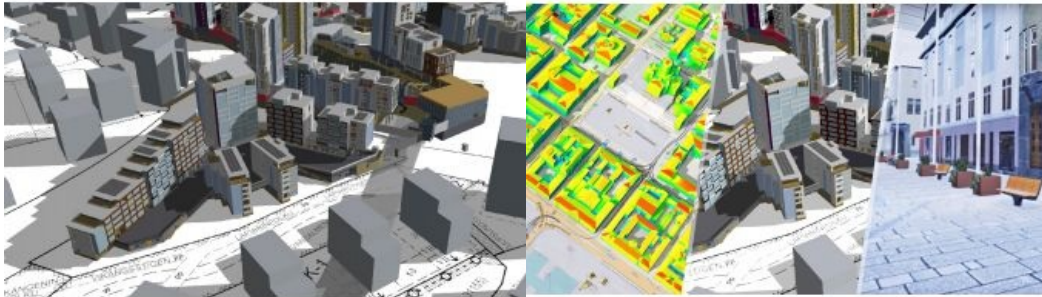


THE QUEST FOR THE BIG PICTURE

Characterizing activities in 3D city modelling



City	Project	Used platform(s)	Data accessibility		Full city data coverage	Utilization of as-planned information
			Data publicly viewable	Data publicly downloadable		
Espoo	3D city model data	Autocad	-	X	X	-
	Mission 3D/4D visualization	CityPlanner	X	-	-	X
	Urban lighting simulation	Unity	X	-	-	X
Helsinki	3D information model	Unity	X	-	X	-
	3D city model data	Autocad	X	X	X	-
	Outlook 3D	Microstation	X	-	-	X
Oulu	3D city model data	Autocad	-	X	X	-
	Virtual Oulu	Unity, Unreal Engine	X	X	-	-
	Helsinki 3D model	Unity	X	-	-	X
Tampere	SmartCity	MAPGIS	X	-	X	X
	3D city model data	Revit, AutoCAD, Vray	X	X	X	-
	3D city model data	Autocad	-	-	-	-
Turku	3D city model data	Autocad	-	-	X	-
	3D model of Turku campus and surrounding area	SketchUp	X	X	-	-
	3D city model data	Microstation	-	X	X	-
Vantaa	3D city model data	Revit	X	-	-	X
	3D city model data	Autocad	-	X	X	-
	3D city model data	Unity	X	-	-	X
Total	19	33	33	10	10	8

3D GIS	BIM	Computer Graphics
Focus in real world data Simplified model complexity (geometry and semantics) Citywide data coverage Global coordinate systems Database approach (maintained models) Automated or semi-automated modeling (geometry)	Focus in as-planned data High model complexity (geometry and semantics) Local data coverage Limited use of coordinate systems Life-cycle approach Manual modeling	Real world and as-planned data Intermediate model complexity (geometry) Local data coverage Limited use of coordinate systems Flexible application development approach Manual modeling User engagement (immersion, interactivity and multi-user environments) Visual realism (real-time rendering)

As 3D models are becoming common geospatial data assets for cities around the world, a recent study reviewed major 3D city modelling activities in Finland. 3D city models can be utilized for tasks including planning, visualization and decision-making. The field of 3D city modelling is diverse, with a multitude of technical solutions. Even the definition of what constitutes a 3D city model still remains ambiguous. Yet, surprisingly few studies have focused on reviewing the existing activities and assembling the big picture. This article presents some of the key findings from the study in Finland.

3D city models can be seen as an enabler in the smart city paradigm, operating as a user interface to the modern urban environment and acting as a platform for cooperation and services. Therefore, a

high degree of interoperability is expected from city models and from the information systems that host them. Also, 3D city models are expected to support a multitude of applications. This remains a challenging task, still hindered by many issues, such as ambiguities and differences in modelling, differences in perspectives, missing guidelines, challenges in data conversion and georeferencing, and problems in data quality.

Quest for data integration

Data integration is an inherent component in city modelling. 3D city models are commonly built through 3D reconstruction and data integration, by merging photogrammetry or laser scanning data with GIS data such as building footprints and IDs. Also, the use of highly detailed building information models (BIM) as a source of as-planned data remains a significant development topic. Another development direction is the integration of time series and sensor data to the objects in a city model. Rather than being static representations of the environment, inclusion of live data is turning city models into increasingly dynamic artefacts and towards the concept of a 'digital twin' of the city.



Figure 1: Different types of 3D city models. Helsinki Energy and Climate Atlas (left, courtesy City of Helsinki), BIM visualisation in Espoo (middle, courtesy City of Espoo), and Virtual Oulu (right, courtesy University of Oulu).

Expanding field of applications

The application space of 3D city models has expanded hand in hand with the technical development. In addition to the 'traditional' use cases in urban planning and zoning, 3D city models are expected to facilitate energy analysis, detailed architectural visualization, interactive and immersive applications development, and participatory GIS. All this places challenging requirements on the platforms of the 3D city models.

The discussion on 3D city models is further complicated by the amount of different platforms used for 3D city model applications. In addition to the professional GIS/CAD tools, 3D city models are used on game engines and various web-based 3D viewers, such as virtual globes.

Reviewing the major 3D city modelling projects in Finland

In a recent study, the authors took a closer look at some of the 3D city modelling projects in the six largest cities in Finland, using project descriptions maintained by the cities to obtain an overview of the current activities. To support further understanding, local city representatives in the studied cities were interviewed. A summary of the analysed projects is presented in Table 1.



Table 1: A summary of the analysed 3D city modelling activities.

Excess of platforms

Firstly, the studied 3D city models utilized a great variety of platforms. In the 19 studied projects, a total of 13 different platforms were discovered for hosting the models. These included GIS/CAD software (e.g. Trimble Locus and Bentley Microstation), virtual globes (e.g. Cesium, CityPlanner, Sova3D, MAPGETS) and game engines (e.g. Unity, Unreal Engine). Some of the software solutions applied in Finland were more or less unique and have not seen wide adoption globally.

Secondly, the authors noted that in each studied city the maintenance and upkeep of the 3D city models was tied to the statutory base mapping process that heavily relies on the chosen GIS/CAD software. In many cases, the 3D model data maintained by the city itself was used as an input or reference data for virtual globes and 3D game engine-based projects, which focused on specific applications often aimed at broader audiences.

Data quality and accessibility

The studied 3D city modelling projects contained a variety of different levels of detail, ranging from simple block models to highly photorealistic models containing facades modelled in great detail. Fewer than half of the models utilized as-planned information such as BIM or architectural plans. More than half of the city models covered the full regional area of the city.

In addition to data quality, accessibility plays a vital role in 3D city modelling, especially when models are to be used as a basis for developing new applications. Almost two-thirds of the studied city models could be freely viewed via a web-based viewer. This was realized either via separate viewer utility or, in the case of virtual globes, natively by the platform itself. More than half of the city models studied were offered for download over the internet. However, none of the cities offered any original raw data such as Lidar point clouds. This hinders possibilities to freely edit the models or to run additional analysis.

The ideal of a general model

Producing and maintaining a 3D city model requires an interplay of several technical solutions and stakeholders, both of which vary from project to project. Many of the studied cases were likely to serve only a limited number of purposes or to pilot 3D modelling in a limited area. However, the interviews showed that this had not been the original intention in the cities. On the contrary, the common vision was close to the ideal of 3D city models serving as general platforms, including the capability to re-use the gathered data and models.

Further, an increased degree of realism in visualizations, attained with 3D models, was seen as a key element in enhancing the interaction and trust between different stakeholders. This includes the notion of demonstrating impact as well as including all relevant stakeholders in the co-design and decision-making processes.

Stakeholders inside and outside city organizations are a heterogeneous group of users that have varying needs, expectations and views of 3D city modelling. The city interviewees stated that up-to-date guidelines and policies were missing or that the existing guidelines were not followed. Ambiguous terminology, lack of coordination and leadership, and the slow adaptation of standards frequently crippled communication and collaboration. Additionally, the lack of expertise was said to result in an incapacity to recognize the need for 3D city modelling and hence to define the requirements for the modelling projects.



Table 2: The characteristics of the operational cultures in 3D city modelling.

Understanding the big picture

By looking at the characteristics of the studied 3D city modelling projects and literature, it was possible to identify three partially overlapping operational cultures in the 3D city modelling scene: 3D GIS, BIM, and computer graphics. Each of these operational cultures (Figure 2) has a unique perspective on 3D city modelling and they often lead to differing realizations (Table 2).

In the 3D GIS category, the modelling projects typically have a large regional coverage but a limited level of detail in 3D reconstruction. Further, the role of semantic data and connection to the existing city GIS data is emphasized over mere geometric reconstruction. Most of the applications focus on professional uses like city planning, mapping and various geospatial analysis. Projects in the BIM category focus on integrating as-planned data from individual buildings to models of limited regions. Understandably, aspects like model conversion and inclusion of interiors are pronounced. Typical applications in this category include urban planning, building permit processes and architectural visualization. The projects in the computer graphics category are based on game engines, offering the highest level of photorealism facilitated by advanced real-time rendering. At the same time, models are typically limited to local coordinate systems and they rarely utilize semantic information. Also, the 3D game engine-based models have a clear emphasis on game-like interaction and immersion, with the goal of engaging users to collaborate in and explore the models, even on a pedestrian level.



Figure 2: Three categories representing distinct operational cultures in 3D city modelling.

In the big picture, 3D city modelling is revealed to be a diverse and multidisciplinary field with steadily increasing interest and demand. It is

often accompanied with visions of a high degree of interoperability and platform-like characteristics. However, when reviewing the modelling activities more closely, they appear fragmented and fail to reach the broad applicability envisioned.

This is, to some extent, explained by the complexity of the situation. Modelling projects are carried out by people from different fields, using varying tools and aiming for different outcomes. Further, the future uses for 3D city models can be hard to predict – and not only because the user group is heterogeneous with different levels and types of expertise. As an outcome, the quest for a single, completely harmonized 3D city model becomes demanding and laborious. Improving the interplay and communication between people and technologies across these three operational cultures is a key element in advancing the interoperability and creating flexible, demand-driven 3D city models of the future.

Further reading

Julin, A., Jaalama, K., Virtanen, J. P., Pouke, M., Ylipulli, J., Vaaja, M., Hyypä, J., & Hyypä, H. (2018). Characterizing 3D City Modeling Projects: Towards a Harmonized Interoperable System. *ISPRS International Journal of Geo-Information*, 7(2), 55.

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