

# 3D City Modelling for Planning Activities, Case Study: Haydarpaşa Train Station, Haydarpaşa Port and Surrounding Backside Zones, Istanbul

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## ABSTRACT:

**Haydarpaşa Train Station** was built as the terminus of the Istanbul-Baghdad and Istanbul-Damascus-Medina railways during the final years of the Ottoman Empire. Its construction started in 1906 by German architects who chose a neo-renaissance German style. They designed a large building, much in accordance with the ambitions of the German investors who were building the Istanbul-Baghdad Railway and undertaking the consultancy works for the Istanbul-Damascus-Medina Railway. The train stations surroundings is coined by **Haydarpaşa Port** which includes the country's most industrialized areas.

Construction of the Bosphorus Tube Transition (Marmaray) Project will heavily affect the area including Haydarpaşa Train Station, Haydarpaşa Port and the surrounding backside zones. To visually analyse proposed changes in the region and compare planning scenarios developed by urban planners, a 3D city models should be obtained quickly, precisely, in detail, and with full completeness. For this, a 3D city model was prepared in three different level of detail (LOD), basic block models with flat roofs (LOD 1), building models with roof forms (LOD 2), and architectural models with façade texture and proper building geometry (LOD 3). In addition to the 3D shape of buildings, (attribute) information about specific buildings was also added to the model. Into this 3D city model developed for the planning area, development scenarios and construction proposals envisioned by city planners were integrated as 3D models. Hence, the usefulness of the generated city model from the user's point of view (especially urban planners) is judged based on these detailed analyses.

## 1. INTRODUCTION

3D city models are increasingly used for the presentation, exploration, and evaluation of urban and architectural designs (e.g. Döllner et al. 2006, Kibria et al. 2009, Song et al. 2009, Ross et al. 2009). Visualization capabilities and animation support of upcoming 3D geo-information technologies empower architects, urban planners, and authorities to visualize and analyse urban and architectural designs in the context of the existing situation. To make use of this possibility, first of all a 3D city model has to be created. In a second phase urban and architectural designs are added to the model. Real-time 3D visualization and interactive exploration of such models can support planning processes by providing multiple stakeholders such as decision-maker, architects, urban planners, authorities, citizens or investors with a three-dimensional model. It is argued that this method can help to identify design errors or conflicts of interest, to arbitrate conflicts, and for facilitating understanding. Moreover, it might offer a solution to make competing designs better comparable (Lange et al. 2004). In summary it is expected that the use of this technology can support communication and information processes, which will lead to more transparency in planning processes and also to better designs. An important factor which is seldom mentioned is that the use of 3D city models might help to save money and time. Large urban regeneration projects for example, often have a long planning history. Environmental damages, conflicting interests, a large diversity of stakeholders, legal requirements, political interests and many other issues are factors that have to be obeyed, moderated and finally lead to planning decisions. Thereby, it is very usual that plans are continuously changed,

reworked and updated and often several physical models on different planning scales are created during the planning process. Digital 3D plan representations in conjunction with 3D city models might reduce costs and effort spent on preparing high quality presentations, map-print outs and physical models. This contribution details a case study located in Istanbul, Turkey, on creating and utilizing a 3D city model in a planning process. The project entitled "Analytical Study, Consultation and 3D City Modeling for 1:1,000 Scale Implementation Plan of Haydarpaşa Train Station, Haydarpaşa Port and Surrounding Backside Zones" was developed by Istanbul Greater Municipality and given to BIMTAS company. The main aim of the project is to create a 3D city model of Haydarpaşa region and its surrounding city districts, into which urban design proposals can be integrated. It is the first 3D city modeling project implemented at BIMTAS on this scale and therefore, further aims are to evaluate and develop workflows, test the capability of the software product Autodesk LandXplorer 2009 (Autodesk 2009, online), and the applicability and usefulness of the technology in urban planning processes.

## 2. STUDY AREA, METHODOLOGY AND DATA USED

### 2.1 Study Area

Haydarpaşa region is located at Anatolia shoreline of Istanbul Bosphorus and is one of two main centers in the Metropolitan Area of Istanbul for sea, railway and land transportations. The region carries a heavy transportation burden and contains Harem Bus Station, Haydarpaşa Port, Haydarpaşa Train Station and further small stations. In addition the region has also an

historical importance due to Haydarpaşa Train Station which is a main gate of Istanbul opening to Anatolia. The station was built by two German Architects who choose a neo-renaissance German style and it is a registered old national monument. However, by finishing the Bosphorus Tube Transition (Marmaray) Project, Haydarpaşa Train Station and its completing structures, i.e. railways, warehouses, repair and maintenance services, loading and unloading facilities, custom units, entrepot and silos will lose their functions. To develop a concept for the reuse of the area gained from these facilities, BIMTAS was given a mandate by Istanbul Greater Municipality. The actual planning area consists of Haydarpaşa Train Station, Port and surrounding backside zones which are situated in Kadıköy and Uskudar districts. It forms a visual and historical entirety with Historical Peninsula, Galata, Beyoğlu, and Besiktas districts. Therefore, the 3D city model prepared for the case study encompasses these districts as shown in Figure 1. One of the most important aspects in the study is to protect the historical values of Istanbul and also the silhouette of Bosphorus.



Figure 1. Study Area

## 2.2 Methodology

Digital aerial images with 10 cm GSD and a digital elevation model (DEM) are main data used during the generation of the basic 3D city model. The digital aerial images are used to extract roof structures using photogrammetry. To increase the quality of the visualization, several landmarks and protected buildings are modeled as textured LOD 3 buildings. Additionally, vector data layers including buildings, transportation network, railways, trees, etc. were obtained from 1/1,000 scale maps and some 3D city objects which will complete the appearance of the model were also added. The created basic 3D city model can be queried based on attribute information of the vector data layers and will be used for the integration and evaluation of different scenarios designed by city planners. Data types used in the model and flowchart of processing steps are given in Figure 2.

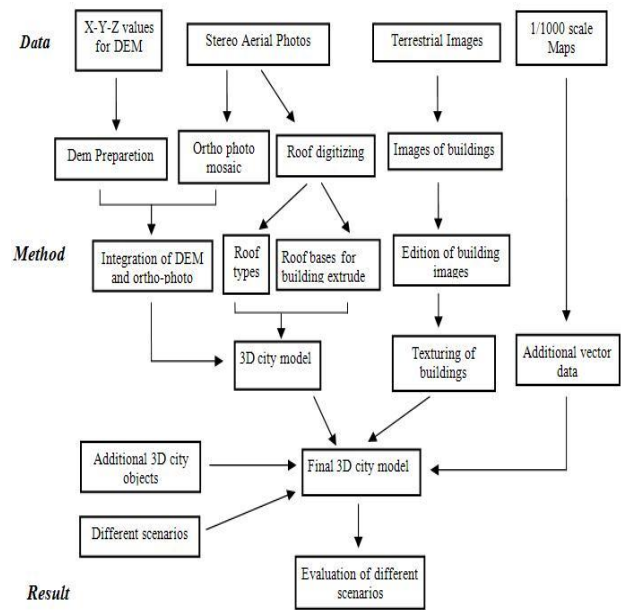


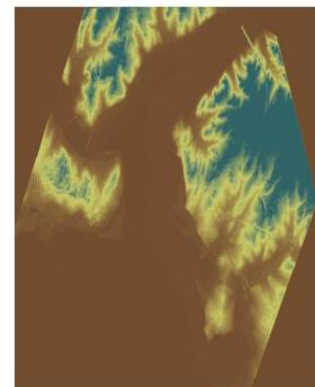
Figure 2. Flowchart for the generation 3D city model

## 2.3 Digital Elevation Model

For the creation of a DEM of the area under examination, four blocks of 5 m grided x-y-z point data, taken from Istanbul Great City Municipality of Directorate of Cartography, are used. First, these 4 blocks of x-y-z points are converted to raster images using Erdas Imagine 9.1 software and then mosaiced. An example of x-y-z point data and generated DEM is given in Figure 3.

410613.70	4546180.35	2.30
410618.70	4546180.35	2.26
410623.70	4546180.35	2.23
410628.70	4546180.35	2.19
410633.70	4546180.35	2.17
410638.70	4546180.35	2.18
410643.70	4546180.35	2.21
410648.70	4546180.35	2.20
410653.70	4546180.35	2.14
410658.70	4546180.35	2.08
410663.70	4546180.35	2.04
406368.70	4546175.35	90.80
406373.70	4546175.35	90.28
406378.70	4546175.35	89.72
406383.70	4546175.35	89.14
406388.70	4546175.35	88.55
406393.70	4546175.35	87.95
406398.70	4546175.35	87.35

x-y-z values used for DEM generation



Generated DEM

Figure 3. X-Y-Z values and generated DEM

## 2.4 Images

As basic image layer for the terrain model, orthoimages with 50 cm ground resolution are taken from Istanbul Great City Municipality of Directorate of Cartography. The images are mosaiced using Erdas Imagine 9.1 and presented in Figure 4.



Figure 4. Ortho-mosaic of the study area

## 2.5 Vector Data

Vector data which will be added to city model, such as buildings, transportation network, trees, railways, etc. are obtained from 1/1,000 scale maps as GIS data. The vector data is used for several purposes. First of all the building footprints are used to prepare LOD 1 buildings for the extended study area. Furthermore, vector data is directly integrated as terrain texture. Finally, point information is used to place tree and object representations.

## 2.6 3D Objects

Additional to vector information 3D objects of Suleymaniye and Blue Mosques, Galata Tower and other important landmarks are integrated into the 3D city model to increase the visual quality of the model. These 3D objects are produced using Autodesk 3ds Max software.

## 2.7 Roof Models

Stereo aerial images with 10 cm GSD are used for digitizing roof structures in the Haydarpasa Region. For this purpose, Z-Map Photo software from Italian Mencisoftware company is used. In this software, first, interior orientation step was completed with the help of camera calibration file of the camera. For the exterior orientation adjusted center point coordinates, elevations, and rotation parameters of the images were used. After completing the orientation phase, 3D digitization of roofs is done manually using the AutoCAD tools of the software. An example from the digitized roofs is shown in Figure 5.

The completed roof vector data is converted to polygons and separated into two layers, including the roof faces on the one hand and roof floors on the other, which will be used to generate buildings models in further steps.

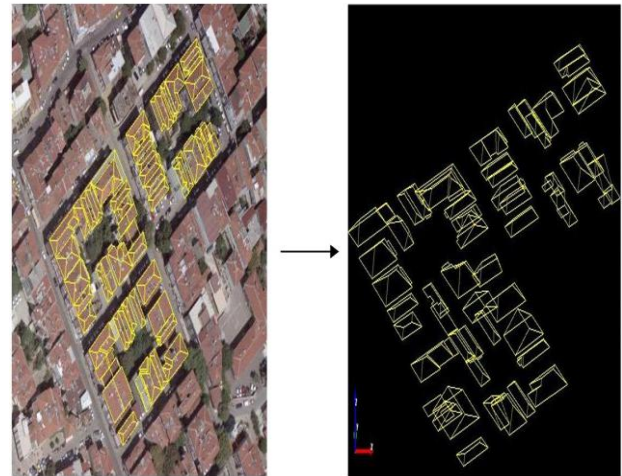


Figure 5. Example of roof digitizing

## 3. 3D CITY MODELING

The 3D city model for the project is created using Autodesk LandXplorer Studio Professional. This software supports the use and visualization of very large DEM and aerial images. Building models can be created from building footprints in conjunction with height information, from 3D shapefiles, and various 3D model formats (e.g., .3ds, .x3d). Besides this, multiple layers of vector and raster data can be added as terrain textures and labels or (3D)-symbols can be added manually or based on point information. Users can interactively navigate through the 3D city model and attribute information attached to buildings or vector data can be queried. In this project, elevation values of buildings and names of blocks are attached as attribute data to the buildings.

Generation of the model begins with the integration of the generated DEM onto which the mosaiced orthoimages are projected. In a second step, buildings are added into the project. Here, three methods were applied. In the first method, roofs digitized from stereo aerial images (cp. 2.6) were converted to 3d polygons with the help of AutoCAD software. For this, each constituent of roofs are converted to polygons. An example of roof polygon is given in Figure 6.

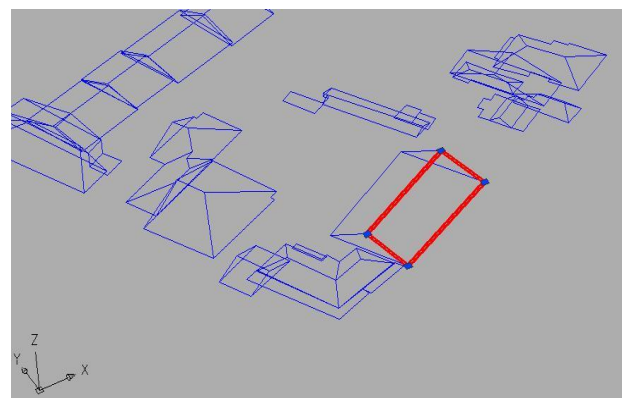


Figure 6. An example of polygon constitutes of roof geometry

During the conversion process roofs are separated into two layers: One includes the roof geometries (faces) and the other the roof floor (roof footprint). Taking advantage of the fact that the roof data has original elevation data, the roof floors are



extruded to the ground and accepted as buildings. Then, in a second step, the roof geometries are imported as aggregation of several geometries, which is also called explicit buildings in LandXplorer. This way LOD 2 representations of buildings were integrated. The second method is used to integrate LOD 1 buildings obtained from 1/1,000 scale maps, which are extruded depending on their number of floors. As default height for each storey 2,8 m is used, which is a average height of storey in Turkey. Finally, a third method is used to place 3D building models (LOD 3) created in 3ds Max. Placement of the 3D models is done either manually or based on point coordinates.

After finishing the basic 3D city model, there are 3 different levels of detail (LOD) in the project. The red colored area in Figure 7 shows the buildings which are modeled as LOD 2. The buildings colored light gray are LOD 1 buildings. Altogether there are about 50.000 building as LOD 1 in the whole project and about 14.000 of all buildings are modeled as LOD2.



Figure 7. General view of buildings

LOD 3 detail buildings in project are restricted to important landmarks such as historic buildings or special buildings in the planning area (Figure 8).



Figure 8. LOD 3 example

To adopt the base model to the specific planning task Selimiye and Rasimpasa quarters which include Haydarpasa Port and the Train Station are chosen as sub-study area. Into this area tree representations are integrated by obtaining location of trees from the 1/1,000 scale maps. Utilizing the point locations, trees are placed within the 3D model. The bridge located at backside zone of Haydarpasa Train Station is also modelled based on its original elevation values. Besides, containers seen at Haydarpasa Port for loading are modelled regarding to their elevations. Some screenshots of the model are given in Figures 9 and 10.



Figure 9. Haydarpasa Train Station and Port



Figure 10. Backside zone of Haydarpasa Train Station

#### 4. EVALUATION OF DIFFERENT SCENARIOS

The generated 3D city model shows the existing situation as it can be observed right now. It enables city planners to see the region in 3D. To enable them to see their designs and compare it with the region's present appearance, it will be necessary to integrate urban planning concepts as 3D representations. This is implemented by adding LOD 1 models of culture, trade facilities and some other buildings. Also some cruise ships with varying length and height are added to the model to evaluate how their presence will affect silhouette of Bosphorus, if they are allowed to anchor at Haydarpasa Port. The intended function of the proposed buildings is shown by utilizing different colors. Figure 11 shows one of the scenarios implemented.



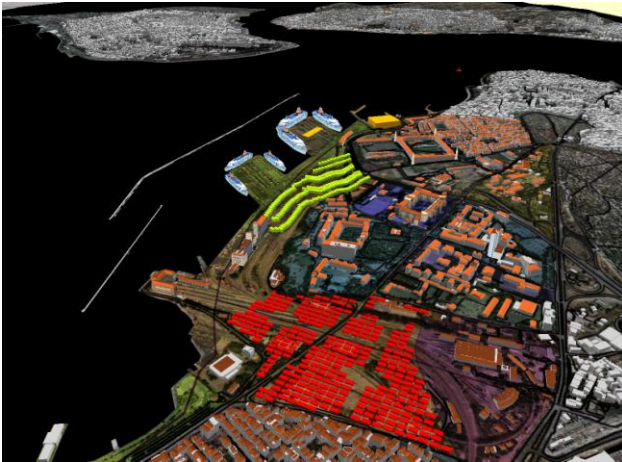


Figure 11. Visualization of the scenario

In the other scenarios shape, number of storeys, functions and locations of buildings are changed. Numbers of cruise ships are decreased and the scenarios are compared to each other (Figure 12).

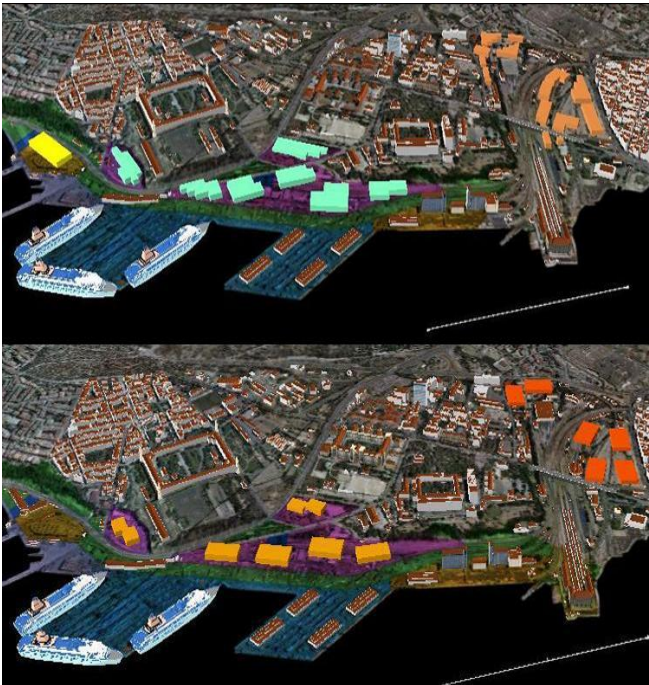


Figure 12. Comparison of different scenarios

All phases of the city modelling and the developed different scenarios are exported to CityGML to submit them to city planners. This format is a common information model for representing 3D urban objects (<http://www.citygml.org/1523>). CityGML does not only represent the graphical appearance of city models, it also take cares the presentation of semantic, thematic properties and aggregations of digital terrain models, sites including building, bridges etc, vegetation, water bodies, transportation facilities and city furniture.

Another interesting application that urban planners would like to see using the 3D city model is to visual check of the so-called building silhouettes. In such analysis, first, the heights of the buildings which eventually affect the Bosphorus view are taken into account. Then, based on this analysis, new urban designs

which will not destroy the view to Bosphorus can be developed precisely.

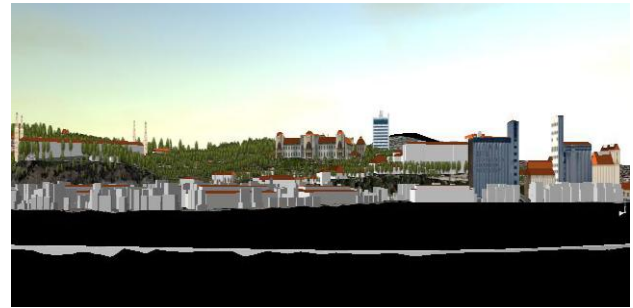


Figure 13. Silhouettes of the study area

## 5. RESULTS

The primary result of our case study is a 3D city model encompassing about 50.000 buildings and covering an area of about 2600 hectares (cp Fig. 8 to 13). Into this base model several urban designs are integrated and visually analyzed. A comparison of the model and a photo of Haydarpasa Port are given in Figure 14. It shows that the 3D city model represents the cityscape very well. Thus it is possible to visually access the impact of proposed urban design concepts.

The results from a methodological point of view are that 3D digitized roof geometries from digital stereo images with 10 cm GSD are a good starting point to create building models in LOD 2 from remote sensing data. In contrast to methods based solely on building footprints and average height information, this method allows to represent the building structures much better. The achieved 3D city representation provides a good and reliable media (or geovirtual environment as it is called by Kibria et al. 2009) into which urban design proposals can be integrated during the planning process. During first presentations and meetings the quality and applicability of the model was rated very good by the involved stakeholders.

However, we found that it is not possible to control parameters such as field of view of the virtual camera in LandXplorer Studio Professional. Thus it is very difficult to compare photographs of the cities silhouette with the model, which would be a very helpful functionality in planning processes.



Figure 14. Comparison of model and current situation

## 6. CONCLUSIONS

3D city models provide an intuitive media for the visualization and comparison of urban design proposals. With contemporary 3D city modelling methods 3D city models can be prepared in a level-of-detail sufficient for urban master planning as well as for detail studies. Software solutions for the authoring, management and visualization of 3D city models such as LandXplorer Studio Professional provide powerful tools to support the utilization of the chosen approach.

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