GEOSPATIAL THINKING

Educating the Future Spatial Citizens

Proceedings of the GEOTHNK Project Closing Conference

M. Kavouras, S. Sotiriou (Eds.)

Lifelong Learning Programme

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GEOTHNK: SEMANTIC PATHWAYS FOR BUILDING A SPATIALLY-THINKING SOCIETY.

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7. Geographic Information Need to Know (GI-N2K): towards a more demand driven geospatial workforce education system

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Abstract. The development of the Geographic Information Science & Technology (GI S&T) Body of Knowledge (BoK) in 2006 was a milestone achievement in the geospatial domain. It collects, describes and structures important concepts in the scientific field, and exposes them for theoreticians and practitioners alike. Today, after almost 10 years of scientific and technological developments in the geospatial field, the original BoK has become outdated. Geographic Information: Need to Know (GI-N2K) is a European project that intends to bring the original GI S&T BoK up to date. This paper explains the GI-N2K project objectives, the work already done, as well as next steps in reaching a renewed GI S&T BoK.

Keywords. Body of Knowledge, Geographic Information, Geospatial market

7.1. Introduction

The geospatial industry is a fast growing sector, generating high value/high tech jobs, innovative services and fast evolving technologies. In 2012, Donert reported over 100,000 mapping professionals in Europe, with a prognosis to employ more than 550,000 people by 2014 (Donert, 2012), and having a GIS market to reach US$3,323.62 million by 2016 (GIS market, 2013). Despite these staggering numbers, employers still find it hard to find well-trained and skilled GI S&T employees: *"A recurrent complaint among companies and organization in the domain of GI is that the current supply of geospatial professionals is inadequate and the geospatial workers appear to be inadequately prepared to answer to the challenges and opportunities of this field"* (Vancauwenberghe and Vandenbroucke, 2015).

Hence, in order to increase Europe's economic competitiveness in the geospatial sector, there is a clear need to align demand and supply, and it is paramount to establish more demand-driven educational programs that effectively meet the requirements of the European market.

7.2. GI-N2K Project[18]

7.2.1. Facts and figures

GI-N2K is a project funded under the EU Lifelong Learning Program (LLP) as an ERASMUS multilateral network, running from October 2013 until October 2016.

[18] www.gi-n2k.eu

One of the most relevant contributions and pillars of the GI-N2K project is the network of partners, collaborators and contributors the project is building up. The consortium is formed by 31 partners, from 25 European countries, coming from Academia, and non-academic sectors, such as leading GIS companies or professional associations, as well as individual experts (Fig. 1, Table 1)

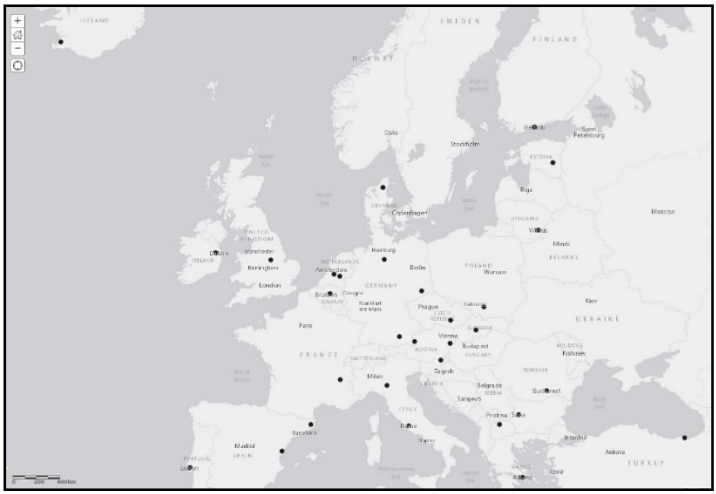

Fig. 1 *Overview of GI-N2K partners*

Partner	Country	Partner	Country
KU Leuven (coordinator)	Belgium	NUI Maynooth Ireland	Ireland
Aalborg university	Denmark	SIGTE	Spain
AGILE	Netherlands	The Slovak environmental agency	Slovakia
AGISEE	Bulgaria	UJI	Spain
AMFM GIS Italia	Italy	University of Bundeswehr	Germany
CEKTRA	Slovenia	University of Dresden	Germany
CISIG	Italy	University of Muenster	Germany
ESRI Romania	Romania	University of Nottingham	United Kingdom
Finnish geodetic institute	Finland	University of Salzburg	Austria
GEO-SEE	Macedonia	University of Tartu	Estonia
ISEGI	Portugal	University Pierre Mendes	France
Jagiellonian University	Poland	University West-Hungarie	Hungary
Karadeniz Technical university	Turkey	Utrecht university	Netherlands

LISA	Iceland	Vilnius university	Lithuania
Masaryk University	Czech Republic	Wageningen university	Netherlands
NTUA	Greece		

Table 1 *GI-N2K partners*

7.3. Objectives and expected outcomes

The general objective of GI-N2K is to update and bring the existing Geographic Information Science & Technology Body of Knowledge (GI S&T BoK) in line with new scientific and technological developments, keeping a European perspective in mind.

With the rapid advancement of technologies, the current GI S&T BoK (DiBiase et al., 2006), developed by the American University Consortium for Geographic Information Science[19] and published by The American Association of Geographers[20], presents some limitations. These are not only related to the obsolete, incomplete or missing concepts, but also to the way the BoK can be explored, and to the predominance of American bias.

Having an updated GI S&T BoK as a final goal, the project also aims to find answers to other questions such as:

- how can education and vocational training in the domain of GI S&T match the actual job requirements in the job market?

[19] UCGIS http://ucgis.com
[20] AAG http://www.aag.org

- how can the GI S&T BoK be used in order to fulfill employers' and job demanders' needs as well?

The new GI S&T BoK therefore also aims to be a user-friendly, evolvable knowledge base for geospatial information geared to better define curricula and career paths, attending the needs of different profiles:

- **For Academia**. Universities are not always as close as they should to the real market. A renewed and constantly updated BoK will give academic programs a flavour of the kind of professionals the market is demanding from the university, resulting in graduates with stronger GI competences.
- **For professionals or students**. Exploring the GI S&T BoK will serve as inspiration for individual lecturers or professionals in order to update their skills or better define their curriculum. It will also give them the opportunity to create their own market-responsive curricula, as well as improve professional certification mechanisms.
- **For companies and employers**. A renewed GI S&T BoK will offer the possibility to check if the knowledge of the companies' staff fully covers project needs inside the company, or simply better outline job offers. Another interesting utility for companies is benchmarking their knowledge against their competitors.

So, the expected project outcomes will be:

- An overview of the demand and supply in the GI sector.
- A revised, evolvable GI S&T BoK with new areas, units and topics, that reflects the most up-to-date state of GI

technology, as well as the European perspective (considering concepts like the INSPIRE directive)

- A new set of tools that permits to explore, analyse and update the new BoK.
- Promoting and disseminating the use of the dynamic GI S&T BoK, toolsets and guidelines, and the GI S&T BoK itself.

7.4. Description of work

The project is composed by 7 work-packages (WP) with associated tasks and outcomes. WP5, WP6, WP7 and WP8 were related with the usual tasks of a European funded project: Quality assurance, Dissemination, Exploitation and Sustainability, and Management, respectively.

In WP1 "Analysis of the demand and supply", demand with regard to the knowledge and skills is assessed, and compared with the current training offer in the GI S&T sector. Partners conducted two surveys addressed to organizations involved in GI teaching in Europe (supply side) and GI-professionals from different sectors (demand side) (Hofer, 2014). The integrated analysis of both demand and supply surveys stated that the awareness and use of the actual GI S&T BoK is limited. It "*does not (yet) function as a common reference for GI-user and GI-employers"* (Rip, 2014). Despite the fact that the surveys also revealed that the need for competences and the teaching supply seemed different, there was no conclusive evidence found for a teaching gap. From the survey results, lots of new concepts not present in the first version GI S&T BoK were identified.

WP2 is about the "Revision of the Body of Knowledge" and the establishment of a strategy for the revision of the GI

S&T BoK. Despite the detected shortcomings, the existing GI S&T BoK as it was conceived (Table 2), is being used as starting point for discussion.

Analytical Methods (AM) AM1 Academic and analytical origins AM2 Query operations and query languages AM3 Geometric measures AM4 Basic analytical operations AM5 Basic analytical methods AM6 Analysis of surfaces AM7 Spatial statistics AM8 Geostatistics AM9 Spatial regression and econometrics AM10 Data mining AM11 Network analysis AM12 Optimization and location-allocation modeling	**Data Manipulation (DN)** DN1 Representation transformation DN2 Generalization and aggregation DN3 Transaction management of geospatial data
Conceptual Foundations (CF) CF1 Philosophical foundations CF2 Cognitive and social foundations CF3 Domains of geographic information CF4 Elements of geographic information CF5 Relationships CF6 Imperfections in geographic information	**Geocomputation (GC)** GC1 Emergence of geocomputation GC2 Computational aspects and neurocomputing GC3 Cellular Automata (CA) models GC4 Heuristics GC5 Genetic algorithms (GA) GC6 Agent-based models GC7 Simulation modeling GC8 Uncertainty GC9 Fuzzy sets
Cartography and Visualization (CV) CV1 History and trends CV2 Data considerations CV3 Principles of map design CV4 Graphic representation techniques CV5 Map production CV6 Map use and evaluation	**Geospatial Data (GD)** GD1 Earth geometry GD2 Land partitioning systems GD3 Georeferencing systems GD4 Datums GD5 Map projections GD6 Data quality GD7 Land surveying and GPS GD8 Digitizing GD9 Field data collection GD10 Aerial imaging and photogrammetry

	GD11 Satellite and shipboard remote sensing GD12 Metadata, standards, and infrastructures
Design Aspects (DA) DA1 The scope of GIS&T system design DA2 Project definition DA3 Resource planning DA4 Database design DA5 Analysis design DA6 Application design DA7 System implementation	**GIS&T and Society (GS)** GS1 Legal aspects GS2 Economic aspects GS3 Use of geospatial information in the public sector GS4 Geospatial information as property GS5 Dissemination of geospatial information GS6 Ethical aspects of geospatial information and technology GS7 Critical GIS
Data Modeling (DM) DM1 Basic storage and retrieval structures DM2 Database management systems DM3 Tessellation data models DM4 Vector and object data models DM5 Modeling 3D, temporal, and uncertain phenomena	**Organizational and Institutional Aspects (OI)** OI1 Origins of GIS&T O2 Managing GIS operations and infrastructure OI3 Organizational structures and procedures OI4 GIS&T workforce themes OI5 Institutional and inter-institutional aspects OI6 Coordinating organizations (national and international)

Table 2 *GI S&T BoK 2006 Knowledge Areas and Units*

The main pillar of this WP is to create an active network of GI experts and professionals that contribute to the modernisation of the GI S&T BoK, as well as the definition of a methodology which ensures the GI S&T BoK is constantly in synch with technological advances. Taking into account the results obtained in WP1 and relevant literature (Wilson, 2014) (Baker et al., 2015) (Blaschke and Strobl, 2010), the 10 Knowledge Areas present in the original GI S&T BoK, plus a

newly identified area related to “geoweb”, started a process of the revision of the current GI S&T BoK contents. Through the network of partners’ personal contacts and also through an open invitation[21] for participating in discussion groups and similar relevant fora, the project gathered around 150 experts and contributors to this revision process which are at the moment of writing revising GI S&T BoK contents.

GI-N2K wants to benefit from the experiences gained in designing the original GIS&T BoK, but also wants to align with recent initiatives in the US to update the GI S&T BoK and make it more dynamic and usable. Therefore, cooperation and exchange of knowledge and information with the US colleagues (UCGIS and CARSI[22]) is essential. As a result, these organizations are involved in the project through their participation in the advisory board. In the long term the project envisions an easy way to involve experts participating in different steps of the revision projects, and even after the project’s completion.

In WP3 “The Virtual Lab for the BoK: VirLaBoK”, the GI-N2K project sets out to create a dynamic up-to-date environment for the Body of Knowledge. It should thus be easily updateable, and allow community-based, participatory discussion and evolution of the BoK. Furthermore, the resulting BoK environment should cater to various audiences and communities, and offer them useful tools on top of the BoK.

In the context of the GI-N2K project, it was decided to use the ontology-based participatory BoK platform of our US colleagues (Ahearn et al., 2013). It offers a wiki-based participatory platform, where domain experts can continuously assess, discuss and decide how evolutions in the GI field are

[21] http://www.gi-n2k.eu/gi-n2k-is-looking-for-experts/

[22] The GeoTech Center and the Center for Advanced Research of Spatial Information http://www.carsilab.org

reflected in the BoK, thereby keeping it up to date. The platform is based on an underlying ontology, which essentially stores GI concepts and 5 types of relationships between them: similar, broader, narrower, post-requisite and pre-requisite. As such, the BoK is structured as a semantic graph of concepts, which is stored in a semantic repository as an OWL ontology. This structure is more expressive and flexible compared to the older purely hierarchical structure of the BoK, and the semantic representation allows semantic querying and reasoning. Next to the wiki component, the BoK platform also offers several visualization tools to browse the Body of Knowledge.

The BoK knowledge is made programmatically accessible through web services, which allow for building tools on top of it. The GI-N2K project foresees a curriculum tool and a job profile tool (Hossain et al., 2014). The curriculum tool allows GI educational organizations to create curricula (i.e., consisting of study programs, program tracks, modules, lectures, exercises, etc.), and students, teachers and GI professionals to browse and compare curricula, based on the BoK. The job profile tools allows the GI private and public sector to define, search and browse job profiles, based on the BoK. Both tools are envisioned as state-of-the-art web-based applications, using HTML5 & CSS3 as Web standards, and JavaScript to provide highly dynamic and responsive behavior. Both tools are currently under development.

WP4 consists of testing the GIS&T BoK, its toolsets (VirLabok) and guidelines through real world use cases, with participation of target groups from the private, public and academic sector. These test will be structured as plugfests and take place during workshops and seminars, organized independently or as a part of bigger events.

7.5. Conclusions and further work

The renewed GI S&T BoK will apply an ontological approach and will take the form of a dynamic e-platform (wiki-based format) including tools to use, explore the BoK, to define curricula, training opportunities and courses and to define job profiles.

The new version of the BoK will be grounded in the discussion generated by a worldwide network of experts, and an effective methodology for including GI emerging knowledge areas and concepts into an evolving GI S&T BoK.

The growing importance of the GI sector, together with the development of improved tools on the top of the GI S&T BoK, should foster its use. These include defining vocational and academic curricula, outlining job profiles, etc. as it was foreseen in the GI-N2K work plan. We are nevertheless fully aware that these uses of the GI S&T BoK are only a first step, and other uses may be envisioned for the rapidly evolving GI sector. The GI-N2K consortium is therefore foreseeing to study non-intended uses during their validation and testing activities. We also welcome potential uses and use cases from the external stakeholders, with whom we are happy to cooperate.

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