

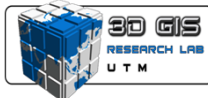



**AN AMALGAMATION OF 3D SPATIAL DATA MODEL  
FOR SURFACE AND SUBSURFACE SPATIAL OBJECTS**

**Edward Eric Duncan, and  
Alias Abdul Rahman**




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## Introduction

- **The current city Earth surface is actually an amalgamation of natural and man-made objects above, on and below the city terrain surface.**
- **3D modelling of subsurface objects and their integration with the surface and above surface objects currently lacks behind and attempts at viewing above surface and subsurface man-made objects for earth realism difficult to achieve.**




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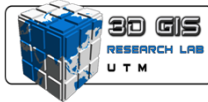





## Introduction (continued)

- Currently the urban space is a complex cadastre issue where land parcels or lots can be described for the above, on and below surface parcel lots
- Recent disasters in mining areas (Chile and New Zealand in 2010) should inform the geoinformation community of the need to incorporate the integration of surface objects with man-made subsurface objects or cavities.




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## Introduction (continued)

- Above surface objects have been studied: 3D FDS(Molenaar, 1990) 3D TIN (Abdul Rahman, 2000) SSM ( Zlatanova, 2000) UDM (Coors, 2003). 3D TEN (Pilouk, 1996) the constrained tetrahedral network (TEN) (Penninga and Oosterom, 2008), the Object Oriented Data Model (OODM) (Wang, 2006; Wenzhong et.al. 2003; Koshak and Flemming, 2002), Unified Data Model (UDM) (Coors, 2003) and the Simplicial Simplex Model (SSM) (Zlatanova, 2000) approaches have been used for 3D city models. The 3D Formal Data Structure (3D FDS) has been the basis for most models for surface and above surface objects




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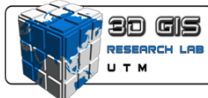





## Previous works

- These models have been used for above surface city models, below surface models (geology) and on surface (terrain) but these have not been integrated for man-made features.
- Surface 3D objects have made significant impacts in the areas of 3D structuring and topology (Zlatanova et. al., 2002), 3D visualization and virtual reality (Zlatanova, 2000; Coors, 2003; Shi and Yang, 2002; Horne et. al., 2007; Charlton et. al., 2008; Podevyn et.al. 2008, Thompson and Horne, 2010)




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## Previous works (continued)

- Stand-alone subsurface 3D models have been investigated and implemented (Raper, 1989; Raper and Maguire 1992; Latuada, 2006; Hack et. al., 2006; Apel 2006; Breunig and Zlatanova 2006; Tegtmeier and Zlatanova 2009) it is yet to be integrated with the on and above surface scenarios
- Research into subsurface data models have been reported extensively by Breunig et. al., (1994, 2001).




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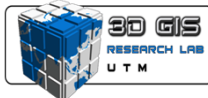





### Previous works (continued)

- Abdul Rahman (2000) used the 3D TIN for drillhole locations, This idea was extended by Wang (2006). Breunig (2001) carried out extensive research on geological bodies (GeoToolKit) using the TEN model. Tegtmeier and Zlatanova (2009) implemented the simplex concept for subsurface geotechnical consideration. Zhou et. al. (2008) also used the cell complex and implemented the model for geology.




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### Previous works (continued)

Facial model	Volumetric model		Mixed model
	Regular	Irregular	
TIN	CSG	TEN	CSG-TIN
Grid	Voxel	Pyramid	TIN-Octree
B-Rep	Octree	Tri-Prism	Octree-TEN
TEN	Cube	GTP	TIN-Octree

Table 1. Some models being used for 3D GIS




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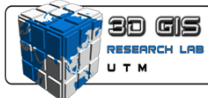

## Previous works (continued)

3D Spatial Model	Subsurface Application	Researcher
3D TIN	Borehole data	Abdul-Rahman and Pilouk, 2008
OODM-ISDM (TIN +TP)	Borehole and Geological data	Wang, 2006
GTP	Geological bodies and engineering excavations	Wu and Shi, 2004
0-3 Cell complex	Geology	Zhou <i>et. al.</i> , 2008

Table 2. Spatial models and subsurface applications




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## Unified concepts

- **Emgard and Zlatanova (2008) discussed an information model under development which will integrate features above, on and below the surface into a common semantic and geometric model by representing two alternatives in a conceptual model. Some of these concepts have been adopted and modified in this research.**




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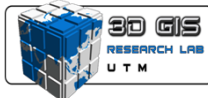





## Unified concepts (continued)

- The 3D unified model for the above, on and below surface has been adopted based on 3D TIN (Abdul Rahman and Pilouk, 2008; Emgard and Zlatanova, 2008; Wang, 2006).




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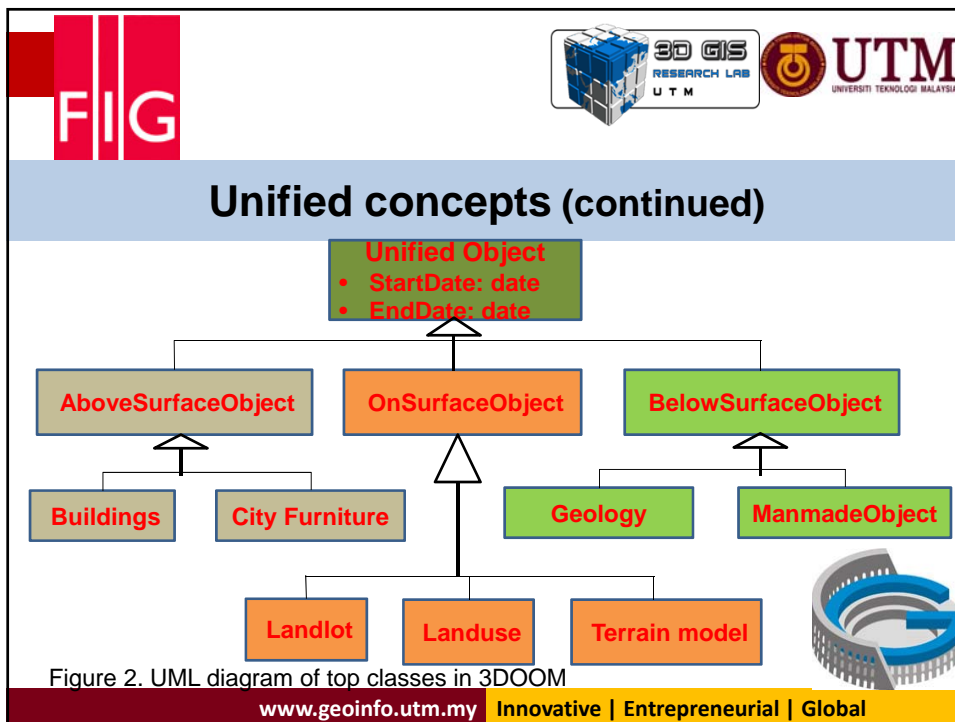
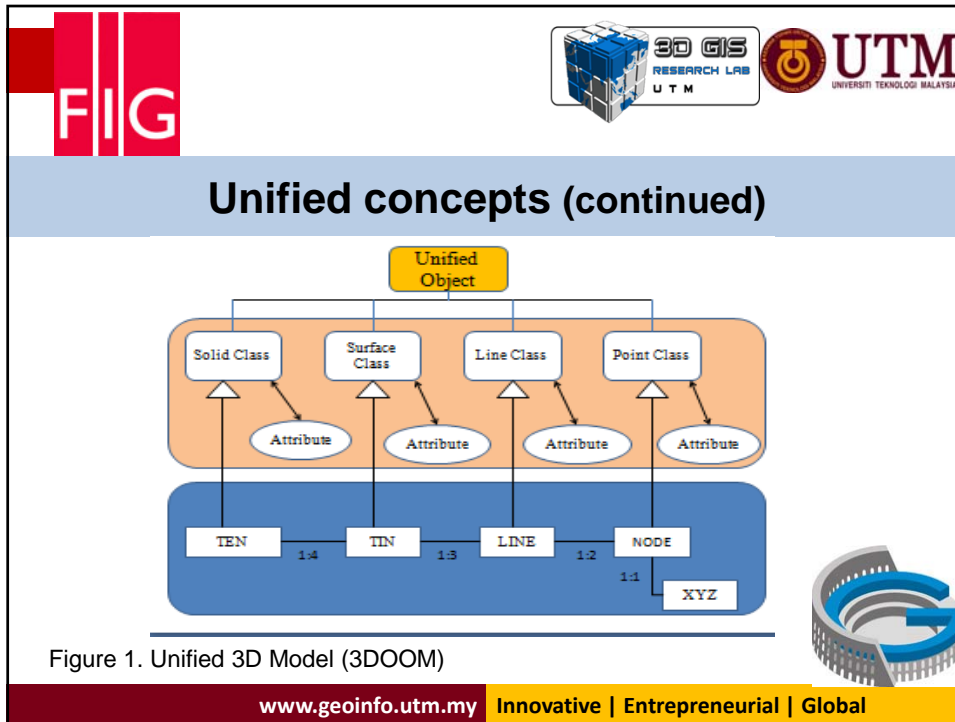




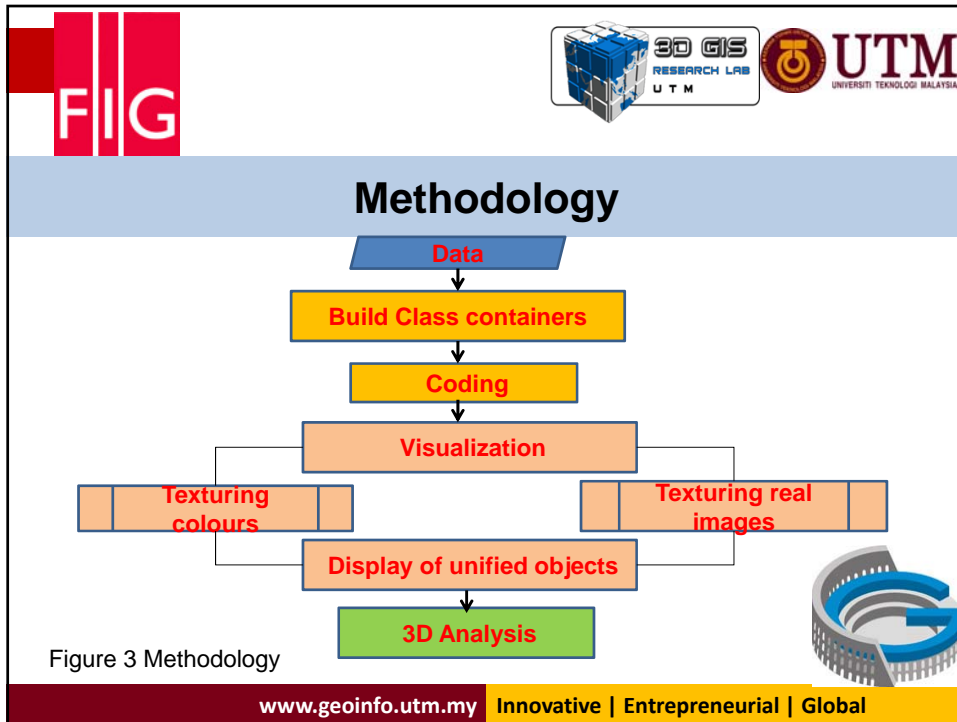
## Unified concepts (continued)

- The concept for a unified model based on man-made features for above, on and below the earth surface is the basis for this research.
- The geometric primitives of node, line, triangle and tetrahedrons is considered.
- Topological relations such as: *is in*, *is on*, *near to* *is* explored in conjunction with other relations..






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### Initial results (continued)

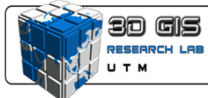

LoD	Above Surface	Subsurface	Integration	Map Type
LoD0	√	√	√	2D
LoD1	√	√	√	3D
LoD2	√	–	–	3D
LoD3	√	–	√	3D
LoD4	√	√		

Table 3. LoD combinations for the unified model




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### Concluding remarks

- An in-depth review of current surface and subsurface models showed that the concept of 3D FDS has been enhanced in various applications for 3D GIS with 3D TIN being adopted or used in a hybrid model for most applications for the city Earth space.




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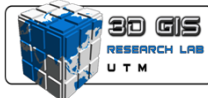





## Concluding remarks (continued)

- Unified models in the area of above surface objects and below surface geology has been studied. The concept for a new unified model seeks to enhance this further by incorporating the above surface objects and below surface geology and man-made objects which are naturally part of the complex city Earth surface. The UML diagram seeks to show this concept and the top classes of 3DOOM.




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- Unified models in the area of above surface objects and below surface geology has been studied. The concept for a new unified model seeks to enhance this further by incorporating the above surface objects and below surface geology and man-made objects which are naturally part of the complex city Earth surface. The UML diagram seeks to show this conceptual idea and shows the top classes of 3DOOM.
- The algorithm for the unified model if adopted will find useful applications in 3D Cadastre and Mining.



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## Future works

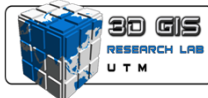

**Possible application areas:**

- A prototype interface.
- An improved 3D cadastre showing land parcel ownership for, on and above surface (strata) and below surface (stratum)- useful for multipurpose cadastre for cities.
- A possible mining application for surface and subsurface mines-useful for mine planning and mine disasters.
- Facilities management.

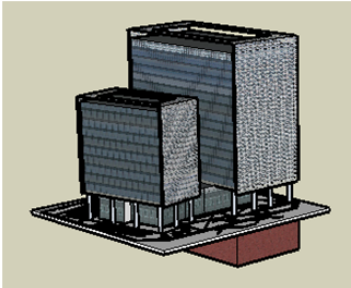



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## Future works (continued)

UNIFIEDMODEL1																
File	View	Query	Database	Applications												
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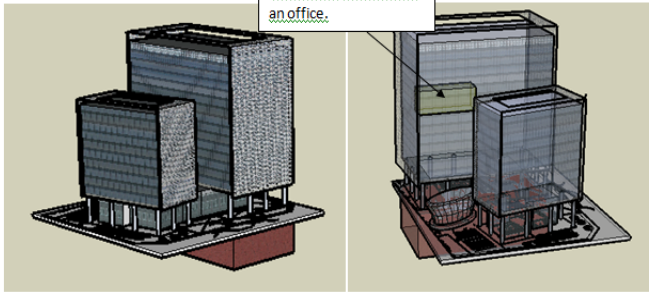


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### Future works (continued)

UNIFIEDMODEL1				
File	View	Query	Database	Applications
		Finding the Location of an office.		3D Spatial operation



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