CROSS-BORDER SPATIAL DATA HARMONISATION FOR A FLOOD EARLY WARNING SYSTEM AT THE LAKE CONSTANCE

Ö. Ertac*, A. Fichtinger, F. Luderschmid, U. Schäffler, M. Schilcher

Fachgebiet Geoinformationssysteme, Institut für Geodäsie, GIS und Landmanagement, Technische Universität München, Munich, Germany – (oezguer.ertac, ulrich.schaeffler, astrid.fichtinger, fabian.luderschmid, Matthaeus.Schilcher)@bv.tum.de

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ABSTRACT:

European initiatives like the European Water Framework (WFD) Directive and the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive are dealing with cross-border issues. One of the best known examples of hazards that adhere strongly with cross-border aspects are floods, since water doesn't stop at borders. In a cross-border flood situation, heterogeneous data which are necessary for a GIS-based visualisation and analysis of flood areas in the affected countries cannot be manually integrated at each command and control centre. A common data model based on European-wide standards is therefore required which was developed for the scenario European Risk Atlas (ERiskA) in an EU funded project HUMBOLDT. HUMBOLDT, which has started in 2006 and was completed in March 2011, has the aim to contribute to important parts of the implementation process of a European SDI. In this sense, ERiskA aims at facilitating cross-border cooperation between the agencies responsible for disaster management in the Lake Constance Region that covers Swiss, Austrian and German territories. A prototypical add-on to a disaster management system was developed to facilitate exchange of information on potentially flooded areas and inundation of infrastructure like roads and railways. In this context, a number of interoperability and data harmonisation issues were addressed within this scenario. This paper represents 4 years of experience and results of ERiskA in the field of flood information.

1. INTRODUCTION

Under the management of the Fraunhofer Institute for Computer Graphics 28 organisations from all around Europe have worked together in the EU-funded project HUMBOLDT, to solve data harmonisation problems in the INSPIRE context. Nine different application scenarios (European Risk Atlas, Ocean, Urban Planning, Sustainable Urban Atlas, Protected Areas, Border Security, Forest, Atmosphere and Transboundary Catchments) defined user requirements for the development of the software framework, and served as test cases. Results are now publicly available for a wide audience through an e-learning platform of HUMBOLDT that demonstrates the implementation of data harmonisation in the scenarios.

By the completion of the project this year, a prototype open-source framework for data harmonisation and service integration was developed that consists of tools for coordinate transformation, edge matching, data model transformation, and other aspects. For instance a sophisticated tool is developed namely "the HUMBOLDT Alignment Editor" (HALE) for defining mappings between source and target data models (HUMBOLDT 2010). At http://community.esdi-humboldt.eu, interested parties are invited to test the software and use it for their requirements.

With regard to the HUMBOLDT, "Technische Universität München led the development of the European Risk Atlas (ERiskA) Scenario in co-operation with Intergraph SG&I Deutschland GmbH. A cross-border flood application for the Lake Constance region, which can be used as an add-on to existing flood risk management and emergency operation systems, was developed. ERiskA is to enable the exchange of spatial information on potentially flooded areas and infrastructure, thus facilitating cross-border cooperation between the authorities responsible for disaster management in the Lake Constance region" (Fichtinger et al. 2010a). This paper represents 4 years of experience and results of ERiskA as a cross-border disaster management system.

Figure 1. Study area, Lake Constance (© HVZ).

2. DATA HARMONISATION

Data harmonisation is a crucial element for efficient integration of heterogeneous information in cross-border projects and SDIs as for example envisioned by the INSPIRE Directive. INSPIRE Annex I have already been described in Data Specifications which contain harmonised pan-European data models and further requirements. The challenge for data providers is now to adapt their legacy data to the final data specifications (Fichtinger et al. 2010b).

* Corresponding author. Email: oezguer.ertac@bv.tum.de

In the HUMBOLDT project, "Data harmonisation is about creating the possibility to combine data from heterogeneous sources into integrated, consistent and unambiguous information products, in a way that is of no concern to the end-user." (HUMBOLDT 2009).

2.1 Data Harmonisation in HUMBOLDT

Several data harmonisation issues have been identified in different HUMBOLDT application scenarios such as data formats, spatial reference systems, conceptual schemas (data models), classification schemes (e.g. different ways to classify land cover or flood risk warning levels), metadata (e.g. different metadata profiles or lack of formalised / standardised metadata), terminology (de Vries et al. 2007a, 2007b).

The main focus in the ERiskA and other Scenarios was put on heterogeneities between conceptual schemas of the data sets used. The way, in which similar real world objects e.g. representing hydrography are modelled, differs considerably across countries or application domains. Figure 2 illustrates the structural differences in modelling a river object in topographic vector data provided by the mapping agencies of the Austrian state of Vorarlberg (left hand side) and the German state of Bavaria (right hand side). In addition to that, in some cases, different conceptual schema languages like the Unified Modelling Language (UML) or the Swiss INTERLIS are used. In other cases, data is not described in a formal way in a conceptual schema at all (Fichtinger et al. 2010b).

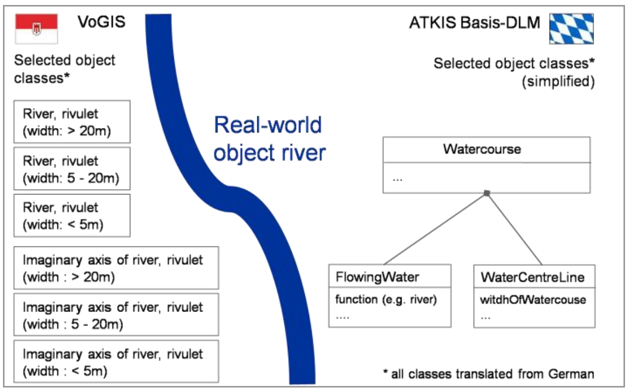

Figure 2: Different ways to structure the real-world object river (Fichtinger et al. 2010b).

2.2 INSPIRE Context

In the INSPIRE Directive, interoperability is defined as "the possibility for spatial data sets to be combined, and for services to interact, without repetitive manual intervention, in such a way that the result is coherent and the added value of the data sets and services is enhanced (Commission of the European Communities 2007). INSPIRE represents 20 different aspects relevant for data harmonisation (figure 3) which have to be covered by the provisions in the INSPIRE implementing rules and technical guidelines.

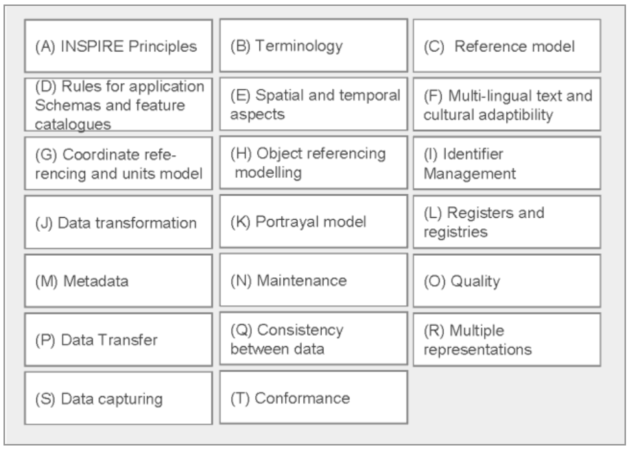

Figure 3: INSPIRE Data Interoperability Components (Drafting Team Data Specifications 2008)

The list above represents the elements of data harmonisation and interoperability in a spatial data infrastructure (SDI). On the one hand, there are some data model issues, such as rules for application schemas or spatial and temporal aspects. On the other hand, issues related to the data instances are also addressed like spatial reference systems, data quality and consistency e.g. at borders or in cases where there are multiple representations of the same real-world object. In addition aspects related to data capturing and maintenance as well as visualisation (portrayal) are covered. Some, but not all of these aspects were addressed in the different HUMBOLDT Scenarios (Fichtinger et al. 2010b).

3. DATA HARMONISATION IN PRACTICE WITH ERISKA

3.1 ERiskA

ERiskA is designed to be used as an add-on to existing emergency operation systems at command and control centres dealing with the different steps in the disaster management cycle against floods. It aims at facilitating cross-border cooperation between the agencies responsible for disaster management in the Lake Constance Region by enabling the exchange of information on potentially flooded areas and inundation of infrastructure like roads and railways. For instance, currently the disaster management centre of Vorarlberg can't access other data sources for emergency management from the neighbouring countries in an easy way. In this context a number of interoperability and data harmonisation issues are addressed and the following use case specified within the scenario:

- Information exchange among responsible institutions on potentially flooded areas and resulting inundation of infrastructure like roads and railways.
- The end user of spatial information requests information if roads or railways in his area of interest are still passable already flooded or probably flooded soon.
- The "end user of geodata" selects the gauges relevant for the area of interest and accesses information on the current water level at these gauges.
- The "end user of geodata" delivers the information either as a map or he calls the "end user of spatial information".

3.2 INSPIRE and ERiskA

For the ERiskA scenario application, a common data model was created to which the legacy data models of the data from the different countries of the test area were mapped. The ERiskA data model was designed taking into consideration INSPIRE Annex I Data Specifications like

- Hydrography, Transport Networks and Geographical Names as well as an early draft version of some elements belonging to the Annex I data theme
- Natural Risk Zones.
- Geographical Names

The common data model was designed as an extension to the above mentioned INSPIRE Data Specifications, following the guidelines given in the INSPIRE Generic Conceptual Model document (Drafting Team Data Specifications 2009).

As the ERiskA data model was designed based on the limited scope of the ERiskA use cases and the functional requirements of the ERiskA application prototype, it naturally doesn't cover the whole application domain of risk management. However, it can be extended as needed for other use cases and applications.

3.3 Implementation and User Interface

Functionalities required for the ERiskA application include:

- providing harmonised cross-border base data for the test area including roads, railways, watercourses, standing waters and elevation as well as background raster data including topographic maps and aerial images. Data harmonisation needs to be done in pre-processing and harmonised base data needs to be stored locally for fast and secure access also during disaster event (complete system is time critical)
- desktop GIS (or an adapted rich client) as front-end for accessing online and offline data sources as well as visualisation and processing functions (e.g. intersection, buffering, etc.)
- selecting features based on spatial operators using interactively created features (e.g. area of interest polygon) or stored features
- selecting features according to different input parameters (also by resolving non-spatial references e.g. between a certain water level and a corresponding flood area extend feature)
- integration of in-situ measurement values at gauges (water level and discharge) by accessing the relevant information published online (different providers in the regions of the test area) or by editing of measurement values manually (in case of non-availability of web service)
- recalculating measurement values (e.g. taking into consideration different vertical reference systems)
- reclassifying warning levels according to different regional classifications (optional)
- applying individual styles according to different classifications (optional)

The following data harmonisation requirements have been identified for ERiskA:

- Data formats, and spatial reference systems, scale and resolution
- Conceptual schemas (data models)
- Classification schemes
- Terminology
- Metadata profiles
- Portrayal
- Multilinguality
- Spatial consistency of data
- Multiple representation of the ‘same’ spatial objects

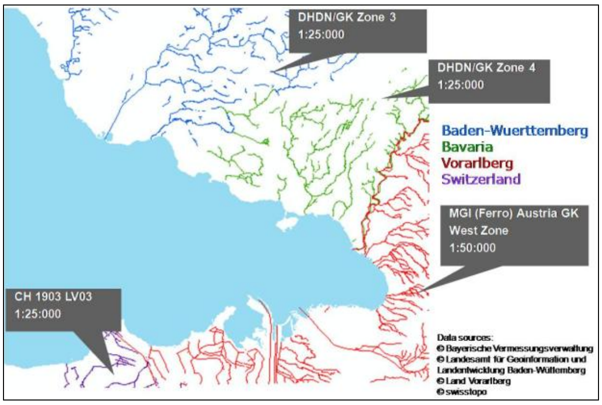

Figure 4: Different spatial reference systems and scales in the Lake Constance Region (river data)

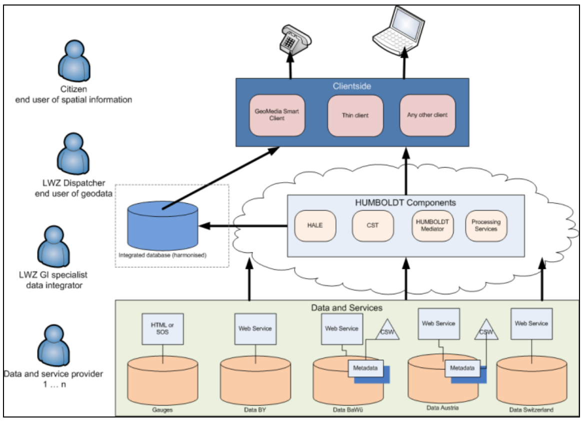

Figure 5: ERiskA’s three tier architecture (Fichtinger et al. 2010c)

Since fast and secure access to the ERiskA system is critical also during a disaster event (e.g. in case of non-availability of web services), the workflow is split into two main parts:

- pre-processing and storage of harmonised data sets
- analysis on harmonised data e.g. for potentially flooded areas

Figure 6 shows the use of the HUMBOLDT Alignment Editor (HALE) in the ERiskA scenario, with the source schema (Vorarlberg river data read from an OGC Web Feature Service) on the left hand side and the common ERiskA target schema (read from a GML application schema) on the right hand side. Figure 7 illustrates how the values of one attribute of a feature class in the source schemas are mapped to values of two attributes in the target schema.

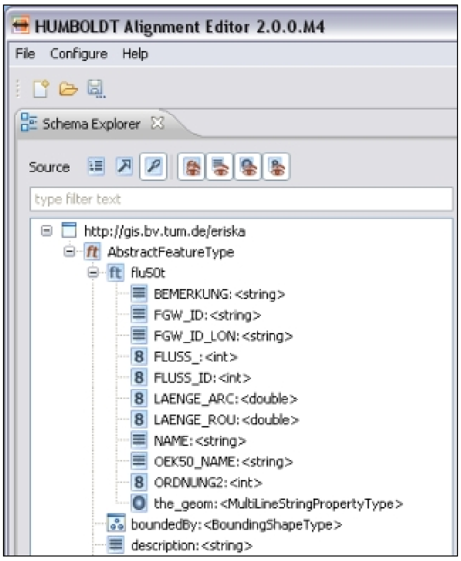

Figure 6: Mapping task in HALE

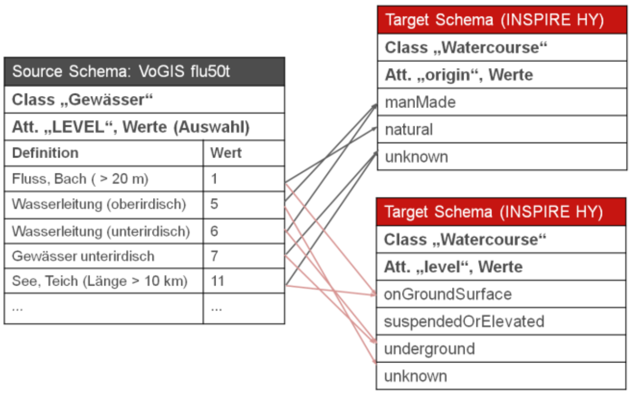

Figure 7: Example of mapping attribute values of source schema (Vorarlberg) to ERiskA target schema (based on INSPIRE data specification Hydrography)

A desktop-based as well as a web-based demonstrator prototype were developed by the Intergraph SG&I Deutschland GmbH based on GeoMedia. Figures 8 and 9 illustrate two functions of the desktop-based ERiskA demonstrator. First, a gauge is selected and the current water level at this gauge is retrieved from the website of the water management agency. Based on the water level, a pre-calculated flooded-are extent feature is loaded and displayed.

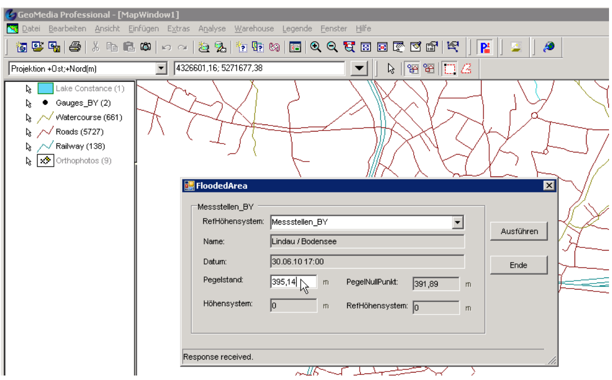

Figure 8: Retrieving current water level (screenshot from the ERiskA demonstrator)

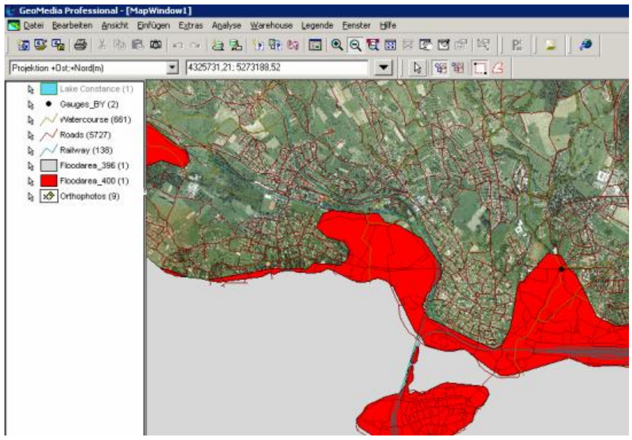

Figure 9: Mapping flooded areas at current water level (screenshot from the ERiskA demonstrator)

4. CONCLUSIONS

In the course of developing the ERiskA cross-border application, the heterogeneity of spatial data in the states bordering the Lake Constance has been investigated and solutions to overcome different heterogeneity issues have been tested. Some of these issues can be solved using tools of the HUMBOLDT Framework, which have proven very useful. Some harmonisation tasks, which are very specific to the ERiskA application might need additional tools. Other aspects, like different flood warning level classifications based on different types of input data and different methods of calculation in the countries / states of the Lake Constance region, need to be investigated in more detail.

In case of a real disaster, dependence on internet might cause some bottlenecks in the system as a time critical application. Therefore the data harmonisation was done in pre-processing to provide a harmonised base-data set. All know-how gained during the implementation has been shared in the ERiskA training material which is available at the HUMBOLDT e-learning platform.

ERiskA is also fully integrated with the test platform of the Runder Tisch GIS e.V. (an association established for GIS and land management specialists). ERiskA online training material and the project documentation are now available online at http://eriska.gis.bv.tum.de/. In this sense support by the Runder Tisch GIS e.V. is acknowledged and greatly appreciated.

In conclusion the tools developed in Humboldt open up new opportunities in the area of data harmonisation, and that are a very good addition to existing commercial software products. A healthy mix of both would probably be the best solution.

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