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Advancing Open 3D Modelling Standards in National Spatial Information Policy

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Individuals and organisations around the world - facing extraordinary challenges and new opportunities - are together engaged in numerous projects, involving natural and built environments. Spatial information policy is at the heart of these projects. The information technologies available enable individuals to observe, measure, describe, map and portray these environments with increasing ease, flexibility and precision. In our time, individuals create digital geographic objects that reflect the ones of the real world, so that we can better understand it, sharing our understandings and managing our diverse activities.

National Spatial Data Infrastructures (NSDIs) provide public information about survey points, elevation, roads, political boundaries and water bodies. Basic aerial images are widely useful, as are data about land use and land cover. The purpose of this paper is to help policy makers understand the role of policy in advancing standards that support the goals of INSPIRE, the overarching European SDI effort, and SDIs in general.

To illustrate the role of policy in SDI formation, the National Spatial Data Infrastructure (NSDI) executive committee in the Netherlands called Geonovum, will be examined. It has been working on behalf of the Dutch Kadaster, the Netherlands Geodetic Commission and the Dutch Ministry of Infrastructure and Environment towards the establishment of a national 3D standard that aligns both the existing national 2D standards and the International OGC standard for 3D geo-information, CityGML (OGC, 2012). The Netherlands' CityGML-based national 3D standard is an important step towards the inclusion of comprehensive 3D information about the built and natural environment within the Dutch SDI.

Keywords

Geonovum, 3D, CityGML, OGC, urban modelling

> "Geonovum and partners have made 3D information a key part of the Dutch National Spatial Data Infrastructure."

1. Introduction

The European Commission (EC) has extensively promoted the reuse of public sector information, with basic geospatial data being of a particular focus. The European Commission's INSPIRE Directive, established in 2007, is a policy infrastructure for sharing geospatial information in Europe to support Community policies and activities that have an impact on the environment (EC, 2007). Although environment is the focus, the information gathered, maintained and shared will also bring benefits to many non-environmental activities.

Economic growth is a key driver for NSDI development. In December 2011, in its most recent call for freely available public sector data, the EC announced an 'Open Data Strategy for Europe' (European Commission, 2011), which is expected to deliver a €40 billion boost to the EU's economy each year. "Europe's public administrations are sitting on a goldmine of unrealised economic potential: the large volumes of information collected by numerous public authorities and services" (EC, 2011). A significant percentage of this information is geospatial, referring to or deriving from location data about people, places and things.

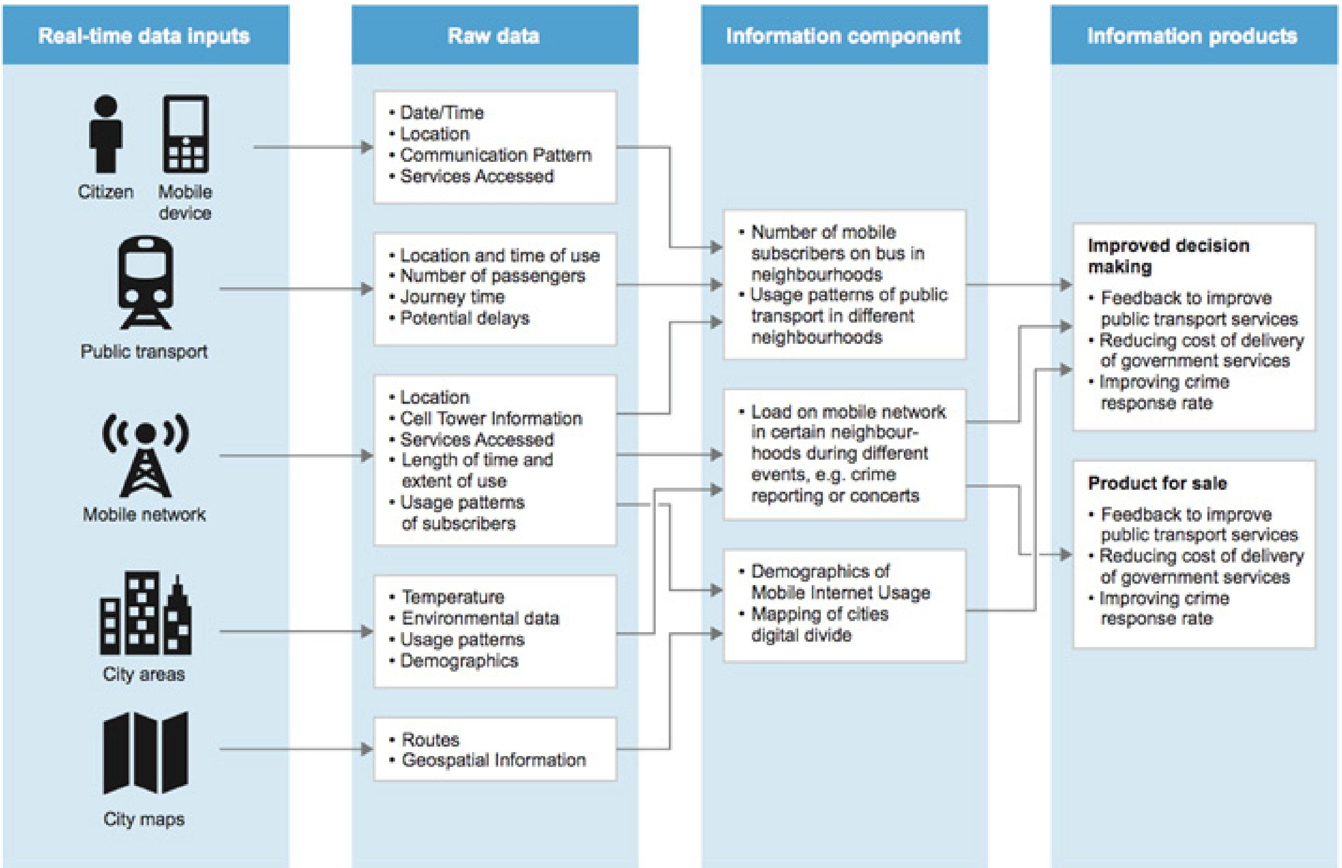


Figure 1: A spatial data value chain - "Information Marketplaces - The New Economics of Cities, (Accenture, 2011).

Open data depends on open standards for ICT interfaces and encodings. Referring to the Open Data Strategy, Neelie Kroes, Vice President European Commission responsible for the Digital Agenda, explained that "In all sectors, standards and standardisation drive competitiveness, promote innovation, and benefit consumers through competition … in the ICT sector, having the right standard-setting procedures and interoperability rules creates the level playing field needed for all parts of the machine to fit together: devices, applications, data repositories, services and networks" (Kroes, 2011).

Standard ICT interfaces and encodings for geospatial data and geospatial information systems should address a wide range of requirements. These requirements tend to be complex compared to those of most other kind of information and information systems. The complexity derives from the diversity of geodesy systems (measurement of the Earth and Earth coordinate systems), 2D vector geographic information systems, 2D raster-based geographic information systems, 3D representations of natural and built objects, Earth imaging systems, navigation systems, mapping systems and systems for naming and describing geospatial features and phenomena.

In 1994, members of the international community of geospatial technology providers and users came together in the Open Geospatial Consortium (OGC) to develop the special interfaces, encodings and best practices (OGC, 2011); this technology sector requires realising the vision described above by Neelie Kroes, as it applies to all geospatial data.

The OGC has developed relationships with a wide variety of other standards development organisations (SDOs) and industry associations (OGC, 2011) to maximize the possibility organisations with different standards to actually "work together". Such relationships are critical as 'geospatial' is a crosscutting issue that is relevant but not central to the agendas of other standards efforts. Most other ICT standards organisations must - at some point - take decisions about how to encode geospatial information and how to enable client-server communication related to geoprocessing requests and responses. These organisations discover 1) that this is seldom simple (Reed, 2004) and 2) that arbitrary decisions inevitably introduce non-interoperability problems for developers and users. Thus, the OGC's policy of active collaboration with other SDOs is critical for the free flow of geospatial data and geospatial processing instructions within the global information system.

In the modern and highly connected world, all countries need to rely on many of the same open standards if they are to take full advantage of the global information infrastructure and the global economy supported by this infrastructure. For this reason, INSPIRE and other SDI programmes in Europe depend on OGC standards, many of which in turn rely on or accommodate standards from ISO/TC 211 Geographic Information/Geomatics and other standards organisations.

The purpose of this paper is to help policy makers understand the role of policy in advancing standards that support the goals of INSPIRE or SDIs in general. Therefore, this paper presents a case study. Geonovum, the National Spatial Data Infrastructure (NSDI) executive committee in the Netherlands is being examined and the way it has been working on behalf of the Dutch Kadaster, the Netherlands Geodetic Commission and the Dutch Ministry of Infrastructure and Environment in order to establish a national 3D standard that aligns to both the existing national 2D standards and the OGC standard for 3D geo-information, CityGML (OGC, 2012). This national 3D standard is an important step towards the inclusion of comprehensive 3D information about the built and natural environment within the Dutch SDI.

One of the reasons why this particular case study is useful is the fact that it portrays a highly evolved model of NSDI building that adds to lessons learned in earlier NSDI efforts in the Netherlands and elsewhere. Much can be learned from Geonovum's approach in using policy and other measures to accelerate the implementation and uptake of open standards for data, interfaces and encodings.

As the world's population is concentrating in cities around the world, governments have an increasing mandate to manage urban resources, waste streams, risks, traffic flows, zoning, energy usage and more. Many of these management issues, such as storm water and wastewater management, energy usage, and pedestrian traffic involve 3D and 4D (temporal) information, and thus 3D geoinformation becomes increasingly important.

CityGML is already in use in Spatial Data Infrastructure programs in Germany, France, Malaysia, Abu Dhabi and other countries, where it provides an important platform for the transition from 2D to 3D data. The Netherlands, however, is the first country to have made CityGML a national standard. Other countries will quite likely do the same for similar reasons, and therefore it will be useful for their policy makers to look at why and how this has been applied in the Netherlands.

CityGML is an information model and eXtensible Markup Language (XML) based encoding for the representation, storage as well as the exchange of virtual 3D city and landscape models. It provides a standard model and mechanism for describing 3D objects with respect to their geometry, topology, semantics and appearance, and defines five different levels in detail. CityGML is highly scalable and datasets can include a very wide variety of different urban entities. Thus, it supports the general trend towards modeling individual buildings and urban landscape features, but also whole sites, districts, cities, regions, and countries.

CityGML allows users to share virtual 3D city and landscape models for sophisticated analysis and display tasks in application domains, such as environmental simulations, energy demand estimations, city lifecycle management, urban facility management, real estate appraisal, disaster management, pedestrian navigation, robotics, urban data mining, and location based marketing. Because CityGML is based on the OGC Geography Markup Language Encoding Standard (GML), it can be used with the whole family of OGC web services for data accessing, processing, and cataloging. These are all open, consensus-derived international standards. CityGML also plays an important role in bridging Urban Information Models with Building Information Models (BIM) to improve interoperability among information systems used in the design, construction, ownership and operation of buildings and capital projects.

The OGC 3D Information Management (3DIM) Domain Working Group, a group whose mission is to facilitate the definition and development of standards for sharing and accessing 3D geo-information, gave the 3D Pilot NL organisers a special award in 2011. According to the Working Group, "The developments in the Netherlands serve as an inspirational example of a national implementation of a 3D standard" (OGC, 2011).

2. The vision behind the 3D Pilot NL

NSDI efforts in general are based on the realisation that standards provide value. Standards support interoperability and help reduce integration costs. They provide flexibility to insert new technologies rapidly and they provide the ability to extend legacy systems to interoperate with new sources of data and new technology services. Standards ultimately make data more discoverable, accessible and usable, which increases the social and economic value of the data. They also promote transparency, accountability and manageability.

The value of open standards has been demonstrated many times over with respect to geospatial data. Geonovum and other groups recognised the value of creating a national standard for 3D data in the Netherlands based on open standards that provide interoperability with open standards for 2D geospatial information. 3D data includes both geospatial and 'building spatial' data; that is, data about the size, shape, appearance, function and content of buildings and physical infrastructure elements such as streets, bridges, pipes and wires.

All countries can benefit from urban 3D models and all cities need elevation data, but, particularly when considering the increased risks of flooding that come with climate change, the Netherlands has a unusually acute need. Accurate and comprehensive 3D data is especially important, in cases where the terrain is flat, heavily built on and close to the sea level. However, in addition to planning and managing flood control, many other benefits were seen to derive from richer 3D data. Promoting tourism, civil security, high tech innovation, business development and efficiencies throughout the building lifecycle were among the reasons for organising the 3D Pilot NL.

3. 3D Pilot NL players and methods

The 3D Pilot NL brought together over 65 private, public and scientific organisations that cooperated in order to advance 3D developments in the Netherlands. The four national organisations that helped establish this collaboration network are the Kadaster, Geonovum, the Netherlands Geodetic Commission and the Dutch Ministry of Infrastructure and Environment. These national organisations recognised the importance of aligning Dutch national standards for 3D content data sharing with relevant international standards. In addition, they value the importance to align to the existing standards and efforts of the 2D domain. The Netherlands has well-established national standards on geo-domain models, but as in most countries, they are all 2D. The new 3D standard preserves valuable 2D concepts from the existing national standard for large-scale topography (Information Model Geography: IMGeo), and extends them with 3D concepts from CityGML. The 3D standard is therefore not just another standard on geo-information; instead the realised CityGML implementation profile bridges the 2D and 3D standardisation developments.

The leading organisations of the Dutch 3D standard effort recognised the importance of enlisting the support and cooperation of a broad base of technology providers and users in the public, private, academic and research sectors. And indeed the involvement of many stakeholders in the development of the standard proved to be essential in obtaining the necessary support for the national 3D standard. The involvement was realised through a 3D Pilot.

The pilot had quite ambitious goals: The creation of a test bed based on use cases related to a predefined test area in order to find consensus on a 3D standard NL, which should lead to a breakthrough in 3D. This required a set of use cases based on well-defined 3D requirements. One difficulty in creating such use cases is that users may not be aware of all the potentials of 3D techniques. Therefore, it was important for users to think about and express their requirements when confronted with the technical possibilities during the research process.

Thus, an inclusive research process was a guiding principle of the methodology of the 3D pilot. In January 2010, more than 45 organisations responded to the call for participation. Since the pilot received a lot of attention during its course, the number of participating organisations grew to about 65. Those organisations consisted of (large) municipalities, provinces, universities, main GIS and DBMS vendors, 3D data suppliers, engineering companies etc. All played a major role in the pilot. The 3D pilot participants are not limited to the Netherlands, e.g. there are participants from Germany and Belgium. In addition, several organisations work beyond the Dutch borders and involve their international counterparts. In addition, the (interim) results of the pilot have been discussed at various international workshops.

In order to realise the pilot objectives with so many contributing organisations, four work packages (WPs) were defined, each one equipped with its own WP leader:

- WP 1. Generation of 3D information
- WP 2. 3D Standard NL
- WP 3. 3D test bed
- WP 4. Use cases

In this way, all participants could contribute their expertise, while pursuing their individual interests and, at the same time, jointly realising the aims of the pilot. An optimal alignment of the participants' interests was also driven by the fact that no budget was available for individual contributions. Intermediate results were exchanged and aligned during plenary sessions, organised every six to seven weeks. Additionally, social media were used to further enhance the collaboration. Currently, the 3D Pilot NL LinkedIn group counts about 500 members.

Policy is also important. It is important to educate stakeholders and participants about the shared benefits of standardisation, but simply creating awareness may not be sufficient. To accomplish socio-technical change, personal and institutional inertia must be overcome. Habits, workflows and business models are hard to change from without, but some methods are generally effective.

One method used to encourage implementation is for government data and system procurements to set up specific requirements for standards in their requests for quotes. There are many examples around the world, from Canada to India to Germany, where OGC standards are mandated for procurements.

Another method, employed in 3D Pilot NL, is a legal requirement for government-funded data producers to 'comply [with standards] or explain why'. Though not yet fully implemented in the pilot, as it is a pilot, this is a powerful strategy employed by the Dutch government. A general governmental policy exists to list open standards on an officially endorsed list. These standards are mandatory for public parties under 'comply or explain' conditions and are officially requested in public procurement processes. A comprehensive set of open geo-standards for SDI components is part of this list, and since November 2011, IFCs for 3D-BIM are included.

Standards help to provide users with assurance that the work they do will not be wasted. It was announced that the new standards set forth by Geonovum are included in a maintenance programme and therefore, the results and efforts of the 3D Pilot NL are anchored. In general, a period of two years is considered to be a proper revision period. But this can be adapted for specific standards depending on the different dynamics. Revision in all cases is considered as a collaborative process to review changes suggested by users and to ensure harmonisation and consistency with the international developments.

4. 3D Pilot NL results

The first phase of the 3D Pilot NL has successfully laid the organisational and policy grounds for one of the world's most comprehensive national 3D geo-information programmes.

A major result of the pilot was the proof of concept for a 3D Spatial Data Infrastructure (SDI), covering issues on acquisition, standardisation, storage and use of 3D data. The findings of the pilot were formally established in a national 3D standard, realised as a CityGML Application Domain Extension (ADE). The ADE completely integrates the OGC CityGML Encoding Standard with a new version of the existing national Information Model for Geo-information (IMGeo) (Van den Brink et al, 2012). IMGeo contains object definitions for large-scale representations of roads, water, land use/ land cover, bridges, tunnels etc. and prescribes 2D point, curve or surface geometry for all objects. As the new version of IMGeo is completely integrated with CityGML, IMGeo version 2.0 also facilitates extensions to 2.5D representations (i.e. as height surfaces; equivalent to the coarsest CityGML Level of Detail (LOD0) and 3D volumetric (CityGML LOD1, LOD2 and LOD3) representations of the objects according to geometric and semantic principles of CityGML.

The close integration between an existing information model for 2D geo-information and CityGML is an important step towards the practical use and re-use of 2D and 3D information.

The pilot fits in with an ongoing national programme for harmonising the semantics of various data sets, looking at feature catalogues, information models, and the naming and mathematical representation of classes, attributes, code lists, etc. UML models were developed and these were used to generate OGC Geography Markup Language (GML) application schemas. Time was spent reaching an agreement on profiles and versions of interface standards such as the OGC Web Map Service (WMS) and Web Feature Service (WFS) interface standards and on coordinating reference systems, image formats, etc. in order to improve interoperability.

There was also considerable investment in online validation and certification. Online validation of datasets against XML schema, schematron business rules and 2- and 3D geometry - including topology - were found to play a key role in improving proper standards implementation. Certification of services was introduced along with European Spatial Data Infrastructure (ESDIN) principles to test but also guide standard-conformant services implementation.

The pilot has demonstrated the added value of 3D geo-information compared to 2D geo-information in various use cases, including:

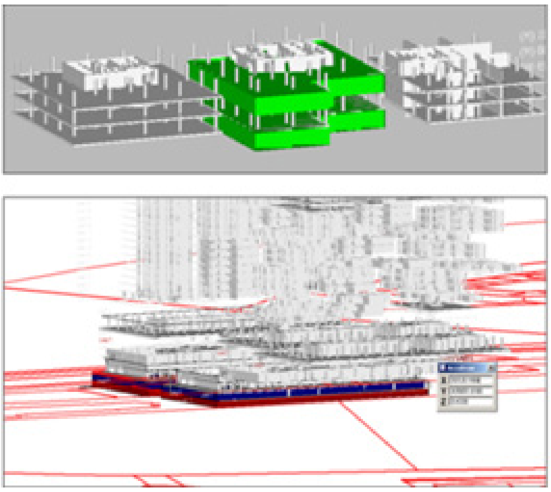
- Interactive airstream simulation, in which mathematical models showing surface movement of air obviously must be based on 3D data;
- 3D cadastre, as for example in describing the properties owned in high rise condominium developments;
- Integrated planning and management of underground and aboveground municipal assets.

Also, it was demonstrated that 3D information automatically generated from laser point data could serve many application domains. Such information about tree heights and sizes, new buildings, roofs, etc. can easily become part of an OGC CityGML model.

The use case studies helped answer questions such as: What applications need 3D information? Which 3D information is needed? What is the state-of-the-art of 3D techniques in relation to 3D needs? In order to answer these questions, six use cases were defined and executed. A selection of these is shown in Figure 2.

These use cases are:

1. 3D cadastre: recording of properties located above and below each other;
2. Generation, maintenance and distribution of 3D topography;
3. Applying voxel data for GIS analyses:
    a. Integration of voxels (3D grids) with 3D objects;
    b. Integration of surface and subsurface data;
4. 3D data integration in construction processes: How to use design data (IFC/CAD/Collada) in GIS applications and how to use 3D geo-information in building information models (BIM)?
5. 3D for spatial planning: generating 3D virtual environments based on architectural models for communication with citizens;
6. 3D change detection.

	
3D Kadaster (Dutch Kadaster and Bentley)	Tree model generated by Alterra for use case 3D topography

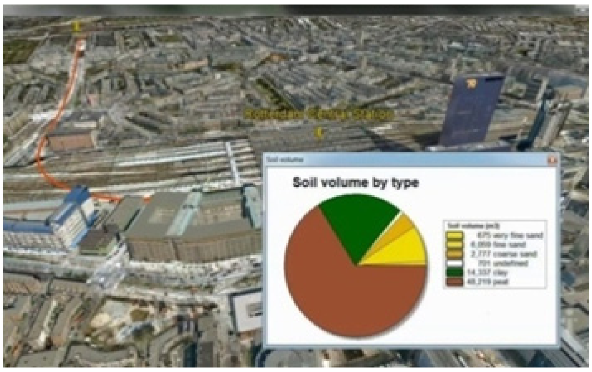
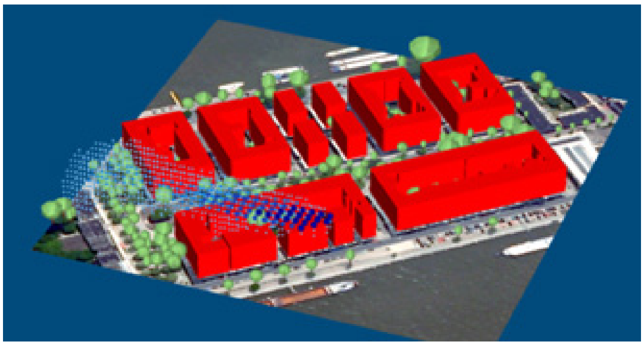
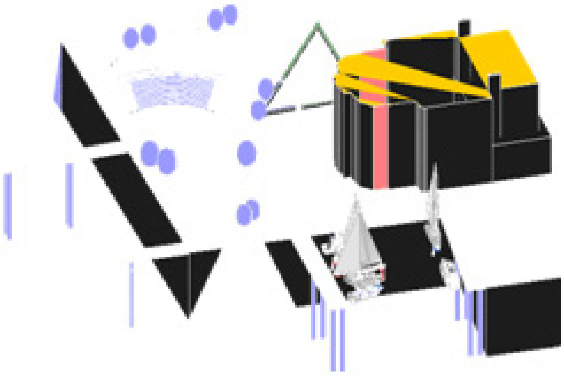
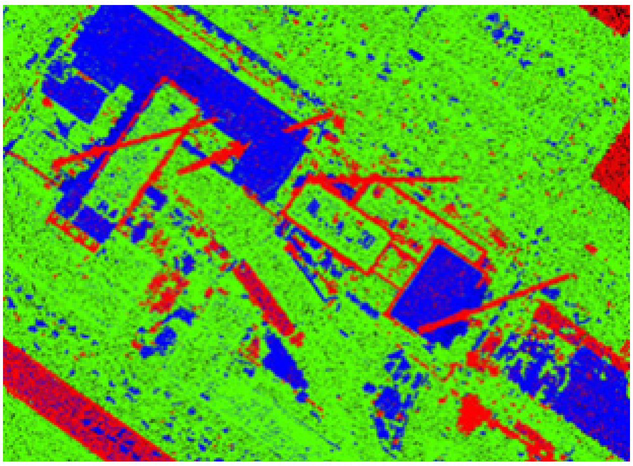
	
Calculation of soil volumes (voxels) at the location of a planned tunnel, by Esri and TNO	Real-time interactive airstream simulation with voxels, Alterra
	
Spatial planning objects in CityGML, Crotec	3D change detection, NEO BV
	
Integrating design models in virtual environments, Gemeente Apeldoorn	3D Change detection based on differences between two point clouds, U Twente

Figure 2: Selection of the executed use cases (Stoter, 2011)1

1 All the images shown in Figure 2 were generated within case studies that were carried out in the 3D Pilot. The main company responsible for each image is mentioned in the image caption.

5. 3D Pilot NL continues

In the development process of CityGML ADE IMGeo 2.0 a number of topics were identified that require further attention before the standard can be widely implemented. These open issues are currently being studied in a follow-up project of the 3D Pilot, described below. A pilot setting is again used because the first pilot has shown that fundamental 3D innovations can best be realised by an intensive collaboration of research institutes and private and public organisations. These organisations all possess unique knowledge and experiences about the complex topic of 3D that need to be brought together to accomplish 3D innovations. Also further agreements between many stakeholders are necessary for advances in 3D.

The goal of the follow-up pilot is more focused than the first pilot and aims at writing best practice documents by joint effort of the 3D Pilot community. The best practice documents are based on tools and techniques that are being developed for supporting the implementation of the 3D standard. Specific attention is being paid to align CityGML to the standard in the BIM (Building information Model) domain, that is, Industry Foundation Classes (IFC).

In summer 2011 a new call was launched and more than 100 organisations (180 persons) responded. These organisations are currently executing the six activities of the second 3D Pilot NL, which are:

1. Generating example 3D IMGeo data for several levels of detail and several classes;
2. Writing example tendering documents for creating 3D information;
3. Designing and implementing a 3D validation tool;
4. Describing a generic approach for maintenance, update and dissemination of 3D IMGeo data;
5. Collecting examples of 3D killer applications;
6. Aligning CityGML and IFC/BIM Building Information Model standards.

6. Challenges remain in the Netherlands

In the Netherlands, as in other places, knowledge of open standards is generally not widespread. The community of implementation experts is not large, and the number of those who have experience implementing the specific national standards and the new OGC CityGML standard is even smaller. A contributing cause of this, as well as a result, is the lack of educational materials and coursework in standards. Geonovum has some free, online training information on a wiki, but this is only the first level of knowledge required.

It was undoubtedly easier in the Netherlands to find and begin working with these experts than it would be in larger countries. However, there is a tremendous need for knowledge and expertise on standards at all levels, and the outreach done by the national partners of the 3D Pilot, which also included a free introduction course to CityGML to the Netherlands 3D Pilot participants, helped to raise awareness of this deficit. Professor Thomas Kolbe, who is one of the creators of CityGML, contributed to this 100 % CityGML course (TU Delft CollegeRama, 2011).

One important new challenge for the Netherlands and other countries that reach a similar point in NSDI development is dealing with issues involved in lifecycle management of standards, training, and further integration of open standards into business applications. This is an ongoing topic of discussion in the OGC. Users of the standards are invited to participate in this discussion, so that they can plan accordingly and influence the roadmaps for standards.

7. Conclusions

The 3D Pilot NL example has been successful as it aims to advance the use of 3D information wherever European governments - national, subnational or local - choose to promote such use. It provides a good model for institutional team building and policies that work in order to bring together a diverse group of stakeholders - nations, professions, industries, and communities of interest - for Spatial Data Infrastructure development.

The need for such a model increases as information technology advances. Many areas of information technology innovation involve spatial information, including Augmented Reality (AR), sensor webs, Building Information Models (BIM), Smart Grid, ubiquitous computing, location-based marketing, crowd sourcing and others. These are all part of visions such as Smart Cities, Smarter World, and the Internet of Things. Each of these areas of innovation offers potential benefits for citizens, consumers, and sustainable and resilient economies and societies. Each of them, where they involve spatial data, shares a dependency on open access to a rich infrastructure of 3D data and services. The 3D Pilot NL shows that governmental promotion of open standards in Dutch national policy accelerates uptake of the standards that make such open access possible. For these reasons, we believe that forward-looking policy makers can learn important lessons from the 3D Pilot NL.

European members of OGC play an increasingly important role in advancing new standards, as well as in providing valuable feedback to improve the current international standards and to ensure that they meet Europe's needs. Ongoing European dialogue with the OGC's international membership is important, as more often than not, standards requirements submitted by one region are also requirements in other regions.

Many members of the OGC are calling for more training and education about open standards, as well as for research on a growing list of interoperability topics. These are areas where European organisations have already contributed significantly, whereas education and research are still areas of great opportunity.

8. References

Accenture (2011). Information Marketplaces: The New Economics of Cities, retrieved April 2, 2012 from http://www.accenture.com/us-en/Pages/insight-cities-missing-smart-opportunity.aspx.

European Commission (2011). Digital Agenda: Turning government data into gold (Open Data Strategy for Europe), retrieved June 20, 2012 from http://europa.eu/rapid/pressReleasesAction.do?reference=IP/11/1524&format=HTML&aged=0&language=EN&guiLanguage=en.

European Commission (2011). Press Release: Public Sector Information - Raw Data for New Services and Products, retrieved April 2, 2012 from http://ec.europa.eu/information_society/policy/psi/index_en.htm.

European Commission (2007). INSPIRE Directive (Infrastructure for Spatial Information in the European Community), retrieved June 20, 2012 from http://inspire.jrc.ec.europa.eu/.

Kroes, N. (2011). Opening up Europe: from Common Standards to Open Data, retrieved June 20, 2012 from http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/11/596&format=HTML&aged=0&language=EN&guiLanguage=en.

Open Geospatial Consortium (2011). About OGC, retrieved June, 2012 from http://www.opengeospatial.org/ogc.

Open Geospatial Consortium (2011). OGC Alliance Partners, retrieved June, 2012 from http://www.opengeospatial.org/ogc/alliancepartners.

Open Geospatial Consortium (2012). OGC City Geography Markup Language (CityGML) Encoding Standard v2.0, retrieved June 20, 2012 from https://portal.opengeospatial.org/files/?artifact_id=47842.

Open Geospatial Consortium (2011). OGC 3DIM honors 3D Pilot NL with OGC 3D award, retrieved June 20, 2012 from www.opengeospatial.org/pressroom/pressreleases/1503.

Reed, C. (2004). Topic 0: Overview - Introduction and roadmap to the OGC Abstract Specification, retrieved June 20, 2012 from http://portal.opengeospatial.org/files/?artifact_id=7560.

Stoter, J., Vosselman, G., Goos, J., Zlatanova, S., Verbree, E., Klooster, R. & Reuvers, M. (2011). Towards a national 3D spatial data infrastructure: case of the Netherlands. Geoinformation 2011(6), 405-420.

TU Delft CollegeRama (2011). 1000 % CityGML Day video recording, retrieved June 20, 2012 from http://collegerama.tudelft.nl/mediasite/SilverlightPlayer/Default.aspx?peid=7b440617cd1342b0b5b006fc0f6563ef1d.

Van Den Brink, L., Stoter, J., and Zlatanova, S. (2012). Establishing a national standard for 3D topographic data compliant to CityGML. International Journal of Geographical Information Science, retrieved June 20, 2012 from http://www.tandfonline.com/doi/abs/10.1080/13658816.2012.667105.

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