

THE HARMONISATION CHALLENGE OF CORE NATIONAL TOPOGRAPHIC DATABASES IN THE EU-PROJECT GIMODIG

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ABSTRACT:

The project GiMoDig (Geospatial Info-Mobility Service by Real-Time Data Integration and Generalisation) started in November 2001 and is funded by the European Union. With a duration of 3 years this EU-project has the goal to develop methods for harmonisation, generalisation and visualisation of national topographic data sets for mobile users in real time. The project partners are the Finnish Geodetic Institute as a project coordinator, the National Mapping Agencies (NMAs) of Denmark, Finland, Sweden and Germany and the University of Hanover, the Institute of Cartography and Geoinformatics. One of the tasks in the GiMoDig project is to define a Global Schema for the core national topographic data sets. For this purpose an inventory on the national databases is prepared to list the differences in data availability and data modelling. Based on that inventory, a selection of feature types suitable for Location Based Services (LBS) is made. The idea is to use the least common denominator as selection criteria but this subset already lacks some important feature types. Finally all features that are supported by a majority of national data sets are integrated in the Global Schema. The Global Schema is defined with a detailed description about feature type, attributes, collection criteria and geometry type. All necessary information about harmonisation operations are given to be able to transform the topographic data from the national schema into the Global Schema. Further scrutinizations of test data lead to an improvement and adaptation of the Global Schema.

1. INTRODUCTION

Location Based Services (LBS) are becoming more and more important in every day life. They are services that enable a mobile user when using a mobile device, e.g. PDA or mobile phone to retrieve spatial information related to his actual place concerning his special wishes. Depending on the usage and location the map visualisation can be performed in various ways. In any case it conditions that the mobile device has the functionality of being locatable, e.g. via radio location in the mobile network (GSM or UMTS) or via GPS if more precise location destination is wished.

Users in foreign environment without any paper map have the possibility to orientate with any problems due to the LBSs. Additionally, they get important information, e.g. on sights. Geospatial data plays an important role in the LBSs. With their help specific locations can be found more easily as a direct relation to the spatial surroundings is given. But topographic information is of value only when linked to other information relevant to the service. Recent studies have found out that users require more object orientation, nonspatial attributes (names, road types etc.), metadata, history and temporal queries, easy aggregation (thematic, geometry), linkage with other data, and unique identification code and conformity to standards like OpenGIS, CEN, ISO. Interoperability with other datasets in terms of semantics, spatial reference, data model and language is getting more and more important.

The field of applications based on geospatial data is wide. It comprises city guiding, routing like navigation systems in cars. But the importance of LBS increases also in other fields, e.g. for rescue services. With precise positioning police, fire brigade or emergency doctors are able to render assistance to an injured person much faster. Even when hiking in nature it can be of

great importance to have LBSs with geospatial data as background information.

2. EXISTING SOLUTIONS

Up to now most of the available LBS are offline solutions with raster maps. However, raster data is static concerning the resolution and the content of the image with no or only minimal flexibility. When zooming in, either the same data is viewed with the same resolution and therefore in a much more coarse way or a new data set has to be loaded. In addition, raster data has the disadvantage of covering a huge data size and therefore requires a lot of memory. In the case of offline solutions the data has to be stored locally on the mobile device (PDA, mobile phone) which leads in most of the cases to the fact that not all necessary raster data can be stored on the mobile device. The user is forced to choose the relevant map part of his next trip and to save only that particular part of the whole map on his mobile device. As a consequence new data has to be provided for each new usage situation. The old data has to be removed from the mobile device in order to make room for the current map part. A lot of manual work has to be done.

There exist some applications based on vector data. They are often visualised in the XML-based (eXtensible Markup Language) vector format SVG (Scalable Vector Graphics). However, map applications based on national topographic vector data as map base do not exist at the moment despite of the fact that these national geospatial data sets are usually available for the whole country. One of the reasons for this lies in the lacking agreement of the national data suppliers. In order to create homogeneous data sets for cross-border applications a big effort has to be made to create them directly from heterogeneous national data sources. Updating data directly

from these sources comprises the same large effort as well. On a long term a trend is pointing towards a decentralised data storage. Therefore implementation of international standards and adaptation of data models from national geospatial data bases are necessary and show the requirements of methods dealing with integration of decentralised data 'on the fly'.

3. THE GIMODIG PROJECT

The objective of the GiMoDig project (Geospatial Info-Mobility Service by Real-Time Data-Integration and Generalisation) is to find solutions for these problems. Funded by the European Union, GiMoDig started in November, 2001 with a duration of 3 years. The target is to develop and test methods for delivering harmonised, European, large-scale geospatial data to a mobile user by means of real-time data-integration and generalisation. The project aims at the creation of a seamless data service, providing access through a common interface, to the primary topographic geodatabases maintained by the National Mapping Agencies (NMAs) in various countries. The Finnish Geodetic Institute acts as a coordinator for the project. The other participants are the Institute of Cartography and Geoinformatics at the University of Hanover, Federal Agency for Cartography and Geodesy (Germany), National Survey and Cadastre (Denmark), National Land Survey of Sweden and National Land Survey of Finland.

For the GiMoDig project we use the national topographic data delivered by the NMAs in vector format. Therefore e.g. zooming in does not cause any quality loss in map visualisation. The access to the data in the GiMoDig project is not implemented as offline but as online application. According to his current position the mobile user receives the appropriate map on his mobile device – again on the condition that the device is able to locate itself. No additional work has to be done before hand e.g. for selecting of the relevant map piece and the storing on the mobile device.

Finally, when the user is moving in a border area he receives the national topographic data of both countries. Here arises the real challenge – the harmonisation of the national data. They are often very heterogeneous, a uniform visualisation is not always possible offhand.

Therefore the focus in the GiMoDig-project also lies on the harmonisation of core national topographic databases and will be described in more detail in the following sections.

This paper has the emphasis on the conceptual aspects of the work. The details about the implementation are given e.g. (Lehto, 2003), which documents the system architecture of the prototype system. A very relevant paper is also (Lehto and Sarjakoski, 2004) describing how schema translations have been implemented using XSLT (Extensible Stylesheet Language Transformations). Other documents of the project can be found at the project's website (GiMoDig, 2004).

4. HARMONISATION STEP BY STEP

Due to historical, organisational and technical constraints the core topographic datasets of the National Mapping Agencies (NMAs) in the GiMoDig Consortium – and elsewhere – are built on different conceptual models. For usage of national data in cross-border applications a common schema has to be defined and the necessary mappings from the national models to the common schema have to be identified. Following the terminology used in database modelling, the common GiMoDig schema is referred to as 'Global Schema', while a national schema is referred to as 'Local Schema' in this paper.

At the same time harmonisation operations have to be defined in order to achieve an automatic transformation from the National to the Global Schema. The Global Schema is to be defined in a way that minimizes the efforts of data harmonisation from national databases. The harmonisation operations from Local Schema to Global Schema have to be limited to those procedures that can be performed on-the-fly in real time when the data in national data bases is accessed.

In GiMoDig the process for creating the Global Schema was realized out in several phases.

4.1 Inventory of the national topographic databases

As a first step in the process, an inventory of the national topographic databases for all map scales is done. A survey on the availability of topographic vector data in Germany, Denmark, Finland and Sweden reveals that all countries can provide national data at resolutions 1:5.000 to 1:10.000, 1:250.000 and 1:1.000.000, whereas data at resolution 1:25.000 to 1:50.000 is available in Finland and Sweden only (Illert, Afflerbach, 2003a).

4.2 Classification into the FACC-Code

The classification of the national topographic data of the participating countries according to the FACC-Code (Feature Attribute Coding Catalogue) is done using this inventory as the background information. The FACC was originally created by NATO as a military standard within the scope of DIGEST (Digital Geographic Information Exchange Standard). It is divided into object types, attribute types and attribute values. Further on it contains notifications in different languages, alphanumeric codes and class definitions. Created mainly for military purposes the FACC is now also used for civil applications. It is already used for other international projects of the National Mapping Agencies. EuroGeographics (2003), the organisation of European NMAs, prepares for pan-European topographic databases at a scale of 1:250.000 (EuroRegionalMap (2003)) and 1:1.000.000 (EuroGlobalMap (2003)).

In terms of consistency across scales the GiMoDig Global Schema will be compliant with the conceptual models of ERM and EGM. This condition applies to the conceptual schema but not to the data models, because the GiMoDig project aims at on-line harmonisation in real time from distributed sources while ERM and EGM constitute harmonised datasets that exist physically. The production of ERM and EGM includes interactive work, e.g. on edge matching, thus facilitating cross-border topology which is not a feature in the GiMoDig project. With the awareness of these pan-European projects at medium and small scales, the efforts in GiMoDig are focused on the base data at large scales (1:5.000 to 1:10.000), thus complementing the other projects. In order to be compliant with ERM and EGM, the specifications of the GiMoDig Global Schema are based on the DIGEST FACC.

The following topographic data bases are used for the common Global Schema:

- Finland: Topographic Database
- Denmark: TOP10DK
- Germany: ATKIS Base-DLM
- Sweden: the Geographic Sweden Data (GSD)

The Global Schema will provide an umbrella over these databases. As described in the goals of the GiMoDig project (Sarjakoski et al., 2002a,b), the Global Schema should

- be compliant with existing or emerging international standards,
- be consistent with EuroGeographics specifications for topographic datasets at medium and small scales (EuroGeographics, 2003),
- serve the user requirements identified in the GiMoDig project (Jakobsson, 2002),
- consider the needs of small display cartography identified in the GiMoDig project (Nissen et al., 2003),
- build on data that is available at the National Mapping Agencies, and
- restrict the harmonisation operations from Local Schema to Global Schema to those procedures that can be performed on-the-fly, in real time.

For the classification into the FACC-code the object types of the national topographic data bases of Denmark, Finland, Sweden and Germany are described together with their attributes, their selection criteria and their data model.

The harmonisation operations used in the GiMoDig project do not aim at creating a consistent cross-border topology, as it seems to be unrealistic to make it fully automatically on-the-fly. Therefore, the data in the Global Schema is not suitable for cross-border spatial analysis like routing applications.

Edge matching is not considered in the GiMoDig project, so the different geometry remains in the dataset and each national dataset uses its geometry for clipping. In practice, the datasets of the GiMoDig NMAs fit very well at the borders, and the difference in geometry is only visible if the data is displayed at a much bigger scale than the intended scale of 1:10.000.

4.3 Selection of relevant feature types

After the classification into the FACC-code it becomes evident that from the approximately 470 feature types in the FACC, 180 have an equivalent in at least one of the national datasets. From these 180 feature types a selection is proposed to be used in the following steps of the GiMoDig project. As a criteria for selection the examinations by Jakobsson, 2002 are raised. They deal with user requirements on a harmonised topographic dataset on mobile devices. Different concrete use cases such as 'Tourist in a city' or 'Hiking in national park' are described which have different requirements to the data content. Also Nissen et al., 2003 are referring to that study and describe the requirements for small display cartography, i.e. cartography for small devices. This study is also considered in the Global Schema. The initial idea for the selection of relevant feature types was to start with the least common denominator, i.e. those feature types that have equivalents in all national datasets or can be derived from national data. However, the least common denominator is small; actually less than 20 feature types have an equivalent in each of the four national datasets. This set lacks of some feature types that are very important to the GiMoDig service. Therefore, we left the idea of the least common denominator and kept those features types that are supported by the majority (i.e. at least three) of the GiMoDig countries (s. Table 1, (Illert, Afflerbach, 2003b).

FACC-Code	FACC-Name
BA040	Water (except Inland)
FA000	Administrative Boundary
BH502	Watercourse(ERM)
BH080	Lake/Pond
BH095	Marsh/Swamp
AK120	Park
AL015	Building
CA010	Contour Line (Land)
EA010	Cropland
ZD040	Named Location
AL020	Built-Up Area
AN010	Railway
AP030	Road
AP050	US-Trail/Footpath
GB005	Airport/Airfield
EC015	Forest
EB010	Grassland

Table 1: Selected object types

In the very beginning of the GiMoDig project it was decided to adapt the classification schema and semantic model of the FACC. This should ensure the compliance with ERM and EGM because both datasets are structured according to the FACC. However, at a closer look it turns out that ERM does not always follow the FACC. For example, ERM has introduced a new feature type BH502 'Watercourse' which is not present in the FACC but aggregates the FACC feature types BH020 'Canal', BH030 'Ditch' and BH140 'River, Stream'. The ERM expert group combined the FACC classes in one feature type because they think the semantic difference between the 'Watercourse' instances does not justify separate feature types. This change is in line with the topographic datasets of many European NMAs. In view of a uniform conceptual model for NMA data across scales, the GiMoDig Global Schema follows the ERM definition if conflicts occur between ERM and FACC.

4.4 Definition and Rules of the Global Schema

The first version of the Global Schema is created for the selected feature types. For the definition of parameters for collection criteria and geometry type, rules are set up to ensure minimal conversion conflicts from the national core topographic databases:

- Geometry type: in case the national specifications define conflicting geometry types (point, line, area) for a feature type, then that geometry type with the majority among the national datasets is chosen.
- Collection criteria: If the collection criteria in national specifications use same rules but different parameters, then the least common denominator is applied.
Example: feature type 'Park'
Germany: size of area > 10.000 m² (1 ha)
Denmark: size of area > 2.500 m² (0,25 ha)
Finland: size of area > 5.000 m² (0,5 ha)
Sweden: size of area > 900 m² (0,09 ha)
Global Schema: size of area > 10.000 m² (1 ha)

If the collection criteria in national specifications use different rules, then the Global Schema does not impose collection criteria, allowing all national data to be entered without harmonisation.

Example: BH502 'Watercourse', subdivision 'natural watercourse'

Germany: complete, if 'permanently water leading', else at a length > 500 m

Denmark: Length > 50 m, or if they are important for the continuity of the hydrography network.

Finland: Width more than 2 m, exception in forest or if they are important for the continuity of the hydrography network.

Sweden: Length > 250 m

Global Schema: the attributes 'permanently water leading' and 'important for the continuity of the hydrography network' are not included into the selection. Concerning the length and width of the watercourse the least common denominator is defined. So all watercourses with more than 250 m length or more than 2 m width are recorded.

Attribute types and values of ERM and/or the FACC are only included to the GiMoDig Global Schema if they are supported by the majority of the countries, or if they appear to be of great importance to the GiMoDig service.

5. VERIFICATION OF THE GLOBAL SCHEMA BY MEANS OF TEST DATA

The process steps above yielded the preliminary Global Schema, preliminary in the sense that it is result of a desktop study but not yet tested on sample data from the NMAs.

For a robust definition, the preliminary Global Schema is tested on sample data. Two test areas across the borders are defined where the differences between national data could be examined. One of the test areas is located in the Tornio/Haparanda area (1) at the Swedish-Finnish border with a size of 10 x 10 km, and the other at the Danish-German border from Højer/Sylt to Augustenborg/Kappeln with a size of about 100 x 30 km (2). Figure 1 shows the location of the test areas.

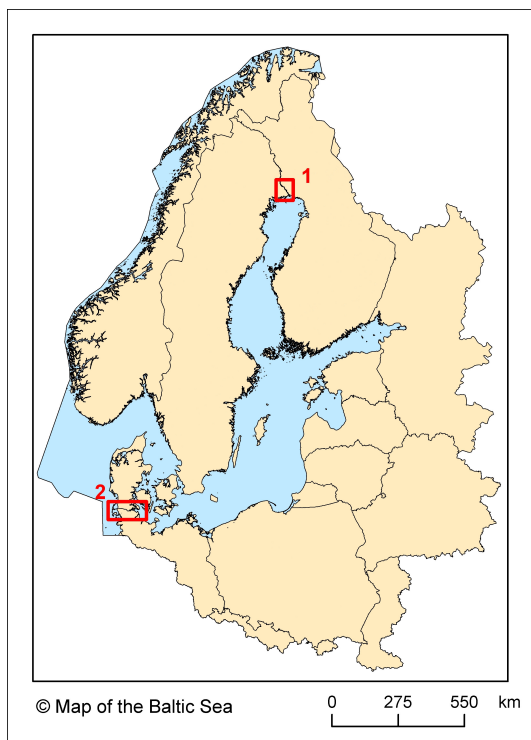


Figure 1: Location of the test areas

The analysis of test data showed that some elements of the Global Schema should be adapted to the situation, and that the content of the national core topographic databases is not sufficient in some cases and therefore data has to be acquired from additional sources. In the following some of these issues are discussed.

5.1 Missing feature types

As already mentioned in chapter 4.3 the initial goal of using the least common denominator of national databases for the Global Schema could not be realized because important feature types would have been excluded. The actual Global Schema contains some elements that have to be acquired from sources other than the core topographic datasets.

In Germany the ATKIS specification considers buildings to be derived from cadastre databases by means of automatic generalisation, but these topographic objects will not be available before finalisation of ATKIS in the year 2006. For GiMoDig they have to be acquired from the cadastre databases. The 'Contour Line' is an optional feature type in ATKIS, it is provided by some but not all German Landesvermessungsämter. For the GiMoDig application they are computed from the Digital Terrain Model (DTM).

The Danish core topographic database does not include the feature type 'Ocean'. It has to be created from 'Coastline' data and/or 'Administrative Units'. 'Grassland' and 'Cropland' are both not available in the TOP10DK but are added from the Danish Ministry of the Environment.

Figure 2 shows the major deficits of the Danish and the German databases in an example of the border area near the German city Flensburg. It illustrates the lack of individual buildings and contour lines in the German ATKIS dataset and the lack of grassland and cropland in Danish TOP10DK dataset. Other elements of land cover such as built-up area, forest and lake are present in both datasets.

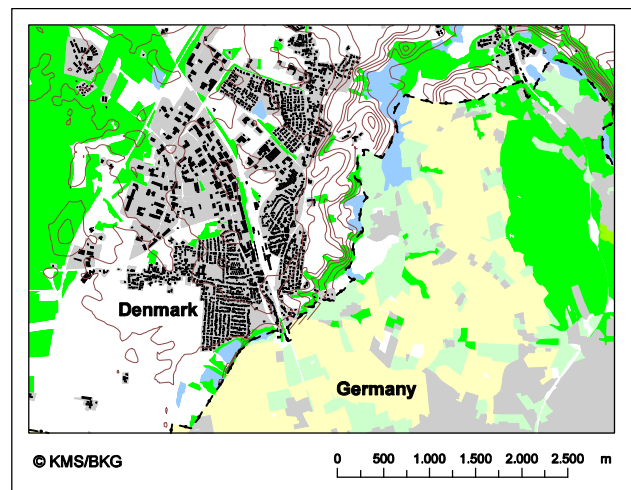


Figure 2: Differences between Germany and Denmark

In the case of Sweden, only the major buildings are recorded. So a complete record of buildings from the Swedish municipalities is required for the GiMoDig prototype. Furthermore, 'Grassland' and 'Forest' are so far not included in the Swedish dataset. Finland lacks data for 'Built-up Area' and polygon feature type 'Forest'.

5.2 Different geometry types

In Finland the forest is not available as an area feature. The large scale topographic map depicts forest by a point symbol, so does the topographic database (see Figure 3). Area colours (in the map) or area features (in the database) are used for other land cover features such as agricultural land, mire, meadow and water body. The built-up area and forest share the background (white colour in the map). The human map reader can distinguish these two land cover classes from each other by interpreting the symbols for individual houses and trees, but this method is not easy to implement in a geographical information system (GIS).

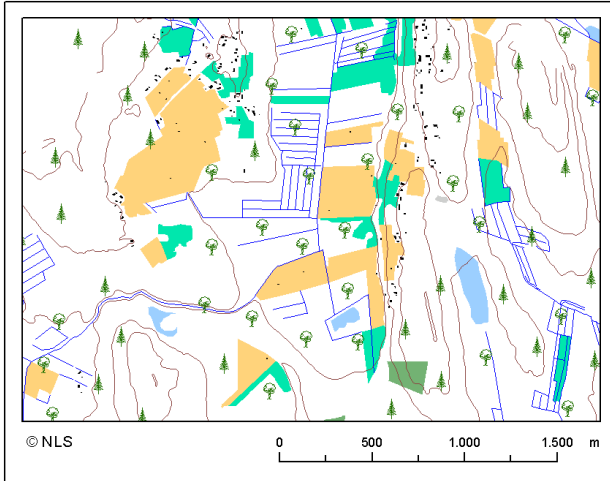


Figure 3: Finnish Forest as point feature type

5.3 Differences in conceptual modelling

Some feature types and attributes of the Global Schema have no or only ambiguous relationship with the Local Schema because of the significant differences in conceptual model, related e.g. to watercourses. The GiMoDig Global Schema proposes a classification into feature types 'Water except Inland' (i.e. Sea, Ocean), 'Watercourse' (which aggregates 'River', 'Canal' and 'Ditch') and 'Lake/Pond'. Sweden does not distinguish 'Ocean' from 'Lake' and from area-type 'River', instead they put all instances into one feature type 'Vatten' and only separate area-type features from line-type features. Finland has a similar approach but distinguishes at least the 'Water with Current' (Watercourse) from 'Water without Current' (Ocean, Lake). For visualisation purpose this generalised approach does not matter since all water area is displayed in same blue colour, but for GIS applications the approach of Sweden and Finland may lead to difficulties.

Denmark does not make any distinction between 'Airports', 'Railway stations' or 'Power Plants'. They are all together recorded as 2700 'Technical Area'.

Another problem in Denmark is the 3119 'Recreational Area'. This feature type comprises all kind of recreational areas, e.g. 'Amusement Park', 'Campground' and also 'Park'. There is no attribute that further specifies the instances according to the type of the recreational area.

The criteria for classification of roads into primary, secondary or local road differs between countries. Germany applies the official administrative categories. The other countries classify

by the width of the road. There is no uniform European classification scheme except for the few trunk routes with 'E'-numbers.

5.4 Differences in data modelling

Concerning data modelling there also exist differences between the four participating countries.

The German dataset differs from the data model of the Scandinavian partners especially for roads with separated lanes. The NMAs of Sweden, Finland and Denmark portray the lanes in each direction with individual centre lines. In contrast, the German dataset models the motorways by a complex feature that is composed of road body (one centre axis) and road lanes (two centre lines). For the Global Schema we decided to include only the individual lanes and skip the centre axis of the German motorway, with the lanes inheriting the attributes from the complex feature and the road body.

Concerning railway features each track is modelled separately in Finland, Sweden and Denmark. It appears that Finland shows the complete layout whereas Sweden and Denmark apply some generalisation. Double track railways appear as two parallel lines in Finland and Denmark. In Sweden and Germany the railway is recorded as a single centre line if tracks are parallel, the number of tracks is stored as an attribute. In case of tracks not being parallel the German data model applies a complex feature like the motorway. In case of complex railway yards or stations the German data model applies an area-type feature 'railway station' where only the major track is continued through the area and connected with the railway lines leading to/from the station. In the Global Schema we keep both approaches as it is neither feasible to generalise the Scandinavian track layout nor to add the missing tracks to the German data.

5.5 Level of Detail

From the sample data in the cross-border test areas it becomes obvious that the level of detail differs from country to country. Germany and Denmark have great differences in their hydrographic network. The network of drainage canals and ditches in Denmark is much denser than in Germany. The difference is less significant in hill areas where the selection criteria for natural watercourses appear quite homogenous at both sides of the border.

The hydrographic network at the border between Sweden and Finland can be compared with the German-Danish example. The network of artificial watercourses appears much denser in Finland than in Sweden. Another problem illustrated in the example is the lack of connectivity in the Finnish and Swedish network. We can recognize many gaps and isolated objects (see Figure 4).

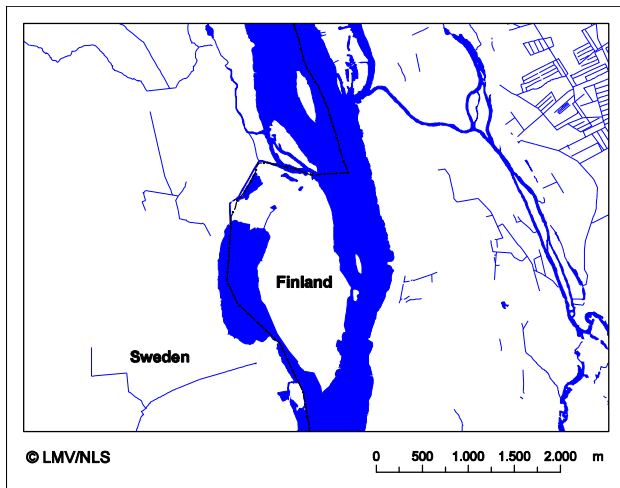


Figure 4: Hydrography differences between Sweden and Finland

6. CONCLUSION

As described in this article, there exist a lot of difficulties concerning the harmonisation of the national topographic data bases, especially because of different data models. A simple and ideal solution for the definition in the Global Schema is not always given. The European Union is aware of these problems. The INSPIRE (Infrastructure for Spatial Information in Europe, 2003) initiative of the European Commission aims at making available relevant, harmonised and quality geographic information. This includes specifications for interoperable reference data and services to fully integrate data from various sources. The goal of the INSPIRE is a European legislation. The EuroGeographics has responded to the requirements formulated in INSPIRE by launching the EuroSpec project (2004). The EuroSpec constitutes a long term process that will develop over a period of 10 years at several stages. The scope of the EuroSpec project is common specifications for reference data that will ensure the interoperability of geo-located data across boundaries, themes and resolution ranges. This scope is much wider than the goal of the GiMoDig, which – in first place – focuses on a mobile cartographic application. Nevertheless the GiMoDig Global Schema might provide a platform where the EuroSpec can further build on. It would be desirable that on-line based access to topographic data, like the one of the GiMoDig prototype, would evolve as real alternative, in contrast to existing off-line solutions.

7. REFERENCES

EuroGeographics, 2003. EuroGeographics – Europe's National Mapping Agencies Working for the European Geographic Information Infrastructure. At <http://www.eurogeographics.org/>, (accessed March 29, 2004).

EuroGlobalMap Project, 2003. 1:1 million Digital data base covering Europe. At http://www.eurogeographics.org/eng/03_projects_EGM_overview.asp (accessed March 29, 2004).

EuroRegionalMap Project, 2003. Incremental Development of a Pan-European Vectorial Database at Medium Scale. At http://www.eurogeographics.org/eng/03_projects_euroregional_map.asp (accessed March 29, 2004).

EuroSpec, 2004. European Specifications for reference data. At http://www.eurogeographics.org/eng/03_projects_eurospec_act.asp (accessed March 29, 2004).

GiMoDig, 2004. Geospatial Info-Mobility Service by Real-Time Data Integration and Generalisation. <http://gimodig.fgi.fi/deliverables.php> (accessed March 25, 2004)

Illert, A. and Afflerbach, S., 2003a. Die Entwicklung eines gemeinsamen Modells für europäische topographische Geobasisdaten im GiMoDig-Projekt, In: Kartographische Schriften, Band 7: Visualisierung und Erschließung von Geodaten, Deutsche Gesellschaft für Kartographie (Hrsg.), Hannover, 27.-28. Februar 2003, pp. 163-170.

Illert, A. and Afflerbach, S., 2003b. Report on Global Schema, IST-2000-30090, Deliverable D5.2.1, Public EC report, 65 p. also available at <http://gimodig.fgi.fi/deliverables.php> (accessed March 25, 2004)

Jakobsson, A., 2002: User requirements for mobile topographic maps. GiMoDig-Projekt, IST-2000-30090, 93 p., also available at <http://gimodig.fgi.fi/deliverables.php> (accessed March 25, 2004)

Lehto, L., 2003. Architecture specification. GiMoDig-project, IST-2000-30090, Deliverable D4.4.1: Final system architecture, Public EC report, 41 p., also available at <http://gimodig.fgi.fi/deliverables.php> (accessed March 25, 2004)

Lehto, L. and Sarjakoski, T., 2004. Schema Translations by XSLT for GML-Encoded Geospatial Data In Heterogeneous Web-Service Environment. International Archives of Photogrammetry and Remote Sensing, Commission IV, Istanbul.

Nissen, F., Hvas, A., Münster-Swendsen, J. and Brodersen L., 2003: Small-Display Cartography. GiMoDig-Projekt, IST-2000-30090, also available at <http://gimodig.fgi.fi/deliverables.php> (accessed March 25, 2004)

INSPIRE-Homepage, <http://www.ec-gis.org/inspire> (accessed March 25, 2004)

Sarjakoski, T., Sarjakoski, L. T., Lehto, L., Sester, M., Illert, A., Nissen, F., Rystedt, R. and Ruotsalainen R., 2002a. Geospatial Info-mobility Services – A Challenge for Interoperability and National Mapping Agencies. Proceedings of the 5th AGILE Conference on Geographic Information Science, Palma (Mallorca), Spain, April 25–27, 2002, pp. 585–589.

Sarjakoski, T., Sarjakoski, L. T., Lehto, L., Sester, M., Illert, A., Nissen, F., Rystedt, R. and Ruotsalainen R., 2002b. Geospatial Info-mobility Services – A Challenge for National Mapping Agencies. Proceedings of the Joint International Symposium on "GeoSpatial Theory, Processing and Applications" (ISPRS/Commission IV, SDH2002), Ottawa, Canada, July 8–12, 2002, 5 p, CD-rom.

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