New York City Unlocks the Value of 3D Cadastre with GIS

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SUMMARY

The two-dimensional cadastral maps have been relied upon by tax assessors for centuries but are limited due to their inability to show what is happening above and below ground. By leveraging Geographic Information Systems (GIS), New York City developed a state-of-the-art three-dimensional tax map and a one-stop shop portal for property owners. Property owners can verify their building and land data for accuracy, view and challenge their assessments and exemptions, view their sales, mortgages and recordings, and trace the history of lot changes to their parcel. Developers can digitally submit their BIM models to seamlessly populate the 3D cadastre.

The three-dimensional perspective allows assessors to walk around buildings and see interior floor plans. The 3D feature enables the potential development of 3D variables, such as views and weathering, for valuation. The 3D visualization is particularly important for air lots as it shows the potential for development.

We discuss the limitations of 2D maps, the long-term benefits of moving to a 3D system, challenges in building a 3D cadastre, applications of the 3D parcel map beyond the use for assessments and taxes, and integration with other city agencies, along with advances in technology that made it all possible.

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1. OVERVIEW OF NEW YORK CITY'S CADASTRAL SYSTEM

A cadastre is a system that registers and manages land and building information, including their physical status and legal rights. There are many benefits of maintaining a cadastre including the ability to regulate and manage property rights, resolve property disputes, and assess properties for taxation.

A primary component of New York City's cadastre is its tax map. The tax map is a special-purpose map used for property taxation. The tax map shows, in graphic display, the inventory of assessable properties used to produce the tax roll. Linked to the tax map are land and building information such as ownership, transfers, liens, metes and bounds description, zoning, permits, and other real property information.

The tax map dates to 2008 when the maps were converted from Mylar maps into 2D GIS. Figure 1 shows a two-dimensional tax map. With a two-dimensional coordinate system, the x and y coordinates denote parcel location and the metes and bounds show its size and shape.

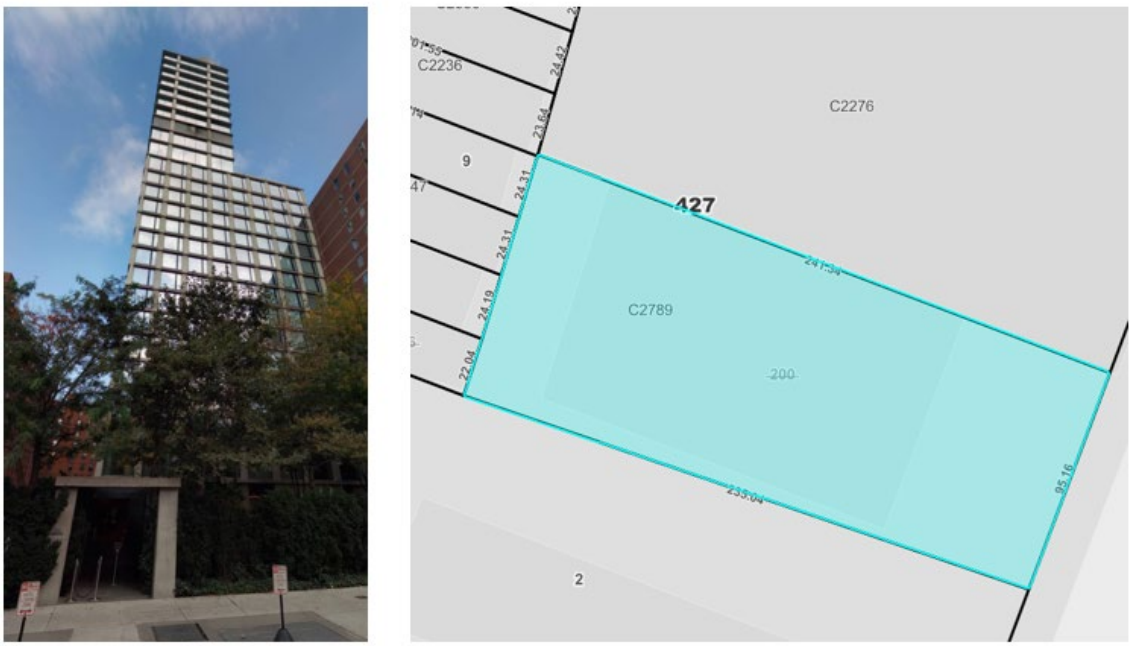

Figure 1. Condominium lots in a 2D tax map.

A major limitation of a 2D tax map is that it is restricted to the analysis and display of land boundaries. Tax lots that sit above or below ground level cannot be displayed in a 2D map. For example, the condominium development in Figure 1 can only be labeled with its identification number in the 2D map, in this case a condominium identified as 2789.

2. THE ROLE OF GIS IN DEVELOPING 3D TAX MAPS

GIS technology provides a comprehensive geospatial infrastructure that supports all aspects of cadastre, including 2D, 3D, and 4D dynamic datums, strata rights, condominiums and common property, mineral rights, utility corridors, et al. This secure and extendable geospatial infrastructure has data and services delivered via modern technology architecture. An organization's geospatial infrastructure enables the entire organization and its stakeholders to take full advantage of all the capabilities of GIS, including 3D GIS. These robust capabilities not only include maps, apps, and dashboards, but also a platform for sharing and collaborating that keeps everyone connected and informed and delivers a holistic view to the entire organization. New York City's Property Information Portal serves as a great example of this.

Building Information Modeling (BIM) process standard ISO 19650 (ISO, 2018) and industry standard formats deliver efficiencies for developing 3D cadastral data, including direct data import from the building design and construction process, including common CAD formats. This includes the structure for electronic submission and eliminating duplicate data entry efforts to populate the GIS.

3. ADVANTAGES OF 3D TAX MAPS

A 3D tax map is not limited to displaying ground level boundaries. For a condominium, this means a 3D tax map shows the boundaries of each condominium unit and its access to building common elements. A 3D map essentially shows the floorplans of condominium buildings, as shown in Figure 2.

There is a significant advantage of being able to view the internal layout of the building when producing an accurate tax roll. The tax assessor can view the interior layout of a building at different angles, verify the amenities that units have access to, confirm square footage, unit condition, use of space and other factors that affect sales prices and rents of commercial properties.

Perhaps the more significant advantage of introducing the z coordinate is that it enables 3D analytics both at the unit and building level. Geospatial models that currently use location can be extended to estimate and predict a 3D surface, calculate 3D variables such as unit views, or incorporate height in estimating the probability of damage to a building and to each unit.

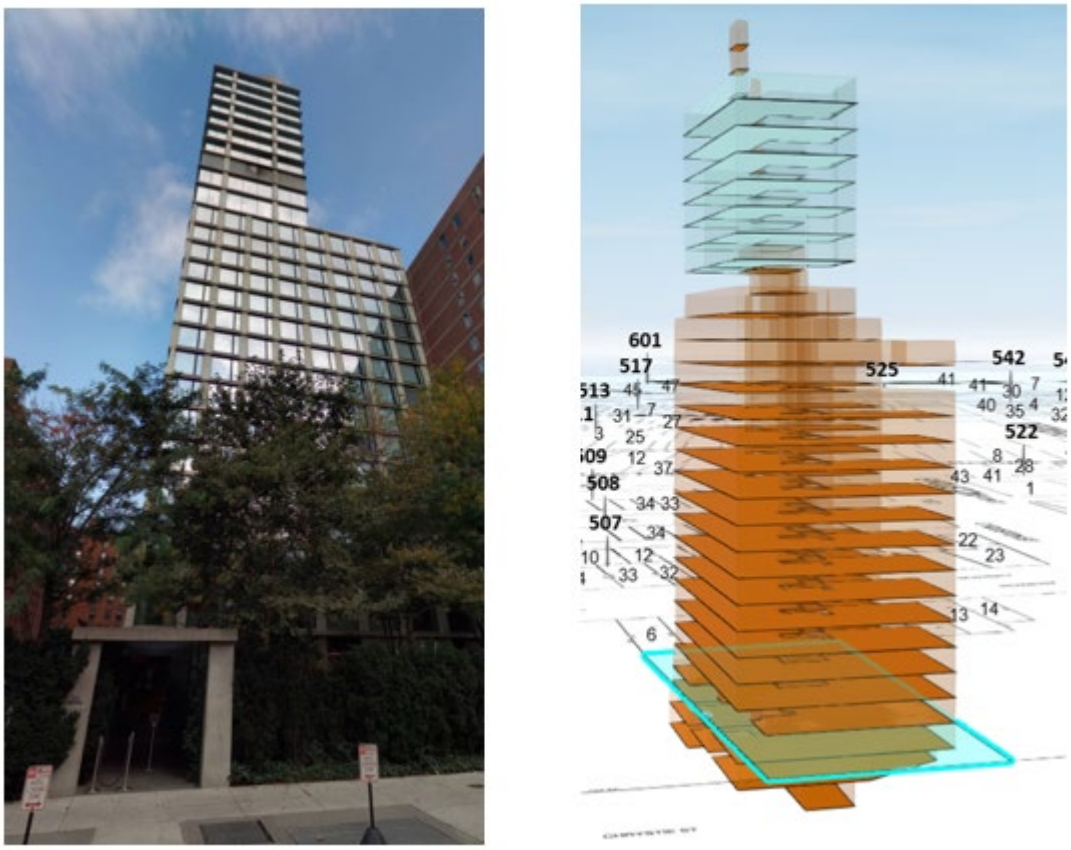

Figure 2. Condominium lots in a 3D tax map.

4. CHALLENGES

There are many challenges in upgrading from a two-dimensional to a three-dimensional tax map, primary is the source of the 3D data. In our case, the data source are pdf floor plans which need to be converted into 3D GIS. This requires software, hardware, and staff that are familiar with 3D GIS, AutoCAD, and perhaps BIM – resources that require funding. Even if these resources are available, the conversion of pdf floorplans into 3D GIS is a manual process with no known technology to make the task scalable.

The capability to accept BIM models as digital submissions is in place. However, there is no citywide strategy for uniformly accepting digital plans across departments, currently making it infeasible to make digital submissions mandatory.

5. OPPORTUNITIES

When available, a 3D tax map presents many opportunities to improve performance across agencies. Instead of pdf's, dynamic mapping to view changes in floorplans over time aides in space management, monitoring compliance with building codes, workflow efficiency in using

digitized maps instead of pages of pdf's, and richer spatial models with the addition of 3D variables through time. For example, building models that estimate wear and tear can be used to trigger inspections, and deterioration of building façade materials can be correlated with elevation. Additionally, climate change and digital twin models can vary by elevation, potentially affecting condo units differently.

REFERENCES

International Standards Organization (ISO). "ISO 19650-1:2018 Organization of information about buildings and civil engineering works, including building information modeling (BIM) – Information management using building information modelling." 2018. https://www.iso.org/standard/68078.html

BIOGRAPHICAL NOTES

Linda oversees Esri's worldwide strategic vision for land administration and surveying. With over 20 years of experience working in the land and resource industry, she is a registered professional land surveyor and certified GIS professional. A leader in professional organizations, Linda is the President of the National Society of Professional Surveyors. She also holds a Bachelor of Science degree in Geological Engineering and a Master's degree in GIS from Penn State University.

Carmela is Assistant Commissioner of Property Valuation and Tax Mapping at the Department of Finance. Under her supervision are the production of New York City's property tax roll and the creation and maintenance of the City's cadastral maps. Prior to being appointed to this position, she held academic positions at the University of Rochester, New York University and Washington University in St. Louis, and worked in the private sector at Lehman Brothers and The World Bank. As an economist and data scientist, her interests center on the applications of technology and statistical techniques to improve accuracy, efficiency and transparency of government services.

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