3D GIS: It's a Brave New World

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SUMMARY

For the past several decades we have been enjoying the power of GIS. The introduction of 2.5D concept in GIS in the late 80's and early 90's has enabled GIS to take on other dimensions and enabled users to get closer to the real world. However, the absence of a near-reality visualization was still required. The oblique photography has solved some of these issues in the early 2000's and was able to provide tools that allowed the users to get some of their problems solved. This, however, was less accurate than what most of the users were used to. All of this has created the need for 3D Models or what is known today as 3D GIS for better visualization, simulation…etc.

New technologies such as Mobile Mapping, Oblique Photography…etc. have allowed us to develop cost effective and photo-realistic texturing of 3D models. Standards have been developed such as CityGML for better utilization. The advancement in web technologies has also greatly contributed to the successful implementation of 3D City Models to support town planning, environmental analysis, security and emergency management as well as many other applications.

This paper discusses the usefulness and advantages of 3D GIS as opposed to 2D GIS and how this natural evolution will help plan for the growth of our cities.

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Reida Elwannas
3D GIS: It's a Brave new World

FIG Working Week 2011
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Marrakech, Morocco, 18-22 May 2011

1/9

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1. INTRODUCTION

In a simple definition, a City is an area of interconnection between people and numerous factors that govern our daily lives such as Housing, Transportation, Water, Wastewater, Climate…etc. We have long been worried about how to improve the existing infrastructure in our cities while planning properly for their growth. Mapping and GIS have long contributed to these efforts ensuring that the latest technologies have been deployed to facilitate the decision making process and provide accurate and up-to-date information to various stakeholders. The continuous improvements in GIS (and for that matter in many other technologies which inter-relate with GIS) over the past 20 years are now allowing us to visualize our cities in a true 3D environment which will in turn allow us to better manage our cities. GIS is no longer 2D, but is now 3D. The fact that we are now capable of building 3D City Models in a GIS environment is going to allow numerous activities such as Cadaster, Public Safety, Traffic Control…etc. to take on other dimensions.

2. WHY 3D GIS?

The real question should be "Why not 3D GIS"?

Certainly our world is 3D and not 2D. Any simulation or decision we would want to take should be based on what our real world looks like. Although this seems to be natural, it is not as straightforward as one would think.

Everything around us is in 3D. The world is definitely not flat. Everything is impacted by the third dimension. For example, the energy consumption in any city is directly linked to the shadows, airflow, sun reflection…etc. Energy consumption is therefore directly linked to the heights of the buildings and thus the third dimension of our cities.

The modeling that we were able to conduct so far in 2D, gives results that do not take into consideration the third dimension. For example, a 2D flood simulation will only provide us with areas that are potentially to be affected. Unless and until we have the third dimension component built into our models, we will not be able to determine which floors will be impacted and which ones will not? And under what conditions?...etc.

Building Permits issuance, in many countries, represent a very lengthy process especially in crowded cities. Modeling the building before it is even built and checking its impact will definitely help expedite this process.……GIS must be 3D simply because our world is 3D.

3. 3D GIS: THE TECHNOLOGY:

Up until the 80's, the use of maps was widely restricted to the use of paper maps. We began transforming paper maps (and mapping) in CAD formats in late 80's. The CAD layering process was a breakthrough which many enjoyed but not for too long. The need for better analysis and the advancement in computers led to GIS (or 2D GIS). Because of the importance of the third dimension, we began including it in what was called 2.5D GIS in mid to late nineties. The advancement in Photogrammetry and production of digital Orthophotos as well as the wide availability of Satellite Imagery have given a boost to GIS to become more and more useful by larger communities. In early 2000's, oblique photography was a real breakthrough. Pictometry, for example, was able to produce 3D simulations of cities, which became quickly very popular in many countries. These simulations were considered a good bargain, which allowed the users access to the real world. Soon these users, however, realized that they needed more. They needed a more structured and more accurate GIS model, which is now called a 3D Model or what we are referring to here as 3D GIS.

Oblique Aerial Cameras, Mobile Mapping, Aerial Triangulation for Oblique Imagery, Semi-automated Texturing Techniques, Standards for CityGML…etc   are technologies which allowed the development of 3D GIS. 3D City Models can now be stored and shared by various stakeholders using GIS techniques.

4. 3D GIS: THE DATA

According to Wikipedia, 3D City Models are digital representations of the Earth's surface and related objects belonging to urban areas. CityGML is an open source modeling language for 3D City Models that defines the classes pertaining to various features included in the 3D City Models. While there are many data models that support 3D Modeling such as X3D, KML, VRML…etc. CityGML has emerged as an open source tool or method for modeling 3D City structures and objects.

In a 3D City Model, objects are represented in various Levels Of Details (LOD). There are five levels of details, which are:

LOD0: This is basic regional representation of a Digital Terrain Model.
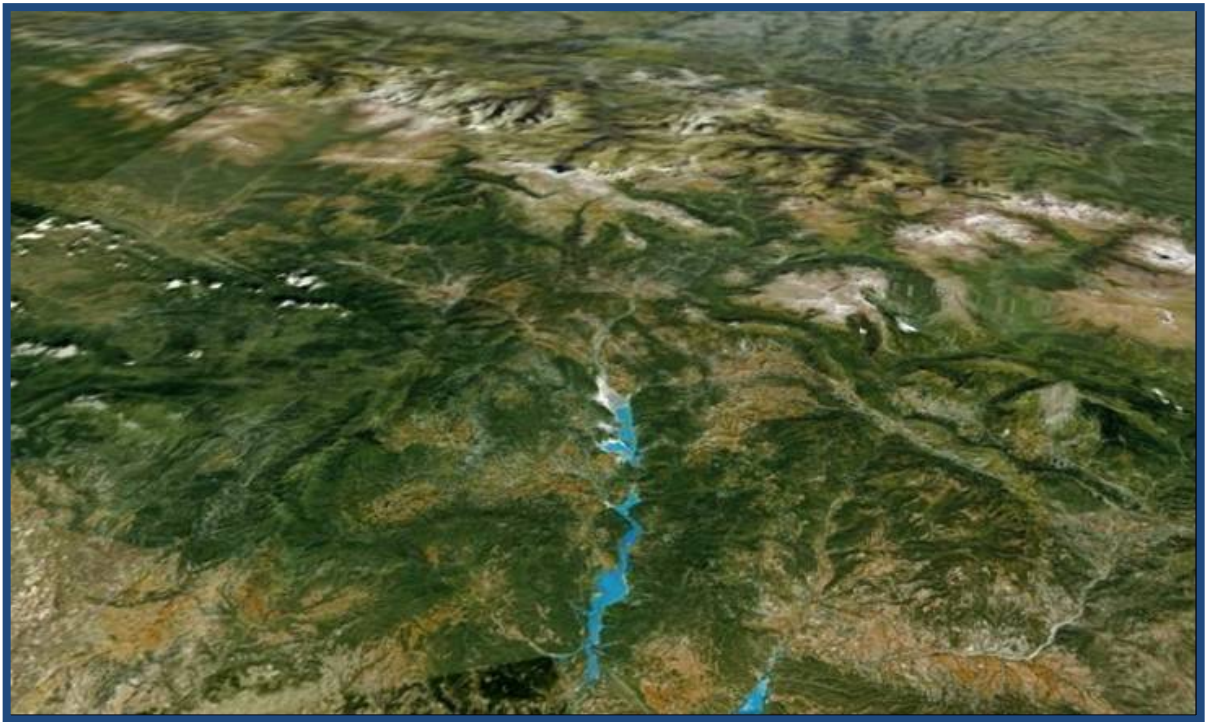
TS01C - 3D Cadastre and 3D Information   3/9
Reida Elwannas
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FIG Working Week 2011
Bridging the Gap between Cultures
Marrakech, Morocco, 18-22 May 2011

Figure 1 : LOD0 Representation

LOD1: The buildings are, in this case, produced with 2D Geometry from the highest point of the Building 3D Polygon. The vertical faces are added between each segment of the roof and the ground surface.

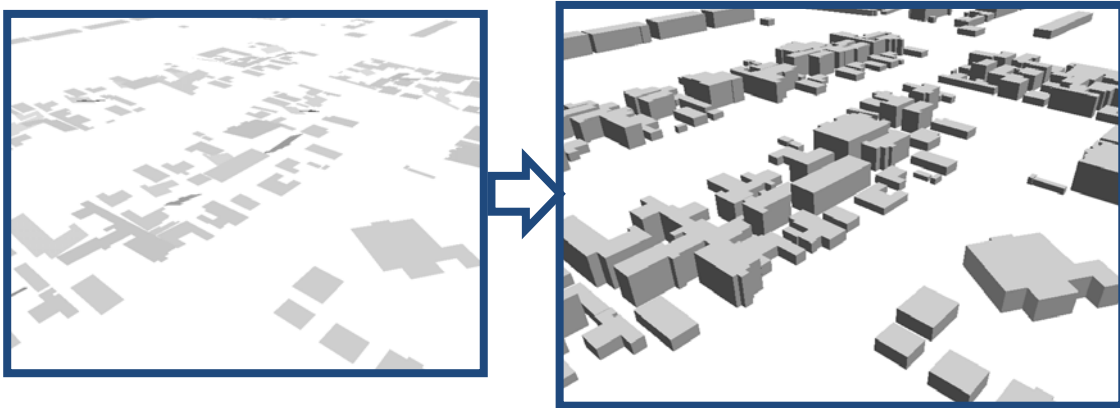

Figure 2 : LOD1 Representation of Buildings in a 3D City Model

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Reida Elwannas
3D GIS: It's a Brave new World

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Marrakech, Morocco, 18-22 May 2011

LOD2: The representation of the ground surface is the same as in LOD1, however, the 3D polygons are not flat and the roofs are geometrically accurate. The facades can be texturized using nadir aerial photography if required.
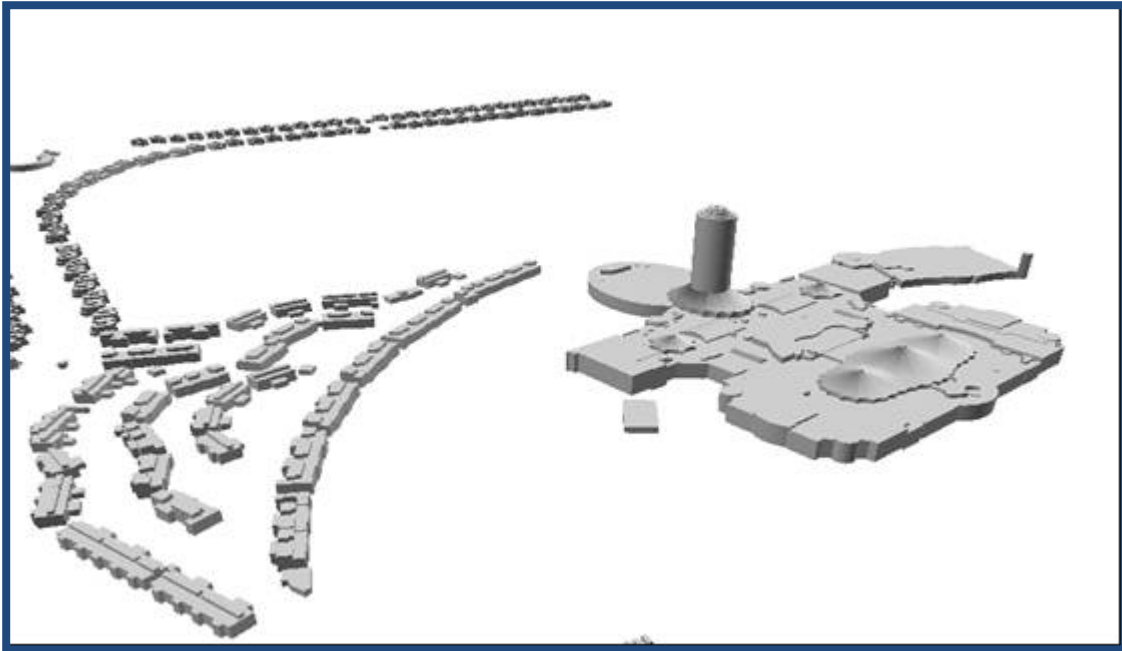

Figure 3: LOD2 Representation

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Reida Elwannas
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FIG Working Week 2011
Bridging the Gap between Cultures
Marrakech, Morocco, 18-22 May 2011

LOD3: The buildings are mapped in details. The details of the facades are mapped and texturized using oblique aerial mapping or mobile mapping techniques.

Figure 4 : LOD3 Representation of Buildings (Berlin 3D City Model on Google)

TS01C - 3D Cadastre and 3D Information   6/9
Reida Elwannas
3D GIS: It's a Brave new World

FIG Working Week 2011
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Marrakech, Morocco, 18-22 May 2011

LOD4: This is an inside representation of the buildings. Several techniques can be used to model inside the buildings (Digitizing of existing floor plans, Terrestrial LiDAR…etc.).
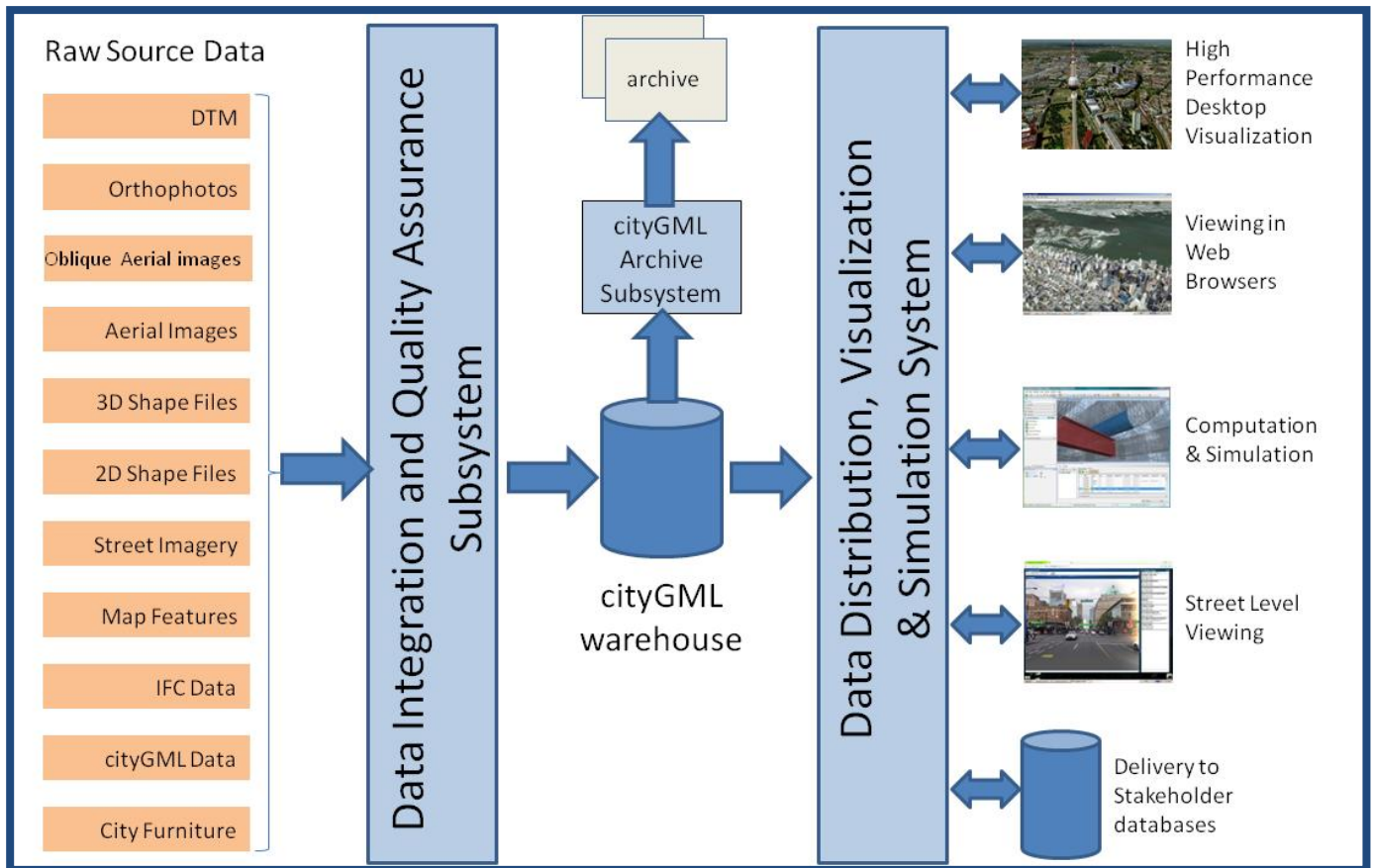

Figure 5 : LOD4 Representation

5. 3D GIS: THE DEPLOYMENT

3D GIS Models have long been deployed by Google and Microsoft. These already offer tremendous content for users. However, in the commercial arena, we would need more "Intelligent" 3D Models. These would consist of a combination of spatial and non-spatial data using web-GIS platforms such as OnPoint. We would also need to have repositories for 3D data which would be designed to support analysis and integration of complex geospatially referenced data.

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FIG Working Week 2011
Bridging the Gap between Cultures
Marrakech, Morocco, 18-22 May 2011

7/9

A typical dataflow diagram would look like the following:

6. CONCLUSION

3D City Models are a natural transition from the usual GIS. The advancement in technology allows their deployment and delivery to various users and stakeholders for various applications.

3D City Models are the results of a fusion of several technologies such as Oblique Aerial Photography, Photogrammetry, LiDAR, Mobile Mapping…etc. Once they are built, they serve as the basis of an unimaginable amount of applications and simulations that can be made available to a large number of stakeholders.

As technologies continue to advance, we should see that 3D City Models become more and more affordable, thus allowing a faster transition to 3D GIS.

TS01C - 3D Cadastre and 3D Information   8/9
Reida Elwannas
3D GIS: It's a Brave new World

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BIOGRAPHICAL NOTES

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Experience Summary:

Mr. Elwannas has over 16 years of experience in the fields of Photogrammetry, Remote Sensing and GIS. He oversees Rolta's Mapping & GIS Operations for the Middle East and Africa. He is also a Certified Photogrammetrist by the American Society for Photogrammetry and Remote Sensing (ASPRS).

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TS01C - 3D Cadastre and 3D Information   9/9
Reida Elwannas
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FIG Working Week 2011
Bridging the Gap between Cultures
Marrakech, Morocco, 18-22 May 2011