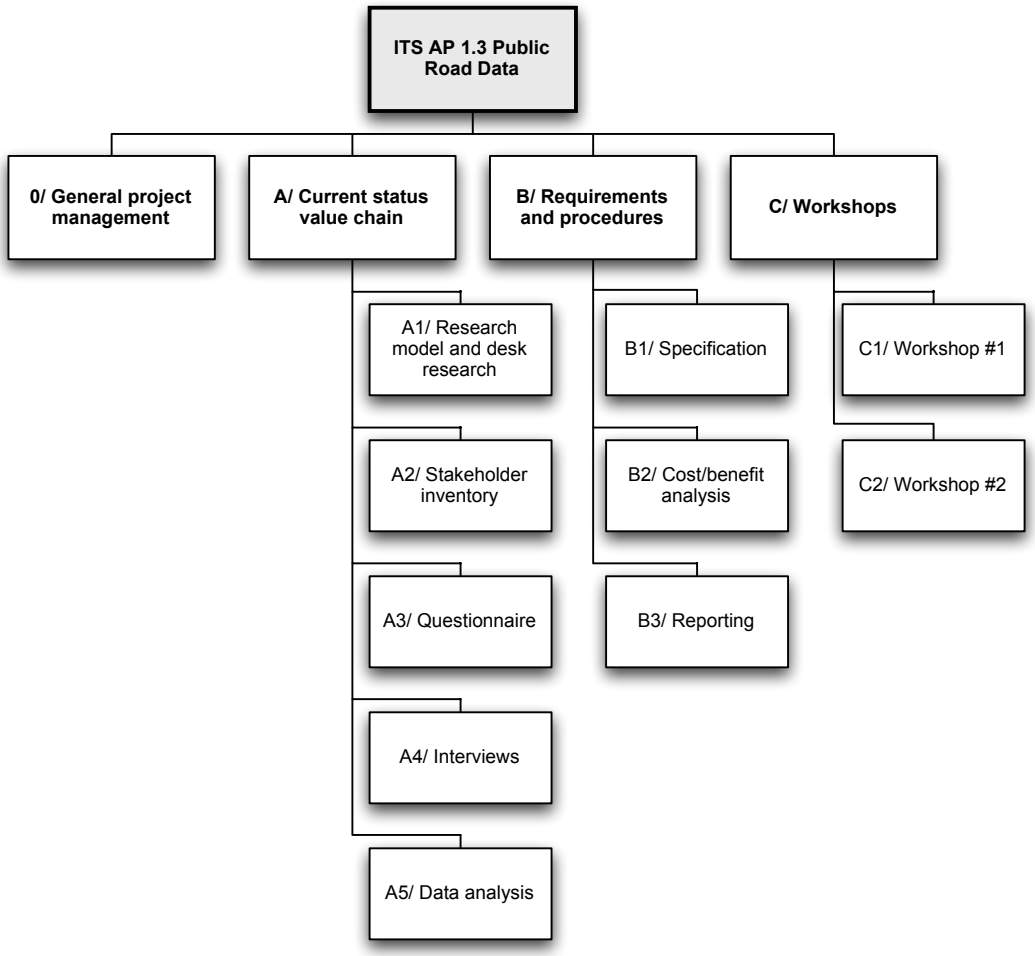


Figure 2 Methodology of the requirement phase.

In Action B2, the cost/benefit analysis, five possible scenarios were developed based on key policy options. The scenarios ranged from a 'minimum' scenario, without regulation and minimum involvement from the

EC, to a 'maximum' scenario, with strict regulation and a legislating and monitoring role for the EC.

The scenario descriptions, and information from the state-of-the-art study on the current availability of public road data, were used to estimate what public road data will be available in 10 years. This information was then used to derive the expected level of fulfilment of the minimum application requirements. The application requirements were compared against the functionality offered by existing spatial data infrastructures (ROSATTE and INSPIRE).

The costs and benefits of each scenario were consequently assessed based on information from the state-of-the-art study, the organisational and legislative aspects described in the scenarios, and the level of fulfilment of the application content and procedure requirements. The standardisation needs were then derived from the minimum requirements of the applications.

The conclusions from the analysis of the application requirements, the analysis of existing spatial data structures, the cost-benefit analysis, and the standardisation requirements analysis were used to produce the 'common minimum requirements' and 'possible procedures'.

The intermediate findings of the requirement phase were presented at a second workshop where additional feedback was obtained from stakeholders.

Key stakeholders were later provided with the opportunity to provide feedback on the conclusions before the finalisation of the document. Their comments were incorporated in the final version of deliverable D4 – Requirements and Procedures [15]

Based on the analysis and findings of D4, the Study Team drafted recommendations and assessed these against the principles of the ITS Directive and the recommendations of the eSafety Digital Maps Working Group. The recommendations and the results of this assessment are included in this document, the final report of the study.

3. State of the Art

3.1. Introduction

At the onset of the study a state-of-the-art assessment was carried out to determine the current situation of the road map data value chain in the Member States.

The State-of-the-Art study was based on desk research, the results of an online survey, interviews with stakeholders, and the consultation of key people in related projects, programmes and standardisation bodies.

3.2. Data Collection and Publishing

Results from the survey and interviews suggested that data collection is as much of an issue as data sharing. Although large volumes of public road data are available, many authorities, in particular in less developed regions of Europe and in general at local and regional level, do not collect and digitally store road geometry and/or attribute data in a structured way.

Public road data that is collected is not available to digital map providers in one third of all cases, and only 18% of public respondents provide an online data access service. 37% of respondents from the public sector indicate that the data they collect is aggregated at a higher geographic level, of which 19% is aggregated at the regional level, and 43% at the national level. 45% of public respondents indicate documented quality control measures are in place to manage data quality throughout the road data value chain.

Road authorities in some Member States consider it of vital interest to have high-quality road geometry data of their road infrastructure to support business processes such as road design and maintenance. Such map data is in some cases developed by road authorities themselves, sometimes by public or privatised ordnance survey organisations. In some cases the map data is licensed from digital map providers. Availability, ownership and access, and quality of public road geometry data therefore vary significantly between Member States.

These results suggested that further promotion of relevant standards, and the promotion of common access conditions could lead to better availability of public road data to digital map providers.

3.3. Specific Stakeholder Needs

Digital map providers indicated that public authorities are, and will remain, important sources for road data. This holds in particular for information that is created by public authorities, namely road regulations and traffic management measures, and the geometry and topology of new roads and road network changes.

The leading map providers argued that making public road geometry data available for free or below market prices would reduce their willingness to invest in data collection and that such a change could disrupt the market for digital road maps. The community-based mapping initiative Open Street Map however, was in favour of making all data collected by public authorities available free of charge immediately.

Public authorities indicate they need a clear roadmap to secure support from legislators and lower level authorities, and to secure funding for the deployment and operation of the required value chains.

3.4. Technology Roadmap

Any analysis of the potential minimum requirements for digital mapping for ITS applications over the next 10 years would be incomplete without considering the likely roadmap for the development of relevant technologies and the development and deployment of key applications using such systems.

Although predicting the future is impossible, some trends can help to indicate possible future directions and needs, and their implications for digital road mapping in Europe. The likely technological developments and current market developments are therefore identified in this section.

With the rapid development of science and technology, continued exponential growth in processing power and memory capacity will significantly enhance the performance of applications using digital maps. Enhanced processing capabilities will improve efficiency in a range of important domains such as data collection, storage, aggregation and map displays, while enhanced memory devices will provide greater capacity to store digital map data, giving users much more detailed map information.

At the same time, more accurate and reliable positioning technology is likely to be achieved. The augmentation system EGNOS is now available. A number of countries are improving, implementing or developing

sophisticated satellite positioning and navigation systems, such as the European Union's Galileo, the United States' GPS-III, the Russian GLONASS-K and the Chinese Beidou-2. The improvement of accuracy, availability and the provision of integrity information as a result of these developments will enhance existing ITS applications such as pedestrian navigation, and will enable new ones such as co-operative driving.

The likely developments in wireless and mobile connectivity will also support the development of new map-based applications. A series of wireless communication architectures and technologies, such as WIFI, WiMAX, DVB-SH, Bluetooth and CALM can be expected to enhance map information updating, map exchange and navigation capabilities, in real-time, for people and vehicles on the move. The emerging Navigation Data Standard (www.nds-association.org) will allow for on-the-fly updating of in-vehicle maps.

The prospects for digital mapping markets can be expected to be very strong over the next 10 years. More and more mapping technologies will find utility in commercial markets, extending from R&D to operational business environments, for example through the use of Floating Vehicle Data (FVD) and community based mapping technology. The mobile device markets can be expected to be buoyant too, with a growing demand for personal routing and navigation services and rich point of interest (POI) content.

Meanwhile, route planning web services and existing private vehicle navigation applications are expected to reach saturation in the European markets. Product offering and diversification will drive the markets instead of costs. Products will focus more on their content and services, product innovation, product quality, and niche content (trucking, motors, pedestrian) will be covered in new generations of applications.

Future digital road mapping services are expected to have strong links to the automotive market. For example, Advanced Driver Assistance Systems (ADAS) can be built on more detailed maps and attributes, including relevant information on road geometry, road regulations, driving restrictions, parking facilities, accident hotspots etc. In addition, all these data will need to be highly reliable.

The figure below demonstrates a possible roadmap related to applications or services that consume digital mapping information for the next 10 years.

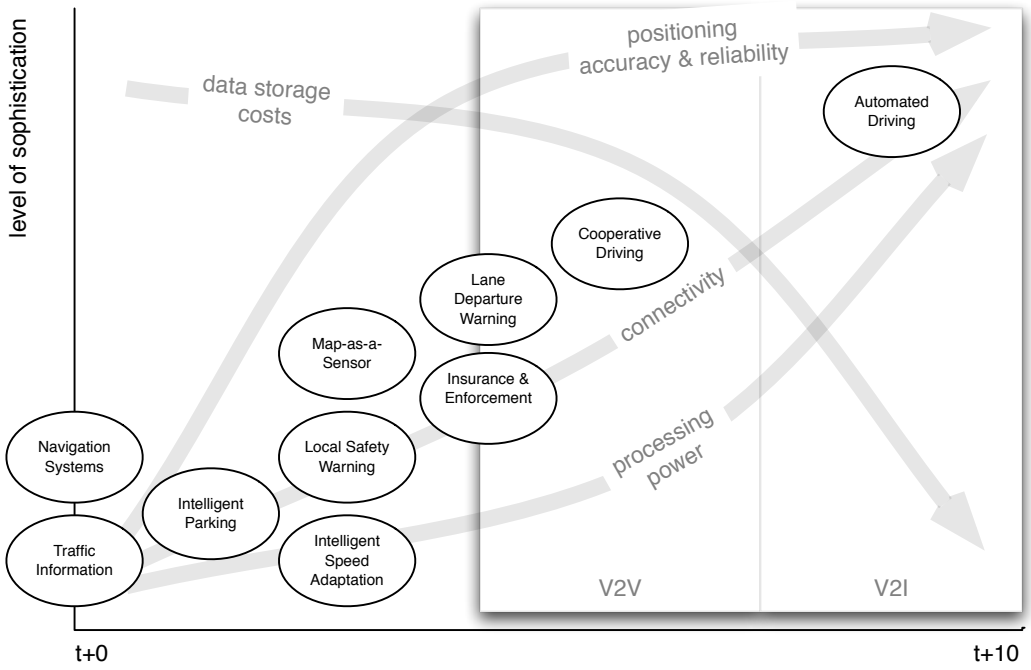


Figure 3 Possible roadmap for map-based applications and services over the next 10 years.

4. Minimum Requirements

4.1. Introduction

Based on the state-of-the-art study and the technology road map, current and future applications can be identified that rely on digital maps. From these applications it is possible to derive the minimum data and procedural requirements before considering the potential role of the public sector in helping to meet those needs.

This chapter summarises the results of the three analytical frames of the specification phase, identifying and describing subsequently relevant applications, their minimum data requirements, and their procedural needs.

4.2. Analytical Frame 1: Applications

A wide range of ITS applications was investigated to assess their requirements for road geometry and attribute data.

An assessment was made whether digital map data is required by the application, and if so whether it needs to be in the vehicle and/or in the back-office. Only applications that must/may use digital map data have been evaluated.

For those applications where maps were only optionally relevant, consideration was also given to whether the application was likely to be of considerable interest in terms of public sector data. If not, they were excluded from further analysis. Where appropriate the remaining applications were aggregated into functional “application groups”.

Some more futuristic applications were considered unlikely to reach effective deployment within the next ten years because of the time taken for suitably equipped vehicles to become commonplace. However, for some their potential benefits were considered sufficiently significant to warrant including them in the study to try to ensure that enabling developments in digital mapping do not become an obstacle to their deployment.

In total, ten key application groups have been investigated to identify their minimum data and procedural requirements for map-related information. The analysis of these applications helped to develop the understanding of what might need to be supported by the study’s recommendations. The

mapping of applications to their application groups are illustrated in the following figure, and each application group is described below.

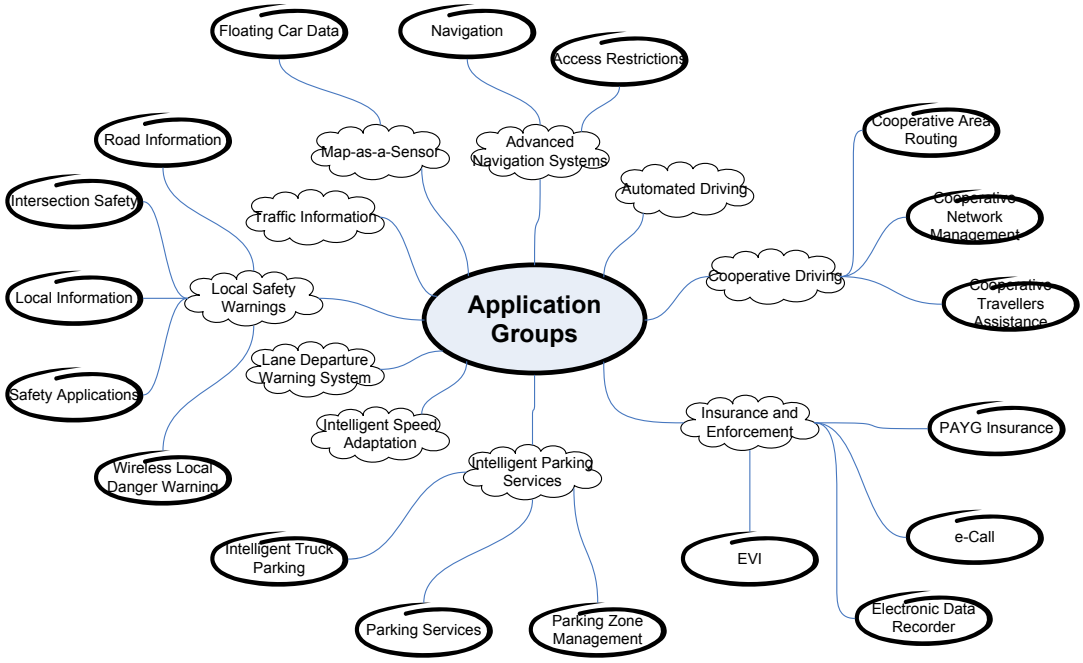


Figure 4. Application groups where public sector data may be relevant to digital mapping

AUTOMATED DRIVING: These applications allow equipped vehicles to drive from one location to another without driver input. In its most advanced form this could involve a complex door-to-door journey. More realistically, perhaps, in the shorter term is the possibility of its being used for simple journey elements, such as junction-less sections of inter-urban road, where such systems can be engaged by the driver temporarily. Digital map information will be vital to ensuring safety, particularly at the very detailed level of road geometry[1], and locally updateable digital maps will have a more substantial role to play for full-functionality systems of the future.

[1] Although Automated Driving can also be achieved without digital map data, this is costly as it requires roadside beacons to guide vehicles.

COOPERATIVE DRIVING[2]: These applications use communication between vehicles and with road infrastructure to enable for example broadcast warnings to vehicles about congestion, emergency braking, airbag deployment or a slippery road surface in the area.

INSURANCE AND ENFORCEMENT: Applications monitoring driver performance (e.g. Electronic Data Recorder) can be used to identify accident causes, to log driving behaviour in relation to road, vehicle & traffic regulations (e.g. of repeat offenders), and to offer pay-as-you-go and advanced driver insurance. Others assure rapid notification of accidents, and provide access to information about the vehicle and its status (e.g. eCall) to improve emergency assistance.

INTELLIGENT PARKING SERVICES[3]: These applications provide drivers with advanced information on parking facilities, real-time occupancy information, as well as the option to make reservations for parking spaces. They need accurate maps to display not only the location of parking areas, but in future also to guide motorists to individual parking bays.

INTELLIGENT SPEED ADAPTATION (ISA)[4]: This application constantly monitors vehicle speed relative to the local speed limit and warns the driver, applies resisting force on the accelerator pedal, or actively reduces the vehicle speed, when the vehicle exceeds the speed limit or advised speed. The system can use information provided by digital maps to warn of accident hotspots, schools, etc. Advanced concepts apply dynamic speed limits, e.g. a lower speed around schools only during time slots where children are entering / leaving the school.

LANE DEPARTURE WARNING SYSTEM (LDWS): This application monitors a vehicle's position in its lane and warns the driver if it leaves or is about to leave the lane. It can be implemented without road network data, but digital

[2] Action 4.1 of the ITS Action Plan concerns the definition of an open in-vehicle platform, for future ITS applications such as co-operative and automated driving

[3] Providing secure parking places for commercial vehicles is a priority in Action 3.5 of the ITS Action Plan, including availability of secure parking places and enabling pre- and on-trip reservation. Digital map data helps present this information in its geographic context. These data may also be integrated in navigation systems.

[4] Dynamic speed limits (e.g. as shown on VMS) are not included as the information is considered too dynamic to be considered map data. A map-based ISA system would need to combine information from both the map (regular speed limits) and a source of real-time dynamic speed limits.

maps can be used to detect unintentional lane departure and inform the driver accordingly.

LOCAL SAFETY WARNINGS: These applications alert drivers to local circumstances that might affect road safety, for example uneven road surfaces, accident hotspots, sharp turns and crossings. They could operate using a map-based solution[5], or local beacons.

MAP-AS-A-SENSOR: A digital map in a vehicle can be considered a data sensor, allowing it to look ahead and anticipate local road conditions. It can, for example, provide speed limit and intersection assistance, warn for sharp curves or control curve speeds.

ADVANCED NAVIGATION SYSTEMS: These applications help vehicles or pedestrians to identify their position and obtain route guidance. They may use digital maps to display locations, directions, traffic and points-of-interest, as text or graphically. When determining a route they may also consider restrictions associated with, for example, vehicle characteristics, cargo or temporal access restrictions, as well as information about current traffic conditions. They may provide advanced route planning (e.g. eco-routes) and guidance at lane level.

TRAFFIC INFORMATION[6]: These applications provide motorists with updates on traffic situations that might cause delays or affect road safety. Typically such information is published via a number of methods such as mass media, radio and websites. Such services do not necessarily require digital maps - basic location coding methods such as TMC, and generic location descriptions (radio broadcasts) can also be used to describe the location of traffic incidents. However, referencing incidents on a digital map, or a logical street network, allows for more precise location description and incorporation of traffic information in other applications.

[5] The map-based solution has been explored in the EU project SAFESPOT [14] using the concept of a real-time updatable Local Dynamic Map in which digital maps are integrated with dynamic (short term) and local (short range) layers of information.

[6] Action 1.1 and 1.4 of the ITS Action Plan concern traffic information services.

4.3. Analytical Frame 2: Minimum Data Requirements

The study identified the minimum requirements for digital road network data based on the needs of the application groups described above. The types of data required are summarised in the figure below.

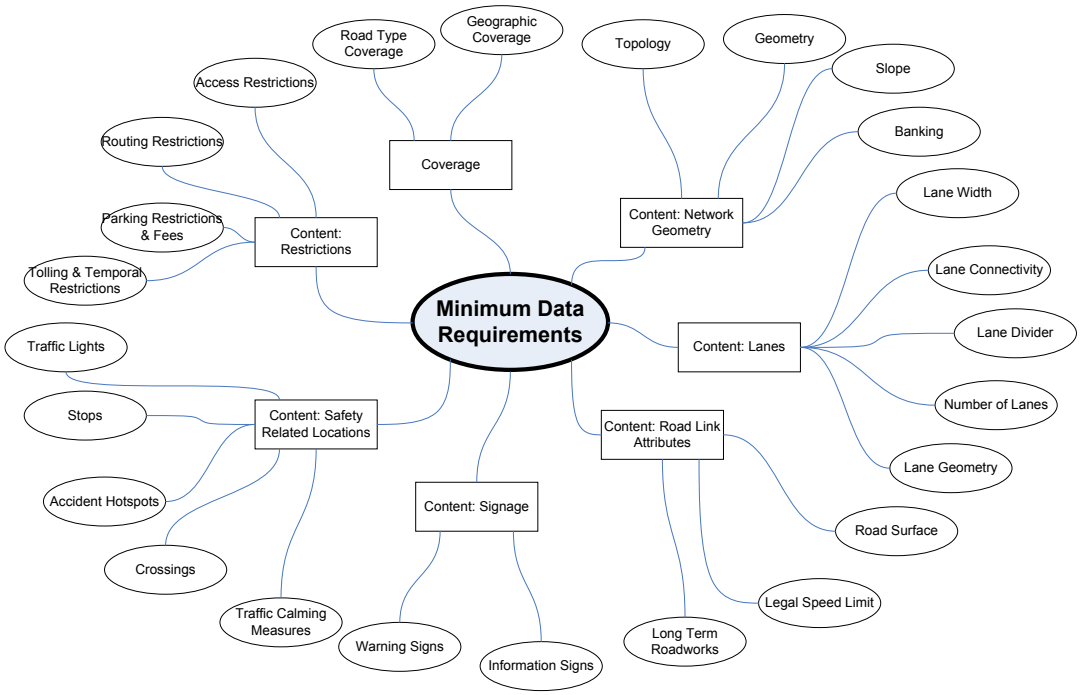


Figure 5. Minimum mapping data requirements for the chosen applications

Not all applications require all these information types, and these information types do not necessarily need to be provided in the form of a digital map for each application. However, they are all relevant in some way for this suite of applications.

4.4. Analytical Frame 3: Procedures

Procedures can affect positively or negatively the conditions and circumstances for the development of map-based ITS applications. The study identified relevant procedures, and assessed the specific procedural needs of the applications identified above. The procedures are summarised in the following figure.

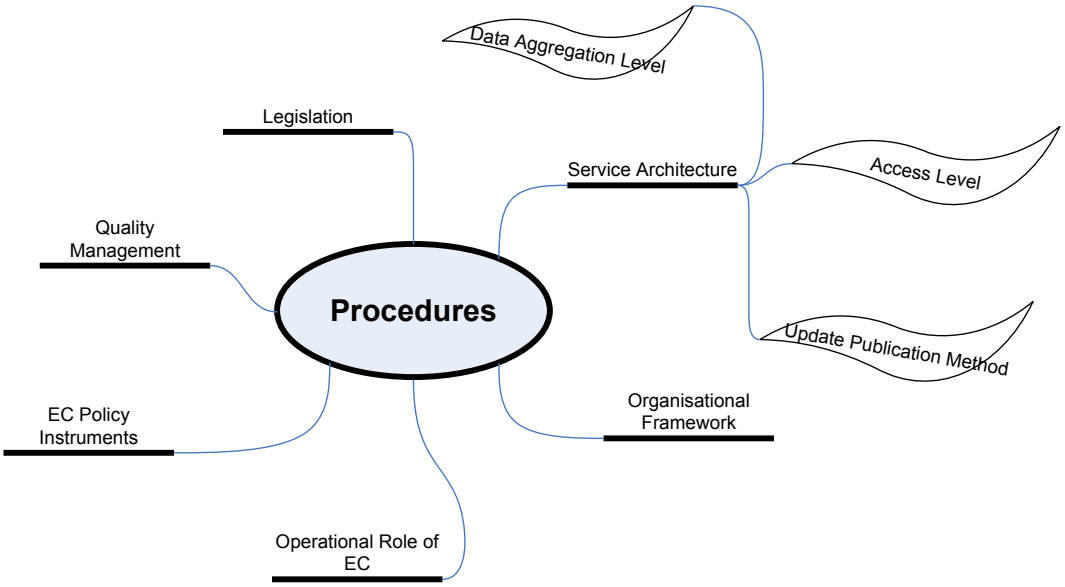


Figure 6. Procedures relevant to the road network data value chain

The list of procedures was compiled from work done in other projects [3,6,7]. It covers fundamental choices regarding the service architecture, procedures for the monitoring and management of data quality, as well as legislative, organisational and policy procedures.

Key aspects of the different procedures are presented below, a more elaborate assessment can be found in deliverable D4 [15].

4.4.1. SERVICE ARCHITECTURE

4.4.1.1. DATA AGGREGATION AND ACCESS LEVEL

Road data is created at different levels of government and a key decision is therefore whether to collect the data in a central data store, and at what level such a data store should be made available: at the regional, national or European level.

Integrating data at a central location provides a central node for measuring and monitoring data quality and managing data consistency. It also facilitates a single access point for digital map providers and other information service providers.

There is however a trade-off to be made. Aggregating data from different levels of government is feasible only if a limited number of organisations is involved. If data needs to be aggregated from large numbers of local road authorities, aggregation becomes complex and costly.

4.4.1.2. UPDATE METHOD

Road data can be published and updated in different ways:

1. Publish and update as full data sets
2. Publish as full data set, update using case-by-case updates
3. Publish only updates case-by-case

Method 1 means the recipient is provided with a full data set when a change to one or more items of the data set is carried out. Because the transfer of full datasets can involve the exchange of very large data volumes, this method is not very practical for road data exchange. A minimum interval can be specified to limit the update frequency, e.g. in terms of a time period or the number of updates, which however reduces how up-to-date the dataset is on the receiving end.

Further, method 1 poses another problem to the recipient when matching data from the sender to his map. The matching of locations is not straightforward; tests by ROSATTE have shown [9] that significant errors can occur when integrating data from one map into another. These matching problems will reoccur with every update if using full data set updates.

The publication of full datasets is complicated for legal reasons. In various Member States (e.g. UK, FR, SE) the ownership of the road data sets lies completely or partially with (semi) private companies. This means legal barriers make publication of the full data sets difficult or even impossible.

In method 2, the recipient receives a full data set at the start of the data exchange, optionally complemented with low frequency (e.g. annual) full updates. Changes are subsequently transmitted individually, and the recipient integrates the individual updates in his data set. This approach limits the amount of data exchanged in the operational phase, and provides quick updating of the dataset of the recipient. These case-by-case updates however also have drawbacks. If the recipients system is offline when an update is sent, the update may go unnoticed. In practice this can be solved

using some unique update identifier, e.g. a sequential update number or a date/time stamp for each update. This allows the recipient to detect when an update was missed, and request the missing update or a full data set update from the sender. This method however also suffers from the same drawbacks for the provision of full data sets.

Method 3 provides only the individual changes to the road data. This approach benefits existing market players as they already have full data sets that they can then easily update. It does however provide an important advantage over the other two methods. As the interviews with key stakeholders showed, many Member States have procedures in place that oblige road authorities to publish any change in road and traffic regulations. In some Member States this is done centrally, but in many other the information is published (i.e. aggregated) in (paper) government announcements. It should be relatively easy for Member States to change the procedures, or if need be the legal framework to assure changes to road and traffic regulations are published both on paper and in electronic form.

4.4.2. ORGANISATIONAL FRAMEWORK

The organisational framework that is to be chosen should be set up in such a way that a growth path is controlled while allowing for adaptation of objectives, and content and coverage requirements to meet the needs of both the public authorities and digital map providers and their customers.

Main tasks that need to be covered are:

- Proposing, developing, testing and adopting specifications for map data coding, exchange network and services, service and content metadata, data and service quality
- Development of working agreements, best practices
- Implementation planning and attuning
- Developing, implementing and operating discovery services and/or a geoportal
- Developing, implementing and operating a data store
- Publishing and maintaining service and content metadata
- Publishing and maintaining of road data

- Monitoring and managing service and data quality
- Monitoring and accommodating the evolving needs of private and public road data users (e.g. navigation providers and road authorities)

A general guideline for the organisational setup should therefore be that it:

- Ensures capitalisation of past EC investments, without being dependent on EC funds.
- Assures a continuous involvement of key stakeholders; i.e. both map providers and public road and mapping authorities.
- Allows for a controlled expansion of content type coverage and road type coverage with the consent of stakeholders.
- Allows for the gradual improvement of the technology that is required to meet the changing content requirements: data coding, location referencing, definition of data services and discovery services, quality monitoring and control methods, etc.

A number of organisational structures are already available that could be used as a basis for such an organisational framework.

INSPIRE

INSPIRE has a functioning organisational structure that meets the guidelines described above. Stakeholder involvement is arranged through the various bodies of INSPIRE:

- The European Commission INSPIRE Team.
- Member States have a seat in the INSPIRE Committee (IC). The IC delivers its opinions on draft Implementing Rules proposed by the Commission.
- Spatial Data Interest Communities (SDICs) bundle the expertise of users, producers and transformers of spatial information, technical competence, financial resources and policies.
- Legally Mandated Organisations (LMOs) are all the Member States' public authorities, institutions and bodies with a legal mandate to run national and regional SDIs.

- Drafting Teams (DTs) and Thematic Working Groups are groups of experts. Their role is to analyse and review, and produce draft INSPIRE Implementing Rules.

ROSATTE

ROSATTE has not yet established a functioning organisational framework. It has however suggested the establishment of a ROSATTE Implementation Platform, a public private partnership that also meets the guidelines specified above. The eMaPS project is contributing to the establishment of this Platform.

Assessment

Both an INSPIRE oriented and a ROSATTE oriented organisation could be established, as well as a range of intermediate solutions.

An INSPIRE based option would limit the implementation and operational effort as many of the public authorities that can serve as sources of road data, already are involved in INSPIRE and many of them already have initiated INSPIRE-based discovery services and geoportals. It would likely assure the active participation of many public authorities in all levels of government.

Because INSPIRE was established as a platform for the exchange of spatial data between public authorities, an INSPIRE oriented option might lead to under-representation of the interests of digital map providers, and their customers in the navigation and automotive industry in particular.

The ROSATTE specifications are based on previous work of various projects wherein digital map providers and public authorities jointly developed specifications for the integration of public road data in digital maps. A ROSATTE oriented organisational setup will therefore likely better serve the interests of digital map providers and their customers.

A combination of the two could also be considered dividing tasks such that the competences of public and private organisations are maximised.

4.4.3. LEGISLATION ON PUBLICATION OF ROAD DATA

Legislation can provide an important pre-condition for the successful harmonisation of access to public road data. This section first provides an overview of the relevant legislation that is in place.

PSI Directive

The European PSI Directive defines the Re-Use of Public Sector Information ("PSI") [10]. This Directive stipulates that Member States shall ensure that existing documents held by public sector bodies shall be re-usable for commercial or non-commercial purposes, and that where possible, documents shall be made available through electronic means.

The PSI Directive further states that the total income from supplying and allowing re-use of documents shall not exceed the cost of collection, production, reproduction and dissemination, together with a reasonable return on investment. The PSI Directive does not provide requirements concerning the re-use of data.

Based on the PSI Directive, existing public road data needs to be made available by Member States in digital form. It however does not provide common conditions on re-use, and does not provide specifications on how the data is to be made available.

ITS Directive

The ITS Directive [2] is an instrument for the coordinated implementation of ITS in Europe. It aims to establish interoperable and seamless ITS services while leaving Member States the freedom to decide which systems to invest in. Under this Directive the European Commission can adopt, as a delegated act, specifications to address the compatibility, interoperability and continuity of a specific ITS solution across the EU. If Member states choose to deploy the specific ITS solution, they need to comply with these specifications.

Furthermore the European Commission can issue an ITS Directive Deployment Proposal, requiring specific action by Member States. An impact assessment proving the purpose of such a proposal is a prerequisite.

INSPIRE

The INSPIRE Directive [5] requires that common Implementing Rules (IR) are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). These IRs are adopted as Commission Decisions or Regulations, and are binding in their entirety.

The current INSPIRE regulations require Members States to publish existing geographic data, it does not require the collection of new data.

The INSPIRE Directive provides a legal framework for the publication of existing public road data but not for its maintenance. The specifications of INSPIRE in its current form do not provide support for the required data that is needed for identified ITS applications.

Assessment

Both the INSPIRE and the PSI Directive provide a legislative framework for the publication of existing public road data. However, the PSI Directive does not specify how public road data should be made available. INSPIRE does provide specifications on how such information should be made available, but these specifications do not meet the needs of the digital map providers.

As recognised by stakeholders [4], achieving harmonised access to public road data does require the harmonisation of content coding, and the definition of access and discovery services.

In general, four legislative high-level options are available:

1. No additional legislation (scenarios Minimum and Low)
2. Adoption of the ROSATTE content specifications as extension to the INSPIRE Transport Network specifications (scenario Intermediate and High)
3. Issuing the ROSATTE content and service specifications as ITS Directive 'specifications' as a delegated act by the European Commission (scenario Intermediate and High), as supported by the definitions in Annex I of the ITS Directive [2]
4. Issuing of new legislation, e.g. proposing a Directive following the mechanism foreseen within the ITS Directive, forcing Member States to publish road data (scenario Maximum)

Under option 1, a number of more advanced Member States is likely to adopt the ROSATTE specifications for publishing public road data. However, despite the PSI Directive, it is unlikely that it would lead to wide-scale publication of public road data by Member States.

Options 2 and 3 both are likely to lead to wide-scale publication of existing public road data in Member States. The downside of these approaches is that the collection and publication of new data is not mandatory.

Option 4 would lead to better coverage but would take several years to implement.

When considering legislation it is important to note that in most Member States public road data are not available in digital form for most roads, and in many cases not even for all main roads. These value chains are under development by the relevant public authorities and brute legislative force seems therefore inappropriate at this moment.

A combination of options 2 and 3 therefore seem most appropriate, whereas Option 4 may be used if necessary.

4.4.4. LEGISLATION ON ACCESS AND RE-USE CONDITIONS

The different conditions concerning access and re-use of the data that are applied in the different Member States are a significant barrier to publishing publicly held road data. Some form of harmonisation will reduce the effort required for digital map providers to access public road data, and to provide their customers with consistent information. This could be achieved by establishing common access and re-use conditions as part of the INSPIRE or ITS Directive.

4.4.5. QUALITY AND LIABILITY

Digital road map data has the potential to play a critical role in future ITS applications, in particular in advanced driver assistance systems. This potential will only materialise if the data is complete, reliable and consistent throughout the European Union.

INSPIRE rules recommend that Member States set up a quality assurance process and have defined quality principles and measures to ascertain the quality of the INSPIRE data. The principles and measures are based on ISO 19113 and 19138 and focus on describing and measuring general data

quality. The INSPIRE Directive and related specifications contain no penal statute limiting liability of the public authorities and organisations on data.

ROSATTE has developed a quality management concept based on the ISO 9000 standards which focuses on the management of the processes in the value chain. ROSATTE concluded that existing standards only provide very general info, and drafted some general guidelines on measuring data quality.

Both quality systems seem to be complementary and could therefore be considered valid. It seems however that a clear definition of quality levels per road data type per application area would be needed, in particular for safety-related ITS applications.

Considering the differences in development of the road data value chains in the different Member States it is essential to have a clear and objective method to describe the level of quality of road data sets of specific data types. Having such a method would also allow having different quality levels for road data types reflecting their importance in road safety. E.g. quality requirements for legal speed limits should be higher than for parking fees.

In particular when public road network data is used in safety-critical applications (e.g. ISA), it is essential that public authorities cannot be held liable for any possible damages resulting from errors in the road map data. This could accomplished by including a disclaimer in the common license agreement that waivers any liability of the public data source.

4.4.6. EC Policy Instruments

Besides legislation, the European Commission has a number of policy instruments available it can use to promote the publication of public road data.

The policy instruments available to the EU can be divided in a number of categories:

- Legislative instruments (regulations and directives)
- Financial support (e.g. subsidizing research or deployment)
- Supporting standardisation (development of standards)
- Other non-binding instruments: recommendations and opinions, organising co-operation, concertation across member states and/or private stakeholders

	Life cycle phase		
Type of instrument	**Development**	**Deployment**	**Continuous Improvement**
Non-binding instruments		• Disseminate best practices across the public and/or private sector • Organise public awareness campaigns at EU and MS level • Voluntary agreements on common approaches with member states or industry sectors • Voluntary agreements on generic requirements for public procurements	
Financial	• Subsidize R&D, • Include in focus of Research Programmes	• Subsidize deployment • Subsidize assessment/ certification • Fiscal incentives • Insurance incentive	• Finance R&D for continuous improvement
Standardisation	• Organise, subsidize, promote development of standards in specific areas	• Organise, subsidize, promote development of standards in specific areas	
Legal	• Research to support legislation	• Adoption of ITS Directive specifications as a delegated act • Adoption of new regulations, directives or decisions	• Adapt existing regulations / directives / decisions

Table 1 Overview of policy instruments available to the EU, in different phases of the product/service life cycle. Examples are given for the types of measures in the different phases.

Enforcement instruments (verification of compliance to legislation, including sanctions and legal action) are sometimes listed as an additional category but can also be regarded as part of the legislative toolbox.

An overview of the instruments and examples in the different phases of the product/service life cycle is presented in Table 1.

In general, legal instruments have a strong impact once fully adopted, yet may take many years to prepare and implement. Non-binding instruments can be implemented much faster, yet will only be effective if sufficiently supported by the Member States and other main stakeholders.

In most Member States the value chain to collect, aggregate and publish public road data need to be established or improved. Still, frameworks are in place for the efficient coding and publication of public road data.

As such the topic of this study can be considered to be both in the development and deployment phase, while the continuous improvement operational phase needs to be prepared now.

4.5. Application Requirements Analysis

A detailed analysis was undertaken which brought together the three analytical frames – the application groups, the minimum data requirements and the procedural requirements.

For each application group the study team identified qualitatively:

- The rationale for the inclusion of the application group (i.e. the need for a map, and/or the application's relevance to identifying public data digital mapping requirements);
- Which of the minimum data requirements were needed to enable the application to function (in terms of yes/no/preferably – i.e. desirable but not critical);
- Which of the procedures were relevant, and what minimum procedural requirements were needed to enable to application to be implemented / operated effectively; and
- Of the information that is needed by the application, which elements can most appropriately be provided by the public sector.

The results of this detailed analysis were a set of requirements for public sector data and procedures relevant to digital mapping on an application

group by application group basis. These results are not provided here because they are necessarily very detailed (a summary for each application group is provided in Annex A, while the full results are available in study deliverable D4 [15]). However they were important in the study methodology because they provided an important input to the subsequent cost-benefit analysis, the outcome of which was used to identify the common minimum requirements.

5. Role of Public Data in Meeting the Requirements

The study went on to consider the extent to which the data and key procedural requirements might be met by available public sources.

5.1. Available Public Data

An assessment was conducted of the road geometry and attribute data that is potentially available from the public sector.

To do this the study drew on the responses to the online survey and the interviews with road authorities which took place during the state-of-the-art phase of this study. These resources provided quantitative and qualitative information on the availability of data from public sources, sources which identified themselves as public authorities operating and offering road and mapping services at a national, regional or local level [4].

The results helped with assessing the extent to which the minimum data requirements of the applications might be fulfilled. The key findings of relevance are illustrated below.

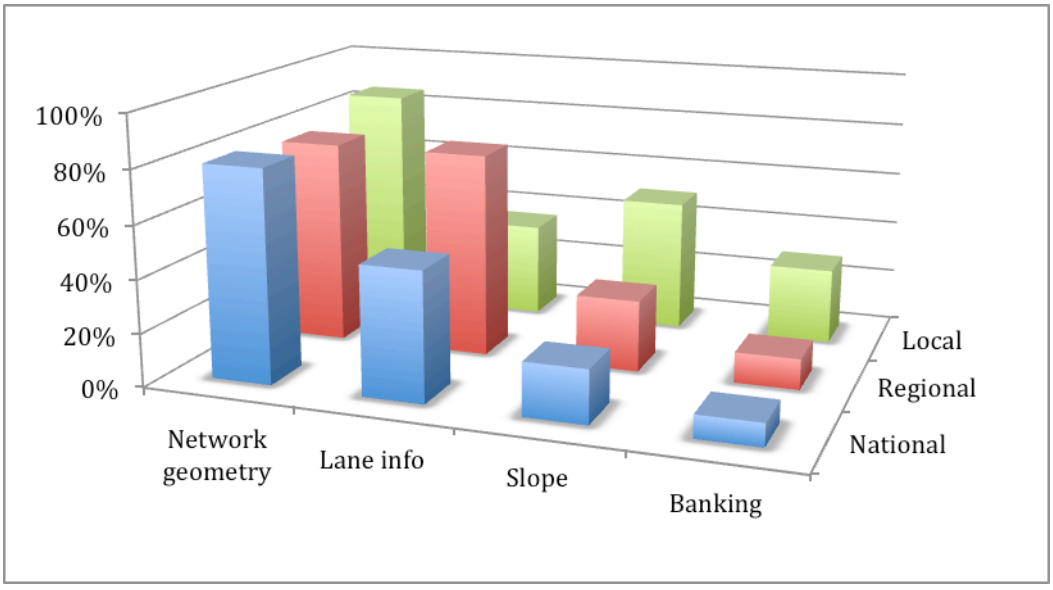


Figure 7 Geometry data collected by public authorities at various levels (proportion of respondents reporting that they collected such data) [4]

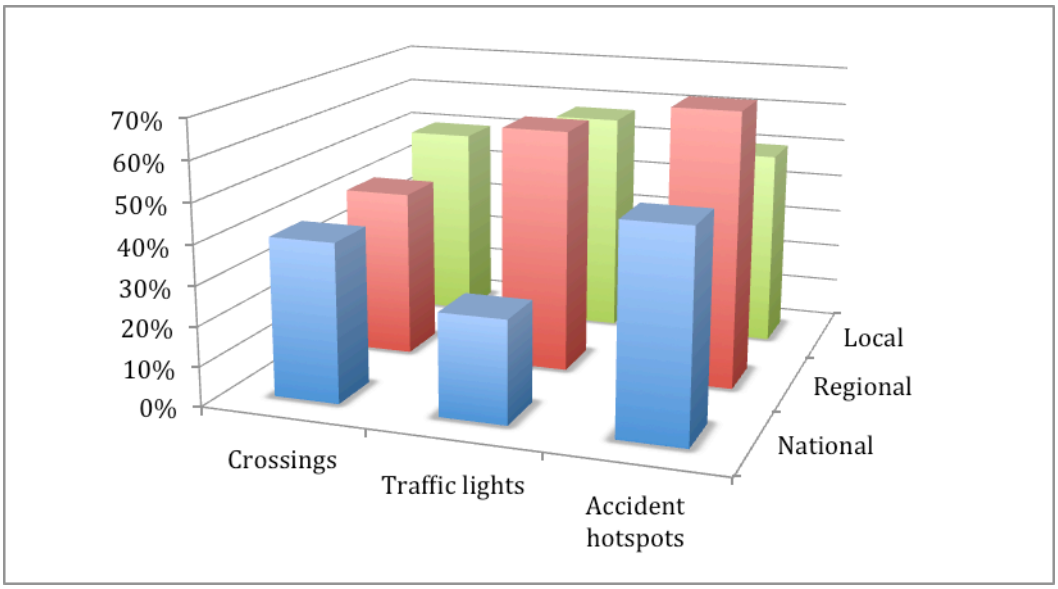


Figure 8 Safety-related locations collected by public authorities at various levels (proportion of respondents reporting that they collected such data) [4]

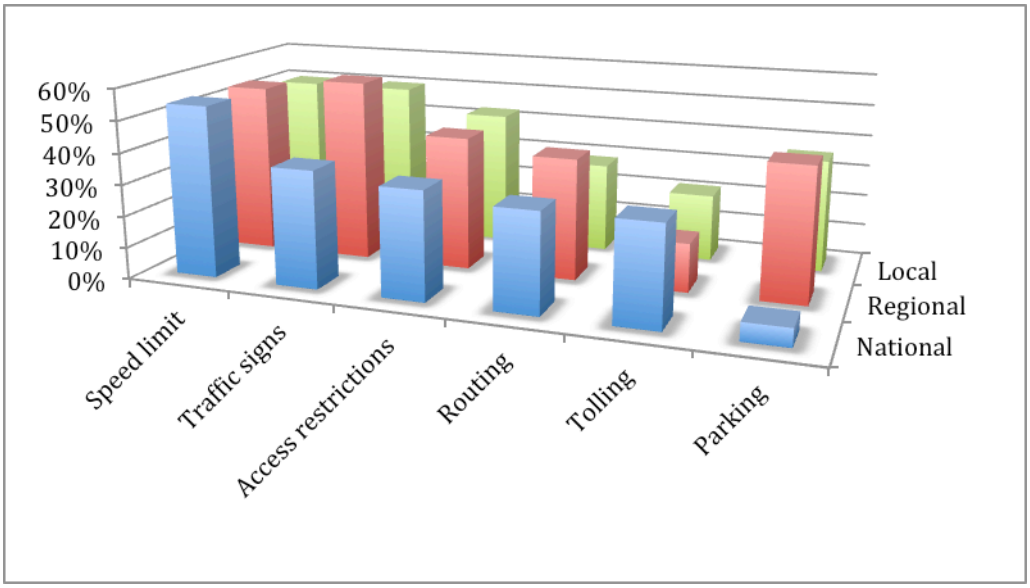


Figure 9 Traffic management data collected by public authorities at various levels (proportion of respondents reporting that they collected such data) [4]

5.2. Procedural Issues

5.2.1. Availability for Sharing and Quality

It is important to note the authorities did not indicate the extent to which:

- The data they collected was in a shareable/transferable format.
- The data was collected for purely internal purposes or whether it was collected with sharing in mind.
- The data covered their entire network or only small sections.

Interviews with road authorities and feedback during the two workshops confirmed that the availability of data for sharing, is as much an issue affecting its publication [4], as its quality. For local and regional roads even the most basic road attribute data (such as speed limits) is either not available in digital form, incomplete or not properly structured and managed. Procedures to monitor and manage quality of road data in general are not in place.

5.2.2. Attitudes to Sharing Data with the Private Sector

Not all types of public data will be useful for digital map applications in the next 10 years.

In the responses to the survey, it was generally reported that geometry and lane data is already disclosed and disseminated to the private sector. This comprises information related to roads that is generated by public authorities themselves (e.g. roadworks, planned new roads, planned changes to the road network, parking and tolling fees, lane and road restrictions). In contrast, other road information generated by the public sector that would be of interest to the private sector / individuals and was not considered to be so readily available (in digital form or otherwise) included traffic rules and regulations, road diversions and parking restrictions and fees. These data will be crucial for applications such as ISA and Navigation [4].

Besides generating their own data, public authorities also collect data that is produced by other authorities or third parties. Depending on the organisation of the road data value chain the types of data to which this applies, as well as their access and usage conditions, varies between Member States [4].

Interviews with key private map providers indicated that some were keen to receive modifications only, and not the underlying base data (e.g. changes to road geometry and attributes, not the whole map database). The map providers would also prefer to receive other forms of data generated by public authorities, such as parking restrictions, which would be useful to ensuring digital maps are as up-to-date as possible [4].

5.2.3. LATENCY IN THE VALUE CHAIN

The time required to process changes in the real world into published maps determines how up-to-date the resulting maps are. As such, a measure for the value chain latency[7] is an important differentiator for data and map quality.

There are two types of latency in the delivery / updating of road information:

- Maximum latency regarding the update of public road data for the use in digital maps by Member States road authorities.
- Maximum latency regarding the update of digital maps when new road data from Member States road authorities become available to the map provider.

In general, publicly managed road data are generated by planned changes to the infrastructure itself or road regulations. It therefore seems appropriate to agree on a procedure that requires publication of planned changes the moment such a change is adopted or planned by public authorities but no later than a specified period before the change is effected (one month in the examples in the table above).

[7] In the terms of reference of the study, the above was described as 'minimum delay'. This is a potentially confusing term to use in this context, so instead the study team adopted the term 'latency', meaning the time it takes to carry out a certain step in the value chain.

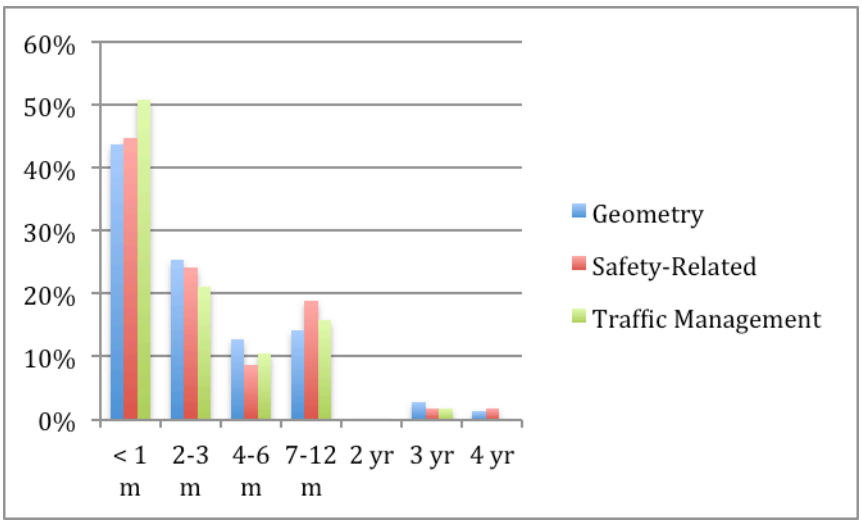


Figure 10. Current update frequency as indicated by data collectors [4].

In the consultation phase, public authorities indicated that they would like to see a clear commitment from digital map providers to make updates provided by public authorities available in their maps within a limited time period. If current latency in the digital map provider's value chains persists this will reduce support from public authorities to invest in, and operate systems for the collection and publishing of road data. It will be difficult to ensure timely updating of maps by private organisations, but maximum delay levels can be agreed in a public-private cooperation.

6. Existing Spatial Data Structures

Various research projects have developed specifications for the publication of spatial data, and structures for the publication or exchange of spatial data already exist in Europe. These spatial data structures can provide important building blocks to achieving an interoperable approach that could be applied across Europe, but respects the diversity of solutions already in use.

The most important initiatives in this area are INSPIRE, ROSATTE and the EasyWay Map Initiative. This chapter first provides a short overview of these projects, which have been described in more detail in study deliverable D2 [4], and subsequently assesses their potential compliance in meeting the minimum requirements described in the previous chapter.

6.1. INSPIRE

The goal of INSPIRE is to establish an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment.

The INSPIRE Directive entered into force on the 15th May 2007 [5]. The Directive requires that common Implementing Rules (IR) are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). These IRs are adopted as Commission Decisions or Regulations, and are binding in their entirety. INSPIRE however does not force Member States to collect specific spatial information. One important aspect of INSPIRE is the development of (non-binding) Technical Guideline documents that specify implementation details and best practices in order to help Member States in the implementation of the legal requirements laid down in the IRs. The INSPIRE data specifications are an example of such Technical Guideline documents.

The INSPIRE Directive defines the spatial data theme Transport Networks as: road, rail, air and water transport networks and related infrastructure, including links between different networks.

The data specifications for the Transport Networks allow the description of road networks through geometric representation of road or carriageway. Topology is derived from the geometric representation based on implicit rules. Further the Transport Network specifications describe a linear location referencing method [6].

Other important principles of the INSPIRE data specifications on Transport Networks are:

- Definition of transport properties (e.g. speed limits) that can be attached to the network representation through the linear referencing method.
- Extensibility: It is the aim of the INSPIRE Data Specifications to specify just the basic reference objects and mechanisms and a small number of widely used transport properties. Other (application-specific) transport properties and network objects (like those required by ITS applications) should be specified in application-specific extensions.
- Default XML encoding: A common default encoding (Geography Markup Language, GML) is defined for all INSPIRE data themes.

INSPIRE allows for data aggregation (or *integration*) on different levels of government, as long as services can be found via metadata published in discovery services. The Joint Research Centre of the EU currently operates a prototype of the INSPIRE geoportal, that provides discovery and viewing services for INSPIRE services operated by the Member States.

Different updating methods are supported by INSPIRE, from full data set updates to individual updates.

The purpose of INSPIRE is to provide a framework for the exchange of spatial data mainly between public authorities. INSPIRE respects current legislation on intellectual property rights in the Member States and requires Member States to adopt harmonised high-level access and re-use conditions.

6.2. ROSATTE

The ROSATTE project was completed in 2011. It aimed to establish an efficient and quality-assured data supply chain from public authorities to commercial map providers with regards to safety related road content [7]. It built on standards, rules and procedures used by or developed for INSPIRE (in particular ISO TC211), and work of ISO TC204 (focusing on ITS).

The ROSATTE project developed an infrastructure and supporting tools to enable European access to road safety attributes including incremental

updates. This infrastructure facilitates administrative internal functions as well as supply of data to third parties e.g. for safety relevant services.

The overall objectives of the project were to:

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

The ROSATTE project tried to align as much as possible with what was provided by INSPIRE [7]. It however adopted another approach in deciding for map-agnostic location referencing, and for exchanging changes to road attributes only. Like INSPIRE, ROSATTE allowed different access points for each Member State, though the discovery services still need to be specified. ROSATTE intends to use the INSPIRE specifications for the discovery service specifications, and augment them where required for ITS applications.

ROSATTE is currently not supported by European legislation, and although ROSATTE recognised the benefit of co-operation within INSPIRE and aimed to align as much as possible with INSPIRE, it recommended setting up a separate organisation called the ROSATTE Implementation Platform [7].

ROSATTE envisioned the Implementation Platform as a PPP, with the following roles [7]:

- Gather an extensive list of active public authorities at local, regional and national levels committed to the deployment of a road data exchange infrastructure,
- Create a pool of experts to support the implementation of a road data exchange infrastructure in the member states,
- Maintain and update the ROSATTE specifications through a centralised change request process,
- Write comprehensive implementation guidelines to support new implementations,

- Define procedures for making ROSATTE services searchable in (third party) metadata platforms. Where possible, implement metadata supply to such platforms,
- Offer map-related tools and services especially with regards to quality assurance and on-the-fly location referencing issues,
- Clarify with member states the legal and licensing aspects related to using the ROSATTE framework for public authorities who provide data to commercial map makers,
- Raise awareness and cooperate at international level on the topic.

eMaPS is the successor project of ROSATTE. It has the objective to revive the eSafety Digital Maps Working Group and establish the ROSATTE Implementation Platform.

6.3. EasyWay

Recently the EasyWay project took the initiative to define the EasyWay map. This map will be based on voluntary contributions of EasyWay members and intends to provide a continuous high-level representation of the main European transport corridors (i.e. the TERN). As minimum resolution for network representation, an exit-exit granularity is pursued.

The purpose of the EasyWay map is to have a common network reference for the harmonisation and interoperability of road and traffic management in the EU.

The EasyWay Map Group suggests using Open Street Map as a low-cost and low-maintenance base map, and to provide EasyWay partners with a tool to publish road related information onto the map.

The EasyWay Map Group further suggests the functionality of the map can be expanded further for a wider range of ITS purposes.

The development of the EasyWay map is in an early stage. The EasyWay Map Group indicated that it should be considered an internal tool for visualising EasyWay deployments and the EasyWay road map. Currently it is not foreseen to use it as an external tool for data exchange or information purposes. It was therefore not considered in the analysis in D4 [15].

6.4. Requirements Coverage

The technical and procedural specifications of INSPIRE and ROSATTE were reviewed to determine to what degree the selected standards and procedures allowed fulfilment of the minimum requirements. The results were included in D4 [15].

The following conclusions were drawn:

- INSPIRE shows significant content restrictions when it comes to road data required for the more advanced ITS applications.
- INSPIRE rates higher in procedures thanks to the established legal and organisational framework.
- ROSATTE provides better fulfilment of the minimum data requirements, although the current ROSATTE data set does not fulfil the data needs of all applications, in particular the more advanced applications such as cooperative and automated driving.

INSPIRE provides a good basis for the description of basic road geometry and road attributes. The functionality provided by INSPIRE is however limited in terms of the details with which road geometry can be described, e.g. intersection layout and lane geometry of dual carriage ways. An accurate and semantically unambiguous description of road section slope, banking and lane characteristics for example is essential for many ITS applications. Further, although allowing location types to be added, most location types required by the described applications are not yet part of the INSPIRE specifications. Adoption of new location types would require adoption of new specifications by the European Commission. For example, a clear description of accident hotspot locations is missing.

While providing a proven legal, organisational and technical framework, the current data specifications of INSPIRE seem insufficient to meet current and future ITS application needs.

ROSATTE was a research project promoted after the conclusions of the eSafety Digital Maps Working Group, bringing together digital map providers and public authorities. The specifications are tailored to meet the needs of digital map users. It allows for better description of road locations than INSPIRE and provides detailed descriptions of attributes specific to ITS applications, e.g. speed limit. ROSATTE however also suffers from the lack of a reliable location referencing standard. For the exchange of information between maps, a map-agnostic method is required. Tests by

ROSATTE have indicated that the currently available methods (AGORA-C and OpenLR) both perform sub-optimally. Locations cannot always be properly matched on the map of the receiving party resulting in omissions and map errors.

Further, ROSATTE took a pragmatic approach in the definition of road attributes, limiting them to the most essential ones while allowing for future extensions [8]. While this is considered a good approach, it does mean that unambiguous definitions of some attributes are currently not available, including those attributes that are required or could be of use to (future) ITS applications, e.g. description of traffic light locations.

These conclusions were used in developing Chapter 8, in which the possible requirements for standardisation activities are considered, to support the delivery of the framework of recommendations identified in this study and hence the progression of Action 1.3.

7. Cost and Benefits Assessment

7.1. Introduction

Thus far the study identified the minimum mapping data and procedural requirements to support key ITS applications over the next 10 years, the potential role of the public sector in meeting those requirements, and the possible sources of solutions to achieving interoperability of spatial data structures.

In considering how this information might be used by the EC to meet the aims of Action 1.3 it is also necessary to assess the range of options open to the Commission and the relative merits of those options at this stage.

To this end, the study developed five scenarios covering a wide range of combinations of available content types, road types covered, update methods, aggregation and data access levels, and EC policies and roles to facilitate and direct relevant actions. A cost-benefit analysis was then used to help to assess the relative merits of the different scenarios. The full scenario descriptions are provided in Annex B.

7.2. Methodology

In broad terms the approach used to evaluate the relative costs and benefits of the different scenarios was based on the Preliminary Business Case structure set out in guidance issued by HM Treasury in the UK[8]. This approach includes the following elements[9]:

- Strategic Case, for which the scenarios were assessed against the Principles for the Specification and Deployment of ITS as set out in the ITS Directive [2].
- Economic Case, for which the scenarios were assessed against broad areas of anticipated cost and benefit for the public and private sectors.

[8] The Green Book: Appraisal and Evaluation in Central Government, http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

[9] It was concluded that in the absence of specific quantitative information it would not be possible to complete the Financial Case and Commercial Case unless/until the preferred scenario was identified and further refined.

- Deliverability (or Project Management) Case – which considered the likelihood of the scenario gaining active support from all Member States (to avoid fragmentation of market potential), which focused on likely affordability, strength of societal benefit-cost ratio and concerns about accountability for such public expenditure,

To inform this analysis it was also necessary to develop a view of the nature and extent of the ITS applications expected to be enabled under the differing scenarios, and hence in particular the likely benefits achieved in terms of safety, efficiency, etc.

This approach ensured the costs and benefits of the scenarios were analysed at several levels, all of which were relevant to the likely suitability and success of the scenario.

7.3. Summary Assessment

The following table draws together the results of the individual elements of the cost-benefit analysis to provide an overall assessment of the relative suitability and feasibility of the alternative scenarios. The complete cost-benefit analysis can be found in D4 [15].

Summary of Assessments

	Minimum	Low	Inter-mediate	High	Maximum
Strategic Case	-5	1	2	3	-5
Economic Case	0	1	2	2	4
Commercial Case					
Financial Case					
Deliverability Case	5	3	3	2	-4
Overall Assessment	**0**	**++**	**+++**	**+++**	**-----**

Table 2 Overview of assessments

The concluding observations were as follows:

- **Scenario Minimum:** This is potentially inappropriate as it does nothing to advance ITS Directive goals. This conclusion depends on whether the EC believes the existing market is working and, if left alone, is capable of delivering change in the right timeframe.
- **Scenario Low:** This seems likely to deliver very limited benefits as any service would potentially only be available on the TERN. The

limited set of required procedures would however mean low implementation costs and a low compliance level for public authorities. This low compliance level would likely increase chances of lower level governments participating.

- **Scenario Intermediate:** This seems to represent a stronger proposition than scenario Low due to wider network coverage and hence greater potential benefits in terms of the effects of the applications on safety and efficiency of road networks. This, in combination with the binding specifications in case of deployment, seems to provide a good balance between effort and benefits.
- **Scenario High:** This seems to represent a stronger proposition than scenario Intermediate due to wider network coverage and hence greater potential benefits in terms of the effects of the applications on safety and efficiency of road networks. The increased road coverage and requirement of geometry data however significantly increases the investments and operational costs of Member States and the risk of losing the active support of at least some Member States.
- **Scenario Maximum:** This is potentially inappropriate under the terms of the Directive in that the action could be considered disproportionate, paying too little attention to local, regional and national specificities. It also carries a very high risk of lack of active support from Member States due to very high costs placed on the public sector without clear evidence of the ability of the private sector to facilitate delivery of the offsetting benefits via application deployment.

The results of the cost-benefit analysis provided a reference framework that clarified the key enablers and barriers, and helped to understand the positive and negative influence of different measures.

8. Standardisation Requirements

This section provides an assessment of mapping standardisation activities needed to support the minimum requirements of the relevant ITS applications, in effect by addressing the shortcomings of ROSATTE (originating in the ITS domain) and/or INSPIRE (originating in the GIS domain) in meeting those requirements.

8.1. ROSATTE-oriented or INSPIRE-oriented?

8.1.1. ISSUES

The review of existing spatial data structures in Chapter 6 examined the degree to which the standards and procedures in ROSATTE and INSPIRE allowed fulfilment of the minimum requirements identified in Chapter 4.

It concluded that both ROSATTE and INSPIRE had limitations in terms of their ability to support the minimum requirements.

The following figure illustrates the broad content and relationships between ROSATTE and INSPIRE and the groups of standards they have inspired. It also illustrates the area of overlap, confusion and incompatibility as these separate, disparate initiatives have intersected.

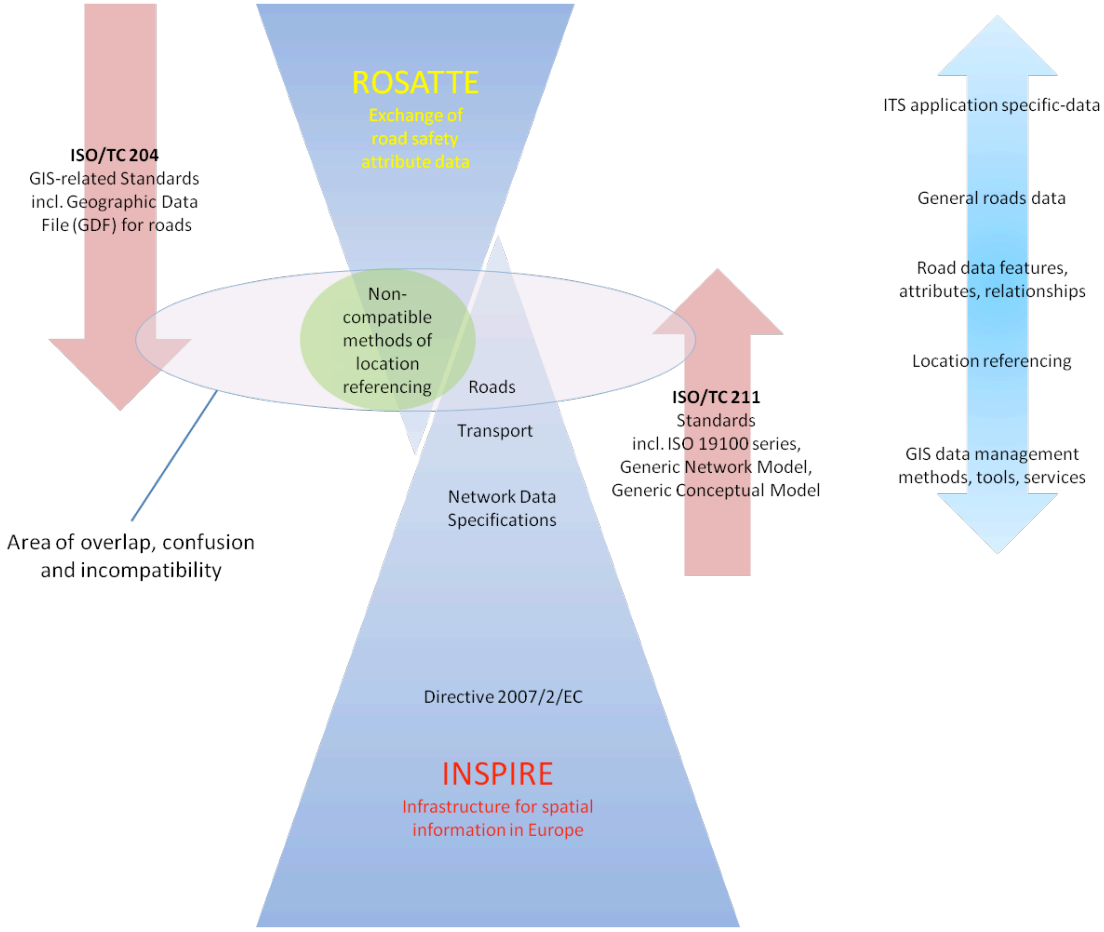


Figure 11. Relationship between ROSATTE and INSPIRE and the core groups of standards they have inspired

8.1.2. POSSIBLE STANDARDISATION REQUIREMENTS

Clearly, the necessary standardisation activities to address these problems will be dependent on which of the approaches reviewed above is followed. An INSPIRE-oriented and ROSATTE-inspired solution were considered:

- INSPIRE-Based Option: develop the INSPIRE data specifications to (a) add functionality for describing road geometry accurately and unambiguously, (b) add the location types required by the applications, (c) adopt a map-agnostic location referencing method, (d)

introduce methods for the monitoring and management of content quality.

- ROSATTE-Based Option: develop (a) unambiguous definitions of some necessary / desirable attributes to support the full range of applications, (b) a service discovery method, (c) methods for the monitoring and management of content quality.

8.1.3. CONSIDERATION

Putting to one side the issue of location referencing for a moment, the information reviewed to date tends to suggest that the ROSATTE-based option will offer the quickest and simplest route forward because it requires the least work to achieve the necessary requirements, and is perhaps most likely to be adopted most swiftly and universally by the industry.

In fact ROSATTE has aligned its activities to be consistent with the INSPIRE specifications, so it ought to be possible to present the adoption of the ROSATTE approach as an enriched / enhanced version of INSPIRE specifically suited to the digital mapping requirements of ITS applications on the road networks of Europe, yet consistent with the overall spirit and intent of the INSPIRE Directive.

The following diagram illustrates this potential future solution, in which the initiatives become aligned - where ROSATTE provides the detailed road data specifications and INSPIRE provides the underlying transport network specifications for GIS data management tools, methods, etc. It also shows that these would then stand on top of the organisational and legal foundation laid by the INSPIRE Directive.

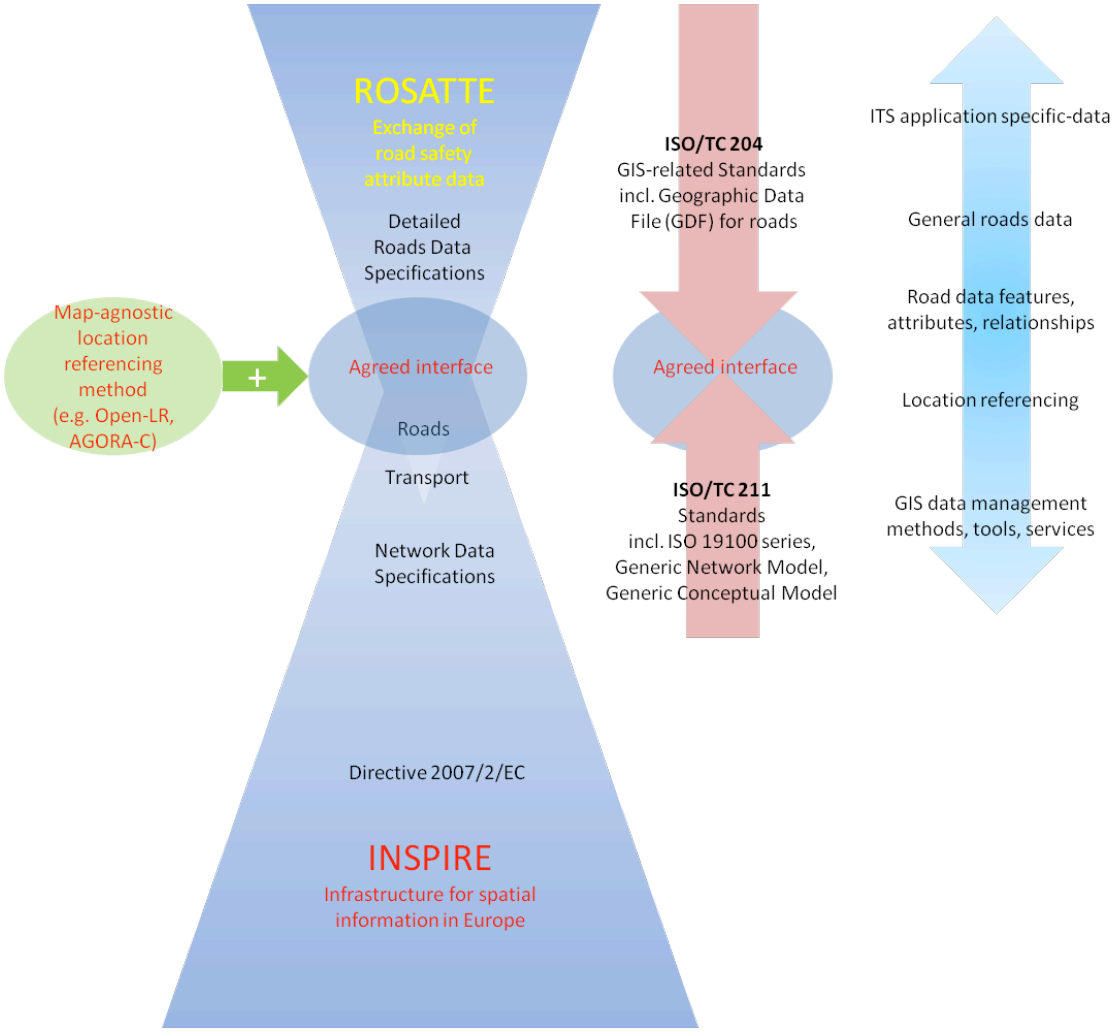


Figure 12. Combining the INSPIRE and ROSATTE specifications, the standards they have inspired and a map-agnostic location referencing method could offer the potential to ensure the minimum requirements are met

8.2. The Location Referencing Challenge

For the standardisation strategy presented in the previous section to work it will be necessary to overcome a notable challenge, that of location referencing.

8.2.1. ISSUES

Over the years various location referencing systems have been adopted by different ITS applications and in different places across Europe. These rely on either the availability of a common map, or a common location table by both the sender and receiver. Huge investments have been sunk into using these essentially incompatible approaches. This means the agreement of a single, standardised, pan-European approach to map-based location referencing is highly improbable.

Potentially standardised, dynamic map-agnostic methods exist which allow maps to exchange location information, thereby providing a means for the existing location referencing systems to continue to co-exist, yet interoperate.

ROSATTE examined the suitability of the two leading map-agnostic data exchange methods, namely AGORA-C and OpenLR[10]. It concluded that in both cases satisfactory results could be obtained, but that for superior requirements these methods might be not sufficiently effective [9]. The following key issues were identified:

- Both performed sub-optimally – locations cannot always be properly matched on the receiving party's map, resulting in omissions and errors. Avoiding any such errors would be of critical importance, especially for safety-related applications.
- Use of AGORA-C is subject to a commercial licensing agreement which means that organisations wishing to use it would need to pay royalty fees to its owners. In contrast, OpenLR is an open source software project and is royalty-free to users. Its development started in September 2009 (which may explain partly the inferior performance relative to AGORA-C at the time of its evaluation by ROSATTE) and is subject to the voluntary efforts of its developer community, which are continuing today.

[10] The project also examined other approaches including ROSA and TPEG-Loc but concluded these were unsuitable for map-agnostic data exchange for location referencing to support the relevant range of ITS applications.

8.2.2. POSSIBLE STANDARDISATION REQUIREMENTS

It seems unlikely that a strategy aiming for a single, standardised, pan-European approach to map-based location referencing will be successful. This suggests that standardisation efforts should rather be focused on improving standardised, dynamic map-agnostic methods to allow maps to exchange location information. This will provide a means for the existing location referencing systems to continue to co-exist, yet be interoperable.

AGORA-C and OpenLR appear to be candidate solutions, but each has different drawbacks. To describe locations, AGORA-C and OpenLR both rely on heuristic rules using the network topology. It therefore seems likely that improving the heuristic rules based on test results can lower the chance of misrepresentation of locations for both methods.

Considering the importance of the reliability of map-agnostic location referencing it seems that further R&D is warranted in this area.

In addition, two possible approaches are possible to resolving the other aspects of the location referencing challenge:

- AGORA-C Option: Further develop the AGORA-C approach to improve performance to the level required by the applications. (Note that AGORA-C is both a standard and a commercial product.)
- OpenLR Option: Further develop the OpenLR approach to improve performance to the level required by the applications. OpenLR is currently only a product, but its open source nature, ready access and free-to-use nature could drive its wide-scale adoption as a location referencing method.

8.2.2.1. CONSIDERATION

Development and publication of an approach based on agreeing a standard for a dynamic, map-agnostic method for exchanging data between maps could represent a standardisation process in itself. If not, it would at least be necessary to specify compatibility / support for AGORA-C or OpenLR in the core spatial data structures.

In choosing between AGORA-C and OpenLR, licensing, royalties and development costs are critical issues. It is not clear how Member States and private sector organisations would respond to a requirement to ensure compatibility with a standard that specified use of a proprietary solution where royalties are part of the conditions for use. This could be an

impediment to the AGORA-C option. An attempt could be made to get the licence holder to give up their licence or to agree to an indefinite free use policy.

It looks likely there will need to be further, possibly substantial, investment to improve the performance of either method to achieve the level of accuracy and reliability required to support the applications (e.g. by layering in additional map matching algorithms). If that is done by a private organisation which owns underlying IPR then the royalty cost could increase further. If it is done by a voluntary community, there might still be no royalty costs, but it could take a long time to complete the work. But this is, at least, analogous to the existing approach to development of standards in the EU, and it might be possible for the EC to accelerate progress in the same way by sponsoring developers to participate in the work.

The ICT standardisation Work Programme of the European Commission identifies this as priority, allowing funding for standardisation projects teams in this area.

9. Synthesis and Recommendations

This chapter presents the recommendations on the minimum requirements and possible procedures for the publication of publicly held road geometry and attribute data.

The recommendations on the minimum requirements are based on a synthesis of the technology roadmap (Section 3.4), the assessment of the minimum requirements (Chapter 4), the currently available public road data (Section 5.1), and the results of the cost-benefit analysis (Chapter 7).

The complete set of recommendations is enclosed in Annex C.

9.1. Common Minimum Requirements

9.1.1. CONTENT

9.1.1.1. GENERAL CONSIDERATIONS

The state-of-the-art study [4] and the cost-benefit analysis have made it clear that a number of aspects need to be considered when selecting what road data public authorities should make available to digital map providers.

- Deployment of future ITS applications require homogeneous and continuous data.
- The level of development of the public road data value chain differs substantially, both between Member States and between the different levels of government [4].
- Few data types required by (future) map-based ITS applications are currently available. Even in the most developed Member States important types of data are not collected for the main roads, or not stored in a structured format [4]. This means that fulfilment of the content and road type coverage requirements of scenario ‘low’ (speed limit as the only attribute, coverage limited to TERN) would currently be challenging for many Member States.
- Digital map providers argue that a step-by-step approach should be chosen, and that ambitions should not be set too high because few data are currently available in a usable form.

- Public authorities argue that they need a clear roadmap to secure support from legislators and lower level authorities, and to secure funding for the deployment and operation of the required value chains.
- Various regulations originating from road authorities that could provide a basis for, or contribute to the development of future ITS applications are currently not considered by ROSATTE or INSPIRE. For example: various access and parking restrictions, as well as parking and tolling fees.
- In general, the successful adoption and deployment of EC policies takes several years. The scope of the study was set at 10 years.

These requirements are somewhat contradictory and therefore a pragmatic approach seems most suitable. Rather than limiting the content to a fixed set of road data types as defined in the 'medium' and 'high' scenarios, a pragmatic approach would make content available on a step-by-step basis, starting with what is valuable and readily available, while allowing for a gradual inclusion of other content types.

9.1.1.2. ROAD GEOMETRY DATA

Road and lane geometry data present specific issues that need to be considered.

- The data requirements analysis has shown that continuous, high-quality road geometry data will be essential for future map-based ITS applications.
- Digital map providers oppose the publication of public road geometry data, arguing it would lead to price erosion in their key markets, limiting in the long run their willingness to invest in the development of high-grade map data that will be required for advanced ITS applications.
- Digital map providers use road geometry data from high-quality public sources in various Member States to improve their map data sets.
- Public authorities have the obligation under INSPIRE to make existing road data publicly available since May 2009.
- Availability, ownership and access, and quality of public road geometry data vary significantly between Member States.

Considering the large differences between Member States in terms of the availability, ownership, access rights and conditions, and quality of road

geometry data, it seems digital map providers will be best positioned to develop the continuous high-quality road geometry data that is required for future ITS applications.

Public road geometry data sets should however remain available as reference sources for digital map providers, and important sources of road infrastructure changes.

9.1.1.3. SYNTHESIS

It is recommended to encourage Member States to publish publicly held road data that either originate from public authorities, or can only be efficiently sourced by public authorities. This implies also that the long-term goal would be the publication of all road data that is generated by public authorities.

The reasons for such an approach are:

- Public authorities are the best source for such data.
- Public authorities by definition hold the property rights to such data (although publication can still be hampered by the license conditions applying to the underlying geometry data set(s)).
- Availability of any public road data is likely to improve (or even enable) future ITS applications, including applications that cannot be envisioned yet.
- According to the PSI and INSPIRE Directives data that are collected with public funding and that have re-use potential should be made available to the benefit of all.

The suggested minimum data requirements distinguish different groups of road data classes, based on a classification of the need from digital map providers, and the costs and effort involved for public authorities to collect and publish the data. The proposed classes correspond with the content requirements for scenarios 2 (low) to 5 (maximum).

9.1.2. ROAD TYPE AND GEOGRAPHIC COVERAGE

Substantial differences in the level of development exist between Member States and the different levels of government [4]. This means not all road

type data required by ITS applications are currently available for all road types. Therefore a pragmatic approach seems most appropriate. Member States should be requested to provide a plan that indicates when what road data content class will be available for what road type, for example as presented in Table 3. To cater for regional differences, Member States should be allowed to adopt a more detailed breakdown of road data types for the 3rd and 4th road type classes.

Road type \ Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Motorways, expressways (including concessionaire roads)	1	1	1	1-2	1-2	1-3	1-3	1-4	1-4	1-4
European, National, state roads	1	1	1	1-2	1-2	1-3	1-3	1-4	1-4	1-4
Regional, county, provincial, district, prefectural roads				1	1	1-2	1-2	1-3	1-3	1-3
Communal roads, municipal and urban roads, streets				1	1	1-2	1-2	1-3	1-3	1-3
Agricultural and forestry roads										
Bicycle and foot paths										

Table 3 Possible road map road content classes EU-27/EEA. The numbers indicate the content classes as defined in [15] and shown below in Recommendation 4.

To achieve seamless availability of public road data throughout the European Union, a definition of mandatory road data class-road type coverage as in Table 3 would be required.

To avoid patchy or limited coverage a common first deployment target should be set that can be achieved by all Member States: coverage of all TERN road plus all motorways with content class 1 by end 2015. This common deployment target should be re-assessed regularly and increased

to what is considered feasible for the Member States. This implies that some Member States will be forced to collect new road data, or make currently held road data available in a standardised electronic format.

9.1.3. LOCATION REFERENCING

The existing spatial data frameworks (INSPIRE and ROSATTE) have incorporated methods to reference locations in published data sets. Accurate location referencing is essential for the exchange of road data, as the information needs to be accurately located on the road network. Data collectors and digital map providers more often than not use different base maps to reference road attribute data and new locations. When exchanging data between data collectors and digital map providers this can lead to location referencing errors, as the combined errors in the two base maps lead to faulty positioning.

INSPIRE specifies a location referencing method that serves the purpose of INSPIRE - the dissemination of data relevant to environmental research policy. This method uses linear referencing to refer to locations on the road network defined in the INSPIRE datasets. This method is error prone. E.g. reference lengths will result in different locations on different maps, in particular when road geometry changes. Another downside of this method is its dependency on the road network defined in the INSPIRE dataset.

ROSATTE adopted AGORA-C as its location referencing method. This method allows the map-independent exchange of road data. It does however have licensing and accuracy problems as described in chapter 8. ROSATTE also tested the alternative OpenLR method with somewhat similar results. Location referencing remains a critical issue.

9.1.4. RECOMMENDATIONS MINIMUM REQUIREMENTS

Recommendation 1

Set as end-goal: the publication of all publicly held road data that either originates from public authorities, or that can only be efficiently sourced by public authorities:

- All road and traffic regulations that can be applied to individual road sections and nodes, such as speed limits, driving direction, access restrictions (based on vehicle type, cargo class, weight, dimensions, time of day, day of the week, etc.), parking fees and restrictions, etc.
- Long-term roadworks.
- Infrastructure changes (new roads, changes to the layout of roads and intersections).
- Position on the road network of public services for vulnerable road users such as (special) schools (or school zones), retirement homes, hospitals, etc.
- Position on the road network of traffic lights, traffic calming measures such as speed bumps, accident hotspots, etc.

Recommendation 2

Make content available on a step-by-step basis, starting with what is valuable and readily available, while allowing for a gradual inclusion of other content types. This may imply the obligation for Member States to organise the collection of new road data.

Recommendation 3

Public road geometry data sets should remain available to digital map providers as reference sources, in particular for road infrastructure changes.

Recommendation 4

Adopt a classification of content as basis for deployment planning. The proposed classification is:

Content class	Costs and effort Public Authorities	Need Digital Map Providers	Data Types
Class 1	Low	Required for the development of basic map-based ITS applications, e.g. ISA, navigation	Speed limit
Class 2	Low	Not required but beneficial to the development of map-based ITS applications	Speed limit, other traffic regulations, position of informatory and warning signs on the road network
Class 3	Medium	Required for more advanced map-based ITS applications	Speed limit, other traffic regulations, and informatory and warning signs, safety locations, road geometry changes
Class 4	High	Required for advanced map-based ITS applications such as co-operative driving	Speed limit, other traffic regulations, informatory and warning signs, safety locations, changes in road and lane geometry and topology

Recommendation 5

Set coverage of the TERN plus all motorways with content class 1 as target for 2015. This may imply that some Member States will have to collect new road data.

Recommendation 6

Request Member States to define a deployment plan for road data; defining per road type when a content class will be made available for digital map providers.

Recommendation 7

Initially adopt AGORA-C as map-agnostic location referencing method.

Recommendation 8

Promote short-term improvement of OpenLR or the development of another license-free map-agnostic location referencing method as alternative to AGORA-C.

9.2. Procedures

9.2.1. General Considerations

Procedures are required to establish the optimal co-operation model, and to guarantee the availability and timely updating of road data compliant with the coverage and quality requirements.

The cost-benefit analysis provided an assessment of the different aspects of possible procedures. This section provides a synthesis of these findings for each procedure and elaborates several options.

9.2.2. Service Architecture

9.2.2.1. Data Aggregation and Access Level

Road data is created at different levels of government and a key decision is therefore whether to collect the data in a central data store, and at what level such a data store should be made available: at the regional, national or European level.

In the synthesis of the content requirements, it was suggested to adopt as common guideline that all content that is created by public authorities should be made available, but that a pragmatic approach should be taken in the implementation; gradually expanding road data type and road coverage.

This implies that in the short term the key sources of road data will be at the level responsible for managing main roads, but that as road coverage

needs to improve, data from lower level road authorities needs to be made available.

It seems that in the short term it makes sense to aggregate data on the Member State level, but that for the future a distributed model is more appropriate whereby the original source of the data, the owner of the data, or the organisation responsible for the data, is also the organisation to publish the data [7]. This approach would be in line with the main principles of the INSPIRE Directive.

European Member States differ significantly in size, number of government levels, and even the area and population of regional and local authorities. It therefore seems most pragmatic to leave it up to the Member States on what level data is aggregated in their country, as long the Member State provides a transparent discovery service for the different sources. Both INSPIRE and ROSATTE adopted such a distributed model, allowing aggregation of data at one or multiple locations in a Member State. Such an approach also allows Member States to develop and adapt the organisation of the road data value chain as requirements change, tailored to the specific circumstances in the Member State.

9.2.2.2. UPDATE METHOD AND LATENCY

Road data can be published and updated in different ways:

1. Publish and update as full data sets
2. Publish as full data set, update using case-by-case updates
3. Publish only updates case-by-case

Although method 3 benefits existing market players as they already have full data sets that they can then easily update, it does provide an important advantage over the other two methods. As the interviews with key stakeholders showed, many Member States have procedures in place that oblige road authorities to publish any change in road and traffic regulations. In some Member States this is done centrally, but in many other the information is published (i.e. aggregated) in (paper) government announcements.

It should be relatively easy for Member States to change the procedures, or if need be the legal framework to assure changes to road and traffic regulations are published both on paper and in electronic form. This method

could be augmented by also allowing regular, e.g. annual, baseline updates of the full data set.

Because changes to road and traffic regulations originate from public authorities, few legal barriers are likely to exist to publication (see also section 9.2.3). Other information generated by public (road) authorities, such as planned changes to the geometry of the road infrastructure, can also be integrated relatively easy (if not hampered by licensing issues concerning the underlying map data).

9.2.3. ORGANISATIONAL FRAMEWORK

As indicated in the previous sections it seems appropriate to adopt a stepwise approach gradually leading to digital publication of all road data that is generated by, or can most efficiently be collected by, public authorities.

The organisational framework that is to be chosen should be set up in such a way that a growth path is controlled while allowing for adaptation of objectives, and content and coverage requirements to meet the needs of both the public authorities and digital map providers and their customers.

General guideline for the organisational setup should be that it:

- Ensures capitalisation of past EC investments, without being dependent on EC funds.
- Assures a continuous involvement of key stakeholders; i.e. both map providers and public road and mapping authorities.
- Allows for a controlled expansion of content type coverage and road type coverage with the consent of stakeholders.
- Allows for the gradual improvement of the technology that is required to meet the changing content requirements: data coding, location referencing, definition of data services and discovery services, quality monitoring and control methods, etc.

Combining INSPIRE and ROSATTE in one organisational framework seems most appropriate, dividing tasks in such a way that the competences of public and private organisations are maximised.

In this solution, ROSATTE data specifications are adopted as extension to the INSPIRE TN specifications, further referred to as the TN-ITS specifications. The Implementation Platform proposed by ROSATTE serves as a forum to discuss, plan and support the implementation of the TN-ITS specifications by Member States and the Digital Map providers. It also serves as a forum where future road data needs of the users of digital maps – private and public - can be discussed and anticipated.

The ROSATTE Implementation Platform would in parallel act as INSPIRE Spatial Data Interest Community on ITS (SDIC-ITS). Representatives of the ROSATTE Implementation Platform can further participate in the various representative and technical bodies of INSPIRE, and experts of ROSATTE should be included in the INSPIRE "expert pool".

9.2.4. Legislation on Publication of Road Data

Legislation can provide an important pre-condition for the successful harmonisation of access to public road data.

When considering legislation it is important to note that public road data in most Member States is not available in digital form for most roads, and in many cases not even for main roads. These value chains are under development by the relevant public authorities and brute legislative force seems therefore inappropriate at this moment.

The INSPIRE Directive was drawn with the aim of exchanging public data between public organisations with a clear focus on environmental impact studies. Although the INSPIRE Directive currently seems to meet the needs for this study quite well, there is a chance of diverging needs in the future.

ROSATTE was tailored to the needs of public authorities and digital map providers, but lacks a legislative framework.

Adoption of the ROSATTE content specifications as extension to the INSPIRE Transport Network specifications in the long run seems to provide the best guarantee for a continuous publication of public road data to digital map providers. It will also allow for future expansion of content type and road type coverage as requirements from ITS Applications change.

This could be achieved through the adoption by the EC of specifications as part of the ITS Directive. These would have to require the adoption of the ROSATTE specifications as extension to the INSPIRE TN specifications,

and require Member States to comply with these specifications if they publish road data.

If the foregoing measures do not result in the required progress, the European Commission may issue a Deployment Proposal within the framework of the ITS Directive (subject to a positive result of the impact assessment).

9.2.5. Legislation on Access and Re-Use conditions

A significant barrier to public road data is the different conditions concerning access and re-use of the data that are applied in the different Member States. Some form of harmonisation will reduce the effort required for digital map providers to access public road data, and to provide their customers with consistent information.

It therefore seems appropriate to establish common access and re-use conditions as part of the ITS Directive. This could be done by drafting common non-exclusive conditions that apply to all road data publishing by public authorities in the EU. Member States and (semi) public sources within each Member State should however be free to add or change conditions as long as the key conditions are not violated.

A model for determining the real costs would be required, clearly defining what types of costs are to be included and what not, how shared costs are to be split, etc.

9.2.6. Quality and Liability

Road map data has the potential to play a critical role in future ITS applications, in particular in advanced driver assistance systems. This potential will only materialise if the data is complete, reliable and consistent throughout the European Union.

The INSPIRE and ROSATTE quality systems seem to be complementary and could therefore be considered valid. A clear definition of quality levels per road data type per application area is needed, in particular for safety-related ITS applications.

Considering the differences in development of the road data value chains in the different Member States it is essential that a clear and objective method to describe the level of quality of road data sets of specific data types is

developed. Such a method should allow having different quality levels for road data types reflecting their importance in road safety.

As pointed out previously, the availability of data in digital form is a key issue. In particular in the early stages of deployment it seems more important to make data available rather than imposing strict quality certification of all public authority value chains. An objective method to classify data quality would still provide insight into the level of quality provided.

It is essential that public authorities cannot be held liable for any possible damages resulting from errors in the road map data. This should be accomplished by including a disclaimer in the common license agreement that waivers any liability of the public data source.

9.2.7. EC POLICY

Besides legislation, the European Commission has a number of policy instruments available it can use to promote the publication of public road data.

The topic of this study can be considered to be both in the development and deployment phase, while the continuous improvement operational phase needs to be prepared now. For the different phases the EC has a number of policy options that are described below.

9.2.7.1. DEVELOPMENT PHASE

Promotion of R&D

A number of technical issues have been identified by INSPIRE, ROSATTE and stakeholders. These issues require additional research and development:

- The current methods for describing road data in digital form provide good frameworks but are still quite limited in terms of the types of road data that can be described.
- No methods exist to efficiently describe and measure road data quality.
- Currently available map-agnostic location referencing methods still result in too high error rates. These methods can be improved by further adding heuristic mapping rules.

The EC could further assure focus on road data in on-going and future EU Research Programmes.

Support to the development of standards

Standardisation bodies that are independent of the EU largely carry out European standardisation, including standards to support EU policy. The EU can however influence the process by issuing Standardisation Mandates to the European Standardisation Organisations, and focusing the process through policy and legislation.

The ICT standardisation Work Programme of the European Commission allows funding for standardisation projects teams in this area.

Research to support legislation

The EC could contribute to the development of a common license agreement for the publication of public road data.

9.2.7.2. DEPLOYMENT PHASE

Best practices

Some Member States already have developed very advanced value chains to collect and publish public road data. Their experience can help other Member States to efficiently implement and operate their value chains. The EC could encourage the development and promotion of 'best practices'.

Assessment / certification

The EC can play a role in setting up and carrying out assessments and certifications of established value chains, which will improve quality levels of the public road data.

9.2.8. RECOMMENDATIONS PROCEDURES

Recommendation 9

Member States should decide on the organisation of the road data value chain in their country. This means Member States are to define what organisations are responsible for the creation and collection of road data,

what organisations are responsible for aggregating and publishing road data, and what organisation co-ordinates these activities and liaises with the various bodies within INSPIRE and ROSATTE.

Recommendation 10

Member States should decide on what level data is aggregated in their country. To facilitate discovery of the data sources, Member States should provide a transparent discovery service providing metadata for the different sources.

Recommendation 11

ROSATTE Implementation Platform should adopt the INSPIRE specifications for discovery services and metadata.

Recommendation 12

Road data changes should be published through case-by-case updates. Additional incremental and full data set updates should be encouraged but not made mandatory. This applies to road geometry, topology and attribute data.

Recommendation 13

Requirements should be adopted for the timely updating of public road data, with clear maximum update intervals per road data type. The intervals should be adopted progressively, ultimately leading to the final target intervals in the table below:

Data types	Change frequency	Maximum latency(s) regarding the update of public road data for the use in digital maps by Member States road authorities	Maximum latency(s) regarding the update of digital maps when new road data from Member States road authorities become available to the map provider
Traffic regulations (e.g. speed limits)	Very high	One month before the regulations take effect	Within two weeks
Traffic signs	High	One month before the regulations take effect	Within two weeks
Road Geometry new roads	Low	One month before opening of the road	Within two weeks
Road Geometry, long-term roadworks	High	One month before the roadworks start	Within two weeks
Traffic restrictions (vehicle dimensions, weight, temporal, tolling, routing and parking)	Medium	One month before the restrictions take effect	Within two weeks
Topology, road surface, lane information (number, width, divider, connectivity)	Medium	One month before road changes are effectuated	Within two weeks
Traffic lights	Low	Within one month before/after it changes	Within two weeks
Crossings and stops (pedestrian, tram)	Low	Within one month before/after it changes	Within two weeks
Speed bumps, accident hotspots	Low	Within one month before/after it changes	Within two weeks
Slope and banking	Very low	Within one month before/after it changes	Within two weeks

Recommendation 14

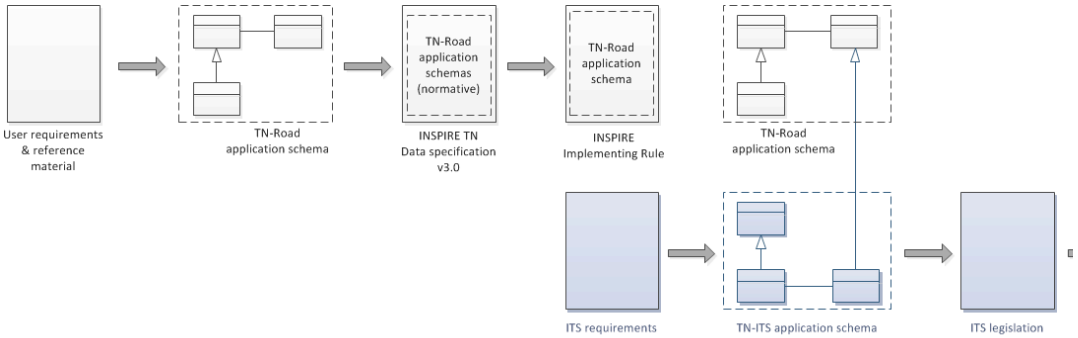
The recommended organisational framework combines INSPIRE and ROSATTE (see table below). ROSATTE data specifications are adopted as extension to the INSPIRE TN specifications, further referred to as the TN-ITS specifications.

	Member States	**INSPIRE**	**ROSATTE Implementation Platform**
Development		Continued development of the INSPIRE service architecture and organization	Adoption of the INSPIRE service and service discovery architecture.
		Adoption of ROSATTE data specifications as an extension to the INSPIRE TN specifications. Compliance testing of ROSATTE.	Developing and proposing ITS specific road data coding specifications, location referencing, quality assessment, best implementation practices, etc.
Operation	Publishing of road data services compliant with the TN-ITS extension	Assuring deployment in MS compliant with the specifications of the TN-ITS extension	Act as INSPIRE Spatial Data Interest Community for ITS (SDIC-ITS)
			Delegation of representatives in other relevant INSPIRE organisations (Expert Pool, LMO, DT)
	Publishing of ITS road data service metadata		Monitoring and accommodating the evolving needs of private and public road

	Member States	INSPIRE	ROSATTE Implementation Platform
			data users (e.g. navigation providers and road authorities)
	Monitoring and managing of ITS road data quality		Implementation planning and attuning between digital map providers and public authorities
	Discovery services development and operation	EU geoportal development and operation	Developing and proposing ITS specific road data coding specifications for new road data types.

Recommendation 15

The ROSATTE data specifications should be adopted as extension to the INSPIRE TN specifications, further referred to as the TN-ITS specifications. The required processes – such as testing of the compliance of the specifications with INSPIRE - should be initiated as soon as possible, in line with the following approach:



Recommendation 16

The Implementation Platform proposed by ROSATTE serves as a forum to discuss, plan and support the implementation of the TN-ITS specifications by Member States and the Digital Map providers. It also serves as a forum where future road data needs of the users of digital maps – private and public - can be discussed and anticipated, and where the development of coding methods and quality levels for new data types are initiated.

Recommendation 17

The ROSATTE Implementation Platform acts as Spatial Data Interest Community on ITS (SDIC-ITS) within INSPIRE. ITS representatives should further become members of the planned “expert pool” for INSPIRE maintenance, from which experts can be selected for updates/maintenance of INSPIRE Technical Guidance documents.

Recommendation 18

The EC should adopt specifications as part of the ITS Directive that require the adoption of the ROSATTE specifications as extension to the INSPIRE TN specifications, and require Member States to comply with these specifications if they publish road data.

Recommendation 19

If the foregoing measures do not result in the required progress, the European Commission may issue a Deployment Proposal Directive within the framework of the ITS Directive (subject to a positive result to the impact assessment), requiring Member States to collect and publish new road data to meet the agreed deployment planning (recommendation 5).

Recommendation 20

The EC should adopt common access and re-use conditions as part of the ITS Directive that apply to all road data publishing by public authorities in the EU. Member States and (semi) public sources within each Member State should be free to add or change conditions as long as the common conditions are not violated. The conditions should cover:

- Guaranteed public access to public road data; fair, proportionate and non-discriminatory.
- The right of digital map providers to create combined datasets from multiple public data sources.
- The rights and obligations of digital map providers when copying, reformatting, rearranging, adapting (e.g. to improve consistency), translating, and reproducing public road data (and its updates).
- The rights and restrictions for map provider to exploit the combined data sets.
- Rules on the use of trade names, trademarks, service marks, etc. of public data sources.
- Basic ground rules for license fees; these should not exceed the total costs of collecting, producing and disseminating road data, together with a reasonable return on investment.
- Waiver of the liability of the public data source for damages resulting from data errors.
- Obligation for map providers to warn the end-user that the map data can contain errors and that the public authorities cannot be held liable for such errors.
- Data quality monitoring, classification and management rules, including timely update arrangements.

Recommendation 21

The EC should support the development of standards for coding road data content classes.

Recommendation 22

The EC should promote the development of an objective optional method to classify data quality of road data sets of specific data types, based on the complementary work of INSPIRE and ROSATTE.

Recommendation 23

The EC should promote the development and promotion of *best practices* for the collection, aggregation and publication of road data by Member States with more developed value chains.

10. Assessment of Recommendations

10.1. Principles of ITS Directive

(a) Be effective – make a tangible contribution towards solving the key challenges affecting road transportation in Europe (e.g. reducing congestion, lowering of emissions, improving energy efficiency, attaining higher levels of safety and security including vulnerable road users);

The recommendations will increase the availability of public road data for digital map providers. This will lead to more accurate and more up-to-date digital road maps, a key enabler of advanced ITS applications. These ITS applications will improve road safety, reduce congestion, lower emissions, improve energy efficiency, and have the potential to increase road safety and security for vulnerable road users.

Relevant recommendations: 1-6

(b) Be cost-efficient – optimise the ratio of costs in relation to output with regard to meeting objectives;

The proposed solution does not make the publication of road data mandatory for Member States. Instead it establishes a harmonised framework for the publication of road data and sets common objectives in terms of content and road coverage. This approach does not force expenditure by Member States while lowering expenditure if Member States decide to publish public road data.

Relevant recommendations: 2, 6, 9, 10-12, 14-16, 19-23

(c) Be proportionate – provide, where appropriate, for different levels of achievable service quality and deployment,
taking into account the local, regional, national and European specificities;

In many Member States even the most basic road data is not stored in a usable way. By stimulating rather than forcing the collection, aggregation and publication of public road data, optimal use is made of the available data sets and infrastructure.

Relevant recommendations: 2, 6, 9, 10-12, 14-16, 19-23

(d) Support continuity of services – ensure seamless services across the Union, in particular on the trans-European network, and where possible at its external borders, when ITS services are deployed. Continuity of services should be ensured at a level adapted to the characteristics of the transport networks linking countries with countries, and where appropriate, regions with regions and cities with rural areas;

By harmonising the platform for the publication of road data, continuity of service is guaranteed. Development of dedicated quality assessment methods assure a transparent definition of data quality.

Relevant recommendations: 7, 8, 14, 15, 17-23

(e) Deliver interoperability – ensure that systems and the underlying business processes have the capacity to exchange data and to share information and knowledge to enable effective ITS service delivery;

Road data is already exchanged between public authorities and digital map providers. The recommendations assure better interoperability through the harmonisation of the methods and procedures that are used between public authorities and digital map providers.

Relevant recommendations: 7, 8, 14, 15, 17-23

(f) Support backward compatibility – ensure, where appropriate, the capability for ITS systems to work with existing systems that share a common purpose, without hindering the development of new technologies;

The recommended solution builds on methods, standards, organisations and legislation previously developed by INSPIRE and ROSATTE. Many public authorities will find that they already have the required infrastructure in place to publish their public road data.

Relevant recommendations: 7, 14, 15, 18

(g) Respect existing national infrastructure and network characteristics – take into account the inherent differences in the transport network characteristics, in particular in the sizes of the traffic volumes and in road weather conditions;

The recommended solution builds on the existing INSPIRE platform, that is (being) implemented by Member States.

Relevant recommendations: 7, 14, 15, 18

(h) Promote equality of access – do not impede or discriminate against access to ITS applications and services by vulnerable road users;

Common access and re-use conditions will be recommended for the public road data sets, assuring non-exclusive and uniform access to public road data for all.

Relevant recommendations: 19, 20

(i) Support maturity – demonstrate, after appropriate risk assessment, the robustness of innovative ITS systems, through a sufficient level of technical development and operational exploitation;

The proposed solution builds on an established framework (INSPIRE) and a data coding method that has been tested in ROSATTE. Additional research is recommended to mend the identified technical and procedural shortcomings.

Relevant recommendations: 7, 8, 13-15, 21-23

(j) Deliver quality of timing and positioning – use of satellite-based infrastructures, or any technology providing equivalent levels of precision for the purposes of ITS applications and services that require global, continuous, accurate and guaranteed timing and positioning services;

The proposed improvements to the location referencing methods and quality monitoring methods will improve digital road map accuracy and reliability. This will lead to higher quality of timing and positioning in ITS applications using the improved maps.

Relevant recommendations: 7, 8, 13, 21-23

(k) Facilitate inter-modality – take into account the coordination of various modes of transport, where appropriate, when deploying ITS;

Intermodal nodes can be provided by public authorities.

Relevant recommendations: 1, 6

(l) Respect coherence – take into account existing Union rules, policies and activities which are relevant in the field of ITS, in particular in the field of standardisation.

The recommended solution builds on existing legislation; INSPIRE, PSI Directive, ITS Directive.

Relevant recommendations: 14-20, 22

10.2. Recommendation DMWG eSafety

The Digital Map Working Group of the eSafety forum identified 3 phases to make public safety-related road data available to digital map providers, and made recommendations per phase. In this section the recommendations of this study are compared with the recommendations of the Digital Map Working Group of the eSafety forum.

10.2.1. DMWG Recommendations of Phase 1: Cooperation

1. The safety attributes list will be made available to the member states by the European Commission. They will be categorised as high, medium or low priority.
2. Upon receipt of a request by a mapping company/organisation, public authorities will indicate what data they have from that list to the mapping companies and make the safety-related data available (as far as it is reasonably possible and at their own convenience).
   Alternatively, they will place the information (the names of the datasets and/or the information within that dataset) on a publicly accessible website. If they do not have responsibility for a particular dataset (within their own geographic area) they may suggest the name of the public (or other) authority that does.
3. Public authorities will fill in and maintain the list of the attributes that they own, to be made available either upon request or on their website. For data that is presently categorised as high priority, where they have incomplete datasets they will endeavour - as far as is reasonable - to collect and maintain the complete set of information.
4. For datasets with high priority safety attributes, public authorities will make updates available to the mapping companies when they become available.
5. For datasets with high priority safety attributes, the safety attributes will, as far as possible, be made available to the mapping companies at cost of their compilation and delivery.
6. If the national government wishes, it may compile a register of the available safety attributes data. Reference to this register should be made on the public authorities' websites.
7. None of the above (items 1-6 as they apply to a particular dataset) applies where a national government (Ministry of Transport) deems that a database containing the relevant dataset already exists (e.g.

one prepared by a mapping agency) and is available at reasonable cost.

8. Private and public sectors will seek to work together to improve the accuracy of routing information, so that navigation systems do not route vehicles illegally (banned turns) and that public authorities can fulfil their road safety and congestion reduction objectives.
9. When public authorities introduce new database or asset management systems, consideration should be given to the introduction of new fields for the safety at- tributes, even if there is currently no intention to collect that data. This WG will maintain and actively provide to public authorities a current list of safety attributes – this list must be maintained and agreed with in an appropriate manner through consultation with the public authorities.

The recommended solution aims for a step-by-step implementation of road data publication, starting with what is readily available, including what is of use to digital map providers, and setting the publication of all road information generated by public authorities as the end-goal. It harmonises to some extent the required content road coverage by Member States while leaving room for more complete sets of data publishing compliant with the ROSATTE data coding and location referencing methods. For the deployment an alternative classification of content is propose.

The procedures for the publication of data sets described by the DMWG are made superfluous through the recommended embedding of the road data value chains in INSPIRE. INSPIRE provides methods and tools for the publication of road data in a standardised and harmonised way.

The proposed solution further recommends supporting the establishment of the ROSATTE Implementation Forum, for the continuous monitoring of data needs from digital map providers.

Relevant recommendations: 1-8, 15-19

10.2.2. DMWG Recommendations of Phase 2: Quality assurance

1. The issue of quality assurance of data will be studied in more detail based on experience and the outputs from other programmes, projects and initiatives.

2. The WG will evaluate the quality of data supplied and where it is not adequate will suggest ways of improving the quality.
3. The public and private actors will evaluate how well this Recommendation is working one year after full operation and make recommendations for improvements, if needed, to the European Commission and then initiate Phase 3.

The study concluded that methods for defining, measuring, monitoring and managing quality levels for the different road data types, are still insufficiently defined. In line with the recommendations of DMWG it also recommends promoting the development of these methods. Relevant recommendations: 21-23

10.2.3. DMWG RECOMMENDATIONS FOR PHASE 3: OPTIMISATION

Phase 3 will optimise the data transfer process based on the experience from Phase 1 & 2.

The recommended solution establishes an organisational framework that allows for a gradual improvement of content coverage and quality. Relevant recommendations: 1, 2, 4-6, 14-17, 21-23

11. Conclusions

Rather than limiting the road data to a fixed set of attributes it is recommended to aim for the publication of all publicly held road data that either originates from public authorities, or that can only be sourced efficiently by public authorities.

Because in many Member States road data are not available in a structured format, it is recommended that content is provided on a step-by-step basis, starting with what is valuable and readily available, while allowing for a gradual inclusion of other content types. As a first step it is suggested that all Member States provide speed limit information for the complete TERN plus motorways in 2015.

Besides road attribute data, public road geometry data sets should also remain available to digital map providers as reference sources, in particular for road infrastructure changes.

Member States should define deployment plans for road data, identifying for each road type when a content class will be made available to digital map providers.

Map-agnostic location referencing methods are methods that can be used for location referencing on any map. Currently these perform sub-optimally, resulting in frequent map matching errors in an operational environment. AGORA-C is currently considered to be slightly better than OpenLR but is subject to commercial licensing requirements. It therefore is recommended to initially adopt AGORA-C as the map-agnostic location referencing method, but to promote the improvement of the license-free OpenLR or development of other map-agnostic license-free location referencing methods in parallel.

Road data changes are recommended to be published through case-by-case updates. Additional incremental and full data set updates should be encouraged but not be made mandatory at first. This limits the complexity of the data processing methods in the value chain significantly, reducing implementation risks for public authorities.

The study proposes a clear target definition of maximum update intervals for each road data type and recommends this to be adopted to ensure the road maps of digital map providers remain up-to-date.

How road data is collected, aggregated and published – the road data value chain - differs between Member States. In general the road data value chain involves public authorities on various levels of government, as well as various private parties. Because of the complexity and diversity of these value chains across Europe, the organisational approach of INSPIRE is recommended. How the road data value chain is organised is to be determined by each Member State on a national level. Road data do not necessarily have to be aggregated in a central national database, but a national register of road data sources should be published and maintained by Member States.

It is recommended that ROSATTE specifications for coding road data are adopted as an extension to the INSPIRE Transport Network Specifications, further referred to as the TN-ITS specifications.

Digital map providers can then find the different road data sources via the national INSPIRE registers, and can use the source through harmonised content coding based on the ROSATTE specifications, significantly lowering the overhead for both the digital map providers and the public authorities.

The recommended organisational framework combines INSPIRE and ROSATTE as follows. The Implementation Platform proposed by ROSATTE should serve as a forum to discuss, plan and support the implementation of the TN-ITS specifications by Member States and the Digital Map providers. It should also serve as a forum where future road data needs of the users of digital maps – private and public - can be discussed and anticipated, and where the development of coding methods and quality levels for new data types are initiated. The ROSATTE Implementation Platform will act as Spatial Data Interest Community on ITS (SDIC-ITS) within INSPIRE. This study defines a clear division of tasks between the two initiatives.

It is recommended the EC adopts specifications as part of the ITS Directive that require the adoption of the ROSATTE specifications as extension to the INSPIRE TN specifications, and requires Member States to comply with these specifications if they publish road data within the framework of the ITS Directive.

The EC is recommended to specify common access and re-use conditions as part of the INSPIRE Directive that apply to all road data publishing by public authorities in the EU. Member States and (semi) public sources within each Member State should be free to add or change conditions as

long as the common conditions are not violated. A first set of conditions has been compiled in this study.

Some technical and procedural aspects of the road data value chain need to be improved or further elaborated. It is therefore recommended the EC should support:

- The development of standards for coding new road data content classes
- The development of an objective optional method to classify data quality of road data sets of specific data types, based on the complementary work of INSPIRE and ROSATTE.
- The development and promotion of best practices and common tools, for the collection, aggregation and publication of road data by Member States with more developed value chains.

It is believed that these recommendations provide the basis of a framework for significantly improving the publishing of public road data for digital map providers to the benefit of both the public and private sector. The recommended solution provides quick wins, while allowing for a gradual expansion of content and road type coverage. By building on existing spatial data structures and standards, and opting for a stepwise roll-out, implementation and operational costs and risks are limited. It is believed that the recommended solution will gain the support of wide range of public and private stakeholders involved in the road data value chain.

- End of main document -

List of Acronyms

ADAS	Advanced Driver Assistance Systems
CEN	European Committee for Standardization
DB	Database
DoT	Department of Transport
EC	European Commission
EEA	European Economic Area
EU	European Union
FVD	Floating Vehicle Data
GIS	Geographic Information System
I2V	Infrastructure-to-Vehicle Communication
IR	INSPIRE Implementing Rule
ISA	Intelligent Speed Assistance
ISO	International Organisation for Standardization
ITS	Intelligent Transport Systems
LDWS	Location Departure Warning System
LIDAR	Light Detection And Ranging
POI	Point of Interest
MS	Member State
PPP	Public Private Partnership
PSI	Public Sector Information
R&D	Research and Development
V2I	Vehicle-to-Infrastructure Communication
V2V	Vehicle-to-Vehicle Communication

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Annex A: Summaries of Assessments of Minimum Application Requirements – Data and Procedures

AUTOMATED DRIVING

Automated driving requires the availability of an in-vehicle road map. Although some automated driving tests have been successfully carried out on the road, it is unlikely that Automated Driving will be deployed on a significant scale in the next ten years.

Map-based Automated Driving requires very detailed geometry data (<1m positional accuracy) and very reliable road attribute data for the roads it covers. The geometry data will probably be produced by digital map providers, as they are best positioned to provide continuous geometry data of uniform high quality for Europe. Public authorities will have an important role to play in providing up-to-date road and traffic regulation data which will be essential for the functioning of Automated Driving.

Besides the required regulatory information, Automated Driving can also benefit from public data on safety-related locations (such as speed bumps, schools, accident hotspots, etc.) and specific traffic restrictions.

COOPERATIVE DRIVING

As with Automated Driving, the Cooperative Driving solution considered in this study also requires an in-vehicle digital road map. Deployment of. It is quite likely that Cooperative Driving will be deployed on a significant scale in the next ten years as the automotive industry has initiated platforms to assure a harmonised deployment of vehicle-to-vehicle communication. Ideally Cooperative Driving would cover all roads, but since the required data quality is very high a more pragmatic deployment path starting with main inter-urban roads seems more realistic. Signalised junctions can also provide a starting point for I2V-based co-operative driving. Therefore the coverage requirement for road data is limited to main inter-urban roads and signalised junctions.

As with Automated Driving, the geometry data will probably be produced by digital map providers, as they are best positioned to provide continuous geometry data of uniform high quality for Europe that is required for Cooperative Driving.

Public authorities will have an important role to play in providing up-to-date road and traffic regulation data which will be essential for the functioning of Cooperative Driving.

Besides the required regulatory information, Cooperative Driving can also benefit from public data on safety-related locations (such as speed bumps, schools, accident hotspots, etc.) and specific traffic restrictions.

INSURANCE AND ENFORCEMENT

Applications in this area may require an in-vehicle road map. In particular the road regulation data linked to the map geometry needs to be up-to-date and correct. Locations of safety-relevant locations such as traffic lights and accident hotspots will enhance the driver monitoring possibilities. Preferably the map is as complete as possible, covering as many roads as possible.

Accident hotspot, slope, and banking, may be useful to the insurer/enforcement agency in identifying the risk of driving in a given location, but is not essential.

Information needed from public sector includes legal speed limit and other road regulations.

INTELLIGENT PARKING SERVICES

Parking services do not necessarily require a digital map. Linking the data to a digital road map however will allow navigation systems to better route to the parking and the entry and exit points. The attributes of the parking itself do not have to be linked to a digital road map.

It is anticipated that future intelligent truck parking applications will provide services across Europe, particularly on the main inter-urban connections.

The information that could be provided in the form of a map relate to information on access restrictions which are related to vehicle type, height, width, length and weight. Parking restrictions and fees are also relevant to this service.

INTELLIGENT SPEED ADAPTATION

ISA does not necessarily require a digital map, it can also use information from local beacons. Linking the data to a digital road map however provides a much more cost-effective way of implementing ISA.

ISA is in particular relevant for all urban connections although it can be implemented on all roads of Europe.

The information that is required for ISA is accurate and up-to-date information on speed limits. For map-based ISA not only the speed limits in force, but in particular planned speed limit changes are of interest. Reliability of the speed limit information is essential.

LANE DEPARTURE WARNING SYSTEM

LDWS does not necessarily require a digital map, it can also use information from (infra-red) cameras with advanced image processing technology. Using lane information from a digital road map could however provide a more cost-effective way of implementing LDWS.

LDWS is relevant for every road boasting multiple lanes, but in particular for roads that are accident prone, such as regional roads with one lane in each driving direction.

The information that is required for LDWS is very detailed and accurate information on the geometry of each lane. For map-based LDWS also planned changes to lane geometry are of interest. Accuracy and reliability of the lane geometry information is essential.

LOCAL SAFETY WARNINGS

For this study it is assumed Local Safety Warnings are based on an updateable digital map. These applications assist the driver in avoiding potential incidents at specific locations, which may lead to typical accidents. Intersection safety applications are currently in their infancy in terms of actual deployment, however they could be deployed on a location-by-location basis depending on the need. This application could be implemented at main inter-urban connections and city arteries in all European countries.

If a map-based solution is used, it would require detailed information under the following categories: accident hotspots, geometry information such as sharp bends, uneven surface, gradient information, banking/curvature, and lane-level information. Information relating to traffic lights / road crossings may also be of use to Local Safety Warnings.

Information needed from public sector include road regulations, safety-related locations, planned road works and infrastructure changes.

MAP-AS-A-SENSOR

To use a map as a sensor, full coverage of roads is required. Detailed and reliable geometry data is required, describing not only centre lines, but also slope and banking angles, of carriageways and preferably of individual

lanes as well. Further, information on road regulation and safety-related locations is important to timely detect dangerous speeds and other incursions.

Public authorities will have an important role to play in providing up-to-date road and traffic regulation data which will be essential for the functioning of the map-as-a-sensor.

ADVANCED NAVIGATION SYSTEMS

Navigation systems and their underlying map bases are increasingly looking to cover all countries and all road types in Europe (and beyond).

To support the services provided by navigation systems, a basic depiction of the road geometry and topology is required. Lane level geometry is also preferable in certain areas, such as major junctions and intersections. It is also important for navigation systems to have a clear and up to date understanding of the traffic rules and regulations affecting a given network. Systems and services providing drivers with routing guidance draw upon a number of sources including legal speed limits and other information that might affect the route such as diversions.

Information that is useful to navigation systems but by no means critical includes general point of interest signs (e.g. advertisements, points of local information signs), information signs and warning signs. Together with more advanced road geometry attributes such as slope, this information allows the planning of eco-friendly routes.

The public sector could provide information on legal speed limits, access restrictions, planned roadwork and diversions to digital map providers.

TRAFFIC INFORMATION

Traffic information should, as a minimum, be available for main inter-urban connections and city arteries in Europe (e.g. TERN). To depict traffic information a map is desirable, to use traffic information in route guidance, network topology and road geometry are required.

Road network topology information and road works information is likely to be necessary for traffic information applications utilising digital maps.

Planned road works (and any associated diversions) information would be very useful if it can be provided from public sector.

Annex B: CBA Scenarios

Scenario:	1) Minimum	2) Low	3) Intermediate	4) High	5) Maximum
Minimum requirements content	No requirements	Speed limit	As scenario 2, other traffic regulations, informatory and warning signs	As scenario 3, safety locations, road geometry	As scenario 4, lane geometry and topology
Minimum road type coverage	No requirements	TERN	TERN, motorways	TERN, motorways, secondary roads and city arteries	All roads
Update method	No requirements	Individual changes only	Individual changes only	Incremental updates	Full updates
Data aggregation level	None, owner level	Regional	Regional and national	Member State	EU
Access level (discovery services)	None	Member State	Member State	Member State and EU	Member State and EU
Operational role EC	None	Facilitating (standards, R&D, implementation support)	Monitoring (legislation, monitoring)	Monitoring (legislation, monitoring)	Monitoring (legislation, monitoring)
Policy instruments EC	None	Non-binding (recommendations and opinions)	Binding specifications[11], best practices, possible financial support, enforcement	Binding specifications, best practices, possible financial support, enforcement	Legislative and enforcement (regulations, directives, decisions, sanctions)

[11] issued as a delegated act, i.e. mandatory only if deployed by a Member State

Annex C: Recommendations

Recommendation 1

Set as end-goal: the publication of all publicly held road data that either originates from public authorities, or that can only be efficiently sourced by public authorities:

- All road and traffic regulations that can be applied to individual road sections and nodes, such as speed limits, driving direction, access restrictions (based on vehicle type, cargo class, weight, dimensions, time of day, day of the week, etc.), parking fees and restrictions, etc.
- Long-term roadworks.
- Infrastructure changes (new roads, changes to the layout of roads and intersections).
- Position on the road network of public services for vulnerable road users such as (special) schools (or school zones), retirement homes, hospitals, etc.
- Position on the road network of traffic lights, traffic calming measures such as speed bumps, accident hotspots, etc.

Recommendation 2

Make content available on a step-by-step basis, starting with what is valuable and readily available, while allowing for a gradual inclusion of other content types. This may imply the obligation for Member States to organise the collection of new road data.

Recommendation 3

Public road geometry data sets should remain available to digital map providers as reference sources, in particular for road infrastructure changes.

Recommendation 4

Adopt a classification of content as basis for deployment planning. The proposed classification is:

Content class	Costs and effort Public Authorities	Need Digital Map Providers	Data Types
Class 1	Low	Required for the development of basic map-based ITS applications, e.g. ISA, navigation	Speed limit
Class 2	Low	Not required but beneficial to the development of map-based ITS applications	Speed limit, other traffic regulations, position of informatory and warning signs on the road network
Class 3	Medium	Required for more advanced map-based ITS applications	Speed limit, other traffic regulations, and informatory and warning signs, safety locations, road geometry changes
Class 4	High	Required for advanced map-based ITS applications such as co-operative driving	Speed limit, other traffic regulations, informatory and warning signs, safety locations, changes in road and lane geometry and topology

Recommendation 5

Set coverage of the TERN plus all motorways with content class 1 as target for 2015. This may imply that some Member States will have to collect new road data.

Recommendation 6

Request Member States to define a deployment plan for road data; defining per road type when a content class will be made available for digital map providers.

Recommendation 7

Initially adopt AGORA-C as map-agnostic location referencing method.

Recommendation 8

Promote short-term improvement of OpenLR or the development of another license-free map-agnostic location referencing method as alternative to AGORA-C.

Recommendation 9

Member States should decide on the organisation of the road data value chain in their country. This means Member States are to define what organisations are responsible for the creation and collection of road data, what organisations are responsible for aggregating and publishing road data, and what organisation co-ordinates these activities and liaises with the various bodies within INSPIRE and ROSATTE.

Recommendation 10

Member States should decide on what level data is aggregated in their country. To facilitate discovery of the data sources, Member States should provide a transparent discovery service providing metadata for the different sources.

Recommendation 11

ROSATTE Implementation Platform should adopt the INSPIRE specifications for discovery services and metadata.

Recommendation 12

Road data changes should be published through case-by-case updates. Additional incremental and full data set updates should be encouraged but not made mandatory. This applies to road geometry, topology and attribute data.

Recommendation 13

Requirements should be adopted for the timely updating of public road data, with clear maximum update intervals per road data type. The intervals should be adopted progressively, ultimately leading to the final target intervals in the table below:

Data types	Change frequency	Maximum latency(s) regarding the update of public road data for the use in digital maps by Member States road authorities	Maximum latency(s) regarding the update of digital maps when new road data from Member States road authorities become available to the map provider
Traffic regulations (e.g. speed limits)	Very high	One month before the regulations take effect	Within two weeks
Traffic signs	High	One month before the regulations take effect	Within two weeks
Road Geometry new roads	Low	One month before opening of the road	Within two weeks
Road Geometry, long-term roadworks	High	One month before the roadworks start	Within two weeks
Traffic restrictions (vehicle dimensions, weight, temporal, tolling, routing and parking)	Medium	One month before the restrictions take effect	Within two weeks
Topology, road surface, lane information (number, width, divider, connectivity)	Medium	One month before road changes are effectuated	Within two weeks
Traffic lights	Low	Within one month before/after it changes	Within two weeks
Crossings and stops (pedestrian, tram)	Low	Within one month before/after it changes	Within two weeks
Speed bumps, accident hotspots	Low	Within one month before/after it changes	Within two weeks
Slope and banking	Very low	Within one month before/after it changes	Within two weeks

Recommendation 14

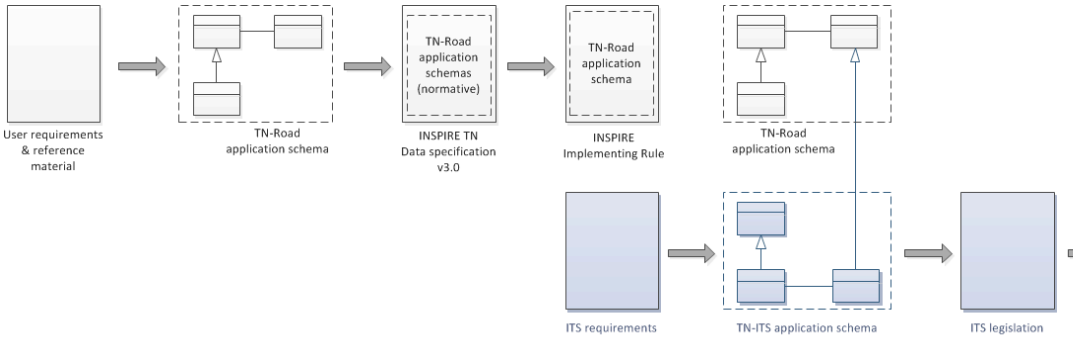
The recommended organisational framework combines INSPIRE and ROSATTE (see table below). ROSATTE data specifications are adopted as extension to the INSPIRE TN specifications, further referred to as the TN-ITS specifications.

	Member States	**INSPIRE**	**ROSATTE Implementation Platform**
Development		Continued development of the INSPIRE service architecture and organization	Adoption of the INSPIRE service and service discovery architecture.
		Adoption of ROSATTE data specifications as an extension to the INSPIRE TN specifications. Compliance testing of ROSATTE.	Developing and proposing ITS specific road data coding specifications, location referencing, quality assessment, best implementation practices, etc.
Operation	Publishing of road data services compliant with the TN-ITS extension	Assuring deployment in MS compliant with the specifications of the TN-ITS extension	Act as INSPIRE Spatial Data Interest Community for ITS (SDIC-ITS)
			Delegation of representatives in other relevant INSPIRE organisations (Expert Pool, LMO, DT)
	Publishing of ITS road data service metadata		Monitoring and accommodating the evolving needs of private and public road

	Member States	INSPIRE	ROSATTE Implementation Platform
			data users (e.g. navigation providers and road authorities)
	Monitoring and managing of ITS road data quality		Implementation planning and attuning between digital map providers and public authorities
	Discovery services development and operation	EU geoportal development and operation	Developing and proposing ITS specific road data coding specifications for new road data types.

Recommendation 15

The ROSATTE data specifications should be adopted as extension to the INSPIRE TN specifications, further referred to as the TN-ITS specifications. The required processes – such as testing of the compliance of the specifications with INSPIRE - should be initiated as soon as possible, in line with the following approach:



Recommendation 16

The Implementation Platform proposed by ROSATTE serves as a forum to discuss, plan and support the implementation of the TN-ITS specifications by Member States and the Digital Map providers. It also serves as a forum where future road data needs of the users of digital maps – private and public - can be discussed and anticipated, and where the development of coding methods and quality levels for new data types are initiated.

Recommendation 17

The ROSATTE Implementation Platform acts as Spatial Data Interest Community on ITS (SDIC-ITS) within INSPIRE. ITS representatives should further become members of the planned “expert pool” for INSPIRE maintenance, from which experts can be selected for updates/maintenance of INSPIRE Technical Guidance documents.

Recommendation 18

The EC should adopt specifications as part of the ITS Directive that require the adoption of the ROSATTE specifications as extension to the INSPIRE TN specifications, and require Member States to comply with these specifications if they publish road data.

Recommendation 19

If the foregoing measures do not result in the required progress, the European Commission may issue a Deployment Proposal Directive within the framework of the ITS Directive (subject to a positive result to the impact assessment), requiring Member States to collect and publish new road data to meet the agreed deployment planning (recommendation 5).

Recommendation 20

The EC should adopt common access and re-use conditions as part of the ITS Directive that apply to all road data publishing by public authorities in the EU. Member States and (semi) public sources within each Member State should be free to add or change conditions as long as the common conditions are not violated. The conditions should cover:

- Guaranteed public access to public road data; fair, proportionate and non-discriminatory.
- The right of digital map providers to create combined datasets from multiple public data sources.
- The rights and obligations of digital map providers when copying, reformatting, rearranging, adapting (e.g. to improve consistency), translating, and reproducing public road data (and its updates).
- The rights and restrictions for map provider to exploit the combined data sets.
- Rules on the use of trade names, trademarks, service marks, etc. of public data sources.
- Basic ground rules for license fees; these should not exceed the total costs of collecting, producing and disseminating road data, together with a reasonable return on investment.
- Waiver of the liability of the public data source for damages resulting from data errors.
- Obligation for map providers to warn the end-user that the map data can contain errors and that the public authorities cannot be held liable for such errors.
- Data quality monitoring, classification and management rules, including timely update arrangements.

Recommendation 21

The EC should support the development of standards for coding road data content classes.

Recommendation 22

The EC should promote the development of an objective optional method to classify data quality of road data sets of specific data types, based on the complementary work of INSPIRE and ROSATTE.

Recommendation 23

The EC should promote the development and promotion of *best practices* for the collection, aggregation and publication of road data by Member States with more developed value chains.