GIM INTERNATIONAL
THE GLOBAL MAGAZINE FOR GEOMATICS
WWW.GIM-INTERNATIONAL.COM
geomares PUBLISHING
ISSUE 7 • VOLUME 31 • JULY 2017


# Bringing Reality into the Information Space

Interview with Dr Bernd-Dietmar Becker, FARO

PUBLIC PARTICIPATION USING 3D CITY MODELS

DIGITAL IMAGE MATCHING FOR EASY 3D MODELLING

GROWING USE OF OBLIQUE IMAGERY BY MUNICIPALITIES

*GIM INTERNATIONAL INTERVIEWS DR FILIP BILJECKI*

# The Tough Road from 2D Maps to **3D City Models**

The demand for mapping intensively used parts of the Earth, including roads and cities, is steadily growing. This is because today's rate of urbanisation requires detailed and up-to-date geodata in its full three dimensions. Such datasets help city managers to prevent a decline in liveability, to limit water, air and noise pollution, and to improve fair taxation and rapid emergency response. Crucial is the abstraction of the 3D real world, a concept known as level of detail (LoD). Since 2012 Dr Filip Biljecki has been investigating how to improve the level of detail (LoD) in 3D city models. For his efforts – which were published in a hefty book called *Level of Detail in 3D City Models* – he recently received a PhD degree from Delft University of Technology. In acknowledgement of the high standard of his research, he graduated with the rarely awarded cum laude distinction, providing *GIM International* with reason enough to interview him.

***What does level of detail (LoD) mean?***

LoD is a key property of 3D city models and its concept is comparable to the scale of maps and the resolution of imagery. LoD is primarily related to semantic and thematic richness and geometric detail (see Figure 1). For example, LoD1 shows buildings as blocks with flat roofs, while LoD2 shows finer details, such as roof shapes and protrusions in the façades. A block model is perfectly suited for placing GSM antennas, while the optimal placing of solar panels requires shape, size and orientation of roofs. So LoD determines the usability of a dataset and has implications for its interoperability, maintenance and the conversion from the one data format into the other. Added to this, the geodata acquisition technique should allow the creation of the required LoD which goes hand in hand with costs.

***Why would cities be interested in the creation of 3D models?***

For the same reasons that they would be interested in 2D maps. 3D city models may be used for many applications. They offer additional insights when using traditional 2D GIS products or enable new applications. Let me give a few examples. Estimating the potential yield of solar panels placed on rooftops is impossible without 3D city models. Estimating noise pollution is more accurate when carried out on 3D models than on 2D maps (see Figure 2). This is because sound propagates through the air in all directions. Therefore, noise levels vary not only based on distance from the source but also based on elevation, which is not possible to account for when working in 2D. Such specialised applications of 3D city models, which often require substantial pre-processing of data, are interesting for city authorities as they improve their management tasks.

***Isn't LoD just another term for abstraction and generalisation in surveying and cartography, and resolution in remote sensing?***

Yes and no. Yes, because LoD has analogies with scale, generalisation, resolution and point cloud density. And no, because 3D city models differ from maps as they encompass metrics other than geometry, such as texture and semantic detail. For example, the geometry of buildings, described by their outlines, can be enriched with photo textures and additional information on, for example, year of construction. The geometric shape of roofs and the age of the building are key ingredients for predicting energy demand. To be honest, I'm not a fan of the term 'scale' in GIS due to its twofold meaning. First, it is related to paper maps, so the term is inappropriate for 3D city models which are usually in digital format. Second, scale has many meanings; large scale, for example, indicates a large spatial extent. The term 'resolution' is not suitable when dealing with 3D city models either. For imagery the term is okay as the resolution of a raster is homogeneous. 3D city models are different and heterogeneous; landmarks or parts of them (e.g. footprint versus roof), for example, may be modelled in different granularities. Discussions on terminology are inevitably subjective, and I'm sure that some colleagues will disagree with what I have just said. Terms have a historical background and often refer to technology which is fading out. As a consequence, terms developed in the heyday of paper maps are falling short now we're in the transition stage from 2D maps to digital 3D models.

***One of the propositions accompanying your thesis reads: "There is no such thing as a general-purpose 3D city model". What does this mean and what are the consequences?***

Practitioners and researchers use the term 'general-purpose 3D city model' to indicate seemingly generic datasets procured by cities

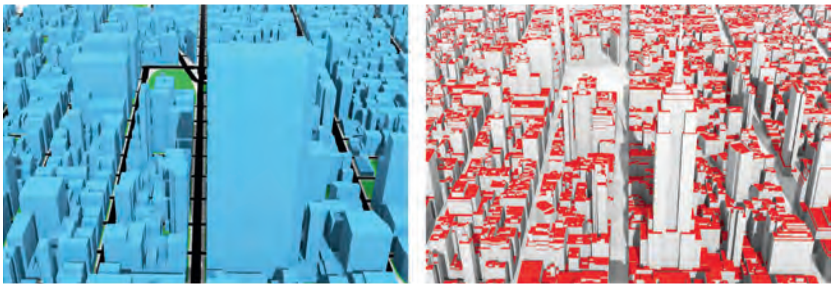

*Figure 1, 3D city models of Manhattan, showing a block model (left) and details of roofs and façades (courtesy: Chair of Geoinformatics at Technical University of Munich, and Department of Information Technology and Telecommunications (DoITT) of the City of New York).*

and released as open data. This challenging proposition expresses that I am not fond of this term. A 2D dataset may be collected once and used for many purposes. Unfortunately the same does not hold true for 3D. Challenges include the fact that: requirements differ per application and software package; data formats are not fully interoperable; and thematic completeness is often lacking. In practice, the creation of one dataset that works with most if not all applications is troublesome and hence there is no one-size-fits-all 3D dataset. Of course, a dataset can serve several uses. An LoD2 CityGML dataset, for example, may be used for solar potential estimations as well as in urban planning, but it is too optimistic to assume that the same dataset would be suited for a wide spectrum of applications as is the case in 2D GIS. When designing specifications and acquiring data, companies and cities should focus on a set of intended applications of the 3D model, rather than on anticipating out-of-the-box uses for virtually everything.

## PROGRESS IN CREATING 3D CITY MODELS GOES HAND IN HAND WITH ADVANCEMENTS IN SENSOR TECHNOLOGY

***Is it feasible to acquire or create a geodataset with a fine level of detail if the data gathering instruments have poor positional precision?***

This depends on the application, but the general answer is no. Often, the improvements a fine LoD achieve do not outweigh the costs. The accurate computation of the volume of a building benefits more from a high positional precision than from fine detail. Coarse but highly accurate may thus result in higher quality than vice versa. However, there are always exceptions. In visualisation, which primarily aims at pleasing the eye, a fine LoD is preferred over high positional precision.

***CityGML is an Open Geospatial Consortium (OGC) standard. What is your experience with the acceptance level of this standard?***

Most 3D city models I've seen recently are available in CityGML. So it seems the standard is well adopted by the GIS community, including researchers as well as practitioners within local governments and companies. However, software adaptation is lagging behind – and CityGML is no exception, since familiarisation of a new standard in a community always follows a steep curve.

*Figure 2, Noise pollution by a tram line simulated with Geomilieu-DGMR on data from City of the Hague and visualised in Blender; the red, orange and green contours represent high, medium and low noise pollution, respectively.*

***The generation of 3D city models with a high level of detail is associated with high production costs. When and why should cities generate 3D city models with a fine LoD?***

That's true, and the reason for high production costs is the same as for creating topographic maps and other 2D maps: manual labour is often prohibitively expensive. Production costs will gradually decrease, mainly because of further automation and augmentation of the details of a 3D city model by exploring architects' design rules instead of using actually acquired data. This process of artificial augmentation is called 'procedural modelling'. Whether it's worth producing a dataset at a fine LoD largely depends on its intended use. Data at a finer LoD may look attractive but, as I already said, the benefit may not always justify the costs.

***A fine LoD contains dormers, chimneys and other roof details. Which applications require such a detailed reconstruction of shape, size and orientation of building features?***

It's true that many applications do not need models with detailed roofs but may suffice with block models. That has been one of the topics of my research. That said, besides estimating the solar potential – which is one prominent use case requiring roof shapes – other applications may also benefit from LoD2 geometry. In the energy domain, roof shapes make it possible to differentiate attics and adjust the estimation parameters. Roof shapes may also support the fitting of indoor datasets and automated property valuation. In emergency response, knowing roof shapes can support advance action planning while first responders rush to the calamity site.

***How do you see 3D city models evolving in relation to the ever-increasing capacities of (laser) sensors to acquire point clouds and the resulting ever-greater point densities?***

Progress in creating 3D city models goes hand in hand with advancements in sensor technology and the capabilities of software to process the data. Until now, the creation of 3D city models has mainly focused on buildings rather than roads or bridges. Perhaps the increasing sensor and data-processing capabilities will result in 3D city models with improved thematic completeness. Improvements in sensor technology will also lead to finer LoDs and higher-quality datasets. If increasing capabilities are accompanied by decreasing acquisition costs, the creation of 3D city models may become easier, enabling more frequent updating. In other words, the higher the point density of point clouds is, the more 3D city models will benefit.

***You published many scientific papers during your research at Delft University of Technology. What's your view on the 'publish-or-perish' mindset at universities?***

First of all I think one should recognise that universities in general have two tasks: scientific research and teaching. With respect to scientific research, I support a publish-or-perish mindset because publication fosters scientific communication and forces researchers to share their work. Some researchers are reluctant to publish their work for various reasons, which is a pity because this impedes scientific progress. Added to this, I believe publicly funded researchers have the moral obligation to share their results, plus withholding or delaying results goes against the idea of science. Furthermore, publication usually initiates new contacts, triggers collaborative partnerships and prevents duplication of work, which is beneficial for all. On the other hand, the publish-or-perish paradigm impedes the teaching task. Staff are usually tasked with both research and education so the pressure to publish may curtail teaching efforts, possibly leading to reduced quality of education. ◀

## PRESSURE TO PUBLISH MAY CURTAIL TEACHING EFFORTS, POSSIBLY LEADING TO REDUCED QUALITY OF EDUCATION


## ABOUT DR FILIP BILJECKI

Filip Biljecki received an MSc degree (2010) and a PhD degree (cum laude) in 3D GIS (2017), both from Delft University of Technology, The Netherlands. His PhD research was supervised by Prof Jantien Stoter and Dr Hugo Ledoux. Filip is involved in the OGC, EuroSDR, ISPRS and other international collaborations. In 2016 the Austrian Academy of Sciences awarded him the Young Researcher Award in GIScience. In July 2017 he started as a research fellow at the National University of Singapore, working on the integration of BIM and GIS data.

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▲ *Dr Filip Biljecki amid members of his examination committee.*