3D North Sydney – Precise 3D database for Retrieval and Visualization

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ABSTRACT

The North Sydney 3D urban information model includes over 20,000 buildings and 100 kilometers of roads in a comprehensive database where the level of detail is at 5cm. This paper reviews the original intentions to establish the database and aspects of the project to collect data from ground and aerial sources and combine the data sets together so that a high level of traceability and integrity were offered as part of the benefits of using the 3D model. A status report of the existing uses of the model is given together with an outlook of expected future uses. The paper concludes with some of the issues that the authors expect will support an increasing trend to further deploy high resolution 3D models.

1. INTRODUCTION

Computer generated three-dimensional models for the visualization of urban areas is, to some extent, common practice for planning purposes. One such example in Australia, Metroscan was produced in the mid 1980's at a resolution of plus or minus one meter. The data source was aerial photographs that were processed and then transferred to raw Microstation DGN files. The data provided 3D visualization for zoning and regional planning. Like many 3D models, Metroscan was application dependent. Its resolution related to the specific application and was funded accordingly. Many planning applications only require a resolution which can cost effectively be produced with photogrammetry techniques or satellite image processing. Generally, cost restraints cause the data sources to be limited to satellite imagery or aerial sensors rather than ground based surveying or other data collection systems. The models also tend to be one-offs and are not kept up to date after changes to the physical environment. Many of these models cannot be used beyond their original intended application. They tend to date due to lack of commitment to maintain them. The return on investment is limited to the application and time period.

There is however a trend toward a higher demand for higher resolution 3D urban models. The three main drivers for this trend are:

- Higher integrity that lessens disputes about data quality and sources and allows management to focus on relevant planning issue.
- Lower costs of data collection and data collection due to improvements in various technologies including ground based systems.
- Broader use of 3D visualization for various purposes and associated initiatives to "collect once, use many times". The cost to produce a higher resolution model is more than offset by the revenue from multiple sales of the data. Higher resolution guarantees multiple uses.

In 1998 a 3D model of North Sydney was completed and delivered to North Sydney City Council. Even today, it is one of the few high-resolution 3D urban information models that have been used for a variety of purposes.

2. THE PROJECT

North Sydney City Council wanted to update information to support their Geographic Information System. The specification was driven by a need to improve the integrity of data for decision-making and was set at 1:1000, so locating detail to around +/- 0.10 meters was considered adequate. Physical structures were to be collected. It included buildings, stairs, trees, assets such as street furniture, signs and physical detail around boundaries. They wanted to be able to have 3D representations and also port data to their GIS "Genamap".

After considering all tenders, North Sydney City Council accepted an offer for a high definition model from PSN Surveys. The model would be collected to an accuracy of +/- 5 cm and compiled from a combination of aerial photographs and ground based surveying systems.

The council's area overage is about 12 square kilometers but the photo coverage was 18 square kilometers which included considerable water areas of Sydney Harbour on the photo edges. The water areas on the edges of the photos did create some complexities in establishing photo control but after several iterations in Socet Set.

Several hundred second order control stations were placed through the area and tied to the NSW state control. Leica GPS System 300 was used for the survey and photo control points including points on top of skyscraper roofs. There were no issues regarding the use of GPS in urban canyons because there was a limited need to use control in those areas.

Leica TPS System 1100 total stations were used to collect corners of buildings, steet furniture, signs, trees, front and back of kerbs, gutter crossings, awnings, hydrants and other services.

Twenty five different software packages were used to collate the data into the final 3D model. Since data integrity was expected to be a crucial feature of the model, proprietary software was developed by PSN Surveys to ensure traceability. It also provided a smoother process for interlinking the various sources of data. The main "viewer" for the model was Bentley's Microstation software.

The project took 18 months to complete.

3. THE RESULT

The North Sydney 3D model includes more than 20,000 buildings including high rise office blocks, residential dwellings and historic terrace houses. 100 kilometers of roads and over 250 kilometers of footpaths are included. Every manhole, gas valve, telecom pit, and hydrant has been mapped and linked to the councils GIS. Trees and sign posts are also included. The physical nature of some of the data did not allow the full 5cm acuracy. This included old rounded sandstone curves, tree canopy and leaning sign posts.

Subsequent to the data collection and compilation of the North Sydney contract, PSN initiated the SAGE project to formalize the processes and procedures of acquisition and communication based upon a set of hardware and software methodologies. Now referred to as SAGE, the project includes the processes and proprietary software, which enable the data to be brought together and form the model.

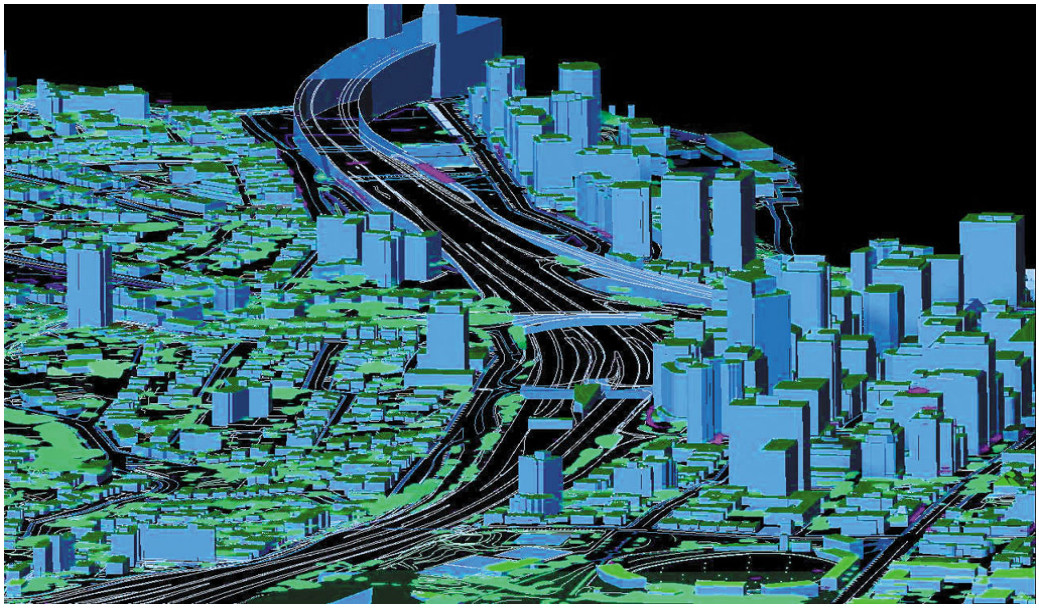

Figure 1: Section of 3D model of North Sydney

North Sydney is now able to produce a variety of deliverables from the data base such as accurate shadow diagrams.

Since the original North Sydney model was delivered to North Sydney Council, the demand for project specific sub models that include photo realistic images has increased and sections of the model now have textural elements. Around 5% of the model includes textured buildings and streetscapes and is rapidly increasing. The authors acknowledge that photo realistic models have also become necessary to promote the data sets and the model itself as well as being suitable for specific, mainly architectural, applications. Textural models are made by fitting digital photos onto wire frames of buildings and is done using a variety of photo fitting software linked to the SAGE datasets. The wire frame of the buildings is uplifted from SAGE and the result including the texture fit is stored and can be reported from SAGE.

4. CUSTOMERS, USEAGE AND FUTURE PROSPECTS

The model has been used for asset management and maintenance, shadow and details “right to light” analysis, view preservation and many other planning applications. Property developers and architects have been customers of sets of the data or for services that draw upon the data. Development applications that use data from the same model as the municipality have the opportunity to benefit from shortened development approval times, since disputes about the quality of the base data are eliminated and visual aids for public participation in development consent can be produced rapidly.

North Sydney Council is the main user and owner of the data model. The council’s Planning Department is one internal user. They conduct “right to light” or shadowing analysis of proposed developments. They are now able to attach 3D views to reports. They also download updated asset information into their GIS: Genamap. Zoning and land and property use classification in conjunction with cadastral information is available within their GIS. The largest benefit of the 5cm acuracy has been the integrity of the “right to light” analysis, particulary in confined spaces.

Shadow paths across neighbouring buildings can be plotted to within a few centimeters and enable optimization of building height and design. The accuracy has greatly aligned visual recognition of physical objects near boundaries with true cadastral boundaries and base Local Environment Plans (LEPs) have been updated to include a more accurate alignment of cadastral boundaries with physical existing information. This has improved recognition of boundaries and potentially minimizes disputes over land use intentions.

The council's Engineering Department accesses the 3D model for a variety of planning and administration tasks. Estimating costs of road resheeting and maintenance for budgeting, reporting and to some extent project supervision are examples of routine use. Documentation and asset management of street signs and street furniture is another use.

The council's Parks Department has similar uses as engineering, but park management is able to plan the design and construction of parks and landscaping including pathways.

The council's Land Information Department administers the database.

The Heritage and Rates department tends to access data directly from their GIS. It is an indirect way of using data from the model data although 2D views are produced rather than 3D visuals.

North Sydney City Council enjoys a reputation as a forward-looking council with many of its ideas and innovations being adopted by other councils (e.g., Smart parking meters). Elected officials and appointed senior managers of the council have supported the urban information model as complementary to their efforts to improve public participation in an overall improved planning process and with the confidence that the high integrity and high traceability back their planning, budgeting, approval and supervisory decisions.

Development constraint analysis tools are derived from the database and subsequent reports commercially provided to architects. One benefit is that the data set is compliant with the regulatory authority (i.e., North Sydney Council). Constraints are topographical (i.e., landform), structural (e.g., neighbouring buildings), environmental (e.g., storm water or energy coefficients) and socio-political (floor space ratios, occupancy densities, provision of handicap access etc.). The resolution of the data allows many architects to prepare proposals and applications for development approval without a new survey.

Property developers are using the data sets for a variety of applications. One developer, who owns a significant number of North Sydney properties, has conducted a cost benefit of adding floors to building based on the existing roof top service infrastructure. The potential extra space without the cost of land acquisition is proving an interesting option and has only been viable to calculate form high-resolution information. Another developer uses the data to identify potential development. Whilst this is not a high-resolution need, the fact that the data is immediately available and maintained by PSN has sped their analysis and conclusions.

5. INTEGRITY AND MAINTENANCE: TOWARDS A SUSTAINABLE 3D MODEL

The 3D model of North Sydney is expanding in terms of usage, level of detail and currency of data. Many future uses have been identified and reviews are presently underway by other state and local government authorities in order to consider applications in emergency service planning, traffic planning and internal security. Security applications would require the combination of interior 3D

visualization. Neighbouring municipalities are examining the potential to expand the area extent. Not only are they considering getting similar benefits to North Sydney, but also they would be able to consider common planning issues such as traffic, neighbouring shadow lines, harbour foreshore development and harbour view optimization.

The learnings of combining data from various ground and aerial sources, ensuring data processing traceability to original measurements and assuring data integrity at the 5cm level has been packaged in a procedural system and software solution called SAGE. SAGE will be used to maintain the North Sydney database. It will also become available as a package for other organizations to roll out similar projects for high definition high integrity 3D urban information models.

Improvements to technologies in data collection and data processing are expected to further lower the costs of building and updating 3D urban information models. These identified improvements include:

- Use of ground based laser scanners to collect 3D detail.
- Use of Aerial LIDAR to improve height resolution and extraction of 3D data.
- Improved resolution of Aerial sensors.
- Combination of point clouds from aerial and ground based sensors.
- Feature extraction from point cloud data.
- Purpose built feature extraction algorithms such as roof top extraction and building shapes.
- Faster techniques to collect and fit digital images to the model to create textured models.
- Change detection logic.

The "owners" commitment and funding to maintain a 3D urban information model beyond the original purpose and funding for the one-off application has been an issue for further deployment of sustainable 3D urban information models. However, wider usage, new applications such as security and lower costs of producing high accuracy models create confidence that sustainable, high integrity 3D urban information models will be widely adopted.

6. CONCLUSIONS

The North Sydney 3D urban information model, based on the SAGE system, has shown that high resolution data can be collected once and commercially used many times. Crucial to the success of such a database lies in the confidence of the integrity of the data and the traceability to original measurements, including the georeferencing. As technological improvements and wider deployment of data sets increase, the viability of new databases and sustainability of existing high-resolution models seems assured. As such the Geomatics profession has a unique opportunity to become the "authority" to provide high integrity 3D urban information models.

7. ACKNOWLEDGEMENTS

North Sydney City Council.

8. REFERENCES

North Sydney CBD Local Environment Plan amendment number 9.