Towards Intelligent Cities with 3D City GIS Initiatives

Cities face the challenge of meeting development goals within a framework of sustainability. **Richard Zambuni, Global Marketing Director, Bentley Systems,** says cities that adopt 3D modelling will be able to manage their infrastructure better.

All levels of government are challenged by growing populations, and in the coming decades most of this growth will take place in cities. This is particularly true for developing economies such as India, where a population shift from countryside to city continues and overall organic population growth is substantial. Cities around the world face the need to expand, improve the quality of life of their citizens, and create better-performing, sustainable infrastructure that, in turn, can help sustain society, the environment, and the world economy.

An effective way in which sustainable infrastructure can be designed and delivered is through a 3D City GIS (or geospatial information system). This type of information management system provides all the functionality required to manage data, users, and processes related to a city's infrastructure.

THE LIMITATIONS OF 2D GIS

Before we look at how 3D City GIS initiatives can help transform the productivity of a municipality and eventually lead to sustainable infrastructure, let's discuss the limitations of legacy 2D workflows. While 2D data continues to be useful in a variety of applications, it lacks the ability to solve complex problems associated with infrastructure engineering planning and design. In fact, it could sometimes lead to misinterpretation of the physical environment.

Now that advances in technology have made it easier and more cost-effective to achieve 3D GIS models, more municipalities are thinking about migrating to this model. A 3D information model increases the use of spatial data to include accurate flood and shadow analysis, line of sight studies, and project simulations. It uncovers the relationships between above-ground and below-ground infrastructure.

WHY 3D CITY GIS?

It's established that users who have been employing GIS's to sustain infrastructure for many years, draw added value from which they continue to benefit. GIS's enable users to see clearly and understand spatial relationships between infrastructure assets. Information stored within a GIS originates as detailed, engineering-level 3D data. Governments understand that this data can help them successfully manage infrastructure assets.

Many architectural and engineering organisations now regularly incorporate real-world coordinate information in their building and civil project models. However, only a 3D City GIS can integrate stand-alone Building Information Models (BIM) and civil engineering project information with the GIS data to create a consolidated urban model. Design and engineering products such as MicroStation and Bentley Architecture include tools to "geo-locate"

Unique to a 3D City GIS model, shadow analysis is used for visualising the impact new infrastructure has upon existing municipal structures. Courtesy BlomInfo A/S

the information contained in a project. Therefore, data from multiple projects and sources can be associated with other data.

The adoption of these geospatial capabilities by engineers is driven by its many advantages. Georeferencing and maintaining engineering data enables it to be reused for the redesign, repurposing, renovation and revitalisation. This leads to savings in capital improvement project planning, design, and operations.

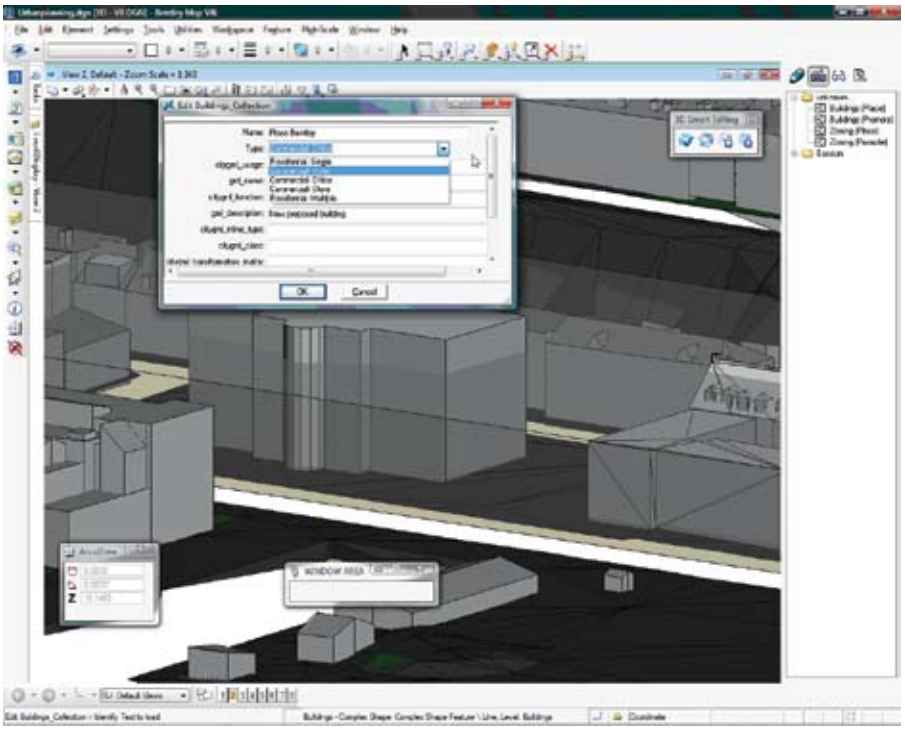
WHY NOW?

Mapping and 3D modelling technologies have been available for many years but several new factors have made a real difference in the adoption of 3D technology—not the least of which is a major decrease in the cost of acquiring data as well as an upgrade in the skills of those working with GIS technology. One development involves spatial databases that support native 3D data storage and result in a more standardised approach to data storage and access. Municipalities can leverage multiple commercial off-the-shelf applications to create 3D city models in a centralised database, with this technology. Desktop GIS applications are also seeing improvements that take advantage of 3D data. Desktop GIS products provide advanced 3D editing, creation of fully attributed objects, 3D thematic mapping, and 3D object support. For example, Bentley Map augments MicroStation's native 3D editing capabilities to create semantically rich features. These features can also be published to CityGML, an open standard adopted by the Open Geospatial Consortium (OGC), to facilitate interoperability or be published.

DECREASING COSTS SPEED THE ADOPTION OF 3D CITY GIS TECHNOLOGY

Since most municipalities don't have large GIS or production budgets, many are concerned about the operational costs associated with working with a 3D city model. But the cost associated with 3D City models has decreased, both on the data creation side and on the data management side. Here are two examples:

- Over the past, we have seen tremendous progress in aerial survey techniques, with the development of LIDAR sensors, in particular, allowing the cost-effective acquisition of 3D point clouds. This kind of data, combined with highly productive processing software, now enables the almost automatic creation of 3D city models with high levels of automation.
- Some people think they need to separately purchase the advanced animation tools used in the movie industry to realise the benefits of 3D modelling and animation. However, this isn't the case now that cutting-edge rendering capabilities are part of products such as MicroStation and Bentley Map, allowing advanced rendering of geospatial data without additional tools, data conversion, or model exports. In the Copenhagen realistic renderings of a cityscape using textures in place of geometric details were created within MicroStation.



Municipalities can analyse noise pollution around airports, roadways and railways using a 3D City GIS model. The results can be used to predict noise levels, develop noise abatement programs and assess the effectiveness of noise barriers. Courtesy Urzad Miasta St Warszawy

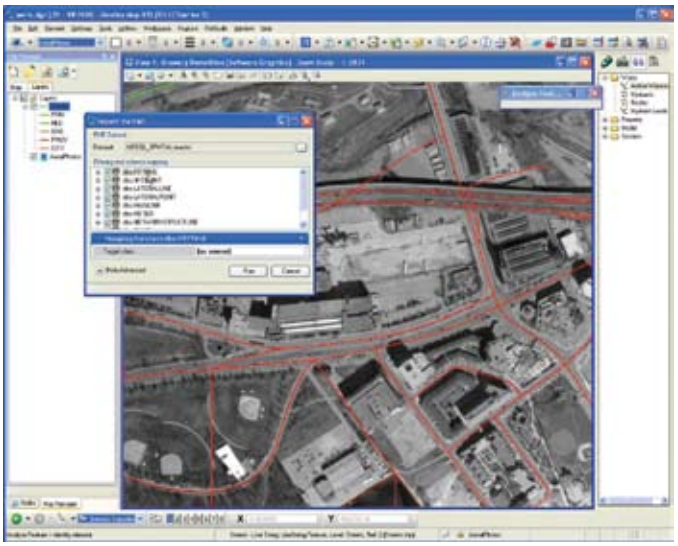
3D CITY GIS DEFINED

A 3D City GIS can be defined as an information management system suitable for geospatial and non-geospatial information. A 3D City GIS may be defined as a collection of functionality allowing data, users, and processes related to a city's infrastructure to be effectively managed. It includes a reference 3D city model suitable for the management and geo-coordination of infrastructure information. It also provides a framework for supporting the information lifecycle–from its creation to its exploitation by different stakeholders. The main functional components of a 3D City GIS can be grouped into three categories:

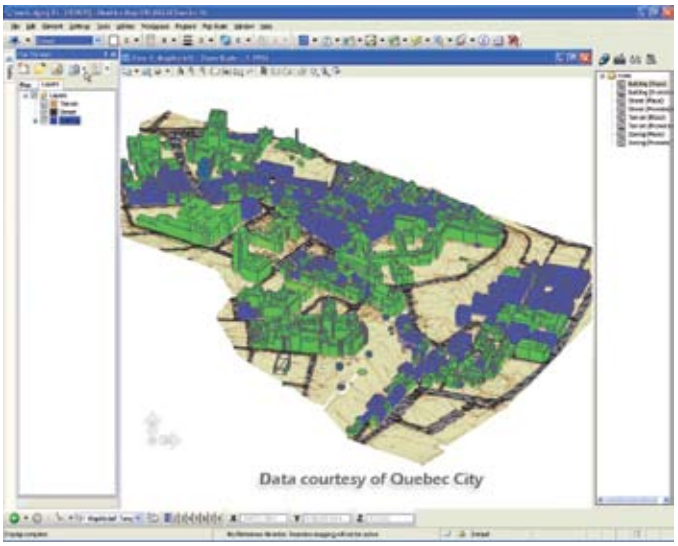
1. 3D modelling and quality control,
2. Persist, manage, and serve,
3. 3D analysis and design.

3D MODELS AND QUALITY CONTROL

Creating 3D models that can be used throughout the design-build-operate lifecycle requires data, techniques, tools, and effort. Depending on the municipality and the infrastructure project, different data creation techniques can be used, including aerial surveying techniques (aerial photogrammetry or aerial LIDAR);



Similar to 2D GIS, a 3D City GIS model can be used to generate powerful thematic maps using semantically rich data associated to 3D objects. Data courtesy Quebec City



This thematic map shows where BIM files are available in the 3D city model. Data courtesy Quebec City

Extract, Transform and Load (ETL) processes; and terrestrial-based surveying. Whether a municipality subcontracts the execution of 3D models or creates them in house, a good integration of acquisition techniques is required since quality control is always an issue for municipalities.

PERSIST, MANAGE AND SERVE

Persisting, managing, and serving constitute the platform of a 3D City GIS. This type of system should provide a secure, collaborative, interoperable, and scalable environment to manage all the infrastructure information, the resources, and the workflows throughout the infrastructure lifecycle.

Practitioners typically use specialised desktop applications to interact with the 3D city model, while front-office users might prefer web applications such as Google Earth, where the data is streamed in by powerful web servers. To satisfy such heterogeneous users, a 3D City GIS should combine flexible capabilities to serve data to users on differentplatforms.

3D EXPLORATION, ANALYSIS AND DESIGN

A 3D city GIS should provide a comprehensive set of analysis, exploration, and design tools for all data types to allow users to make smart decisions from early in the design phase of a project through operations. This includes tools for thematic mapping, joins, spatial queries, and more.

Users of good models have the opportunity to simulate a rise in water level, perform queries on 3D city models, perform shadow analysis, and more. 3D intersections/interference detection capabilities are also available, allowing the detection of any intersections between objects. For example, a building in an airport campus may be shown to be intersected by a 3D buffer defining a flight path. Another example is a Bentley's thematic map that can be created to identify whether or not a 3D building. The 3D city model then becomes the natural environment for navigating between varying levels of geo-coordinated data.

HOW TO GET STARTED

Moving forward with a 3D City GIS is not a simple process. It involves numerous considerations, including the data and technical resources available within the municipality. One approach is to start with a relatively simple 3D City model with a low-level of detail for the entire city and then enrich certain areas later on during the execution of specific projects that generate more accurate data. As the 3D city model matures, its value will increase and encourage broader adoption of this paradigm in municipal organisations, including in the reuse of data during infrastructure operations.

Simple 3D city models can be created by the use of highly automated aerial LIDAR data acquisition as well as by incorporating data that already exists in the GIS database. For example, existing digital terrain models, orthophotography, and building footprints with an attribute defining the building height can be used to establish an initial 3D City model.

CONCLUSION

The complex challenge of managing, operating, and maintaining municipal infrastructure is a lot easier with the implementation of a 3D City GIS. It reduces the duplication of effort found on many projects, facilitates access to relevant information, and simplifies communication among stakeholders. Many world cities including Toronto, Copenhagen, Quebec and Helsinki, are using intelligent 3D city models to solve real problems such as urban planning, noise studies, solar studies, zoning consultations, and flood and disaster planning.

All levels of government are facing infrastructure management and operations challenges. While these challenges are substantial, 3D City GIS projects will play a significant role in creating and supporting intelligent infrastructure that, in turn, will allow cities to grow confidently and sustainably. IT