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APPLICATION OF VIRTUAL 3D CITY MODELS IN URBAN PLANNING

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ABSTRACT

The rapid development of large cities, requires powerful tools for the analysis, design and management. Virtual 3D city models can be an important tool in urban planning. For urban planners, the use of a virtual city model creates completely new analyzing and designing opportunities. It provides unique results that are not available in the case of classical research techniques. The visualization of design and planning concepts in the 3D context provides for more suitable solutions. However, the virtual modelling of cities is still in study stage and possibilities for applying it in urban planning has its challenges. This paper presents some results of virtual 3D city application in urban planning in Kien Thuy district, Hai Phong city. From the virtual 3D city model, the author has developed scenarios of planning and evaluating options through visual spatial analysis to select the optimal planning option.

1. INTRODUCTION

Virtual 3D city models represent spatial and geo-referenced urban data by means of 3D geovirtual environments that basically include terrain models, building models, vegetation models as well as models of roads and transportation systems. In general, these models serve to present, explore, analyze, and manage urban data. As a characteristic element, virtual 3D city models allow for visually integrating heterogeneous geoinformation within a single framework and, therefore, create and manage complex urban information spaces.

In recent years, the rapid development of technology has dramatically altered surface modeling and application methods. With the help of information technology, GIS 3D systems have been studied, built and developed. These 3D GIS systems typically model terrains through the Digital Elevation Model (DEM), which combines with Earth-based emblems with LoD (Level of Detail) different makes the application of 3D GIS in the planning work more and more popular. In particular, the rapid development of technology and modern electronic devices have made the building of databases and displays in virtual models more and more popular among scientists in the world. . Today's models are not just 3D, they are also integrated in 3D in order to increase the reality of the model, for example integrating a temporal dimension to simulate what happens in The future is called 4D, so far, the development of science and technology has launched 5D GIS technology (Rita Yi Ma Li, 2017). This technology has been researched in conjunction with virtual reality technology to build virtual heritage virtual city models (Rita Yi Ma Li, 2017). This is a model that will provide new approaches for scientists in the fields of history, economics, sociology, and especially urban planners. These models are the basis for the deployment of Cyber City models that have been studied and applied in the planning of many countries in the world. (G Drogue et al, 2002), (Masahiko Murata, 2004), (Fuan Tsai, 2013), (Mao Wei-qing, 2014) (Leonidas G, 2011), (S.P. Sekar, 2001) The development of virtual cities (Ciber city) and advances to the smart city (Smart city) has been studied by many scientists around the world. (Leonidas G et al, 2011), (S.P. Sekar, 2001) (Ali Reza Honarvar et al, 2018), (Robert Wilhelm Siegfried Ruhlandt, 2018). So far, views on urban planning and management have changed significantly, especially the development of science and technology in the context of the industrial revolution 4.0. With the development of the internet and the industrial revolution of 4.0, the construction of smart cities has been demanding that planning work be participatory and collaborative among groups and stakeholders. Strict differences in the areas of expertise to create better synchronization and connectivity of the infrastructure.

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2. VIRTUAL 3D CITY MODELS

2.1 Data for virtual 3d city models

In practice, the creation and maintenance of virtual 3D city models is based on a number of independent data sources since the sustainable management of 3D city models requires tight links to existing administrative work flows and databases. As a major challenge, these data sources have to be integrated in a systematic and pragmatic way and include:

- Cadastral Data: The cadastral databases deliver the official footprints of buildings and land parcels as well as ownership and address information. Although typical cadastral databases do not contain 3D data, they provide essential input for 3D building models and a kind of official foundation for virtual 3D city models.
- Digital Terrain Models and Aerial Photography: These data sources include, e.g., grid-based DTMs and true-ortho photos. DTMs are used as a reference surface for all geometric objects of a virtual 3D city model, whereas aerial photography provides essential data for photorealistic visualization, e.g., land coverage images and roof textures.
- 3D Building Models: 3D building geometry can be captured and processed by laser-scanning and photogrammetry-based methods. The buildings are represented at various levels of detail (Kolbe et al. 2005), including block-models (LOD-1), geometry-models (LOD-2), architectural models (LOD-3), and detailed indoor models (LOD-4). In addition, continuous level-of-detail buildings as needed during incremental refinement processes are supported, e.g., by SmartBuildings (Döllner et al. 2005). For capturing and processing 3D geodata, several cost-effective methods have been developed (Ribarsky et al. 2002, Förstner 1999).
- Architectural Models: In addition to 3D building models, architectural models can be incorporated such as historic or future ensembles and redevelopment plans. In general, these models include not only buildings but also their surrounding environment at a high level of detail.

2.2 Virtual 3D city models

In this thesis virtual 3D city models are defined as being digital representations of real cities that can be interactively navigated and explored by users on a computer device and which are based on geospatial data. This definition puts emphasize on three important aspects:

(1) Virtual 3D city model provide an interactive media, a virtual space, which allows users to explore representations of real urban environments.

(2) Virtual 3D city models consist at least out of three components: Geospatial data, visualization systems that transform the data into interactive 3D representations, and computer hardware.

(3) Virtual 3D city models are geospatial, i.e. the real world location of any object represented in the data model and visualized as 3D city object is known.

It is important to understand that, according to this definition, virtual 3D city models are conceived as being digital representations of real urban environments that are based on three basic system components, 3D city model data, 3D visualization systems, and hardware. While the hardware component has been neglected during the thesis, the other two components have been subject to in-depth examinations. Moreover, it is very important to notice and understand the differentiation between the interactive and visible representation - the virtual city - on the one hand, and the data representation - the 3D city model - on the other which are related to each other through the visualization system. In fact, this differentiation leads to the conclusion that three views on virtual 3D city models exist that must be examined separately: the data view, the system view, and the media or user view as depicted in Figure 1.

The proposed definition does not express anything about the quality or complexity of virtual 3D city models, though. Neither with respect to how realistic the city objects are modeled, nor which real world objects are represented in the model or if their digital counterparts display real world like behavior, e.g. growth, movement, or physics. Thus the term virtual 3D city model, and also the terms digital city and virtual city which have been used recently, first of all express an abstract concept. The actual occurrences of specific virtual 3D city models, however, come with very different data (structures), system infrastructures and capabilities, and visual output. Therefore, the next sections provide details about the three views identified.

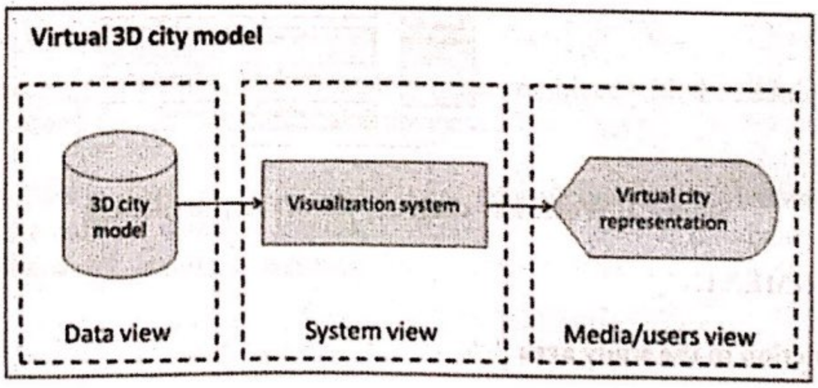

Figure 1. The three basic components of virtual 3D city models

2.3 3D city modeling framework

The main steps in the process of building a 3DCM model, integrated planning and analysis options include:

- Construction of 3D terrain:
- \+ Document preparation: UAV, DEM, 3D model, database.
- \+ Build up the terrain.
- \+ Present a 3D city model.
- Database development and object modeling planning options
- \+ Building 3D models and digitizing planning options
- Integrated planning
- Analyze, test the solution.

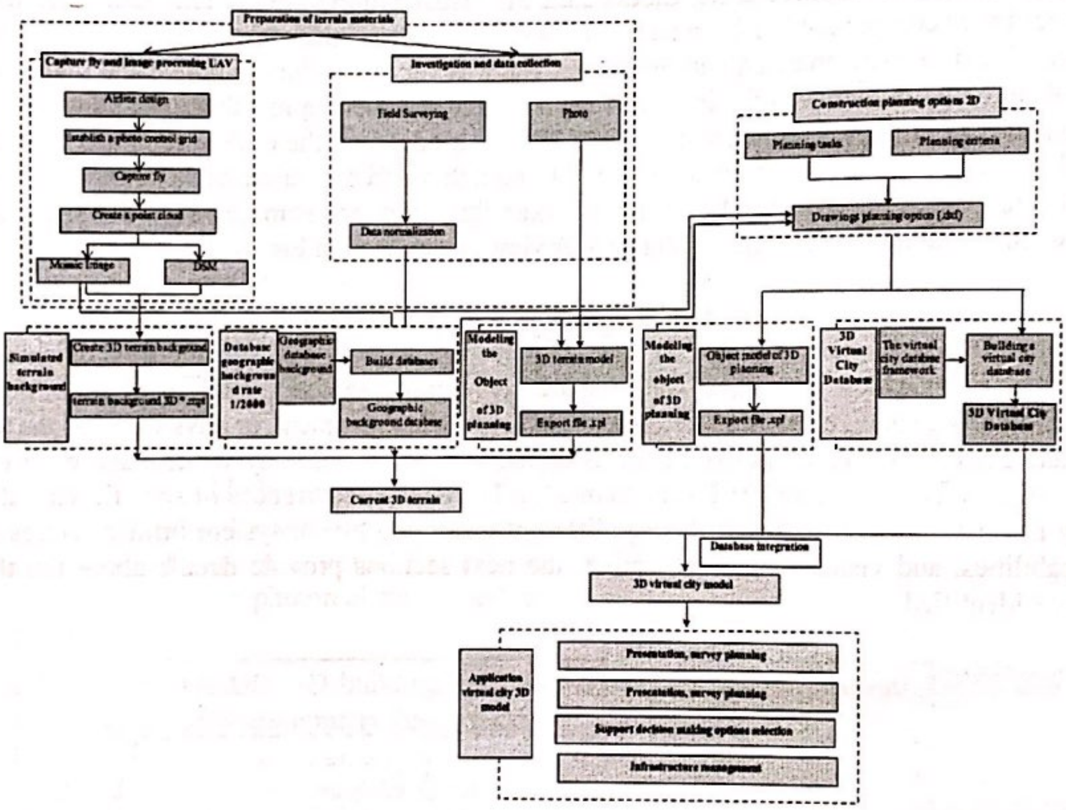

Figure 2. Workflow diagram for 3D city modelling

3. EXPERIMENTS

3.1 Introduction to the study area

The land for project implementation is mainly agricultural land for rice cultivation and aquaculture. Ground level from + 0.70m to + 2.80m. Scale of project: Construction of technical infrastructure of Kien Thuy urban industrial zone with an area of about 912.83 ha;

Planning task:

- Determining the organic relationships of the nature, functions and tasks of the planned study area in the whole industrial park.
- Develop a detailed plan of land use.
- Proposing specific solutions for spatial organization planning, urban design and technical infrastructure planning.

Planning content of Kien Thuy urban and industrial zone: Construction of Kien Thuy urban and industrial zone with total area of 922.83 hectares, meeting modern urban and industrial standards with the following functions: - Urban areas, technical infrastructure works, public utility works, eco-industrial parks, housing areas for workers to combine trade in services for laborers in industrial area.

3.2 Building 3D terrain background

To build 3DCM 3D model requires high resolution terrain image. Terrain covered from Phantom 3 UAV with FC300S and other ancillary equipment. Resolution of 8-10cm, flying height 150m.

UAV images are processed on both software technologies Pix4D mapper software and Agisoft Photoscan software. The result is a UAV image plotter with a resolution of 5 cm and a DSM of 10 cm.

Figure 4. Aerial photography and digital elevation model created from UAV image

- From the image map, the digital elevation model combined with the additional survey of foreign information, to build a 1: 2000 database.

The geographic database of urban areas for construction is now basically organized according to the national database standards. Accuracy and level of information acquisition ensure the criteria for quality assessment for geographic database 1: 2000, structured as follows:

Table 1. Geodatabase for building 3D terrain background

Data subject	UML package
Measurement base	CoSoDoDac
Boundary	BienGioiDiaGioi
Terrain	DiaHinh
Hydrology	ThuyHe
Transportation network	GiaoThong
Population, infrastructure	DanCuCoSoHaTang
Land Cover	PhuBeMat

- In order to build a 3D map, there must be a 3D symbol set. The 3D symbol set must represent the whole point, line, area, and note objects. Point markers can be collected, designed using SketchUp software or similar software that supports the * .fly, * .xpc format. Road signs, design areas directly in the Skyline program.

Symbols must ensure that the visual representation of the 3D map is most intuitive, the symbol must be easy to understand, as closely as possible to the actual shape of the object, of course comply with the rules of the sign. 1: 2000 scale. 3D map symbols are composed of five main types:

Structured Image (Textured Image.gif)

+ Modeling of objects (3D Model * .xpc, * .xpl)
+ Icon (Icon.gif)
+ Map symbol (Map_Sign)
+ Note (Text Label)

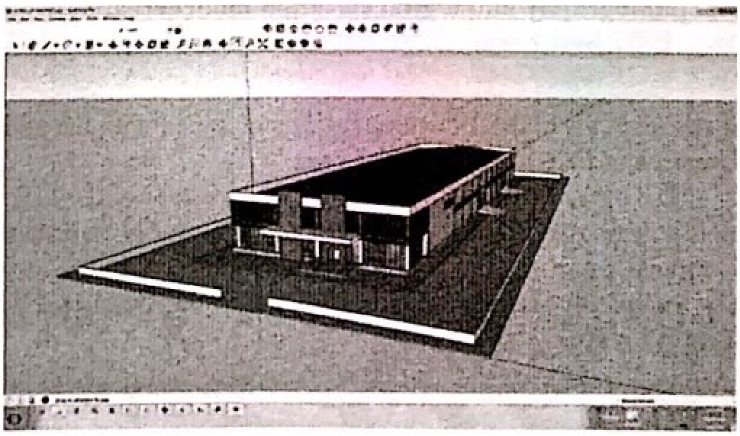

Figure 5. Object model design on SketchUp software

Simulate city terrain and 3D maps

- In order to build 3D city profiles, first need to simulate 3D terrain. 3D terrain built from high altitude model and edited image plot, extracted from UAV image. Use TerraBuilder software to build 3D terrain models. 3D terrain simulation results are terrain files in * .mpt format.

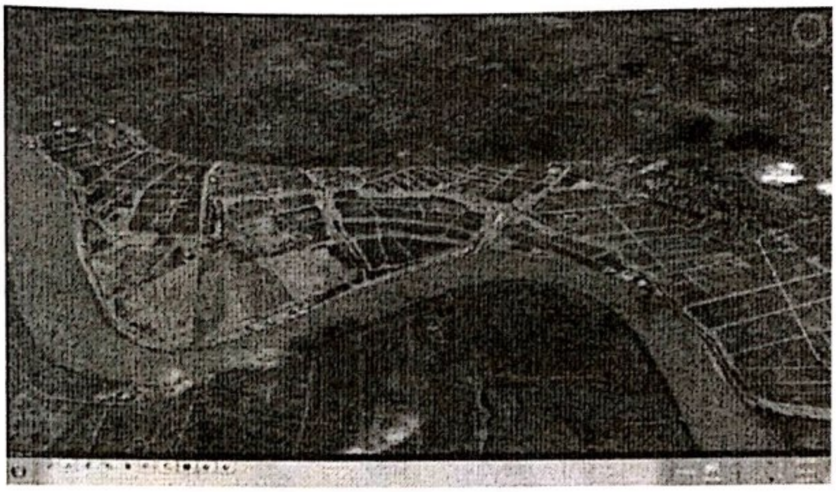

Figure 6. 3D topographic map area

- On the 3D map of geographic models (houses, trees, street lights, gates ...) and road objects (traffic, ...) in the form of areas (lakes ...). The presentation of specific subjects as follows:

+ Geological modeling: models modeled after specialized softwares (Sketchup ...) are extracted into formats such as .dae, .flt ... to be able to use the map presentation. 3D. In addition to the quick display, in TerraExploer Pro there is the makeXPL tool (on the Tools tab) converted to the software's own format (.xpl2). Then users use the 3D Model tool (on the Objects tab) to import the geodetic models.

+ With the objects: Traffic, Water, Geography ... users use the geographic database platform to import software and 3D maps.

3.3 Building 3D city database and 3D object model

Unlike geographic data, most planning plans are not georeferenced and can not be integrated directly into the 3D city model. Furthermore, information about plan objects, such as the number of floors of a building, is not encoded in the attribute tables but is included in the plan graph. For this reason, some preprocessing steps are needed to create a 3D plan image from the plan to be inspected. Therefore, the first must be geo-coded plans and planning features must be digitized before the model is integrated into 3DCM.

In a planning scheme composed of different target groups. For the management and construction of 3DCM mappings from a 2D database, we need to build a 3D city database framework. The database contains classes and classes of objects, for example traffic groups including urban roads, sidewalks, population groups including high buildings, houses, factories, etc. on ArcGIS software.

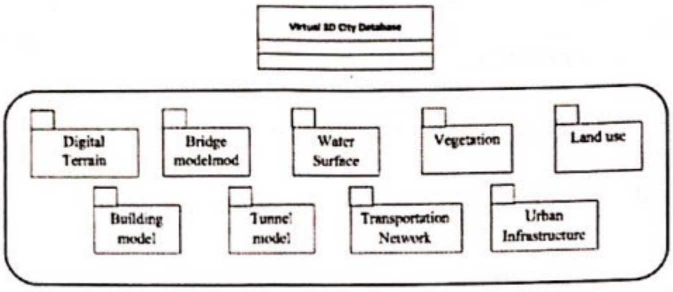

Figure 7. Database schema for planning options

The 3D planning solution database is updated on ArcGIS software. After entering spatial data, objects need to be updated attribute information. For example, all high buildings have information such as: house name, address, height, number of floors ... This information is just to manage, look up objects on the 3DCM model and to automatically generate the 3D object model on Skyline software.

4. INTEGRATION OF PLANS INTO 3D CITY MODEL

4.1 Buildings (high buildings, house, factories)

Key issues in the planning process were the height concepts and the building density of the plan proposals. The master plan and plan versions were continuously integrated into the 3D city model to provide visual simulations during the planning process.

- The first method, the extended model, is used to create a 3D building block from the building footprint (building database) and the height information of the building. This method is applied effectively to the entire building. To ensure an accurate height image, building height is the attribute information of the tall buildings database. With the built-in object constructor function. 3D cube models are simulated from these data, can be queried, colored or textured for roofs and faces. Moreover, the height of the block model can be manipulated and the attributes can be edited. Processes from city planning to digitalisation, updating information and integrating into 3D city models based on planned terrain (Figure 8).

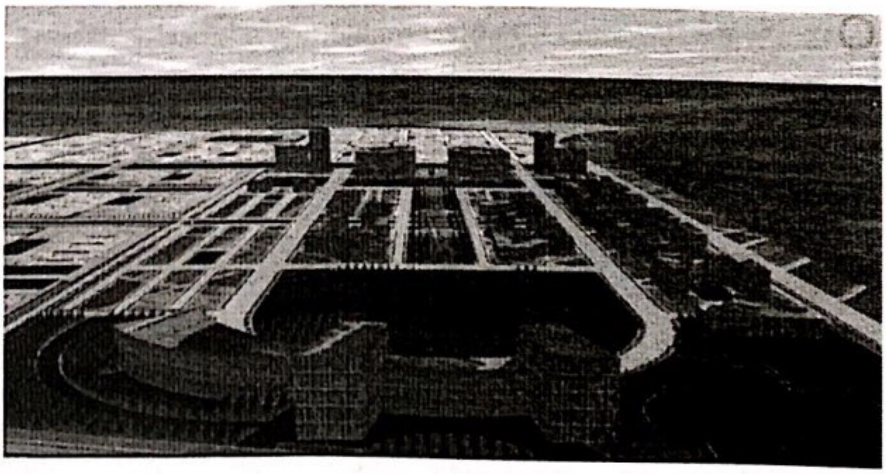

Figure 8. 3D model created from 2D database.

- The second method, a 3D model built from Sketchup software to create 3D images with many geometric and detailed elements in external applications. 3D modeling is an established method for modeling and visualization, and it is very flexible for geometry and superficial modeling. For this reason, it can create realistic and comprehensive 3D imaging not just of buildings, but of space around them including green spaces and trees, streets, open spaces, and furniture. In order to facilitate the construction of 3D models, the planning features are categorized into groups (buildings, transport objects, and vegetation objects), and the height of the building on the ground. and the base height has been added to the building footprint as an attribute in the GIS environment. After this preparatory work, the features were extracted from GIS into 3D modeling software. The built-in function of the extract has been configured to handle the block model from the build and attribute features based on the attribute information. From this basic 3D model, a specific model has been created. 3D models are imported through the * .3ds, * .dae format and the appropriate location is ensured by placing them in the center of the building frame. Figure 3.30 illustrates a 3D approach to the * .dae format.

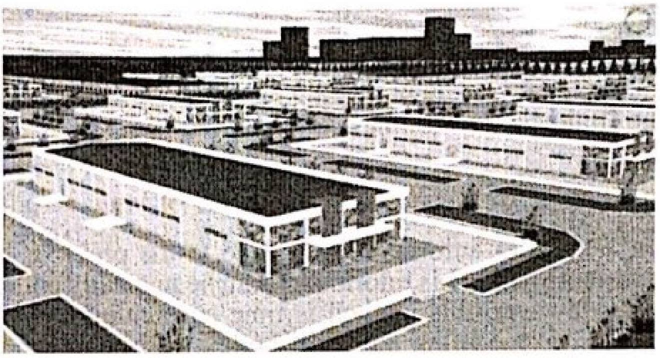

Figure 9. Integrated house model x Roads (spindle, dike, pavement)

- The transportation network classes, dikes, pavements after being digitized on ArcGIS software into the database will be integrated into the 3D city model. On the 3D software there are functions to enter and present these object classes. Software allows to select the color or texture of the object.

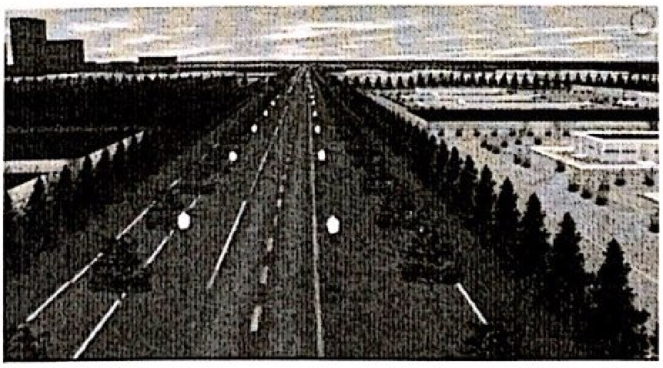

Figure 10. Integrate traffic into the 3DCM model

In addition, the virtual city model must fully integrate the information of the classes: Parks, Trees, Water, Animated Objects, Drainage Works, Powerlines ... into the 3DCM model.

4.2 Roads (spindle, dike, pavement)

The traffic classes, dikes, pavements after being digitized on ArcGIS software into the database will be integrated into the 3D city model. O4 the 3D software there are functions to enter and present these object classes. Software allows to select the color or texture of the object.

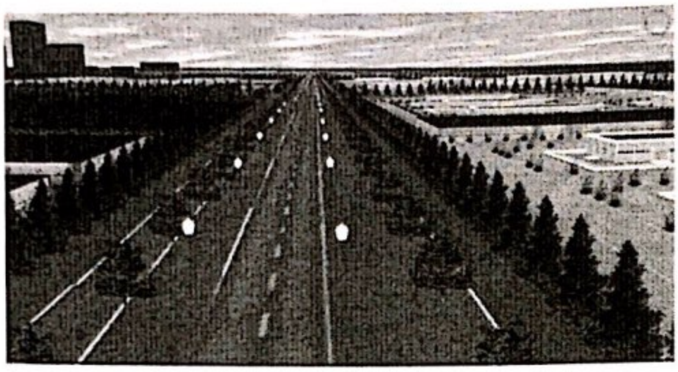

Figure 11. Integrated traffic to the 3DCM model

In addition, the virtual city model must fully integrate the information of the class: Park, Trees, Water, Objects, Drainage, Power lines ...

4.3 Information as object attributes

In the case of a 3D model, information is added to the previous data, lost during the export and import of attribute data. This information can be manually added in the system after the data entry process. However, this method is time consuming and error prone. For this reason, in addition to the 3D modeling model of buildings that have been converted to 3D models using the editing system's functionality, and a function developed to transfer properties from the house's footprints a space. The same functions are used to transfer address information and build data from cadastral maps for buildings.

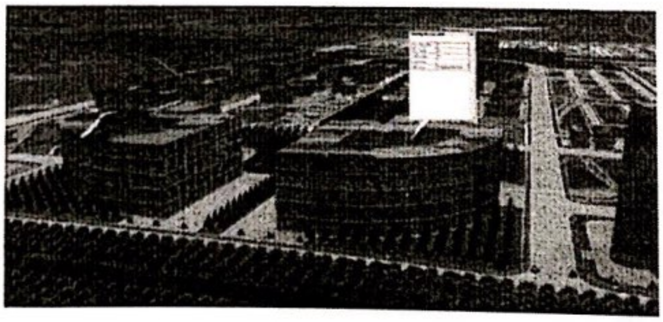

Figure 12. Information object properties on the model

5. APPLICATION OF 3D MODEL

Given these pre-consideration about virtual cities it has to be concluded that a level of maturity has been reached that enables us to capture, process, manage, and visualize geometrical accurate and visually appealing 3DCMs that consist out of terrain data, 3D building models in LOD2 to LOD3 with facade textures, and high resolution orthophotographs. This ability provides the fundament for implementing innovative applications on top of virtual 3D city models and 3D city model data respectively that can be used to support communication and information processes in urban planning and management as well as to conduct complex 3D analyses. Indeed an increasing interest in municipal 3D city models can be observed which manifests itself in the fact that many municipalities now own a 3D city model. However, these existing models are still often used in a limited context for few selected projects but they are not used on a day-to-day basis in municipal business process. The main functions of use were identified for 3DCMs: (1) Presentation & Exploration, (2) Analysis & Simulation, (3) Decision

5.1 Presentation & Exploration

The use of 3DCMs for the presentation and exploration of construction projects, urban design proposals, planning scenarios, environmental data, economic data, and spatial processes within the context of virtual cities is obviously an appealing idea which has been a central driver for their development.

The main purpose of using 3DCMs as a presentation and exploration tool for heterogeneous spatial data is to provide an intuitive visual access to spatial information. Therefore, a common trait of the use of 3DCMs for the presentation and exploration of heterogeneous spatial data, whether it be in planning processes, for the information of the public, or for city marketing and tourist information systems, is that the models are usually intended to create a feeling of presence in the users that enables them to intuitively link the image of the 3DCMs to real locations.

3D software allows users to create scenarios including: Geographic location, Motion object animation, Simulation of building process ... for presentation, presentation of plan zoning.

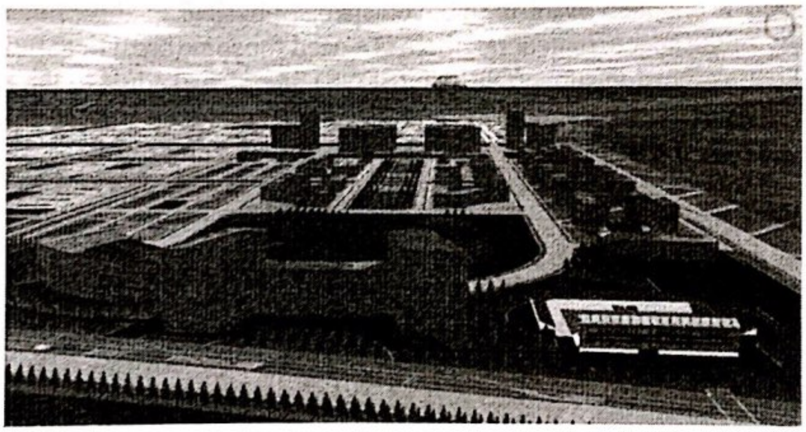

Figure 13. 3DCM model for demonstration and city exploration

5.2 Analysis & Simulation

For urban designers, the most important application based on 3D city models is visual analysis. In the 3D space of dynamic virtual environments, through the visualization of human vision and visual analysis for the visible area to make the design process more realistic and scientific.

By limiting the height of the area, controlling the distance of buildings from the street, or controlling open space, designers can present fully the results of urban design control and Analyze effectively the image quality of urban space.

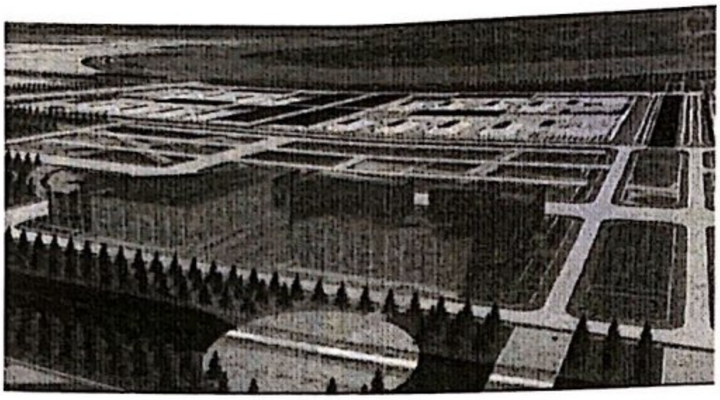

Figure 14. Vision analysis

Visibility or visibility, visual quality is very evident in the materials and practices of landscape and design planners. Fields visible to a certain degree of view and angle - can be calculated, and it is the field that we can see at some point of view. Computation of vision is the premise of visual analysis.

We can choose any day and get sunlight time anywhere on any building the same day. If the sunshine time is fixed, the building will be marked and display the time at that time. In particular, we can see building shifts in time, so that sunlight conditions can be evaluated in the 4D environment as shown in Fig 14.

5.3 Decision Support System

A successful decision support system should be easy to operate. The design process is very complex, and it engages in all the above aspects, physical quality, image quality, and functional quality of the space. In general, there is a need for some analytical functions to make decisions. In a spatial decision support system (SDSS), in order to adapt to the design process, all necessary analysis functions should be integrated. Visual imagery from the computer can change the way we think and how we work. For architects and planners, it can change the way they are designed. The ability to visualize urban structure changes and experience changes in their real context enables planners and designers to evaluate faster, more detailed, and low cost alternatives. than through more traditional analysis.

In moving from abstraction to more specific, the application can 3DCM provide planners and designers with the tools to better understand the three-dimensional space in the design process, as well as control It is better to process the urban space form of the urban governor and allow more people to participate in it.

- Identification of flooded areas
- Check the design of the building
- Check population density.

6. CONCLUSION

The article has studied and synthesized the systematic basis of 3D virtual city model for urban planning and management. It has proposed the application of five LOD levels of 3D virtual city modeling and 3D virtual city modeling technology for urban planning and management. our country.

Experimental results of Virtual 3D City Modeling of Kien Thuy Industrial Park (Hai Duong), has initially demonstrated the potential of modeling and applying the model. virtual city in the planning and urban management in our country.

The scientific basis and experimental results of the thesis on the 3D virtual city model will be an effective support base for urban planning and management in the study area. The scientific basis and technological process of building 3D virtual city model of the thesis can be the foundation for developing and replicating the virtual city application model in the planning of urban development. and industrial parks throughout the country.

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