Public Final Project Report

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1 Summary

EuroRoadS has laid the ground for a European road data infrastructure. The project has identified the business environment and user requirements and based on that, developed specifications to enable a uniform and efficient data transfer between producers of road data and providers of information and services for end users. Furthermore the project has developed methods for evaluation and quality control.

The demonstration part of the project has developed and tested a prototype in order to demonstrate and validate the usefulness of the specifications.

The implementation plan presents possible organisational, technical and business solutions to support a network to deliver harmonised European road data. The exploitation plan explores the prerequisites for a successful roll-out of this network and for creating a sustainable demand for a European road data infrastructure and services.

The project proposes to establish a EuroRoadS Forum to promote and exploit the results of the project and to support both providers and users of public/private-sourced road data. The main task for a EuroRoadS Forum is to explore and promote the EuroRoadS aims and results.

The EuroRoadS project has aimed to find a good balance between far reaching harmonisation and to make use of existing road data.

The project results imply an important harmonisation exercise within transport networks. EuroRoadS has a clear potential to contribute to INSPIRE, national SDI´s and development of ITS.

The proposed implementation and exploitation activities, including the suggested establishment of a EuroRoadS Forum are supported by a number of organisations willing to bring EuroRoadS forward.

2 Objectives and achieved results

EuroRoadS has laid the ground for a European road data infrastructure. The project has identified the business environment and user requirements, developed a specification framework, methods for evaluation and quality control, developed and tested a prototype and devised proposals for implementation and exploitation of the outlined solution.

The EuroRoadS results comprise:

- A framework of specifications describing an information model, core data content, as well as an exchange model and exchange format for European road data. The specifications are based on investigations of the business environment and user requirements.
- A model for handling evaluation and quality control of road data in the information chain (from data producers to end users),
- A metadata catalogue
- A terminology catalogue,
- Results from practical demonstrations verifying: that the specifications function well for likely use cases, that the quality model gives expected results and can be used in practice, and that the metadata catalogue can be implemented in a practical solution and give expected information to the users.
- Furthermore the project has developed a plan for implementation and exploitation as well as information materials. The implementation plan investigates possible organisational, technical and business solutions to support a network to deliver harmonised European road data. The exploitation plan explores the prerequisites for a successful roll-out of this network and for creating a sustainable demand for a European road data infrastructure and services.

The EuroRoadS vision for the year 2012 is a pan-European harmonised, standardised, seamless, up-dated and quality assured, digital road data infrastructure covering at least 25 European countries.

2.1 EuroRoadS and INSPIRE

The proposed INSPIRE Directive aims at giving the legal framework for an infrastructure for spatial information, which will make available relevant and harmonised geographic information. The Directive focuses on information of importance for environmental planning and monitoring. Road data information is of importance for measurement of traffic noise, pollution and energy consumption, management and monitoring of traffic, road tolling and pricing, transport planning, emergency and security.

The results from EuroRoadS are of great interest for the implementation of the European Spatial Data Infrastructure and by that for the proposed INSPIRE Directive. Reports from the EuroRoadS project have been delivered to and carefully investigated by the INSPIRE Drafting teams, who are in the process of developing draft implementing rules for the Directive. Therefore, it can be stated that the project will have an impact on the implementation of the European spatial data infrastructure in general and especially concerning the handling of data on road networks.

Of specific interest is how EuroRoadS has:

- searched to find the right balance between a far reaching harmonisation and to make use of existing data structures,
- focused on core European road network data
- created efficient tools to achieve interoperability
- involved relevant stakeholders in the entire process
- used existing standards,
- demonstrated the feasibility and advantages of an interoperability based solution for sharing spatial data,
- demonstrated a clear potential to contribute to INSPIRE, but it remains to insure coherence (and cross-links) with generic specifications for other data themes being covered by the proposed directive.

When the Directive will come into force it will have a clear impact on the establishment of interoperability between different data themes, organisations and countries and thereby for the implementation of a road data infrastructure.

3 Activities

The project has been built up in a step-wise approach with a number of activities starting with an investigation of the business environment and the most common user groups. Furthermore a detailed description of the user requirements was conducted. Based on these investigations a road data specification framework was developed as well as processes for evaluation and quality control of the information chain. A prototype has been developed and tests have been carried out to prove that the specifications and quality model can be used in practice. To prepare for the deployment of the project results implementation and exploitation plans have been developed. Throughout the entire project dissemination of the project, its aims and results has been carried out.

The different activities have been carried out in separate work packages but at the same time as a relay race as there are clear dependencies between the activities.

The project partners decided early to compile a document (straw-man) giving the common basis for handling of the strategic issues of the project. The aim of the document was to identify a common understanding of the project objectives, link the different work packages to each other in an efficient way, give ideas about the future deployment of the project results and establish a common basis for the communication with external parties. The document has been further developed and published as an information leaflet presenting the vision, results and the way forward.

3.1 The handling of road data

The handling of road data can be described as a business refinement process with four steps (see figure 3.1). The EuroRoadS project have focused on step two, the ”Content provider”, but has also covered the other three steps in order to guarantee that the specifications and technical solutions being chosen for EuroRoadS are efficient for the compilation of raw data as well as for the following steps in the refinement process.

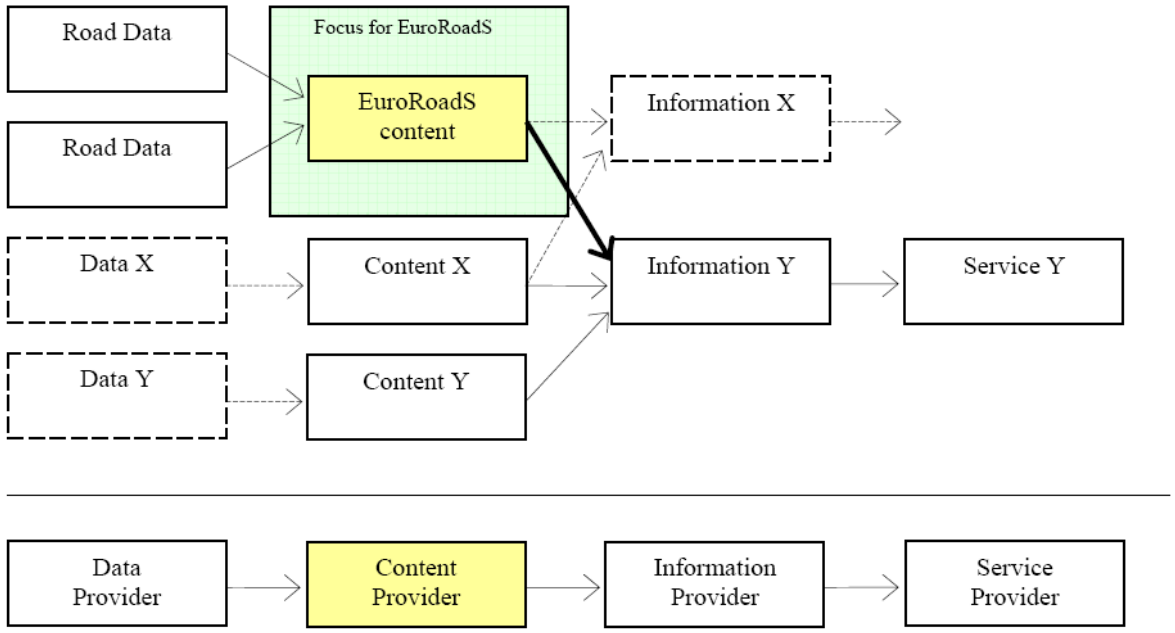

Figure 3.1 Business and data refinement process

Figure 3.1 describes the business and data refinement process, where the end user of data and services is placed to the far right in the figure. Different content providers ideally shall be viewed as keepers of data of a certain domain or possibly also competing providers of data for the same domain. EuroRoadS shall primarily focus on specifications for Content providers for road data.

From a specification development perspective, the business refinement chain can be viewed in the opposite direction (from right to left). In the end, the service users are the ultimate owners of requirements that propagate back all the way to the data providers.

The business refinement view of EuroRoadS points out that:

- End users will need services that make use of data from different domains.
- Every content provider can not (or very seldom) be the one and only provider of data for a certain end user service.
- EuroRoadS – has to be very specific on the question of: what is part of the road data domain, and what is not.

Here follows a more in depth description of each step in the information chain.

3.1.1 Data provider

Step one in the information chain includes data capture of different kinds of ”raw” data, e.g. existing databases with road networks, geo-coded addresses, and information on road technical descriptions, traffic regulations, administrative details, etc. This kind of information is available from national mapping agencies, national road administrations, municipalities and the private mapping industry.

3.1.2 Content provider

Step two is about production – or compilation – of basic data (reference data) needed for many applications, such as intelligent transport systems, mobility management, traffic management, road maintenance, traffic safety, environmental and society planning. This compilation will make use of existing databases with road information, but it is also foreseen that the specification for reference data will have an impact on the future structure of national or regional databases with road data.

3.1.3 Information provider

Step three includes data which are adjusted and ”wrapped up” in order to suit a specific application, for example a road map on a CD for a vehicle navigation system.

3.1.4 Service provider

Step four is about more advanced services with different kinds of functions, e.g. to develop a fleet management system due to specific user requirements.

4 Business environment

The project has investigated the business environment for road data in Europe. This has been made through case studies by which the potential market for different application areas have been identified and by analyses of costs and benefits from a new process chain being established on the EuroRoadS concept. On the basis of potential applications and the cost/benefit analysis the business case for the project has been explored.

4.1 Market analysis

The identification of the potential market is described in a market analysis report. EuroRoadS has concentrated on meeting the core data needs for the following applications: navigation systems, advanced driver assistance systems (ADAS), logistics management systems, tolling and road charging, road asset and traffic management, planning and reporting linked to EU-transportation and environmental directives. In addition there are other emerging business developments seeking more versatile use of the EuroRoadS information i.e. telecommunications, local tourist information services, online map websites.

Of specific interest is that there is a substantial demand for road data held by public bodies with a uniform data definition, structure and availability across Europe. Furthermore, there is a need for quality assured road data with frequent updates.

4.2 Costs and benefits

The project cost-benefit analysis measures the impact of a pan-European road infrastructure in terms of the costs necessary for implementing and running an interoperable service for road data exchange based on the EuroRoadS results and the expected benefits resulting from it, compared to the existing situation.

The analysis consists of three main steps: identification of a proper model for the cost benefit analysis, identification of relevant components of costs and benefits together with an estimation or general description of costs and benefits, and finally analysis and conclusions.

The basis for the analysis is existing digital road data likely to be held or sourced by public sector.

The analysis is based on two phases describing the implementation of EuroRoadS results. One which can be called the pre-operational phase describing a decentralised model based (see figure 4.1) on collaboration between individual data suppliers and users. Another (operational phase), describing a centralised model (see figure 4.2), where an agent is providing services and acting as a link between data providers and users. The later provides information and technical services as well as business services.

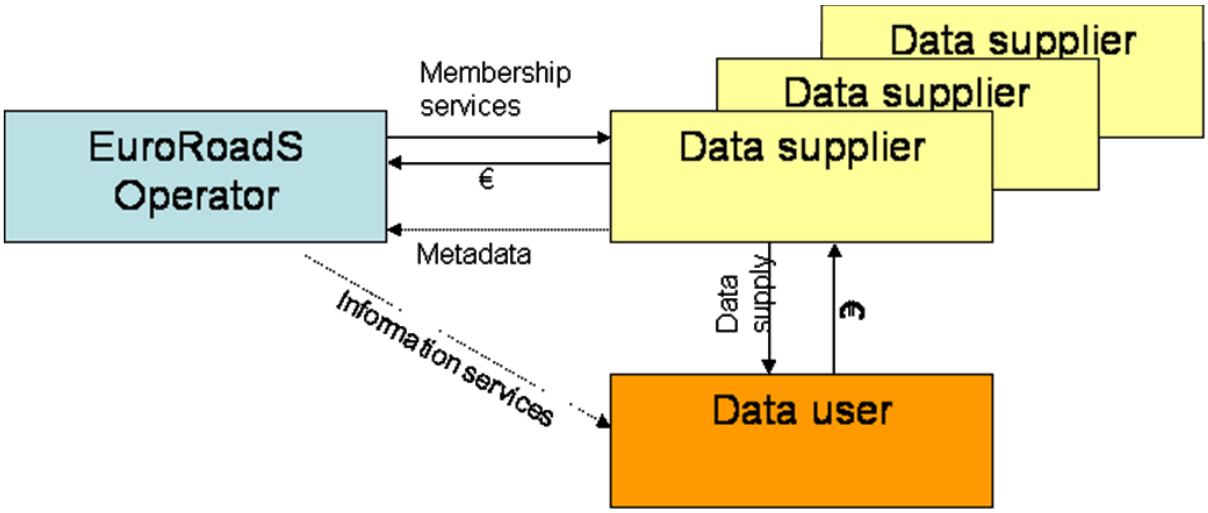

Figure 4.1 Decentralised model

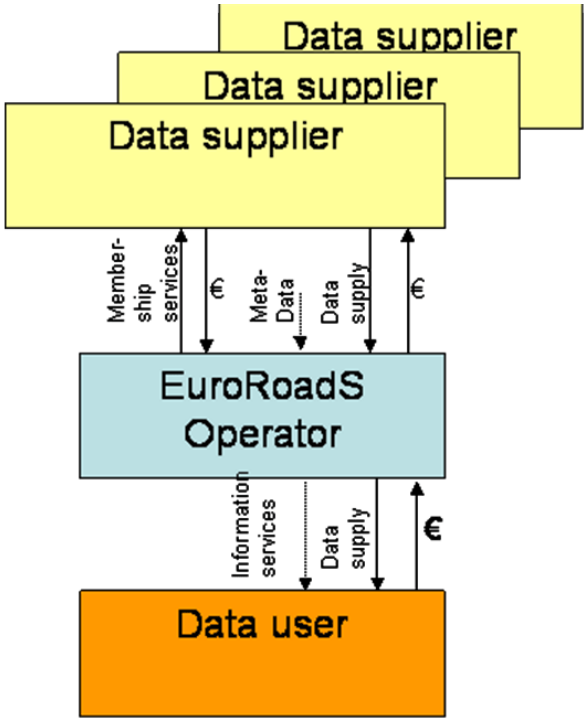

Figure 4.2 Centralised model

Main conclusions from the analysis are:

- Costs for road data suppliers to implement EuroRoadS specifications will vary depending on the existing structure, content and organisation of national/regional road data solutions.
- Main benefits for the road data suppliers are interoperability between different road data suppliers, better prerequisites for building up national road data bases, creation of more efficient cooperation between national mapping agencies and national road administrations as well as easier access to publicly held road data.
- Costs for road data users will include investments to build up know-how concerning the EuroRoadS framework, to adopt the specifications and agree with data suppliers on the conditions for usage.
- Main benefits for the road data users are easier access to publicly held road data with a common description and uniform quality measures, as well as easier integration of road data coming from different sources. This will benefit both national and cross-border applications.
- The ITS community will benefit from the existence of a pan-European road data infrastructure where new or updated road applications can be implemented easier, expanding the market for services like navigation, traffic management, road user charging and new applications like the Advanced Driver Assistance Systems (ADAS).

4.3 Business case

The business case is based on the following approach: identification of the market, analysis of the business environment and business model followed by recommendations for a successful business development.

An important part of the work has been to:

- describe the EuroRoadS framework in relation to the information refinement chain and the main stakeholders,
- conduct an analysis of the current market situation and identification of the applications which can benefit from EuroRoadS results,
- describe business opportunities and define possible business models,
- propose a suitable approach for business development.

The scope of the business case analysis is concentrated on the relation between the data suppliers and data users. This includes the link between suppliers and users, which here is expressed as the EuroRoadS operator(s). The EuroRoadS operator(s) should be recognised as an entity to organise and operate services facilitating the use of road data for example to search and browse data, order and download data and to handle financial, juridical and administrative relations. The information refinement chain below presents the focus area: data suppliers, the EuroRoadS operator and the data users.

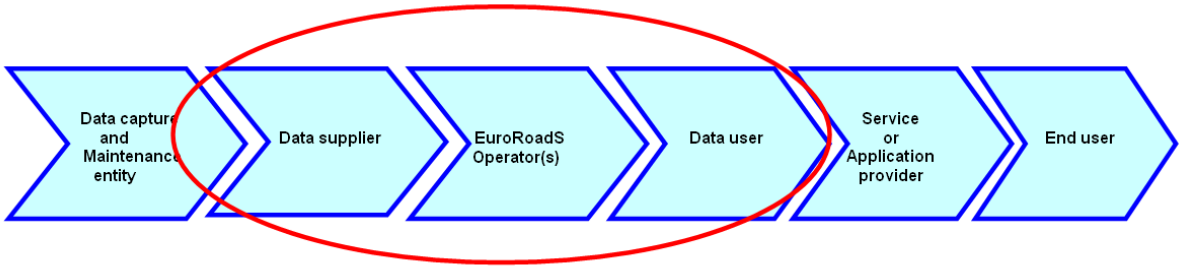

Figure 4.3 Information refinement chain

The analysis of the current market situation presents the development within different areas such as telematics (in particular navigation and tracking service systems as fleet and freight management), Advanced Driver Assistance Systems (ADAS) and tolling and road charging. The current and future expected mass-market growth of the ITS applications (being identified as the most interesting targets for EuroRoadS) creates specific demands in terms of digital road data. These demands are for example: need for road data of high quality, continuously up-dated road data and need for specific attributes supporting ITS-applications.

To a large extent these kinds of road data is handled by public bodies. Of specific interest is that the public road administrations have been given a wider mandate during the last years. Earlier the task was limited to the planning, construction, operation and maintenance of state roads. Now they are commissioned by the national governments with the overall sector responsibility for the road transport system. This involves issues relating to environmental impact, road safety, accessibility, transport quality and regional development. The responsibility also includes intelligent transport systems, public transport, adaptations for disabled persons, commercial traffic, and demonstration activities in the road transport system. The responsibility for this kind of activities is not limited to the state road network, but includes also roads being owned and maintained by municipalities, joint property units and individual property owners. This wider approach has a clear impact on the handling of road data: relevant data necessary to support such road applications are, for example, information about restrictions concerning speed, height, weight, parking, etc. also information on road works, route numbers and classification of roads as well as on weather conditions are important input for ITS applications.

Moreover, the public mapping agencies have gradually been changed from being producers of a national coverage of maps in different scales to be the national coordinator of the spatial data infrastructure (SDI). This coordination role includes the supporting of efficient processes for the production, maintenance, dissemination and use of fundamental geographic data as well as to foster a good cooperation concerning research and development within the field of geographic information. The SDI approach is based on a clear focus on the creation of efficient reference data, e.g. geographic data that forms the basis for many different applications. In many countries this has led to an expanded and strengthened cooperation between the national mapping agencies, the national road administrations, the local authorities and other stakeholders regarding the establishment of efficient handling of road data.

Business opportunities linked to the EuroRoadS concept is to be developed differently for each step in the information refinement chain. By adopting the EuroRoadS framework, the data suppliers are provided with the basis for creating a road data exchange mechanism, to deliver data to potential data users. The road data users are a mix of public and private bodies with a need for public-sourced road data for different applications, products and services.

Normally the data users are acting as intermediaries delivering data to service and application providers, which in a next step are delivering applications and services to end users. It is possible that one or more EuroRoadS operator(s) would become established and empowered to organise and operate the marketing and data supply.

The business opportunities are structured according to two possible business models: one decentralised and one centralised (described above).

The project proposes a step-wise approach for business development: using best practice and making gradual improvements and changes at regional/national level. This is further developed in the chapter on implementation and exploitation.

5 User requirements

Detailed user requirement studies were carried out using interviews, questionnaires and information available in existing reports. The findings are presented as a high level strategic overview of the potential user requirements concerning structure, content, availability, quality and accessibility to road data.

The results informed the development of the road data exchange specification in meeting the core user strategic needs of today and in the foreseeable future. However it recommended that as the EuroRoadS concept advances to focus on specific users and markets, further research would be required to understand the more detailed aspects of completeness, logical consistency, positional accuracy, temporal accuracy and thematic accuracy for each attribute.

6 Road data specification framework

The main objective for the project has been to build a platform for a European road data solution through a specification framework. The framework consists of specifications for data content and data exchange. The European road information solution is built and maintained taking full advantage of national road data solutions as well as existing standards. It will make national data available to the market in a harmonised, interoperable and quality assured way.

The project has developed and established a specification framework describing data structure, data content and data exchange mechanisms concerning road data as well as a metadata catalogue. The specifications enable a uniform and efficient data transfer between producers and suppliers of road data and providers of usable information and services for end users. The specification framework consists of:

- A road network information model that defines road network objects and a method for how road related objects (attributes) can associate to the network. This common and agreed structure can be the road data “language” of Europe, a harmonised and unified view of how to describe a digital road network.
- A definition of core European road data within the proposed structure, which points out a basic level of data content proposed to be the data set that in the future might be provided to the European market. The European data set should be built on national road database solutions. The future goal is not to establish a European road database. The goal is to be able to, through national contributions of data, transform data and provide it to the market through a uniform data exchange. In many cases existing data, mainly from the public sector (road administrations, mapping agencies, municipalities etc.), will become easily available in this way.

- A specification of a data exchange model and format supporting exchange of complete data sets and incremental updates. These specifications can be adopted as the basis of an interface solution, supporting an easy access to European road data defined as above. The data exchange model and format will support exchange of complete data sets and just changes.
- A metadata catalogue, showing the characteristics of the accessible information.
- A terminology catalogue including definitions of road data related words used in the different specifications.

These specifications can be implemented in an interface solution, supporting an easy access to European road data defined as above.

6.1 Road network information model

The road network information model expresses the various road data concepts in a formalized way using application schema rules from ISO 19100 in order to create a “unified and harmonized road data language”. Using these rules means in practice to create application schemas using the UML language defining classes that represent the various concepts from the EuroRoadS domain. This is fundamental for exchanging data.

6.2 Core European road data

EuroRoadS is focused on core European road data. The definition of core European road data specifies a basic level of data content that is expected to be needed for the European market. Core European road data can be seen as comprising the minimum requirements for a “road data infrastructure”.

Core European road data is characterised by having an infrastructural role by:

- functioning as reference data, which means that other kinds of information can and will be linked to the core data
- being of interest for many different kinds of applications (and being a common denominator and integrator between different data suppliers and product and service providers)
- containing information of specific interest for the public sector in its role to support efficient transportation, traffic safety, to handle environmental and social planning, etc
- being a part of the European Spatial Data Infrastructure and thereby, for example, being easily linked to other kinds of reference information, such as geographical names, administrative units, and addresses
- covering (the entire) Europe
- having a structure that is stable over time (even if parts of the data content frequently changes)
- having specific interest for cross border (pan-European) applications.

EuroRoadS defines core European road data in three groups:

1. Mandatory – data that must be supplied by the EuroRoadS exchange format regardless of the application to be supported – e.g. geometry, UUID/GUID (Universal Unique

Identifier / Global Unique IDentifier), functional road class, traffic importance, form of way, road type,

2. Optional – data that can be supplied by the EuroRoadS exchange format regardless of the application to be supported – e.g. address, border node information etc. and
3. Conditional – data needed for a specific application area – e.g. data needed for navigation.

6.3 Exchange format

Existing road data arrangements across Europe are highly variable. EuroRoadS specifies harmonized ways to represent road data. Therefore, when providing data in EuroRoadS format, each content provider will need to transform their data according to the EuroRoadS representation. Data users may also need to transform data received, in the EuroRoadS format, according to their own data model.

The data exchange specification defines how the real world objects represented by concepts in the information model are expressed in a data format. The same data format should apply regardless of the data source of the conversion tools used. GML – Geography Markup Language – is prescribed for exchanging EuroRoadS data. There should be a clear connection between the information model classes and the various XML elements specifying the data structures for EuroRoadS data.

6.4 Exchange model

The exchange model can be viewed as an implementation specification for data exchange that is derived from the application schema defined in the Road Network Information Model.

According to the EuroRoadS deliverable on preliminary findings and directions for the specification work (D6.1), GML (ISO 19136) will be used as the foundation for data exchange in EuroRoadS. GML defines a framework for XML encoding of geographic features and rules for mapping UML application schemas into GML application schemas.

This exchange model defines a UML schema according to the GML rules for UML modelling. While the road network information model is concerned with the definition of a conceptual model for core road data, the exchange model is concerned the exchange of road data. As such, this model is allowed to add definitions specifically concerned with data exchange and also make specializations to the classes defined in the information model.

The XML schema for the EuroRoadS exchange model is defined in document Specification of road network exchange format (D6.11). Furthermore, the exchange model defines the anticipated data flow in a EuroRoadS data exchange scenario and the basic requirements for EuroRoadS data suppliers.

In the case of EuroRoadS, data exchange is concerned with moving data from content providers to data users. These actors can use their own schemas as basis for their road data. The EuroRoadS schema for data exchange defines the structure and possible content of datasets containing “Core European Road Data” in an independent and harmonized way. The data exchange specification does not concern media or protocols for data exchange.

In order to be used, the EuroRoadS exchange model must be mapped to the specific models used by content providers and data users in such a way that the exchanged data can be properly encoded, decoded and understood.

6.5 Metadata catalogue

In EuroRoadS, the actors Data supplier, Data User and EuroRoadS operator have been identified. The role of the data supplier is to supply metadata for a centralized metadata service and supply data to data users. Data users can browse the metadata service much like in an ordinary web store. The EuroRoadS operator administers the meta-database and participates in the arrangement of data supplies. This specification together with the EuroRoadS exchange format specification provides the necessary definitions for the structure and possible content of a EuroRoadS data supply.

6.6 Terminology catalogue

The project has developed a terminology catalogue, which compile definitions of important terms used and their relations to each other. As most of the terms used in EuroRoadS already exist, the primary goal of the terminology catalogue is a unified use of terms within the project (not only a definition of new terms) and to find a common definition that is most appropriate for the use within the EuroRoadS project.

The catalogue focuses especially on terms from the development of the specification framework (WP6). Other terms which need to be harmonised within EuroRoadS derives from the reports on quality (WP2), the business case (WP4) and the demonstration (WP7). Nevertheless every term that is included in the glossary of a EuroRoadS deliverable (report) has been reviewed for importance for the terminology catalogue.

Many terms defined in the ISO 19100-series have been useful for the project, which implies that selected terms from ISO have been added to the terminology catalogue as an annex.

The creation of definitions has been carried out mainly according to the selection criteria given in ISO 19104 and other terminological guidelines.

A list of projects and institutions are presented as an annex, as the EuroRoadS has many points of contact to other projects and many institutions are involved in EuroRoadS.

The terminology catalogue is organised term and by subject groups, which makes it possible to see all terms which are defined in a certain subject area.

The question multilingualism is of great importance within the European Union, why the Terminology catalogue also contains translations of the 20 most important terms into 10 European languages.

7 Evaluation and quality control

EuroRoadS has defined efficient procedures for evaluation and quality control of the data flow from acquisition and updating to use in final applications. This concept underpins the integration of a quality management scheme needed to assure data quality.

The EuroRoadS specification contains two quality models (a profile based on ISO 19 113, and a closely linked but more detailed quality model) which have been tested and validated in the demonstrator. The results from these tests have given recommendations for the specifications.

The specific challenge regarding quality assurance is to provide a quality concept which is usable within the entire information refinement chain of acquisition and processing of road data. Regarding practice the applicability of the quality concept has to be ensured by all actors

(data provider, content provider, information provider, and service provider). In addition, the quality concept has to be conformed to the relevant standards, like ISO 19100-series.

The quality model should be usable for the quality description of a geographic dataset as well as the quality description of geographic information within processes. Thus an extended scope compared to ISO 19113 is given and adaptation is recommended. The use of the fixed set of inherent characteristics ensures an objective, complete, and unambiguous description of the geo-information quality. Therefore each quality characteristic has to deal with one definite attributable phenomenon (see figure 7.1).

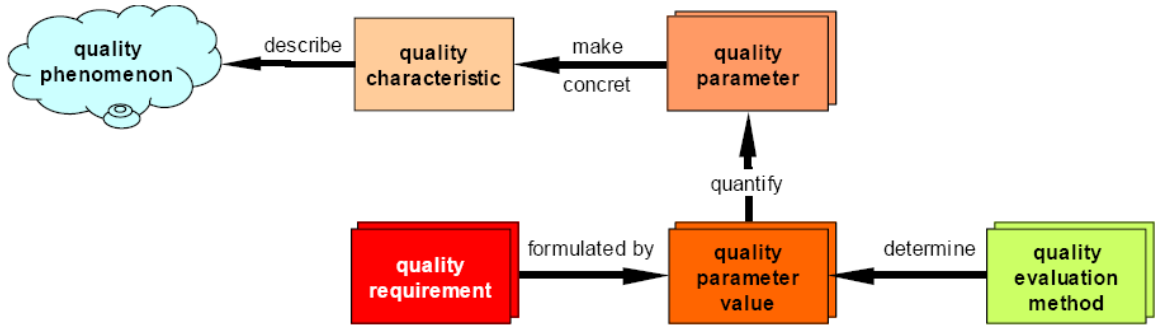

Figure 7.1 Structure of EuroRoadS quality model

The EuroRoadS quality model contains six quality characteristics: availability, up-to-dateness, completeness, consistency, correctness, and accuracy (see figure 7.2). Availability and up-to-dateness are dependability characteristics describing time-related aspects of data quality. The integrity characteristics completeness, consistency, and correctness describe the fitness of use of data. Finally the accuracy: considering that geographic data result from measurement or interpretation, or can be derived from such data and furthermore considering the fact that a measurement or interpretation can be given only with a certain accuracy or resolution, characteristics referring to this problem are essential for an information quality model.

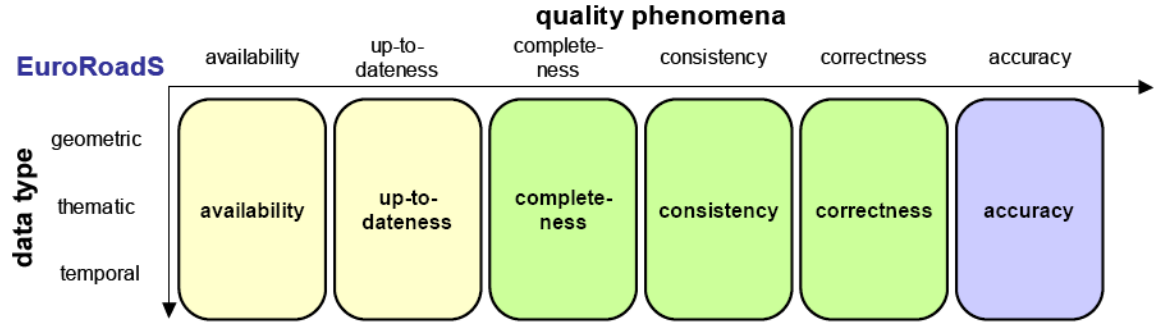

Figure 7.2 Quality characteristics in the EuroRoadS quality model

The quality concept for information, developed and applied in EuroRoadS, consists of two parts (see figure 7.3). One part is the quality, illustrated further up, which contains the set of quality characteristics and the quality parameter, and represents the framework for the quality description of information. The other part is the analysing procedure, which includes the information flow chart and a computing procedure. The information flow chart is graphical representation and is used for modelling the information flow of the system or process. The computing procedure is used for the determination of the information quality within the information flow by evaluation the information flow chart.

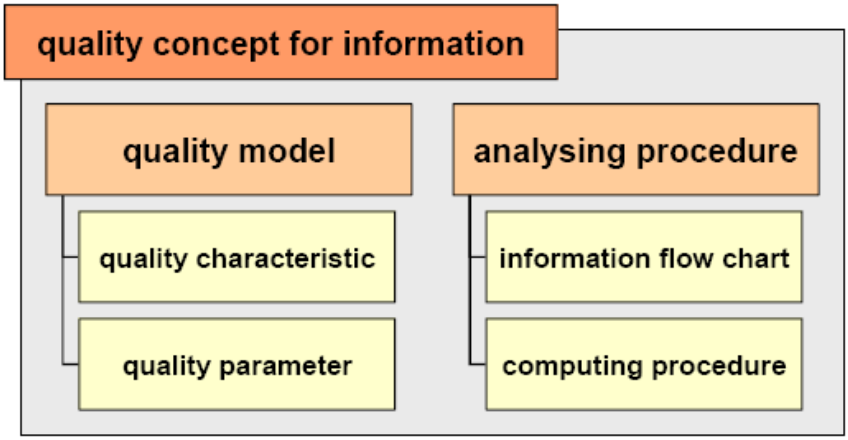

Figure 7.3 Structure of quality concept for information

The analysing procedure is based on the known method of reliability analysis and is derived from the fault tree and event tree analysis. Both methods are based on Boolean modelling and contain graphical and analytical parts. Compared to the reliability analysis, which only use the reliability, the analysing procedure for information has to deal with the six quality characteristics simultaneously. The probability of fulfilment the quality requirement of each quality characteristic is used as calculation quantity. The occurred dependencies, like they illustrated further up, can be modelled and taken into consideration in the computing part.

The quality assurance of road information which is described above, can be integrated into the so-called PDCA-cycle, which include the four components Plan, Do, Check and Act (PDCA). The model provides in general a framework for the improvement of a process or system.

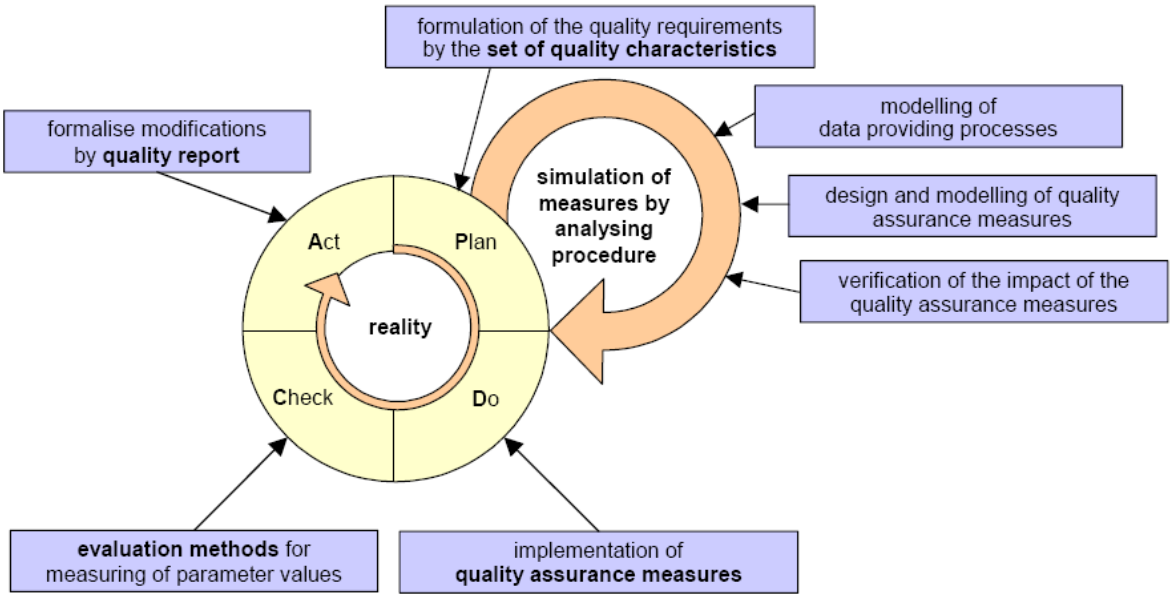

Figure 7.4 Integration of EuroRoadS quality concept into the extended PDCA-cycle

In the phase Plan objectives and processes necessary to deliver results in accordance to a specification will be established. For this purpose, the required quality of road information can be described by the fixed set of quality characteristics and formulated by variable quality parameters.

Furthermore, into the phase Plan the simulation of processes by using the analysing procedure can be included. I.e. additional to the cycle for real processes a second cycle for simulated processes can be useful. This includes firstly the modelling of data providing processes. On basis of the model of the data providing process, quality lacks in the process can be identified and quality assurance measures can be designed and modelled. Their impact on quality can be evaluated by the analysing procedure. In this procedure the new parameter values in consequence of the simulated assurance measures will be calculated and compared with the required parameters values. If this check will lead to the result, that the required quality is reached, the simulated assurance measure can be implemented in real processes. Otherwise, if the quality requirements are not fulfilled, additional measures have to be simulated in a second iteration. For all this phases of simulation the analysing procedures, existing of information flow chart and computing procedure, can be a helpful tool.

After the planning, including the described simulation, the phase Do follows. This contains an implementation of measures in a real data providing process. The following phase Check includes monitoring and evaluating the processes and results against the objectives and specifications. The outcome can be documented in a quality report. Therefore the evaluation methods for measuring quality parameter values can be used. Afterwards it has to be verified whether the required product quality is fulfilled. The modifications have to be formalised in a quality report using the quality framework (Act) (see figure 7.4 above).

The presented quality model with its fixed set of six inherent quality characteristics and a collection of quality parameters is part of the quality concept for geographic data. The quality model is also basis for an analysing procedure allowing the quality description within geo-information processes. The analytic part is effected by a probabilistic model based on the reliability analysis of mechanical engineering. Information flow chart has been used for modelling the information chain.

The project has developed an analysing procedure describing and evaluating quality of geographic data within the entire information refinement chain. The actual data quality and the provision of measures for quality assurance of geographic data has been applied in a test side evaluation. The use of the illustrated quality concept is not restricted to geo-information processes or geo-information systems. The method is directly transferable on each information and information process occurring within ITS-applications.

8 Demonstration

An important task for the EuroRoadS project has been to carry out practical demonstrations verifying that the specifications function well for different use cases, that the quality model gives expected results and can be used in practice and that the metadata catalogue can be implemented in a practical solution and give expected information to the users.

The project has developed a prototype and carried out test to show that the specification framework can be implemented in a realistic working platform supporting end-user services. The demonstration activities include the following components: capture and maintenance of speed limit data, data processing and integration, metadata server and services, and an end user application “SpeedAdvice”.

The EuroRoadS project and its demonstrator have put emphasis on solving problems related to the feasibility of data conversion and use between data suppliers and data providers. The demonstrator focuses on building the information chain, allowing the testing and evaluation of the data processing steps involved. The task has not been to develop and implement an

integrated IT architecture for this purpose, rather to put together existing solutions into a common information chain, without deep technical integration.

The demonstration covers the whole information chain from data capture and maintenance to the final application. However, only the transfer of the data from the data supplier to the data integrator or application developer is specified under EuroRoadS. The demonstrator also includes elements that are covered by the EuroRoadS specification framework – in particular data maintenance and data processing towards a final end-user application.

The demonstration activities have had the objective to gain hands-on experience with the data exchange framework itself and to understand related (quality) issues along whole information chain. It has thereby provided input to the project validation. At the same time the demonstration work have yielded practical insights and tangible showcases useful for implementation and exploitation of the outputs by third parties beyond the project.

With regards to the interface between data supplier and data user the demonstration have generated:

- experiences with transfer and usability of similar data from different (public) sources,
- experiences with metadata and related services.

Data quality issues go beyond the state of data exchange and need to be assessed in view of the whole data chain from data acquisition to the final service:

By implementing a demonstration of a complete data chain the EuroRoadS quality framework have been validated.

The EuroRoadS quality framework provides concepts and methods to support a comprehensive quality description of the EuroRoadS data sets. The underlying idea is that data quality needs to be considered continuously along the whole information chain, otherwise a valid description of the quality of data at a certain stage in the information chain becomes very difficult. The demonstration activities in the Bavarian test site allows to encompass the whole information chain from data capture to the final service and serve as a test case for implementing the EuroRoadS quality framework in a comprehensive fashion.

The EuroRoadS framework – as far as tested in the demonstrator – has been experienced by the data users and data suppliers as well conceived and well documented. It offers a number of concepts e.g. for the network description or the linking of borders which appear well formed. In general and typical circumstances, the barrier to provide data in conformance with the EuroRoadS framework should be relatively low to a data supplier. This is important for the introduction of EuroRoadS.

8.1 Data capture & maintenance

The EuroRoadS specification framework has defined the interface between data supplier and data user. Yet, the usability of the framework – in particular those parts dealing with data quality – can only be fully evaluated if the entire information chain from data supply to end use is well understood. For this reason data capture and maintenance activities are implemented and analysed for the test site Bavaria. Thereby, allowing analyses of the complete information chain from data capture to the final end-use service.

8.2 Data processing

The demonstration activities have validated the EuroRoadS specification framework. This means specifically that experiences with transfer and use of similar data from different (public authorities) sources have been generated and documented at the example of a show case for a concrete data chain. Speed limit data have been chosen for this show case and have been tested in a mobile end-user application providing speed limit information while driving ('SpeedAdvice').

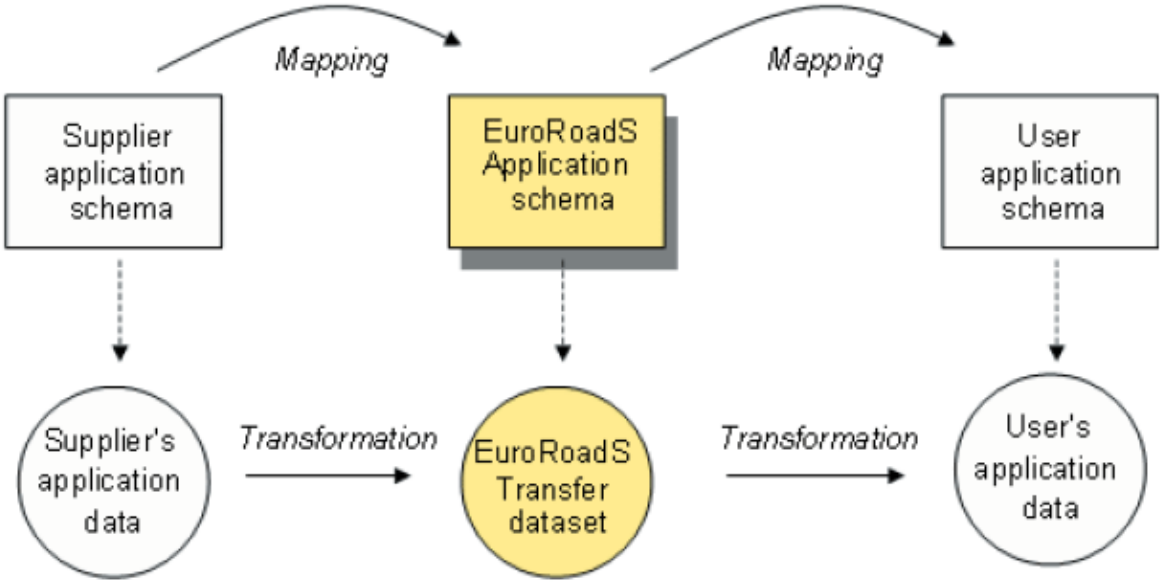

Figure 8.1 Logical mapping, transformation and physical transfer of data

The data processing starts on the supplier's side. The supplier's own local information model (or application schema) needs to be mapped logically to the EuroRoadS information model. This can include the definition of certain transformation steps if no data object/attribute is available, which corresponds directly to those required by the EuroRoadS data model. The local data needs then to be transformed and exported to the EuroRoads exchange format (XML).

On the data user's side following steps can be discerned:

- Again a logical mapping for the EuroRoadS model to (usually proprietary) object schema has to be done,
- The EuroRoadS exchange data set (XML) has to be imported into an internal data base (and schema) on which all further operations are executed,
- The supplier has to do some data merge and integration operations, this is the core part elaborated further below,
- Finally, a conversion into the application specific format has to be done. In case of the SpeedAdvice application this is a binary format which is optimised for mobile devices with regard to performance and data volume.

Every EuroRoadS supplier has to provide at least the mandatory data set comprising a road network description and the speed limit content. The EuroRoadS information model allows different ways to represent these data. Key differences between suppliers include:

- different network representations (geometry only, geometry + topology) and
- different ways to attach specific content such as speed limits (direct link attribute or linear referencing to route)

Hence, the data merge and integration operations of the speed limit data, by the data user (application provider), differs for each supplier. These processing steps have to convert the incoming data and combine them if needed with external data to meet the final application requirements. For the demonstration the final application SpeedAdvice requires a complete, routable network description (geometry + topology) with speed limits attached as attributes to each individual link.

8.3 Client application “SpeedAdvice”

Speed limits have been chosen as a concrete showcase for the demonstration for several strategic reasons:

- Commercially available speed limit content, while becoming increasingly available, has limitations in quality. So, there is a need for additional, better data sources,
- Public authorities are at the beginning of the information chain, since they are responsible for setting speed limits. They could therefore be a valuable source for offering sufficient quality,
- The European e-safety context has raised the issue that public authorities need to play a constructive role to improve road safety by improving the digital road content. The related on-board speed limit information and warning services currently appearing on the market will thereby be improved and can serve as a showcase for the end-to-end information chain in the EuroRoadS.

Therefore, speed limits are considered a realistic application area of the EuroRoadS data exchange framework, providing a precedent for similar, other content types.

The demonstration service ‘SpeedAdvice’ offers on-trip information and warning services on current speed limits on the road as a stand-alone service. The application has been developed to demonstrate the usefulness of the content delivered through the EuroRoadS information chain, via the EuroRoads data exchange framework from the different test beds.

8.4 Metadata service

On an organisational level, potential suppliers and data users need to exchange information on what data and how data are available through EuroRoadS. This is usually done through the exchange of metadata i.e. a formalised data description of the data sets available for exchange.

A metadata server and services enables potential data users to search and inquire available data using a central access and marketing point.

In EuroRoadS the metadata server:

- provides information on all data available through the EuroRoadS suppliers network,
- uses the EuroRoadS conform metadata description

By contributing to the EuroRoadS metadata catalogue and make metadata accessible to others through a metadata server (the one developed by the project or other metadata services able to present the required information) the application of EuroRoadS specified data will increase.

8.5 Test areas

Five organisations have produced EuroRoadS conformant speed limit data set for their respective test beds based on the national/regional data bases in operation at mapping agencies and/or road authorities.

- France: IGN France has delivered data for the Upper-Rhine region (departement Haut-Rhin);
- Bavaria: The Bavarian Board of Building has delivered data in the test area of Ansbach (Landkreis Ansbach),
- Austria: BEV has delivered data for the eastern part of the Tirol region,
- Sweden: The Swedish Road Administration and the National Land Survey of Sweden have generated data from the National Road Data Base for the region extending from Göteborg to the Norwegian border,
- Norway: The Norwegian Road Administration has (not being a part of the project concortium) volunteered to generate data from the national road data base for the Oslo region stretching to the border with Sweden. The Swedish and Norwegian data allow to study issues related to cross-border connectivity and use of data within the EuroRoadS framework.

8.5.1 Test site Norway

A background for the Norwegian participation in the demonstration activities is the newly developed national road database in Norway. The driving force for the development of this database has been to establish efficient ways for continuous data shearing between data suppliers. In this development EuroRoadS has given support:

- By opening up a more efficient cooperation between the mapping and road authorities as well as with the municipalities in Norway
- By expanding the cooperation with the Swedish road administration
- To lay the ground for harmonisation and standardisation of data definitions
- To develop methods to connect road and traffic information to the road network
- To link the Norwegian and Swedish road databases
- To reduce the gap between geographical information, intelligent transport systems and location based services.

8.5.2 Test site Sweden

Another case study is describing the use of the framework to export road data from the Swedish national road database. The objective with the test site was to verify the usability of the framework and evaluate the time and costs to export existing data to the EuroRoadS format. All data from the test site was initially exported and later on only updates were delivered.

Some important findings are:

- The specifications proved to be well defined.

- Mapping data is generally tricky and time consuming but it did not take longer time to export the data to the EuroRoadS format than exporting to another format.
- If a mandatory or optional feature does not exist in the current dataset it has to be "created" by combining a number of existing features, which imply difficulties when updating.
- GML-files get very large, which make it necessary to split the initial delivery into a number of files, but the files including only updates are normally easy to handle.
- EuroRoadS will most likely be used for data exchange between the Nordic countries.
- It is very important that the specification framework will be properly maintained after the project end.

8.5.3 Test site Bavaria

The EuroRoadS specification framework is defining the interface between data supplier and data user. Yet, the usability of the framework – in particular those parts dealing with data quality – can only be fully evaluated if the entire information chain from data supply to end use is well understood. Therefore, data capture and maintenance activities are implemented and analysed for the test site Bavaria, thereby allowing to analyse the complete information chain, from data capture to the final end-use service.

The Bavarian test site has different objectives:

- To test and evaluate different data capturing methods and techniques with regards to resources and quality needed,
- To establish workflows for data maintenance by the administration in charge of speed limit orders,
- To provide data of high detail and quality to the EuroRoadS demonstrator.

The test site is based on the Bavarian INTREST System (Intermodal referencing system for traffic related data), which offers a central server and database for decentralised geo-referencing and data maintenance. This system is extended to speed limits according to the EuroRoadS requirements.

Some of the important findings from the Bavarian test site are:

- The EuroRoadS quality framework proved to be efficient for evaluation of each of the tested data acquisition methods.
- The experiences from the Bavarian test site shows that useful content apart from the network (e.g. speed limits) can be transferred and integrated into a final application without full harmonisation of the road network description.
- The EuroRoadS quality framework provides concepts and methods to support a comprehensive quality description of the EuroRoadS data sets.

The demonstration activities in the Bavarian test site serve as a test case for implementing the EuroRoadS quality framework in a comprehensive fashion.

8.6 Important findings

Important findings from the demonstration activities are:

- EuroRoadS framework documents are built on a suitable technical approach making use of existing standards and are generally of high quality. The documentation is consistent, which is a good starting point for the establishment of European road data infrastructure.
- Concepts of the information model are well described,
- EuroRoadS exchange format (GML) for complete data sets, which are covering large areas, leads to very large data volumes. This requires special technique to handle when delivering complete data sets, as the format primarily is developed to handle transfer of data change.
- EuroRoadS information model for network description offers a lot of flexibility and for usage/interpretation by suppliers. This implies a low entry barrier for suppliers as they rather easy can transform their data model to the EuroRoadS data model, at the same time the users have to interpret the data according to the model used. It might be necessary to build a profile on the EuroRoadS specifications giving more strict definitions, which also will be of help for countries/regions developing road databases.
- Border linking is required for routing applications covering several countries/regions. EuroRoadS information model provides good basis to resolve, topological linking.

9 Implementation and exploitation

Implementation and exploitation of the project results are based on a step-wise approach. The recommendations are based on the actual situation concerning the handling of public road data, user needs and possible business model.

The implementation plan proposes recommendations on actions that will promote producers of road data to be able to deliver and exchange data according to the EuroRoadS specifications, including quality and metadata descriptions. Furthermore, the implementation plan includes recommendations on actions that support organisations to develop, organise and restructure databases and processes for handling these databases.

The exploitation plan proposes recommendations to foster the exploitation of road information enabled by the harmonised European road interface and to support a wide use of the European road data infrastructure.

9.1 Implementation plan

The scope of the implementation is to reach best practice for a pan-European road data infrastructure and easier access to data from the public sector by converting existing road data into EuroRoadS format.

The implementation of EuroRoadS concerns first of all the data suppliers, especially the national mapping agencies and the national road administrations. They are encouraged to adopt the EuroRoadS concept as a harmonised European infrastructure for easy access to public road data. In that sense, they will be able to deliver and exchange data according to the EuroRoadS specifications, including quality and metadata descriptions.

The implementation of EuroRoadS will contribute to the development of Intelligent Transport Systems and projects such as ADAS (Advanced Driver Assistance Systems) applications, location-based services and navigation and commercial vehicle applications etc by:

- delivering mechanisms to make the road data infrastructure available and maintained by maximising the use and knowledge of public sector data and taking advantage of existing and future partnerships,
- giving the basis for easier integration of data from different sources which will enable easier cross border cooperation and networking with a common infrastructure,
- supporting development of road databases in Europe: building up road data infrastructures, exchanging of data through a common specification framework.

Existing road data can now be converted from other standards and specifications following the EuroRoadS specifications and the metadata catalogue to make metadata accessible through the Metadata server.

The technical part of the implementation concerns the specification framework i.e. network model, exchange model, exchange format, quality model, metadata catalogue and terminology catalogue. To enable many suppliers to deliver data in the EuroRoadS format, the format has been designed open and flexible. There is only a minimum set of mandatory attributes. Most attributes are optional or user defined. Together with the fact that there are many optional attributes, the EuroRoadS format makes it possible for many suppliers to provide data and does not discourage suppliers to transform their data into a new format. Some of the fundamental issues in the specification framework are the road network in form of geometry and centrelines and the definition of core road data.

EuroRoadS model for evaluation and quality control supports organisations holding road data in assessing and describing the quality of the data. The availability, up-to-dateness, completeness, consistency, correctness and accuracy can be described in a structured way. The potential users can be informed about the quality – on a general level – by the metadata. The quality descriptions of data supplied in the metadata server allow users to determine, if the data has sufficient quality for the user's needs.

Useful tools for making data availability and harmonisation apparent are metadata services. Road metadata can be described according to the EuroRoadS metadata catalogue. This will give potential users a possibility to understand the content of the actual road database and its conformance with EuroRoadS specifications.

By using the EuroRoadS terminology catalogue as a basis the actual organisation holding road data can describe their data content more precisely in relation to the EuroRoadS terminology.

One example where the EuroRoadS framework of specifications now is in use for data exchange is the co-operation between the Norwegian and Swedish road administrations. There are also a number of other projects considering the establishment of a cross-boarder road data solution on EuroRoadS. Such an example is the Barents GIT project, which includes the establishment of a harmonised road data infrastructure for the Barents region (covering large areas above the Polar circle within Norway, Sweden, Finland and Russia). Road data of better quality than today is needed for transport planning, traffic safety work, and support to the development of tourism in the Barents region. The EuroRoadS solution has also proved to be of interest for the exchange of road data between different national organisations. For example, the Norwegian Road Administration considers establishing a deeper co-operation between the National Road Administration and the municipalities on EuroRoadS exchange model and exchange format as well as quality model.

The EuroRoadS framework has been experienced by the data users and data suppliers as well conceived and well documented. It offers a number of concepts e.g. for the network

description or the linking of borders which appear well formed. In general and typical circumstances, the barrier to provide data in conformance with the EuroRoadS framework of specifications should be relatively low to a data supplier.

The implementation involves organisational issues, both internal and external cooperation with other national road data providers. EuroRoadS offers mechanisms to establish a road data infrastructure by taking advantages of partnerships and using the common specification framework. This will make the integration of different data sources easier, give better data quality and lower the costs.

An effective cooperation, especially between national mapping agencies and national road administrations, is an important pre-requisite for the development and implementation of EuroRoadS results.

There are two sides to the EuroRoadS implementation process. On one hand, individual actors need to evaluate and implement the EuroRoadS specification framework, so that their data can be supplied accordingly. On the other hand, the approach needs to be introduced as a de-facto standard for data exchange in the 'data market'. This requires a gradual approach involving decisions and actions of individual market actors, coordination between different actors as well as other drivers.

The implementation process can be conceived as a step-wise approach and is a long-term endeavour. Every national or regional supplier can contribute with existing road data – whether they can provide mandatory data only or a more exhaustive road dataset with additional features and attributes.

The organisations with no existing digital road data infrastructure can profitably use the EuroRoadS specification framework when starting building up a road database on a local, regional or national level.

Organisations with existing digital road databases need to analyse the compatibility of their own data and data-handling with the EuroRoadS specification framework. When providing data in EuroRoadS format, each content provider will need to transform their data according to the EuroRoadS representation. Data users may also need to transform data received, in the EuroRoadS format, according to their own data model.

The EuroRoadS transformation or conversion can take place at the local level, and subsequently be unified at the national level from where data and metadata can be entered to the EuroRoadS metadata server.

If a country already has a national road database and a good cooperation with other organisations in the country, the conversion to EuroRoadS specifications can be done directly from the local/regional/national road data and described from there in the EuroRoadS metadata server.

In practise, different countries and regions might follow different models. Different players at local, regional or national level can start using the specification framework for their specific data exchange purposes, customers and use cases.

The project proposes a stepwise approach for the implementation using best practice and making gradual improvements and changes at a national/regional level. It is also important to set up short term targets and strengthen the organisational cooperation both within countries/regions and cross border.

The success of EuroRoadS requires a widespread adoption of EuroRoadS implementation.

9.2 Exploitation plan

EuroRoadS has developed an exploitation plan to support a wide use of the European road data infrastructure and to facilitate services built on it. The aim is to start building a supplier community that will eventually extend across all countries of Europe and that will offer a harmonised range of compatible and interoperable road data – a pan-European road data infrastructure. While the first priority is to open up access to existing publicly-held and public-sourced data, even commercial providers could become part of the supplier community, and offer EuroRoadS compliant products to a wider public-private market.

The aim of the exploitation is to promote the future take-up and exploitation of EuroRoadS results. This will effect the data supplier community, the customer community and others, for example EU (INSPIRE). The basics for the exploitation is to ensure continuity of support services for suppliers and users i.e. provide user support, act as help-desk, take care of eventual errors and updates in specifications, promote standardisation of EuroRoadS results, dissemination of information and development of liaisons etc. It is also important to develop documents like guidelines for suppliers and users, examples of best practice. Also could be included to establish quality certification and compliance testing procedures.

The project proposes to establish a EuroRoadS Forum to promote and exploit the results of the project and to support both providers and users of public/private-source road data. The main task for a EuroRoadS Forum is to explore and promote the EuroRoadS aims and results. A draft memorandum of understanding (MoU) has been developed as a basis for discussion between potential founders of a EuroRoadS Forum. The MoU includes a description of tasks and how to organise a EuroRoadS Forum and to distribute undertakings.

The process to establish a EuroRoadS Forum starts with finalising the MoU. The final content of the MoU will be decided by stakeholders participating in this process. All providers and users of road data, European organisations working with road information as well as other as other interested parties are welcome to take part in this process.

The EuroRoadS vision is in short: to establish a European-wide road data infrastructure delivering access to harmonised and quality assured road information covering EU25+ by end of 2012. The timetable will however depend on the willingness and readiness of the national road data providers to make use of EuroRoadS results and give access to their road data through EuroRoadS exchange format. The EuroRoadS project partners and other stakeholders already using parts of EuroRoadS results will be the frontrunners for introducing the concept by implementing EuroRoadS and by best practise encouraging others to do the same.

It is assumed that the EuroRoadS Forum will for the next two years consider how a more sustainable organisation for EuroRoadS can be organised and how each organisation can be engaged in implementing and exploiting EuroRoadS.

10 Conclusion

EuroRoadS has met the operational goals being defined in the project setup. The project is timely and meets important requirements. In most countries the spatial data infrastructures (SDI) are now in the process of being developed both on national, regional and local level. Also on the European level – pushed by the INSPIRE initiative – the European SDI are now developing rapidly. However, the INSPIRE initiative is on one side promoting the implementation of EuroRoadS results, but on the other side it creates different kind of uncertainties.

EuroRoadS has a suitable technical approach and links ITS and geomatics. Already now the results are being used in practice and there are also projects and initiatives planning to make use of the specifications, quality model and other results. Still it is important to promote a wider practical use of the results giving more experiences and basis for further development.

The specification framework is – as far as having been tested and verified until now – proved to work in practice for efficient exchange of road data. But to go from the existing specifications to a formal CEN or ISO standard there is a need for further development, and bringing in more stakeholders in the process. It also seems as the EuroRoadS specifications will be a good basis for the preparation of the INSPIRE implementing rules concerning transportation networks. However, it is important to insure coherence (and cross-links) with generic specifications for other data themes being covered by the proposed directive.

The implementation and exploitation plans including the business model gives a good starting point for further deployment of the EuroRoadS results. EuroRoadS has a strong infrastructural approach on public road data which results in a high level description of costs and benefits as well as the business model.

It is important to keep the EuroRoadS vision alive but to concentrate on and set priorities for the coming two years. An important starting point is to establish efficient forms for co-operation supporting the deployment of the EuroRoadS results by dissemination of information, best practises, etc.

Another priority is to focus on benefits of using the EuroRoadS results on the national/regional level and disseminate best practices. On a European level it is important to support the INSPIRE process and represent the road data community e.g. when developing implementation rules for transportation networks. Of importance is also to develop an organisational and business model for pan-European service giving access to national/regional maintained road databases

Appendix

D2.1 Evaluation methodology

D2.2 Report on Quality Frame for Information

D2.3 Probabilistic model for information chain

D2.4 Quality Management Concept

D2.5 Evaluation Scheme

D4.1 Market Analysis Report

D4.2 Cost Benefit Analysis

D4.3 Business Case Report

D5.2 Final Report on User Requirements

D6.3 Final Specification of Road Network Information Model

D6.5 Final Specification of Core European Road data

D6.8 Metadata Catalogue

D6.10 Final Specification of Road Network Exchange Model

D6.11 Final Specification of Road Network Exchange Format

D6.12 Terminology Catalogue

D7.5 Sample Mobility Service Demonstrator

D7.6 Measuring results

D8.4/D9.3 Implementation plan and Exploitation plan

Memorandum of Understanding of EuroRoadS