



Geographic Information – Need to Know (GI-N2K)

Towards a more demand-driven geospatial workforce education/training system

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Executive Summary

Geographic information and services have become part of our daily live. Therefore, it is not surprising that the geospatial industry is rapidly growing and involves high-value, high-tech jobs, innovative services and fast evolving technologies. People working in the geospatial field or people entering the geospatial field need to get pace with these technologies. Handling and using geospatial data and information requires specific skills, and the demand for well-trained geospatial professionals is high. Employers in the geospatial domain often find it difficult to find well-trained and skilled employees, as geospatial workers appear to be inadequately prepared to answer to the challenges and opportunities in the field. In order to set-up a more demand-driven workforce educational program, there needs to be consensus about what geospatial professionals in Europe should know (knowledge requirements) and be able to do (skills requirements).

The GI-N2K (Geographic Information: Need to Know) project, a LLP-Erasmus Network with 31 partners from 25 countries aims to make the geospatial workforce education and training system more demand driven and flexible by developing an agreed ontology for the GIS&T domain. GI-N2K builds upon the existing Geographic Information Science and Technology Body of Knowledge (GIS&T BoK) that was developed by the American University Consortium for Geographic Information Science (UCGIS), published in 2006 by the Association of American Geographers. However, the current GIS&T BoK is out-of-date, too much geography oriented and it does not include a European perspective.

The main objective of GI-N2K is to develop an up-to-date and dynamic GIS&T BoK which is in line with the latest technological developments and takes into account the European dimension. To achieve this objective, five key activities were undertaken: 1) an integrated analysis of the demand and supply of geospatial education and training; 2) a revision of the content of the GIS&T BoK to bring it in line with technological developments and the European context; 3) the development of a European platform and a series of tools (VirLaBoK) to maintain and explore the BoK; 4) the testing and validation of the GIS&T BoK and VirLaBoK through participation of dedicated target groups from the private, public and academic sector; and 5) the promotion and dissemination of the project results.

GI-N2K has performed a series of activities throughout the 36 months of the project which resulted in several tangible outputs and less tangible outcomes.

In order to analyse the (mis-)match between the knowledge and competences that are required by employers and organizations in the field of geospatial information (demand side) and the knowledge and competences that are central in the current offer of GIS&T curricula, programmes and courses in Europe (supply side), two surveys were conducted as part of the WP1 activities of GI-N2K. The surveys revealed that awareness of the GIS&T BoK among the survey respondents is low: 30% for the demand side and less than 50% for the supply side. The comparison of the demand for geospatial competences with the supply of geospatial teaching resulted in the observation of a teaching gap on several topics, e.g. competences regarding mobile mapping. The demand and supply surveys produced about 50 terms of subjects that are missing in the current GIS&T BoK. This provided a good starting point for revising the GIS&T BoK (WP2).

The development of a revision strategy for the GIS&T BoK seemed to be more difficult than originally expected. It had to be decided whether the revision should follow a hierarchical approach or an ontology-based approach. Finally a mixed approach was followed. All the 11 Knowledge Area groups that were set-up to revise the GIS&T BoK followed a hierarchical approach, while some also tested the ontology-based approach. The revision process was carried out by 161 geospatial experts from Europe and other parts of the world and resulted in a revised BoK containing 411 new and revised concepts which were uploaded in the ontology-based VirLaBoK platform.

After investigating existing technical solutions, analysing the user requirements and carrying out some tests, it was decided that the VirLaBoK (WP4) should build further upon existing solutions developed by a consortium of US universities. A European platform was set-up in the cloud, providing an ontology-based visual BoKWIKI that allows exploring and maintaining the BoK. Two web services were setup to expose the content of the BoK. A curricula design tool was developed allowing to design curricula and embed learning paths. The platform and tools were thoroughly tested and the first hands-on exercises allowed consortium partners to get acquainted with them. Real-World use cases (WP4) were defined to support the design of the VirLaBoK but also to validate the developed tools. More than 170 people attended 7 plugfests/workshops in 7 countries to 'play' with the BoK and the tools and to provide feedback.

A key aspect for the GI-N2K project is the extensive partnership covering the whole of Europe, even going beyond that. These partnerships helped realising, but also promoting the GIS&T BoK and the VirLaBoK platform. Towards the project end, there was a shift from revising the GIS&T BoK and developing the VirLaBoK towards exploration, testing & validation, and dissemination & exploitation. Already during the project lifetime the benefits became more visible and tangible for the different target user groups. There is a strong believe among the GI-N2K consortium that a revised GIS&T BoK provided through an innovative ontology-based platform will help in reaching the goals of a more demand driven geospatial workforce and that it also will contribute in finding answers on current societal challenges by helping to realize the goals of different European policies such as the 'Digital Agenda for Europe' and 'Agenda for new skills and jobs'. The interest for the BoK has been clearly demonstrated by Commission services (JRC, DG GROW), but also through different new initiatives (e.g. European projects) and individual actions from project partners.

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1. Project Objectives

Over the last two decades, geographic information and services have become part of our daily lives. Let's alone think about the use of our car navigation systems, or the use of Google Earth to plan our next trip. But also in the private and public sector, geographic information is used intensively. Governmental bodies use geographic information to take sound decisions in urban planning and environmental management. Utility companies manage their underground utility networks with geographic information technologies and exchange that information with other companies that carry out road works.

It is therefore not surprising that the geospatial industry is rapidly growing. It involves high-value, high-tech jobs, innovative services and fast evolving technologies. People working in this geospatial field or people entering this field need to get pace with these technologies. In the European context, the need to prepare Europe's GIS&T workforce competently to answer to the requirements of the European knowledge society is driven by the objectives of several European strategies and policies.

Handling and using geospatial data and information requires specific skills, and the demand for well-trained geospatial professionals is high. Employers in the geospatial domain often find it difficult to find well-trained and skilled employees, as geospatial workers appear to be inadequately prepared to answer to the challenges and opportunities of this field. In order to set-up a more demand-driven workforce educational program, there needs to be consensus about what geospatial professionals in Europe should know (knowledge requirements) and be able to do (skills requirements).

The project GI-N2K (Geographic Information: Need to Know) aims to make the geospatial workforce education and training system more demand driven and flexible by developing an agreed ontology for the GIS&T domain. GI-N2K builds upon the existing Geographic Information Science and Technology Body of Knowledge (GIS&T BoK) that was developed by the American University Consortium for Geographic Information Science (UCGIS), published in 2006 by the Association of American Geographers (AAG).

The main objective of GI-N2K is to develop an up-to-date and dynamic GIS&T BoK which is in line with the latest technological developments and takes into account the European dimension. To achieve this objective, the following activities are undertaken:

- ✓ Analysis of the current situation with focus on the demand of private and public sector as compared to the existing academic and vocational training offer;
- ✓ Revision of the content of the GIS&T BoK to bring it in line with technological developments, emerging new knowledge areas and the European context;
- ✓ Development of tools and guidelines that allow managing and using the GIS&T BoK for defining vocational and academic curricula, job profiles, etc.
- ✓ Testing of the GIS&T BoK, its toolsets and guidelines through participation of dedicated target groups from the private, public and academic sector;
- ✓ Promoting and disseminating the use of the GIS&T BoK, tools and guidelines.

The target groups are mainly the providers of higher education and vocational training in the domain of GIS&T, the geospatial recruitment sector (companies, governmental organizations, research institutions, etc.), geospatial professionals, and students studying, or with an interest in GIS&T. While the first two target groups are represented in the project consortium, the two other groups are only reached indirectly through the project activities.

The benefits of the project are mainly related to the two main outputs, i.e. the revised version of the GIS&T BoK and the VirLaBoK, the tools used to maintain and explore the GIS&T BoK. The GIS&T BoK and the VirLaBoK will both be made available to the geospatial community.

The systematic use of both outputs will impact and even change the behaviour of the different target groups.

A revised and collaboratively designed BoK offers all providers of GIS&T education and training a complete, agreed and understandable overview of the knowledge areas that are relevant in GIS&T education and can be used for the design and implementation of education and training programs in the GIS&T domain. A specific tool to define curricula based on the GIS&T BoK will enable and stimulate the use of the BoK by academic institutions, but also by providers of vocational training offers, including private companies.

Employers in the domain of GIS&T can use the BoK in several ways: to prepare job profiles, to analyse the available skills and knowledge in their organization, and to define learning paths for their staff. While the BoK itself provides an overview of all relevant knowledge areas, the VirLaBok is composed of several tools that enable and stimulate the use of the BoK for different needs and objectives. The VirLaBok can always be extended, with new tools and applications to further stimulate the use of the BoK.

Both students and practitioners with an interest in GIS&T can make use of the BoK and the VirLaBok tools in several ways as well. For example, they can use the BoK to evaluate their own knowledge and skills and identify the knowledge areas and units they need to improve. The VirLaBok allows them to define a learning path to acquire the necessary skills. On the other hand, students and practitioners can use the BoK to compare and evaluate the content of different education and training programs.

From a broader perspective, it is believed that a dynamic GIS&T BoK will improve the readiness of the geospatial workforce that will be better prepared to help answering the societal challenges of these times by using geospatial technology in the most optimal way.

2. Project Approach

The GI-N2K project aimed to reach its objectives and implement its core activities by using different methodologies. Indeed, the different nature of the four major implementation Work Packages required a differentiated approach: the integrated analysis on demand and supply, the revision of the GIS&T BoK, the development of the VirLaBoK platform and tools, and the testing and validations are all activities serving the same objectives of GI-N2K but using a different method.

WP1 – Integrated Analysis of Demand and Supply – This study is mainly based on two extensive surveys and a series of in-depth interviews for capturing qualitative information on the demand and supply of geospatial education and training.

WP2 – The revision of the GIS&T – The revision process required a highly collaborative approach making use of a WIKI type of platform (VirLaBoK) to allow interaction between the experts that propose changes to the GIS&T BoK and many, often informal, meetings using online tools such as skype, LYNC or GoTo meeting.

WP3 – Development of the VirLaBoK – Is based on a service-based architecture, using semantic web technology and AGILE development methods. Besides the input from WP1 it used surveys to collect information on requirements.

WP4 – Testing and validating of the GIS&T BoK and VirLaBoK platform – These activities are highly interactive, following a sandbox approach in which users can ‘play’ around to better understand, appreciate and evaluate the content and the tools.

It must be noticed that the different activities and methods complement each other, but also that the thread throughout the different methods is the collaborative effort between the different partners of the consortium, an extensive network of more than 150 individual geospatial experts from all over the world, and with other partnerships (associations, private companies, UCGIS ...). The main advantage of the approach is that they allow flexibility, they can easily be extended and repeated, and they allow a quick and fair evaluation of the outcomes.

In addition to the four implementation WPs, also dissemination and exploitation are deemed to play a crucial role in the project. The general objective of the awareness & dissemination, and exploitation & sustainability activities of the GI-N2K project is to promote and ensure the use of the project outcomes by its target groups, both during the project and after its conclusion, i.e. the results of the study (WP1), the revised GIS&T BoK (WP2) and the VirLaBoK (WP3).

Key principle of the dissemination strategy is to make all data and results of GI-N2K as much as possible publicly available and accessible. However, controlled access is necessary, so interested parties must contact GI-N2K to participate and contribute¹. The exploitation and sustainability strategy on the other hand is based on five key principles: 1) a strong stakeholder involvement; 2) the effective testing of the ideas, methods and tools; 3) a customized exploitation reflecting the interests of different target groups; 4) taking advantage of the composition of the consortium and 5) international cooperation to find synergies and common approaches.

¹¹ Exploring the BoK does not require any access mechanism, but is deemed not meant for the broad public, but still rather for the geospatial expert community.

3. Project Outcomes & Results

There are many outputs and outcomes of the GI-N2K project after it ran for 36 months, including the fact that the consortium partners worked together intensively. But in this report we will focus on the four major activities that resulted in several key documents and operational components. These four activities are: the analysis of demand for and supply of geospatial education and training; the development of a strategy for the revision of the BoK, the development of the VirLaBoK platform and tools for exploring and maintaining the GIS&T BoK, and the results of the testing and validation of the BoK and VirLaBoK. Even though the project finished formally at the end of September 2016, the GI-N2K network continues to exist and follow-up activities are already ongoing at the time of writing of this report (December 2016). GI-N2K has clearly generated results and outcomes on which to build further.

Results of the study on demand and supply

One of the objectives of the GI-N2K project was to better understand the demand for and the supply of geospatial education and training in Europe. In order to analyse the (mis-)match between the knowledge and competences that are required by employers and organizations in the field of geospatial information (demand side) and the knowledge and competences that are central in the current offer of GIS&T curricula, programmes and courses in Europe (supply side), two surveys were conducted as part of the WP1 activities of GI-N2K: a survey on the demand for and one on the supply of geospatial education and training. In both surveys the original Geographic Information Science & Technology BoK (Body of Knowledge) developed by the American University Consortium for Geographic Information Science (UCGIS), was used as a starting point for designing the survey.

The main objective of the GI-N2K demand survey was to assess the relevance of individual Knowledge Areas and Units of the existing GIS&T BoK and to identify additional and potentially new areas that should be included in the GIS&T BoK. In total, 435 surveys were fully completed by professionals actively working in the GIS&T domain in Europe. Answers were collected from professionals working in the public (39%), private (35%), academic (23%) and not-for-profit sector (3%). The main objective of the GI-N2K supply survey was to describe and analyse the current supply of GIS&T education and training in Europe in terms of course size, level and content, and to collect information on the awareness and use of the GIS&T BoK. The supply survey was successfully completed by 234 organizations involved in GIS&T teaching and training in Europe. 570 courses on GIS&T in Europe were identified, of which 427 are currently on offer, and 143 are intended to be offered in the near future.

The three main sectors – public administration, private organisations and academia – evaluated the BoK Knowledge Areas congruently. However, the GIS&T community evaluated the relevance of the current GIS&T BoK Knowledge Areas in their professional work differently. ‘Geospatial data’ and ‘Cartography and Visualization’ were considered as the most relevant BoK Knowledge Areas, whereas advanced ‘Geo-computation’ received the lowest rating. The gap analysis revealed several topics that are not fully covered in the current GIS&T BoK, including programming, Web GIS, Spatial Data Infrastructures, data acquisition and other ‘hot’ topics such as big data and augmented reality.

Most of the identified courses have a study load between 0 and 11 ECTS (European Credit Transfer System), and are given on the levels 5_6 and 7 of European Qualification Framework (EQF). The current GIS&T Knowledge Areas ‘Analytical Methods’, ‘Geospatial Data’ and ‘Cartography and Visualization’ were most often indicated as the subject of the existing courses. The most favoured subjects of the planned courses were ‘Data Modelling’, ‘Geospatial Data’ and ‘Analytical Methods’. Web services, data acquisition technologies, point cloud analysis, programming in Python, UML, XML, Qualitative GIS, and Open source

In order to mobilize as many experts as possible, a call for experts was launched in July 2015 to extend the existing network of geospatial experts of the GI-N2K consortium. Experts from Europe and other countries in the world joined the network (e.g. India, South-Africa, USA, Canada, Australia, Middle-East). A core group was formed of 108 experts working intensively on the revisions, supported by another 53 people (that provided rather input/comments on the proposals). More people from the consortium partners helped in the process in the background.



Figure 2: Consortium partners contribute to the revision of the BoK Knowledge Areas during the Lisbon workshop (March 2015)

Between September 2015 and May 2016, the network of 161 experts worked on the revision of the BoK. They started the work in 11 working groups, according to the 11 Knowledge Areas. When discussing the final structure of the Knowledge Areas it was decided to integrate the concepts of Knowledge Area “Data Manipulation” into two other Knowledge Areas “Geospatial Data” and “Analytical Methods”. Furthermore, the Knowledge Areas “GI and Society” and “Organizational and Institutional Aspects” were kept as separate Knowledge Areas but joined forced and worked in practice together as one working group (with the same group of 15 experts).

Geospatial Data	Analytical Methods
Cartography and Visualization	Geocomputation
Organizational and Institutional Aspects	Web-based GI
Data Modeling, Storage and Exploitation	Conceptual Foundations
GI and Society	Design and Setup of Geographic Information Systems

The working groups defined for their Knowledge Area a total of 63 sub-concepts which were further sub-divided in 301 other concepts. For some Knowledge Areas more levels were added below that 3th level, detailing concepts up-to 5 levels with an additional 29 concepts defined. For example, the concept of ‘geospatial data’ contains 5 sub-concepts including ‘data quality, metadata and data infrastructures’ of which the sub-concept ‘data quality’ was further sub-divided in 6 other concepts including the concept ‘uncertainty’ which in turn consists of 6 other sub-concepts. Finally 81 more concepts were kept but relationships that existed in the former version of the BoK were ‘cut’, or defined as new concept, but ‘isolated’ from other concepts. So the new version of the BoK has 411 concepts defined. The groups worked also on the relationships between concepts (besides super- and sub-concepts, pre- and post-requisite and similarity), and on the description of the concepts, as well as the related learning objectives. At the time the new version of the BoK became ‘frozen’ (May 2016), this work was not yet entirely finished. The objective is that the work will be continued in a ‘permanent’ way, i.e. that in the context of other projects, or specific activities at different universities, the BoK will continuously evolve.

In one Knowledge Area, i.e. “Design and Setup of Geographical Information Systems”, efforts were made to rely on another existing BoK, i.e. the “European Foundational ICT Body of Knowledge”, in view to be in line with work done in the ICT community.

The VirLaBoK: an ontology-based visual WIKI

The work on the VirLaBoK started with an analysis of existing technical solutions and of the user requirements which resulted in a document “VirLaBoK – User Requirements and Architecture”. After a detailed screening and the extensive testing of these existing solutions, it was decided to build the VirLaBoK further on an existing solution from a university consortium in the US, i.e. the City University of New York (CUNY) and the San Diego State University which created a small company, BigKnowledge, to exploit and further develop their technical solutions. It was deemed more logic and more feasible to re-use existing components than to start from scratch. Making a final technical choice was not an easy task and took much longer than expected. In the beginning it was not clear whether the existing US solution could be used at all. It required extensive testing against the GI-N2K requirements and specifications, in several iterations. During the set-up of the VirLaBoK platform, several improvements were made to match the platform and tools better with the described functional and non-functional requirements.

The BoKWiki which resulted from this preparatory work is a web-based tool to organise the collaboration between experts to discuss and agree upon new concepts in the GI S&T field (theory, method, technology ...), or to revise existing concepts. The BoKWiki can also be used to explore the content of the BoK, e.g. to define job profiles, by browsing the different concepts and their relationships, or by searching for a particular concept. The BoKWiki can be used in text or graphical mode (see figure 3).

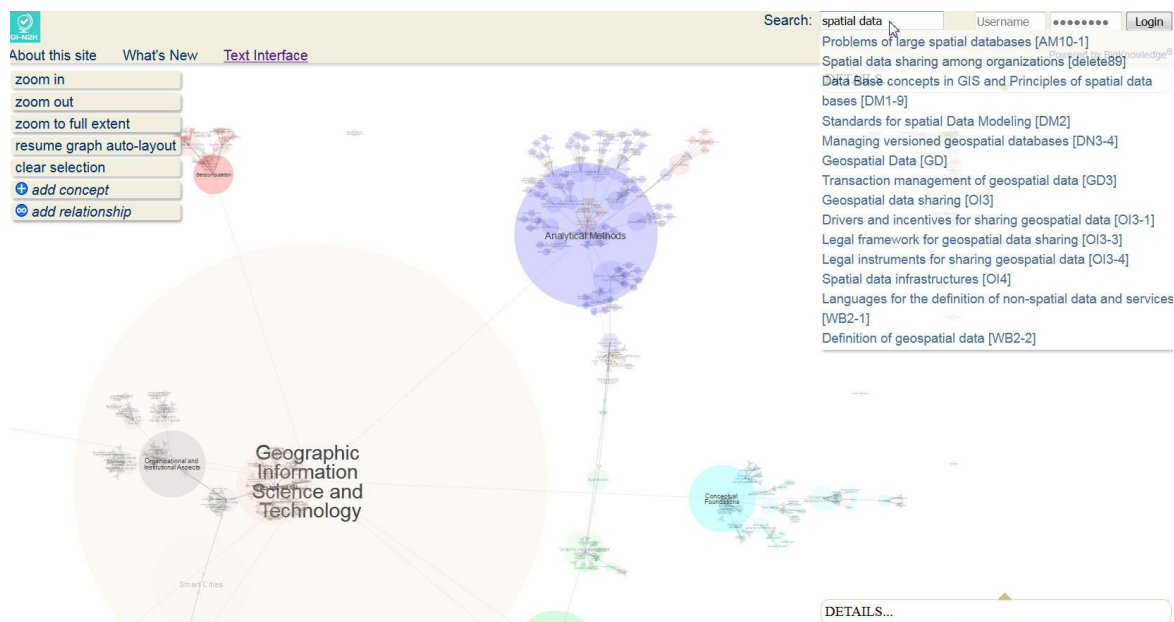


Figure 3: Screenshot of the ontology-based visual BoKWiki of the VirLaBoK

The architecture consists of a data repository that holds the BoK and a visual BoKWiki to allow interactive cooperation among the geospatial experts. The repository contains all the (revised) topics, units and Knowledge Areas from the ‘old’ BoK, stored as concepts, as well as newly defined concepts (at the time of reporting 411 concepts in total). Also the relationship between them is defined and stored: ‘super-concept’, ‘sub-concept’, ‘similar’, ‘post-requisite’ and ‘pre-requisite’ are the type of relationships that can be defined. The graphical user interface allows exploring the BoK in text as well as in visual mode. Users can obtain a username and password if they want to contribute in the revision process. They can be ‘regular’ users that are allowed to propose new concepts or propose to revise existing concepts, or even propose to ‘delete’ concepts that became obsolete. The role of ‘editor’ is reserved for Knowledge Area leaders and co-leaders and they together accept (or not) these proposals.

In the Lisbon workshop in March 2015 the VirLaBoK platform was successfully used in a training session. However, this session also revealed that further improvements to the tools should be made to allow using them in an operational setting, e.g. to revise the BoK. Therefore it was decided not to use the platform for the revision process, but to use a 'simplified' WIKI instead. At the end of the revision process, the resulting revised BoK was imported in the VirLaBoK for further testing and use (plugfests). Some Knowledge Area groups also used both the simplified WIKI and the VirLaBoK to further test the latter and to provide input that allowed improving the platform and tools. At the end of April 2016, the BoKWiki was stable and ready to be used in the plugfests / workshops. The BoKWiki platform can be reached at: <http://gin2k.bigknowledge.net/bokwiki/bokwiki.html>

On top of the BoK repository, two web services were developed to expose the content of the BoK for developers of the VirLaBoK tools. A Curriculum design tool was developed to support the design of academic and non-academic curricula and to integrate learning paths (pre-requisites and post-requisite conditions) into the curricula. New curricula can be defined, existing ones modified or printed. It is also possible to compare two curricula. The system allows the user to manage their own curricula, but the community can also see and re-use all the curricula already defined. Curricula can have up-to 4 levels: programmes, modules, courses and lectures or practical works (see figure 4). While defining a curriculum, concepts from the BoK can be 'borrowed' to populate the curriculum with the learning objectives, the description of the concepts, reference materials, etc. For modules and courses the number of ECTS (European Credit Transfer and Accumulation System) can be defined, while at the level of lectures and practical works the EQF (European Qualifications Framework) level can be defined as well.

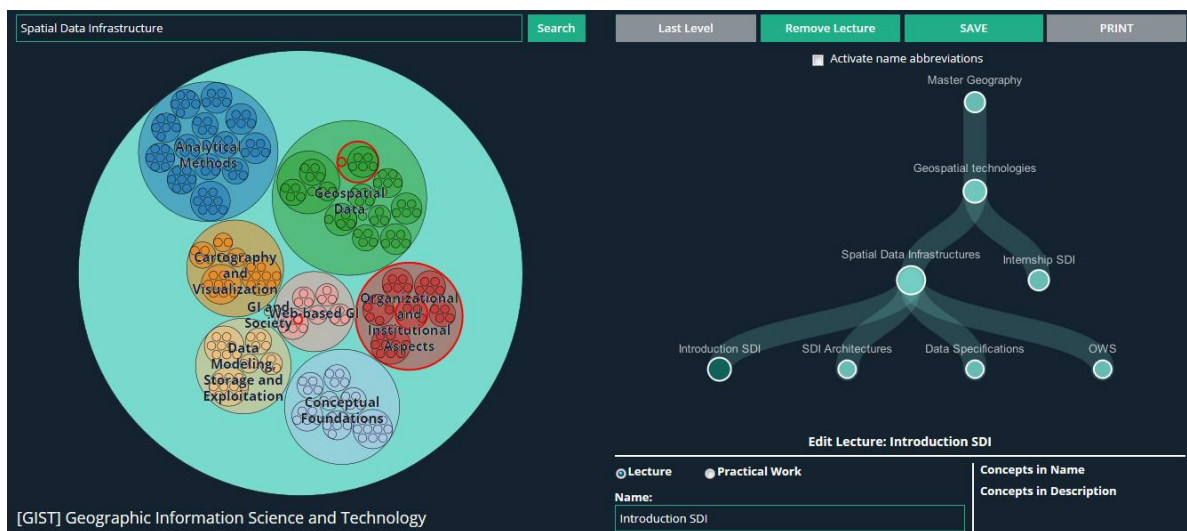


Figure 4: Screenshot of the Curricula Design Tool of the VirLaBoK

Testing and validating during plugfests

Between 23 May and 9 September 2016, GI-N2K organised 7 workshops in 7 different cities (Girona, Debrecen, Salerno, Helsinki, Salzburg, Sofia and Leuven) to discuss the approach and results of the GI-N2K project and to organise hands-on sessions to test the BoK and its tools based on 'real-world' use cases. In total more than 170 people participated from academic, private and public sector. The feedback collected during the workshops was used to resolve remaining bugs and to describe potential improvements and functionalities when the tools will be further developed in the future.



Figure 5: Participants working on the hands-on exercises during the GI-N2K workshop in Sofia, 1 September 2016

Dissemination and exploitation

Throughout the project, three factsheets and five newsletters were published (see <http://www.gi-n2k.eu/publications/>). Many partners presented the GI-N2K project and the first results by means of papers and presentations at conferences or during national events. The discussion on the exploitation of the project results and the sustainability in the long term started early and resulted in a series of concrete measures. Questions that were raised are: *“Who will become the owner of the revision process after the life-time of the project?”*, *“Who will become the hosting and supporting organisation for the VirLaBoK?”*, *“How will the VirLaBoK platform and tools be maintained?”*, *“What with licensing and IPR?”*.

The exploitation and sustainability strategy is based on five key principles: 1) a strong stakeholder involvement; 2) the effective testing of the ideas, methods and tools; 3) a customized exploitation reflecting the interests of different target groups; 4) taking advantage of the composition of the consortium and 5) international cooperation to find synergies and common approaches. Based on those five principles it was decided to make the BoK and VirLaBoK publicly available, although controlled (a request for becoming member of the community is possible by contacting Danny Vandebroucke via e-mail – danny.vandebroucke@kuleuven.be). The platform and tools will remain operational over a long period and the necessary IPR arrangements have been initiated with the US colleagues from UCGIS and BigKnowledge. Moreover, GI-N2K will make available the web services to the broader geospatial community to make the development of additional tools possible. The maintenance process will be continued by different initiatives whether these are new (European) projects – Erasmus+ and other – or at the faculty level.

4. Partnerships

GI-N2K is following a collaborative approach. It is conceived as a network (of networks) spanning the whole of Europe (and beyond). Working with such a broad network is interesting and certainly pays off, but is challenging at the same time. It creates benefits for all involved.

Covering Europe and linking to the rest of the world

GI-N2K has 31 partners from 25 European countries: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, Greece, Hungary, Ireland, Italy, Lithuania, Macedonia, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia Spain, Sweden and UK. Moreover, in practice many more countries are covered thanks to the involvement of the different networks (associations) participating in GI-N2K: e.g. AGILE has members in Norway, Israel, and even India; AGISEE has members in Croatia, Serbia and other Balkan countries. Also GISIG has an extensive network, mainly in the environmental community. In addition, many of the associated members are associations in the geospatial field and cover usually the whole of Europe: OGC is a key standardisation body which works globally; EuroGeographics and EuroSDR have National Mapping Agencies and Universities as members covering geographic Europe; EUROGI reaches the private companies and user communities, etc. But GI-N2K even goes one step further: it connects to what happens in the rest of the world. GI-N2K is not only working with partners in the US, but involves also individual geospatial experts from other places in the world (e.g. India, Middle-East, Canada, Australia, South-Africa ...) to help revising the BoK. Also the UN-GGIM initiative has shown interest (<http://ggim.un.org/>) during a session of their academic network in Addis Ababa (April 2016).

The need for European cooperation comes from the nature and methodology of the Body of Knowledge itself which is a commonly agreed ontology for the geospatial domain. In order to reach consensus it is necessary to set up the network in a dynamic way, i.e. it is open for new members whether these are individuals that want to contribute to the development and the revision of the BoK, or organisations that want to use and promote it. This intensive European cooperation adds value that goes beyond the single organisations participating in the network. This can be illustrated by the recruitment needs of one of the associated partners of this project, Shell, who develops activities all over Europe (and beyond) and therefore seeks geospatial professionals that can be recruited in one country and employed in the same or in other countries. This means that the professional needs to be adequately prepared to be possibly employed across country borders, which is one of the fundamental principles of the European Union. A commonly agreed BoK provides a sound basis to do so. At the end, also the end-users will be people and organisations from all over Europe. For the academic sector, the use of a common BoK and VirLaBoK platform will improve cooperation between universities, and will stimulate the mobility of students.

Experiences of working together: challenging but enriching

The cooperation with so many organisations, from so many countries is creating some challenges, but it is enriching at the same time. Not only, consists the network of 31 partners, but many people from those organisations are involved. Throughout the project, 120 people from the consortium members contributed in one or another way to the activities of the project. Together with the additional geospatial experts from outside the consortium and people from associated partners, more than 220 people were active in the GI-N2K project. This 'army' of contributors is in reality an amalgam of people with different backgrounds, different expertise, different interests and different roles in the GI-N2K network. Some of them are mainly interested in the GIS&T BoK itself. They want a high quality and dynamically

revised BoK, and they want to use that BoK. Other contributors are willing to develop advanced tools making use of new technologies. Others are 'only' interested in the usability and usefulness of the BoK and VirLaBoK for their daily work: they are end-users. Finally also administrative staff made the GI-N2K project working, while many people from the associated partners and the advisory board were 'promoters' of the GI-N2K results. Matching and streamlining these interests and expectations is not easy. It is a challenge on its own. Fortunately GI-N2K defined many different activities that met these different interests. Furthermore, not all the people and not all the organisations worked at the same pace and intensity: e.g. their role and thus their available resources were very different. People outside the consortium were doing this by definition on a voluntary basis.

The extent of the consortium and the variability of its contributors required another way of working, including a decentralised steering. Work Packages were led by different partners in a relatively autonomous way. Work Package leaders and co-leaders supported each other, while the project coordinator was mainly facilitating their cooperation. There were multiple lines of collaboration and communication which required trust, but also left room for own dynamics and different ways of working. Another 'lesson learned' is that the work with other experts (from outside the consortium) required a high degree of flexibility. Not all of them could or wanted to work according to strict (and heavy) procedures, but were nevertheless willing to contribute in their own way.

Working with associated and other partners: what can they expect?

The cooperation with the members of the Advisory Board, the associated members and the extension of the network with new associated members was not the central focus during the first half of the project. During the first 18 months, the focus was on having the consortium up and running and to prepare the ground for the second phase of the project: the strategy for the revision of the GIS&T BoK required many and intensive discussions, the development of the VirLaBoK platform and the first tools brought up several scenarios to be chosen from, and required extensive testing. During the second half of the project the external partners played a more prominent role. Many people from other universities, private companies, other associations were involved in the 7 plugfests (more than 120 people participating were external people and people from partners not actively involved in the project), others requested access to the tools. Structured discussions took place with European and global associations such as EuroGeographic, OGC, EuroSDR, ICA, UN-GGIM and others to use the BoK and VirLaBoK and to contribute in the future, after the project ended. Also representatives from the academic world including Singapore, China, Australia, Canada, USA, South Africa ... showed interest and want to re-use the results of GI-N2K. The partners in the US are very happy with the GI-N2K project and refer to it in their conferences and other activities as a good way to cooperate. They see it as an interesting experiment and the fact that Europe and the US are working together, use a common methodology and similar technical environments allows finding synergies. For example, GI-N2K and UCGIS will work towards a common network of experts that can serve the European as well as the US needs. They get feedback from the European experience and have the opportunity to improve their own solutions.

5. Plans for the Future

During the project lifetime succeeded to finalize the study, to go through a full revision cycle and add content, and to set-up a European platform with a rich CDTool for designing curricula and embedding learning paths. However, the BoK needs continuous updating, while the platform and tools should be promoted for broader use. GI-N2K took the necessary steps at the end of the project to guarantee this.

Revision of the GIS&T BoK: continuous update is required

The revision of the BoK took place in two cycles: first the structure and concepts were defined for all the Knowledge Areas and in a second phase content was added (descriptions, relationships between concepts, learning objectives, reference materials ...). Even though there is a lot more content available, more can and should be done. The GI-N2K network decided to do so through several mechanisms. First, it was agreed upon that during the next AGILE Conference (Wageningen, May 2017) a workshop would be organised to re-visit the BoK as it stands now and to work out a plan for further improvements and maintenance. This workshop would target the KA-leaders and co-leaders and most active contributors. Second, several members engaged themselves to further enhance the content in the context of their day-to-day activities as faculty members (using the BoK and adding/modifying). Third, consortium members and other interested parties are looking into new projects through which content could be further improved. Several projects were already identified in the course of 2016. For example, in the Erasmus+ BESTSDI project, the area of Spatial Data Infrastructures will be revised and completed. Finally, key for a successful maintenance of the BoK will be the extension and animation of the network of experts. AGILE will take a leading role, but will work together with EuroSDR to facilitate this. EuroSDR is an association in which not only universities are active, but also mapping agencies (which provides access to even more experts).

Exploiting the VirLaBoK environment and tools

At the end of the project, a stable version of the platform, services and tools was ready. It was thoroughly tested during the seven plugfests / workshops and some improvements were made. At the time of reporting discussions were ongoing to migrate the tools and the repository of curricula to a platform that will be maintained over a longer period of time. Several options for hosting the tools remain open: 1) KU Leuven (the university is quite big and could sustain the hosting over long period of time); 2) GISIG which has already a collaborative e-learning platform up and running and 3) EuroSDR as part of their EduServ services. The different organisations and the partners currently hosting the tools (UJI and UniBW) will jointly decide on this in Spring 2017. Regarding the BoKWiki it was decided that the platform remains in the cloud and KU Leuven will pay an annual fee for keeping it up and running. Also the web services remain available.

In addition to guaranteeing the hosting of the platform, services and tools, their use will be further promoted. Again, several ways are followed to promote the use / re-use of the platform and tools. First, several academic and other members of GI-N2K will use the platform and tools in their daily work, e.g. by documenting existing curricula in the curricula repository. Some partners will present the results even to their university board (e.g. Wageningen). Second, partners will promote the use of the platform and the tools in the context of other projects. Third, AGILE and other associations will promote the use of the platform and tools among their members. KU Leuven will manage the requests from universities and companies (already 15 requests were received by the end of 2016). Finally, KU Leuven will take the initiative, together with some of the partners to organise regular webinars to demonstrate the platform and tools.

Further disseminating and exploiting the BoK and VirLaBoK

Dissemination did not stop at the end of the project, but continues. Moreover, the real exploitation is even intensifying after the end of the project. Besides the already mentioned maintenance of the BoK and the promotion of the exploitation of the BoK and VirLaBoK, several specific initiatives are on their way at the time of writing this final report. First, GI-N2K continues the work it started during the project with European Commission services that showed their interest in using the BoK and/or VirLaBoK. EC JRC is using the BoK in the context of the ELISE action as part of the ISA² programme for defining a vocabulary of INSPIRE implementation and usage tasks. EC DG GROW is interested in the results of GI-N2K to help them defining a curriculum to support the uptake of Copernicus data and services. Second, new consortia are being formed to prepare one or more new project proposals under Erasmus+, H2020 or other programmes. As it stands at the time of reporting, a first project would focus on the further development of an ontology for the geospatial field with special attention for multi-lingual aspects. Also the link to other existing Bodies of Knowledge is of high interest. A second project proposal will probably focus more on the further development of tools and the application of new technologies for doing so making use of the GI-N2K web services.

6. Contribution to EU policies

The GI-N2K project addresses many of the objectives and challenges put forward by EU legislation and policies. These include two main categories. First, GI-N2K is directly related to the aims and priorities of the EC policies to support the development of higher education policies in EU. Second, through its focus on digital geo-ICT skills, the work and outcomes of GI-N2K are of great relevance to all policies for which geospatial technology is important.

The Modernisation Agenda for higher education fixes five key priorities for higher education in the EU (COM/2011/0567): increasing the number of higher education graduates; improving the quality and relevance of teaching and learning; promoting mobility of students and staff and cross-border cooperation; strengthening the "knowledge triangle", linking education, research, and innovation; and creating effective governance and funding mechanisms for higher education. It can be noticed that GI-N2K mainly focuses on improving the quality and relevance of teaching and learning and on promoting the mobility of students and staff and on cross-border cooperation.

GI-N2K aims to contribute to improving the quality and relevance of teaching and learning by making the EU geospatial education and training system more demand-driven and preparing Europe's GI&T workforce more competent to answer the requirements of the rapidly evolving European knowledge society. The GIS&T BoK can be considered as a reference framework on knowledge and skills in the GIS&T domain, ensuring that all involved parties speak the same language when dealing with education and training in GIS&T.

Moreover, the GIS&T BoK that is developed through the GI-N2K project also contributes to the promotion of the mobility of students and staff, and stimulates cross-border cooperation. Standardization of the descriptions of study programmes is one of the mechanisms that would contribute to increased mobility of students and staff and enhanced cooperation between institutions in different countries. The GIS&T Body of Knowledge that is developed by GI-N2K can be used as a common language for describing the content of programs and courses in the domain of GIS&T. Such a common language will help students in comparing and evaluating the content of education and training programs in different countries and designing their educational pathway across different education institutions. It must be noticed that the objectives of one of the Erasmus+ projects, BESTSDI, is focussing on the definition of a common core curriculum on Spatial Data Infrastructures for all the Western Balkan countries and the design of particular curricula on top of that by making use of the GI-N2K BoK and its platform and tools.

GI-N2K is also strongly related to several of the targets and Flagship Initiatives as put forward in the EUROPE 2020 strategy for smart, sustainable and inclusive growth. The 'Agenda for new skills and jobs' is about ensuring that the competences required to engage in further learning and the labour market are acquired and recognised. The 'Digital Agenda for Europe' is about promoting digital literacy, skills and inclusion and increasing education and training in digital skills for the workforce. And also the 'Digital Single Market Strategy for Europe' one of the ten priorities from the new European Commission underlines the need to address digital skills and expertise as a key component of future initiatives on skills and training. The updated BoK has now embedded many of the new technologies which are driving those developments: e.g. augmented reality, sensor web, web GIS, UAV's, etc.

Of particular relevance to the GI-N2K project is the European INSPIRE Directive, establishing an infrastructure for spatial information in Europe, as the implementation of this Directive requires specific skills and knowledge in the GIS&T domain. This is also valid for the more thematic oriented Directives, e.g. the Water Framework Directive, in which geospatial data and technologies play a prominent role. The fact that EC JRC is using the BoK to design a vocabulary of INSPIRE implementation and usage tasks is a direct indication of its relevance for this particular Framework Directive.