ENABLING GEO-DESIGN: EVALUATING THE CAPACITY OF 3D CITY MODEL TO SUPPORT THERMAL DESIGN IN BUILDING

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ABSTRACT:

This paper reports a study that has been undertaken as part of an on-going project to examine the capacity of 3D city models to support thermal design of building. The two standard used for this is CityGML and gbXML. The first is an OGC standard for the exchange of 3D city information, and the second is a CAD standard to exchange of information between engineering and environmental analysis software. In particular, our premise is that effective thermal design relies on the ability to exchange urban environment information such as surrounding building, green areas, streets, trees. CityGML is a 3D information model that provides a detailed information about the topography and manmade objects - surrounding environment data in a robust way using an open information standard GML. The focus of this present work has been on the processes involved in design with the urban context and how it could affect the design workflow for advising on thermal performance issues. We begin by looking at the kinds of data that needs to be exchanged to support such design in context. We then test the exchange using a pilot project model and finally review the capacity of the CityGML standard to support such processes.

1. INTRODUCTION

The development of semantic 3D city models has allowed for new approaches to town planning and urban management (Benner et al. 2005) such as emergency and catastrophe planning, checking building developments, and environmental design.

Building sector in the world presents a great amount of energy consumption in comparison to other sectors such as industry, transportation. This energy is mostly used to improve the thermal performance of living spaces (NREL, 2006; Karasu, 2010; Geetha & Velraj, 2012).

Building thermal performance and energy efficiency is greatly influenced by urban planning legislation and surroundings environments (Geetha & Velraj, 2012)). Architects took account of the relationship between newly designed building and the surrounding environment. 3D city models can play an essential role for energy engineer by facilitating design simulation within the surrounding environment and urban context in early design stages. Currently, thermal simulation tools do not easily integrate the urban context (surroundings) of the new design; this is related to the interoperability issues between CAD and GIS.

This paper report the result of investigation undertaken to examine the capacity of 3D City models specifically CityGML - OGC standard; to support design process related to thermal performance issues. The paper use a case study approach to define the data required for heat demand calculation and thermal data processing including geometrical data processing. Then the paper investigates the possibility to extract the required data from the 3D city models in order to be exchanged using Green Building XML schema (gbXML) and to be used by thermal simulation software. The exchange then tested using a pilot project model and finally reviews the capacity of the 3D City model standard to supports such process.

2. BACKGROUND IN CITYGML/GBXML

gbXML is an extensible markup language that was developed to facilitate the transfer of building information between different CAD standard and engineering environmental analysis software. It aims to enable interoperability between design models and a wide variety of engineering software. Nowadays, gbXML is considered a de facto industry standard schema. The standard has industry support and wide adoption by the leading CAD vendors, Autodesk, Graphisoft, and Bentley (gbXML, 2014).
CityGML is an OGC standard, which provides a specification for the representation of 3D urban objects (CityGML, 2012). It is the only 3D information model for the exchange of 3D city models. One of the reasons for creating such a model was to enrich 3D city models with thematic and semantic information. The information model of CityGML is an XML-based format implemented as an application schema of Geography Markup Language (GML3). Today, CityGML seems to provide the best framework for semantic-geometric relations of 3D objects above the earth surface (Emgaard and Zlatanova, 2008;

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Groneman and Zlatanova, 2009). It maintains a good taxonomy and aggregations of Digital Terrain Models (DTM), sites (including buildings), vegetation, water bodies, transportation facilities, and city furniture. The underlying model differentiates between consecutive Levels of Detail (LOD), where objects become more detailed with increasing LOD regarding both geometry and thematic differentiation. In LODs 2-4 of CityGML the building facade is defined in the form of boundary surfaces, i.e. wall surface, roof surface, ground surface or closing surface. The LOD4 allows the representation of interior building elements, e.g. rooms, furniture, interior wall surfaces. Nevertheless, the current version of CityGML integrates the subsurface features, such as underground constructions (e.g. tunnels).

3. ONGOING WORK AND OUTLOOK

An important step in this study is the development of the use case. A conceptual model is built for a typical quarter (Figure 1a), a building (in green) need to be extended horizontally and vertically. The urban model is consisting of 25 plots of 36X36 m2 for each (Figure 1b). Seven typologies are proposed for this urban scale model (Figure 1a). The plots number 8 and 22 are green areas on the site, while plot number 13 is the location for our apartment block. A vertical extension of two floors (in red) is asked for this case block, which is already composed of three floors (Figure 1c).

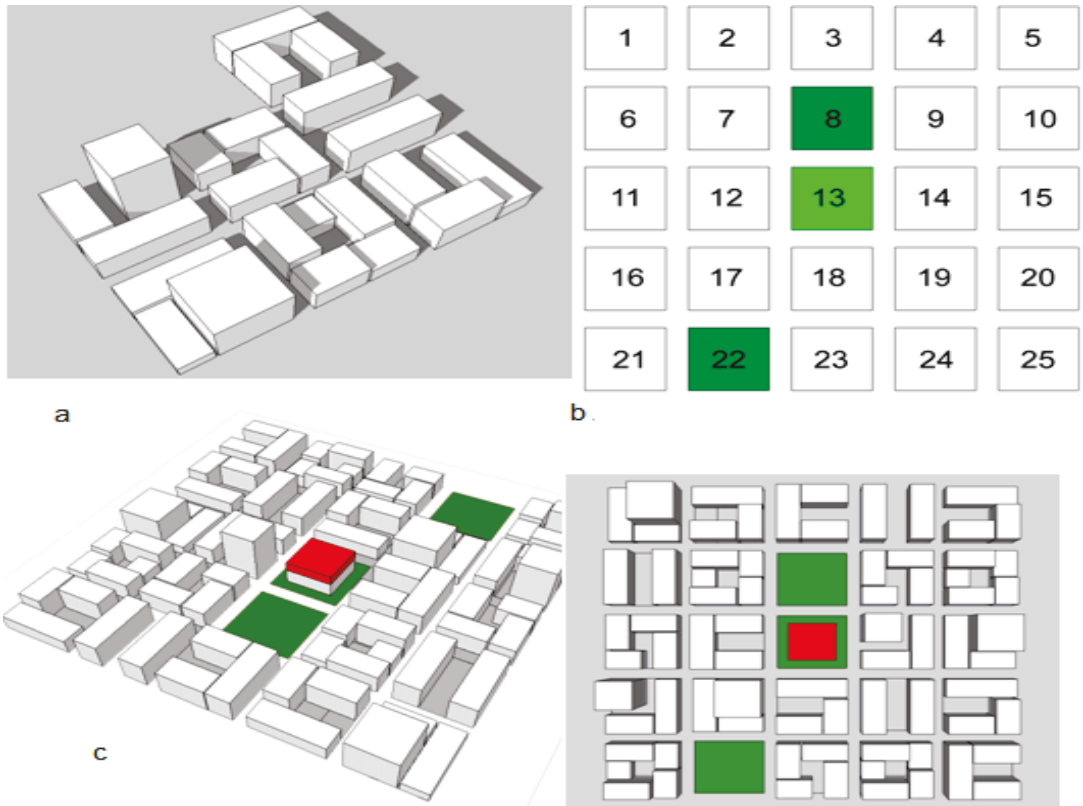

Figure 1: The quarter model, a) the seven typologies, b) plots uses, c) the proposed model in 3D and 2D

The purpose is to get to know the different variables affecting thermal performance. Until today, the factors that intervene is categorized under four main categorizes (Figure 2).

- Space uses and users activities
- Geographical and climatic factors
- Design variables
- Surrounding features

4. EXPECTED RESULTS

The work will illustrate the information requirement for thermal analysis and simulation in geo-context. Also, it will provide initial understanding for building a formal framework for the geometric and semantic transformation of 3D city objects (related to thermal design) between the two data models, gbXML and CityGML. To demonstrate the applicability of the developed framework, a number of trial conversions will be carried out between gbXML and the CityGML models, the conversion will be performed using the tool that will be developed.

Moreover, the work will demonstrate a new possible application for thermal analysis that includes indoor rooms – outdoor space. The prototype capabilities will allow us to answer questions such as: What are the effects of change in the outdoor on the thermal performance of inside of the buildings? Or where the places outside that cause a big change in the temperature of the indoor spaces?

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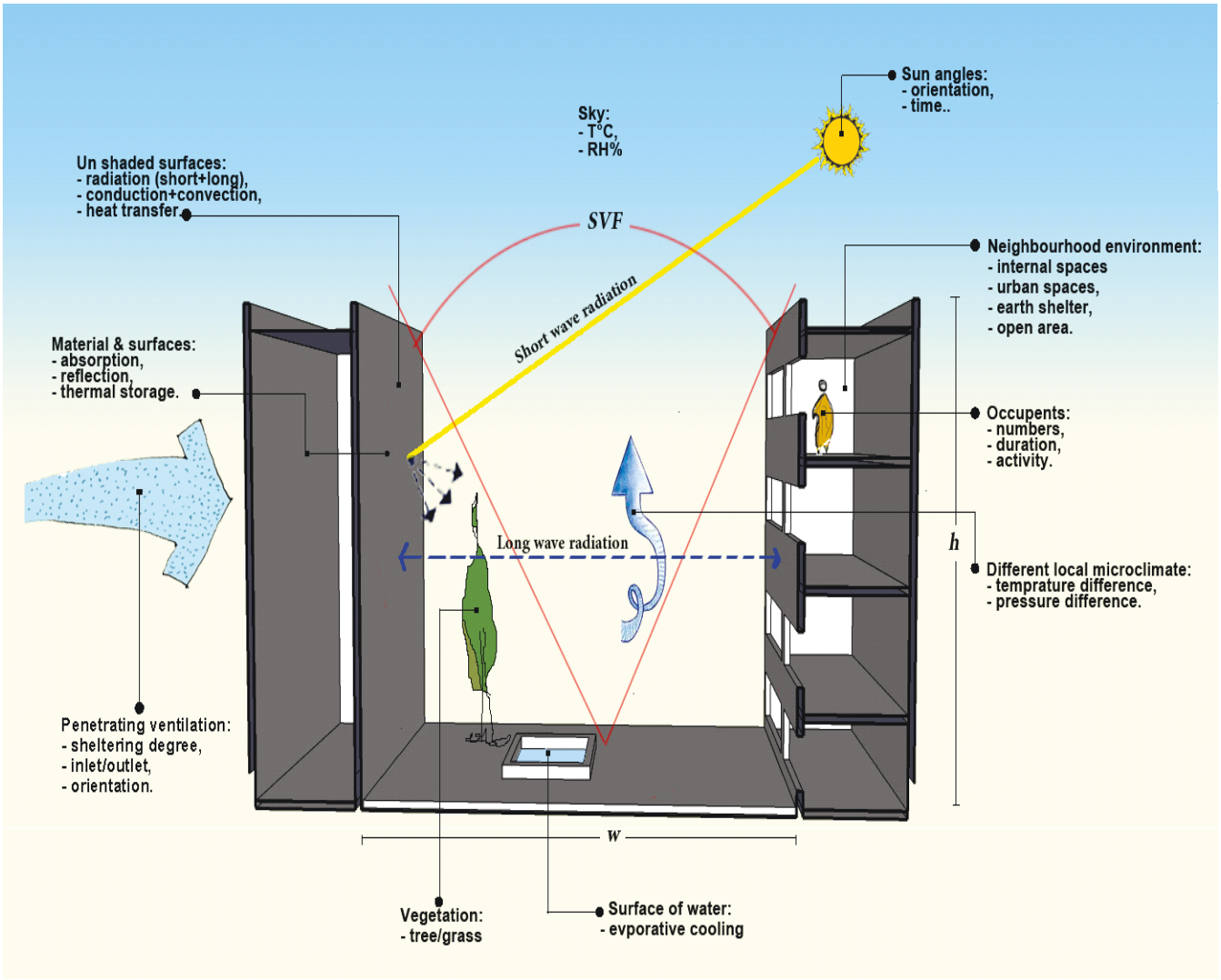

Figure 2: illustrates the different variables intervened in the question of thermal-energy performance of one room located in the new built floor of our apartment block.

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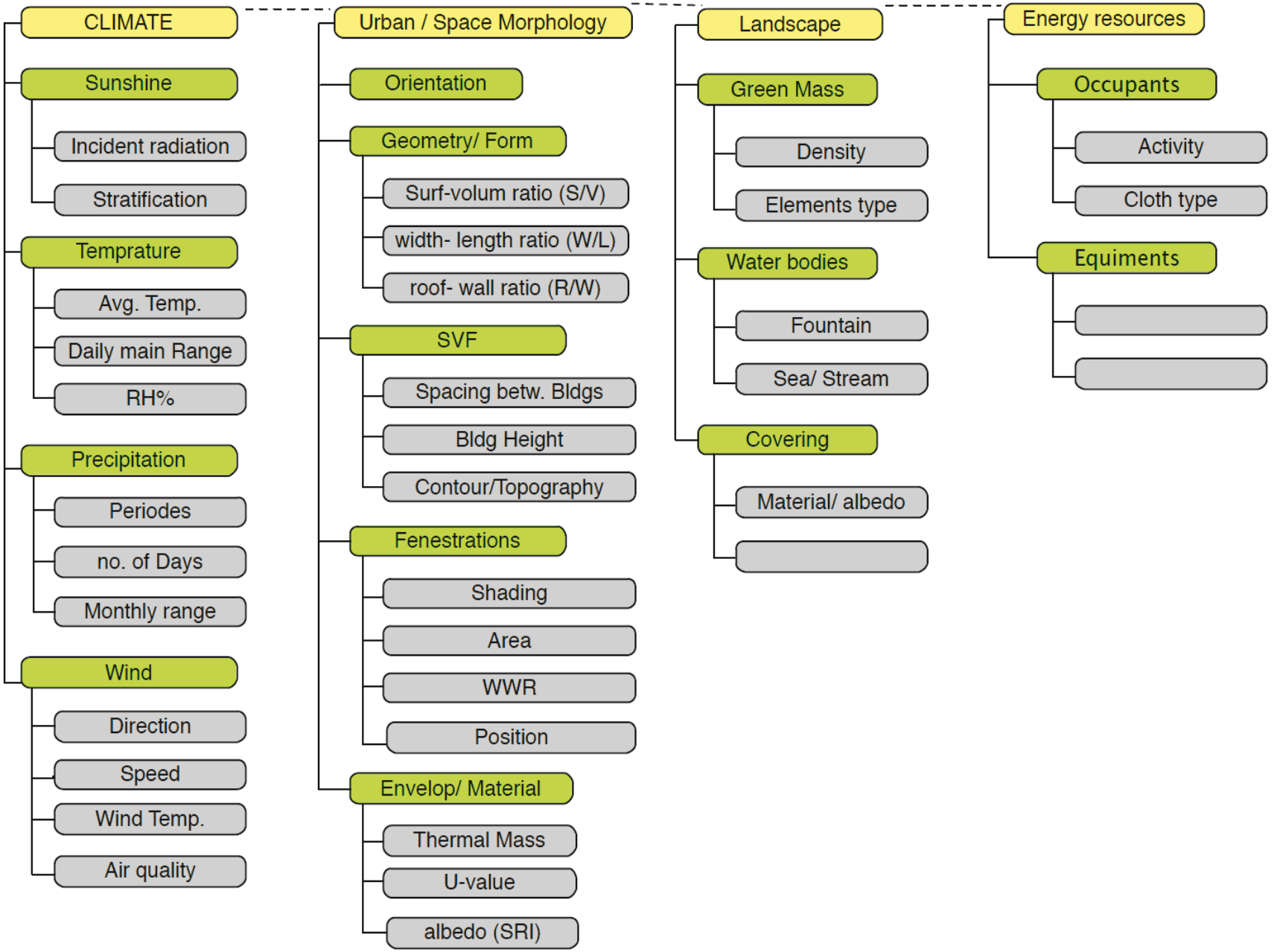

Figure 3: Information requirement for indoor/outdoor thermal analysis