

3D-CAPABILITIES REQUIRED BY USERS OF THE 2D-LARGE SCALE TOPOGRAPHIC REFERENCE DATABASE IN FLANDERS, BELGIUM

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Commission IV, WG IV/8

KEY WORDS: Topographic Reference Data, Inventory, Database, 2D, 3D, User Requirements

ABSTRACT:

Early spring 2010 we conducted a web survey and an interactive workshop among the current user community of the large scale topographic reference database (GRB) in Flanders, Belgium. The aim was to find out more about the needs and expectations of this community for 3D-data and 3D-capabilities. Several subgroups were addressed including administrators at regional, provincial and municipal level, cable and pipeline managers, contractors and road designers, surveyors and urban planners, representatives of the software industry and of education and research. The results reveal that 3D-visualisation is high on the list of all subgroups while more specific requirements are subgroup-specific. It is acknowledged that in order to address this variety of expectations, 3D-data model, data acquisition and database implementation must be developed in an iterative and progressive approach leading to flexible and extensible solutions.

1. INTRODUCTION

Contemporary large scale topographic inventories (LSTI) are undertaken to provide a detailed, topographic reference database (LSTRD) covering a large region in a uniform way. Typically these LSTI and the resulting LSTRD are planimetric in nature and do not include the 3^d dimension of topographic reality. Such reference databases are used as a geometric canvas for additional inventories and related datasets (e.g., of utilities) and as a basis for thematic extensions (e.g., building regulations). In Belgium, each political region has its own 2D LSTI-project. In Wallonia it is called PICC (Projet Intégré de Cartographie Continue) (Région_Wallonne, 2010) while in the Brussels capital region, the project and the resulting database is called URBIS (CIBG, 2010). Flanders is in the process of creating its GRB (Grootschalig ReferentieBestand) (AGIV, 2010). Also in other European countries, efforts are being done to create 2D-LSTRD, for example the UK with the OS Mastermap (Ordnance survey, 2010), the Netherlands with the GBKN (GBKN, 2010) and France with the Référentiel a Grande Echelle (IGN, 2010). With the implementation of the EU's INSPIRE-directive, more 2D-LSTRD-projects are likely to be started throughout the European Union.

Although all of these 2D-LSTRD are created for similar purposes, each of them has its own technical characteristics, and the underpinning data models are not fully identical. For example, the OS Mastermap is stored in an object-based database. In the Netherlands, the GBKN is line based, with no topology between points and lines. The differences between and similarities among the three 2D-LSTRD in Belgium (GRB, Urbis and PICC) have been described by (De Cubber et al., 2009).

Since topographic reality is inherently three-dimensional, it is not surprising that for some of the existing 2D-LSTRD efforts

were done to integrate the 3^d dimension (terrain elevation and/or height and/or 3D-shape of entities like buildings, manholes or trees). As such a whole new Urbis 3D was created for the Brussels region (CIBG, 2010). In Wallonia, every X-Y point captured in the 2D LSTI is accompanied by a Z-coordinate, giving the possibility to create a 3D PICC. In both LSTI, the focus was on the 3^d dimension of entities rather than on terrain elevation.

2. PROBLEM STATEMENT AND OBJECTIVES

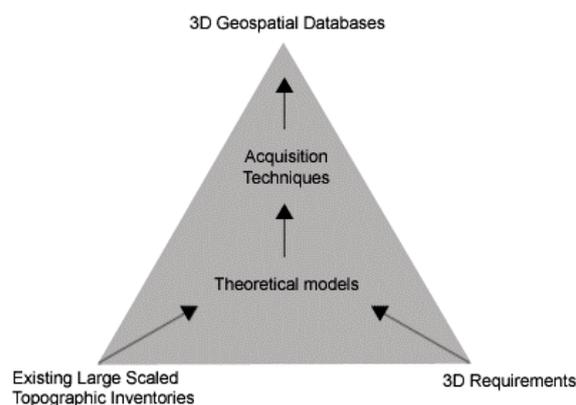


Figure 1. Triangle showing the process of upgrading the existing 2D-LSTI into 3D-geospatial databases, starting with the description of the 3D-requirements of users (De Cubber et al. 2009)

There is a wide variety of ways to upgrade a geospatial database from 2D to 3D. To select and implement the most appropriate among the possibilities, it is necessary to know the user requirements and translate these into use cases describing who

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wants to do what with the 3D-databases. Such use cases will allow to test whether the available 3D-solutions on e.g. Urbis or PICC meet the user requirements and, if not, what modifications are necessary to better meet them. First the conceptual and logical data models need to be designed. Subsequently the physical database structure must be determined and the appropriate 3D-data acquisition techniques chosen. The first task in this process, visualized in Figure 1, is to make clear the requirements users have for 3D-LSTRD.

In this paper we present the results of a survey among and a workshop with members of the current user community of the Flemish 2D-GRB regarding their requirements for 3D-data and 3D-functionality. This includes an overview of recent and potential use types of 2D-GRB and of full 3D-GRB. Furthermore we discuss the perceived advantages and pitfalls and point to the data models and data acquisition techniques which they mentioned.

3. MATERIALS AND METHODS

3.1 Web Survey

A questionnaire was designed and made available online during the month of February-2010. Known users of the existing 2D-LSTRD in Flanders, Brussels and Wallonia were invited by e-mail to respond. They were identified with the help of the Flemish agency for geographic information (AGIV, 2010) and through networks established in other research projects (Cromptvoets et al., 2009; De Cubber and De Ruyter, 2008). They included administrators at regional, provincial and municipal level, cable and pipeline administrators, contractors and road designers, surveyors and urban planners, representatives of the software industry and of education and research (Table 1). The questionnaire addressed three issues: (i) respondent characteristics, (ii) current and potential use of the existing 2D-LSTRD and (iii) needs for a 3D-version of the existing 2D-LSTRD. The questionnaire encompassed both multiple choice questions and open questions. Whereas the former are suited to provide statistics, the latter allow respondents to express their opinion more freely. The fact that 2D-GRB is hardly used in education and research and at the Flemish regional administrative level is reflected in the low number of invitees of these subgroups to the survey. The local governments, for whom the GRB was created in the first place, and the cable and pipeline administrators, financing the GRB project, represent a much larger share of the community.

3.2 Interactive workshop

A second method to obtain information on the 3D-requirements of the current users of 2D-LSTRD, was a participatory workshop. During this half-day workshop, the results of the web survey were presented and various statements on the suitability of spatial data models, structures and formats and data acquisition techniques were discussed. The strength of such a specialized seminar is that participants have more ample possibility to express their opinion with immediate interaction with and feedback from the other participants. The workshop was held on 29-April-2010. Participants (Table 2) were recruited through the web survey in which provision was made for candidate participants to express interest and readiness.

4. RESULTS

4.1 Response to the web survey

Sixty-nine invitations to respond to the web survey were sent out by e-mail. 44 (64%) responses were received (Table 1). The lowest response rate per user subgroup was 54% (software industry). The highest response rate was 77% (municipal and provincial administrations).

Table 1. User subgroups, number of invitations sent out and number of respondents for the web survey

User subgroups	Invitations sent	Respondents	Response rate
Flemish departments	4	3	75%
Local governments and provinces	13	10	77%
Cable and pipeline administrators	16	10	63%
Contractors and engineering offices	10	6	60%
Surveyors and urban planners	10	6	60%
Software producers and dealers	13	7	54%
Educational and research staff	3	2	67%
	Total: 69	Total: 44	64%

4.2 Participants to the workshop

Although municipal and provincial administrations and cable and pipeline administrators expressed most interest in the web survey, their participation in the workshop was weak. The software industry and the education/research community were best represented at the workshop, both in absolute and relative numbers (Table 2).

4.3 Current and potential use of 2D-GRB

Table 3 lists the most popular use types for the 2D-GRB. In Table 4, an overview is given of the strong and weak points of 2D-GRB. The strong points indicate the requirements that are already fulfilled while the weak points indicate the needs that should still be realised. 43% of respondents mention the lack of 3D-data to be a weak point of current 2D-GRB. The data in both tables are retrieved from the web survey results.

Table 2. Respondents to the web survey and participation to the workshop, by user subgroup

User subgroups	Web survey	Present at workshop	Percentage
Flemish departments	3	2	67 %
Local governments and provinces	10	4	40 %
Cable and pipeline administrators	10	3	30 %
Contractors and engineering offices	6	1	17 %
Surveyors and Urban Planners	6	2	33 %
Software producers and dealers	7	5	71 %
Educational and research staff	2	7	350 %
	Total: 44	Total: 24	55 %

Table 3. Applications for which GRB is/can be used, with the number of respondents, the major user groups these respondents belong to and the percentage of the respondents within these groups

Applications using 2D-GRB	Respondents	User group(s)	% of user groups
Managing cables and pipelines	13	Cable and pipeline administrators Contractors and engineering offices	81 %
Delivering recommendations concerning subsidy applications	11	Flemish departments Local governments and provinces	85 %
Design of datasets on destination and licensing	8	Local governments and provinces Contractors and engineering offices	50 %
Assessing dust propagation, soil and sound pollution	4	Surveyors and Urban Planners Local governments and provinces Software producers and dealers	24 %

Table 4. Major strong and weak points of the 2D-GRB with percentage of respondents compared to the total number of respondents (44)

Strong points	Weak points
Reference database for a large area	60 % Not covering Flanders yet 40 %
Georeferenced	48 % Not sufficiently up to date 39 %
High accuracy	43 % Important object classes missing 41 %
Compatible with other datasets	43 % No height information available 43 %
Exchangeable with other users	

4.4 Potential use of 3D-LSTRD

Respondents to the web survey indicate that existing applications may benefit from 3D LSTRD like cable and pipeline management, processing of subsidy applications and other types of study and design projects (Table 5). Potential applications mentioned during the web survey for 3D LSTRD are: design of 3D city models, sound propagation and flood risk and damage assessments, assessment of potential for photovoltaic panels, advices for implantation of high-rise buildings and base transceiver stations, establishment of a 3D cadastre, heritage conservation, creation of long- and cross-sections of roads and architectural design. Fire brigades are interested in evacuation routes of buildings. The police could use 3D LSTRD for intervention in case of emergencies. In terms of desired functionality of 3D-LSTRD, visualisation is high on the list followed by more analytical functions (Table 5). Visualisation is needed to represent reality more realistically and overcome the abstract nature of 2D-data.

5. DISCUSSION

5.1 One 3D-LSTRD-solution for diverse requirements and applications ?

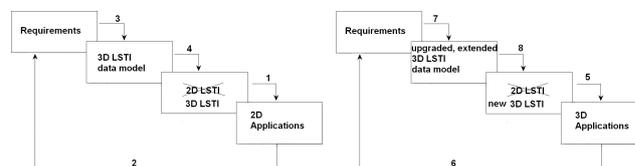


Figure 2. The four component cycle in designing a 3D-LSTRD: the requirements, the data models, the implemented LSTRD and the new applications. The first cycle on the left, (step 1 to 4) starts from the existing 2D LSTRD (GRB) and ends with the creation of the first 3D LSTRD. On the right, the second cycle, (step 5 to 8) leads to an adapted 3D LSTRD

As shown in table 5, each type of application may generate additional requirements for functionality which in turn need appropriate data models to be designed and appropriate data acquisition techniques for implementation of the designed model. This phenomenon can be presented in a four component

cycle: the requirements, the data models, the implemented LSTRD and the applications (Figure 2).

Table 5. Applications and related required functionality for a 3D-LSTRD as mentioned at the workshop

Application	Required functionality/ Use cases
Flood model design	Water level visualisation Analysis of the difference between water level and topographic terrain Flood risk and damage assessment for buildings
City model design	Visualisation of buildings
Sound propagation assessment	Analysis on the effect of high-rise buildings on sound propagation
Advices on implantation of high-rise buildings and base transceiver stations	
Potential for photovoltaic cells	Orientation of roofs
More precise city models and sound propagation assessment and advices on implantation of high-rise buildings and base transceiver stations	Detailed information for analysis on buildings Visualisation of road infrastructures, trees, ...
3D cadastre	Storage of owner information of parcels and buildings/levels
Architectural design	Visualisation of the inside and outside of buildings, with different rooms, ... Surface calculation for walls, floors, ...
Creation of long- and cross-sections of roads	Visualisation of long and cross-sections of roads
Cable and pipeline management	Visualisation of position Analysis of slope for flow direction
Evacuation and emergency planning	Analysis of evacuation routes in case of emergency Analysis of alternative escape routes

From 2D- to 3D-LSTRD: With the available 2D-LSTRD, like GRB, new applications were created (step 1), as described in table 3. By using these applications, the respondents are confronted with the possibilities and limitations, which results in the description of new requirements as listed in table 4 and table 5 (step 2). It is evident that these requirements will affect the need for a 3D LSTRD data model, with extra object classes in table 5 (step 3). With this 3D-LSTRD data model and the correct techniques to feed the model, more functional 3D-LSTRD can be designed (step 4).

From 3D- to adapted 3D-LSTRD: At this point, the existing applications can be upgraded, and new 3D applications can be implemented (step 5). It is not unlikely that once these 3D applications start to be used by different user groups, once again the limitations and possibilities will result in new requirements and new functions (step 6), and the need for a more detailed or extended data model will appear (step 7).

In this cycle, the requirements, the data models, the implemented LSTRD and the new applications follow each other and keep on affecting each other, making it hard to define one single solution for all the recent and future requirements and applications.

5.2 Short and long term visions for a 3D-LSTRD

Designing one final data model for a 3D LSTRD, that fulfils all the requirements the respondents described, would result in an extremely complex, expensive and time consuming implementation process. Therefore, an iterative process may be more appropriate, in which the most basic requirements are answered in the shorter term by a first 3D data model resulting in a first 3D-LSTRD. Afterwards, the requirements can be completed, resulting in a more detailed or extended 3D data model. By following this approach, the first 3D-LSTRD can be available in a relative short time span giving the users the possibility to test, to develop new applications and to describe new requirements. In this respect, it is necessary to define which 3D-requirements are the most important to be fulfilled first. Our survey reveals that emphasis should first be put on meeting the requirements for 3D-visualisation.

In the longer term, a more complete 3D data model should be found, fulfilling the maximum of the present and future requirements. This will require several iterations of the requirements, models and applications cycle.

5.3 3D-Object classes

In the short term approach, not all object classes, available in the 2D-LSTRD, should be upgraded to 3D. Table 6 is derived from our survey and gives an indicative overview of object classes, typically present in a 2D-LSTRD, which need a 3^d dimension for use in the listed applications.

For some applications, only a basic 3D building object is necessary, representing the height of a building. For others, the roof structures and the different floor levels should be modeled, the separated rooms, the wall structures and even the furniture.

6. CONCLUSIONS

With a web survey addressing 69 members of the current user community of the 2D-topographic reference database (GRB) in Flanders, Belgium, and a subsequent workshop the user requirements for the upgrade of the 2D-topographic reference database GRB to 3D were inventoried and new applications for 3D LSTRD were listed.

With the diverse requirements and applications, it becomes an extremely complex, expensive and time consuming process to develop and implement one final data model for a 3D-GRB. Therefore, the cycle of requirements, data model, LSTRD and applications can be followed to develop different data models iteratively. A first 3D-data model should focus on the basic requirement, indicated by the users, namely the 3D-

visualisation. In the next iterations, other requirements can be added, resulting in the extension with new or more detailed 3D-object classes.

Table 6. Application-specific need for 3D-object classes

Object class →	Buildings	Trees	Road infrastructure	Water /river	Terrain model	Cables /pipelines	...
Application							
Design of flood models	(x)			x	x		
Design of city models, sound models, advices on implantation of high-rise buildings and base transceiver stations	x	(x)					
Possible use of photovoltaic cells	x	(x)					
More precise city models and sound models and advices on implantation of high-rise buildings and base transceiver stations	x	x	x	x			
3D cadastre	x						
Architectural design	x	(x)	(x)				
Heritage conservation	x						
Creation of long- and cross-sections of roads	(x)		x				
Cable and pipeline management							
Evacuation and emergency planning	x						

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