# 3D Cartographic Modelling in Educational Process

**Temenoujka Bandrova**

Department of Photogrammetry and Cartography, University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria, e-mail: tbandrova@abv.bg

**Abstract.** The report considers 3D Cartographic modelling presented in students' projects. They were created and developed in Laboratory of Cartography, University of Architecture, Civil Engineering and Geodesy, Sofia. Most of projects start to be realized in the last semester of Master degree of education and finished by diploma theses. The applied technologies contain several steps from data collection to final visualization of the cartographic product. The idea is to find way for 3D data capturing and processing and after that the steps for cartographic applications will be separated according user applications. Some of used technologies are presented and discussed.

**Keywords:** 3D cartography, Education, Technology

## 1. Introduction

Cartography as a science and practice developed a lot during last years in different directions and covered many fields of social life, government decisions, scientific topics, economic needs, etc. One of the most attractive development of the cartography as a science on the base of the modern technologies is 3D mapping. Including this topic in educational process we can attract students and provoke them to find decisions for different kinds of problems. Very often cartographers like to speak about adaptive cartography which will allow us to go closer to our users, especially students. Konecny and Stanek announce that the adaptive cartography has wider context, and suggest that this new cartographic approach establishes new demands and benefits for geographical education, especially in offering the possibility for broader individual participation in the learning process (Konecny M & Stanek K, 2010).

Other topic is the teachers' help. Teachers have very good information about the difficulties when students use school atlases and wall maps on geography, history, or other earth sciences. A multimedia training on these subjects includes "text, images, maps, diagrams, sound, video, etc." (Krygier J B, 1995) and will significantly improve the quality of the material. 3D maps will enable students to understand quickly and easily memorize the material. Very often students have a difficult idea of understanding contour lines or traditional topographic maps. High results are obtained in a study about the heights of the Hawaiian Ridge in the U.S. by special prepared project at Pennsylvania State University (Krygier J B, 1995). 3D maps will help in this aspect and provide not only accurate and precise information but also clear and understandable visualization.

From young ages, students use and like computer games for just playing or studying some topics of geographical or historical environment. For example, ETH Zurich proposes 3D gaming technology to develop 3D cartography (Oleggini et al. 2009). More over D. Worthley announce that "The increasing fidelity of 3D visualization used in video games and virtual words means that we can replicate real-world physical spaces from the present, past and future in an immersive virtual environment that our avatar representations can freely navigate under our control and, in the future, will be able to live and act autonomously through the use of artificial intelligence" (Wortley D, 2012). This means that the development of modern graphics technologies will give to cartography more and more chances to represent the reality by the most attractive way to all users, especially to children and students.

Other authors find cartography as useful tool to represent 3D information to different users and "traditional 3D projection techniques, constrained by the underlying 3D hardware for a long time, now allows us to consider advanced, cartography-oriented projection concepts" (Jobst & Döllner 2008). On this way cartography became more interesting and attractive to students. About 1/5 of all students, studying geodesy, wish to specialize cartography. After that, all of them work on diploma theses on cartographic thematic. They use for realization of diploma theses also their knowledge and practical skills in geodesy and photogrammetry.

## 2. The Laboratory on cartography

The Laboratory of cartography was modernized on the base of a project of the Department of photogrammetry and cartography on a theme "Remote Sensing and mobile spatial data infrastructure". The project was won in a competition "Building and developing of scientific infrastructure", financed by the Ministry of Education in Bulgaria. After finalizing the project, two

laboratories were modernized. The Laboratory on cartography has still hardware with high capacity and a list of software which we need in educational process of modern cartographical subjects: CAD, GIS, image processing, map design and 3D modules of the most world famous software companies and the necessary hardware.

According studying programme the students from Geodesy Faculty can choose one from six different specializations. Those of them who choose specialization cartography have opportunities to study Virtual Cartographic Modeling and 3D mapping. Many of students continue writing of diploma theses on similar topics.

Bulgarian Cartographic Association together with the Laboratory on cartography organizes different GIS and cartography courses. The last one, organized last year, was a training school on 3D Urban Visualisation; Open Web Technologies. The course lasted 40 hours and the keynote speaker was Assoc. Prof. Dr. Sisi Zlatanova, TU Delft (Tsvyatkova S & Bonchev S, 2012).

| | 3DS Max | CityGML |
|---|---|---|
| **1. Topology** | - | ++ |
| **2. Analysis** | - | ++ |
| **3. Semantics** | - | ++ |
| **4. Lighting** | ++ | - |
| **5. Visualization** | ++ | + |
| **6. Details** | ++ | + |
| **7. Texture** | ++ | + |
| **8. Material** | ++ | - |
| **9. Interior** | ++ | - |

**Table 1.** The difference btw 3DS Max and City GML in building modeling: Created during the course 3D Urban by students: Petya Angelova, Simana Michaylova, Christian Panayotov, leaded by Sisi Zlatanova

In this course Open Web Technologies have been presented to the students. They used City GML and gathered data for building of the University by evacuation plans and simple measurements. The constructed model was

represented in LoD4. More information about technologies and software can be found in many of Zlatanova publications, for example (Zlatanova S et al, 2008). Students have been divided into groups by 3-4 people and worked together in different steps of model creation. Last group was responsible for visualisation. In their work a table was created where students found differences between 3D buildings created by City GML and 3DS Max (see *Table 1*).

## 3. Technologies

Different technologies for 3D map creation are developed and presented to the students. All of them give easy and cheap way for 3D map making as well as they are applied for different needs and users.

Symbol system, scale, generalization, object classification, virtual camera, lights, photorealistic texturing are discussed and defined in the context of 3D cartography. Most of these terminologies came from computer graphics and 3D techniques but their cartographic application gave new tasks to cartographers: they should be used for map creation, analysis and visualization but as well described in cartographic science. In this context, symbol system creation is explained and a technology for symbol system design is proposed. One of the easiest and cheaper technologies for 3D mapping is named “From Paper to Virtual Map” (Bandrova T & Ivanova K, 1999).

### 3.1. “From Paper to Virtual Map”

The technology allows students of geodesy to follow all steps for 3D map making. Very often digital cadastral maps are available and students start to work by the 3rd step of the technology (see Figure 1). The 3rd co-ordinate could be found by different ways: taking by architectural plans, geodetic measurements or calculations by numbers of floors. All these methods give different accuracy and students should discuss this problem. Photorealism of the buildings and also 3D maps are achieved mostly by making photos of the building facades from the street level.

All steps of the proposed technology are the following ones:

1. Preparation of sources for map creation;
2. Converting of sources in digital form;
3. Including third coordinates;
4. Reconstruction of digital terrain model (DTM);
5. Designing of main contents (buildings, streets, etc.);
6. 3D symbolization of the 3D Map
7. Preparation of photo textures;
8. Photo-realistic visualization of 3D map.

According to the topic and user needs students choose which steps will be used. They create maps for tourism needs, for architectural needs, for early warning and crisis management, etc.

Other technology aims to use already existing geo-data and geo-information for map compiling for different needs and users, or for multifunctional cartographic application.

## 3.2. Technology for creation 3D Model for Multifunctional Cartographic Application

The proposed technology could be called **"3D Multifunctional Cartographic Model"** (Bandrova T & Bonchev S, 2011). One of the most expensive steps of 3D mapping is gathering of sources and data. Once we have the basic 3D model of the reality, we could use it for different purposes, for different users and for different application. This is our aim: when we have already the main contents of our 3D map, we will have any way and possibility to continue our works using different cartographic applications. *Figure 1* describes all steps of the proposed technology. The technology has one and the same firs steps and after that the steps are divided in three columns: 3D map for paper publishing, Virtual animated map and 3D map for Internet application.

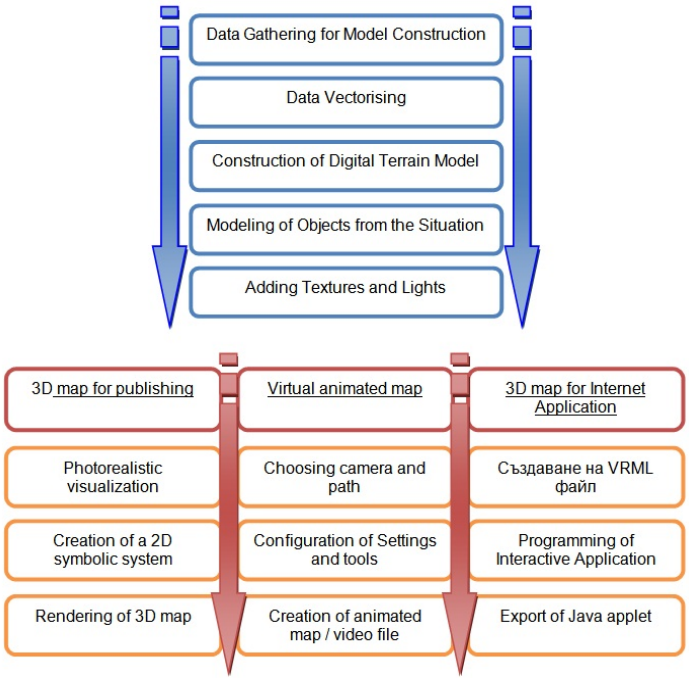


**Figure 1.** The Technology "3D Multifunctional Cartographic Model".

### *3D map for paper publishing*

Two aspects of cartography are considered: visualization and symbol system which transform the 3D model to the 3D map:

- Photo-realistic visualization

After completing the modelling of the entire 3D model we need to make the final frame of the model by already selected camera. A suitable picture of heaven which reinforces the sense of realism and depth, is selected as a background. Light sources and shades are added. The suitable resolution of the image is chosen and after rendering it is stored as a bitmap, see *Figure 2*.


**Figure 2.** A paper map designed on the base of 3D map (Diploma theses of Stefan Bonchev).

- Creation of 2D symbol system and visualization of 3D map

Having already obtained bitmap on the base of the 3D model we need software for image processing, for example Photoshop.

2D symbol system is preferred for the final variant of map design. For this purpose we do not need to design 3D symbols. 2D cartographic symbols are sufficiently intuitive and readable. In most cases, they are standard symbols of 2D maps and users are used to read them (a symbol of medical assistance, bus, parking, restaurant, number of runs and lifts, etc.). Also 2D

symbols are made much faster and easier and save both time and further work on 3D model.

### *Virtual animated map*

Animation by virtual camera in a software, as 3DS Max, resemble real shooting movies with the camera. For this purpose, one or more virtual cameras are created. Their settings - focal length and angle are selected. To animate the movement of the camera we need to create a way on the 3D model and later we should set the movement. The path is chosen to pass between the objects which should be shot according to the direction of the camera movement.

### *3D map for Internet application*

For Internet application a creation of VRML file is used. The advantage of it is the relative autonomy of its platform and on the other hand - its availability in the World Wide Web. So-called hyperlinks can be integrated in both VRML, and the HTML data, see *Figure 3*.

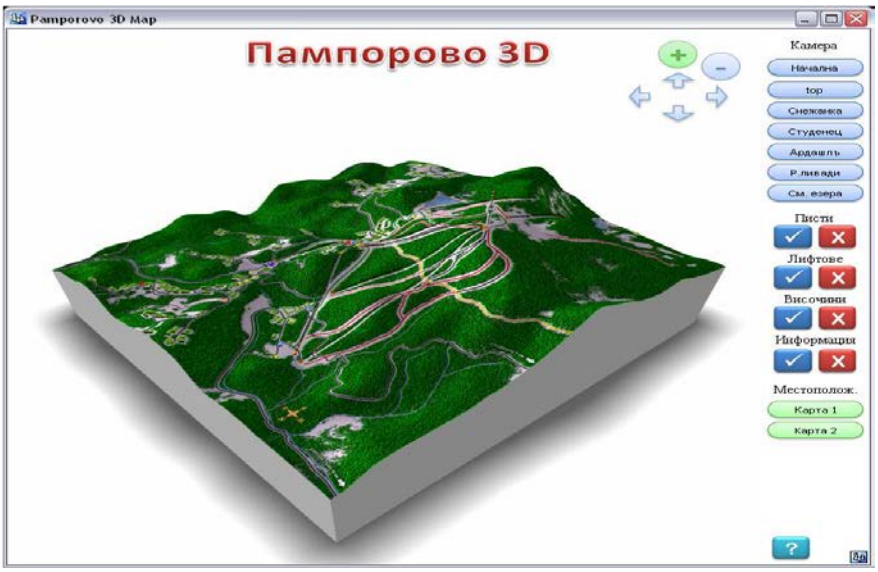


**Figure 3.** Internet cartographic application designed on the base of 3D map (Diploma theses of Stefan Bonchev).

Major disadvantage is the fact that the description of more complex objects can contain vast amounts of information. For those who use the Internet,

this means more time for transfer. In this case, it is essential to optimize the data in such a way as to maintain an optimum speed of information.

## 4. The students projects for 3D mapping – realizations and decisions

The students are educated and informed about the technologies for 3D map making, described above and they used the most suitable one for their purposes, needs and applications. The topics are mostly connected to the 3D visualization of cartographic products. For example, some of topics are: Designing of 3D Map with interactive Internet application (described in point 3.), 3D city mapping for Google Earth, **and 3D mapping for architectural applications**. The last project is based on precise geodetic measurements and accurate modelling of the environment and the result gives possibility to architects to understand the territory better before new buildings modelling (see *Figure 4*).

**Figure 4.** 3D map for architecture: Students should find practical application of their 3D map. This model is created in Laboratory on cartography but it is used in Faculty of Architecture for situation of new designed buildings (Diploma Theses of Kremena Boyanova).

The architectural project is positioned over the photo-realistic 3D map of the ground plan. This gives the opportunity for analyzes and evaluation of

the final result of the project. The information achieved through the visualization is perceptible for professionals (facing the architects) and unqualified users (contractors, buyers, tenants, etc.). Interactivity and the real sizes of the objects in 3D maps make information clear and accessible, close to natural human perception of reality.

At the same time the architect is able to achieve accurate metric measurements from the model for the needs of the planning. The view of the ground plan before and after the positioning of the newly designed building gives to the user clear idea of the size and conception of the project and the effect on the tendency for future planning and design in the area (*Figure 4*).


**Figure 5.** 3D mapping of monuments: Laser scanning is used for modelling of a monument scale-model, 3D city map of central part of Vratca city, Bulgaria (Diploma Theses of Alexandra Todorova).

The data capturing is connected also to geodesy skills of the students. Very often the existing cadastral or topographic maps should be updated by geodetic measurement. This fact gives possibility for students to measure the **3rd coordinate of the mapped objects**.

If the object is a building, the task for measuring is not difficult for students in geodesy field. The task is not so easy, if the object has complicated shape, like a monument. The solution could be using of laser scanning from street level. This decision needs available laser scanner and will lead to huge amount of data for an object and extremely big memory file. For cartography needs, this is very expensive way of gathering data and the users will be not satisfied. One possible decision of the task is to find scaled model of the monument which could be scanned in a laboratory. Such example was shown in one of diploma theses (see *Figure 5*).

Other project in the Laboratory of Cartography was connected to **Google Earth application**. Using a free version of SketchUp as 3D modeling software, students find decisions for different problems, mainly of texturing of the buildings and their situation in virtual environment. Because of not enough good accuracy of terrain model in Google Earth very often students should create additionally platform for building situation (*Figure 6*).

**Figure 6.** 3D mapping for Google Earth by SketchUp (Diploma Theses of Mladen Nikolov).

The last year eighteen students in specialization cartography and those ones who had chosen 3D modelling for elected subject had a task about building

a model for Google Earth. They had great interest to this idea and had "blind" competition between them for the best created model. In the end of semester seventeen new buildings in Bulgaria and one in Hungary appeared in Goodle Earth. Such projects provoke students' thinking to choose the best, fast and attractive way for building modeling. They exchange ideas and solutions about problems appeared in their work.

Usually students on cartography have good skills in art, drawing and painting. Such students like to create special and more art oriented maps. In this case they have interest also to **hand-painted panorama maps** and later to create 3D maps on the same regions. In this case students make comparison analyses between created and painted maps. Similar projects could be finding also in ETH Zurich (see Jenny H.M, 2011).

## 5. Results and plans for future works

Special decision in different areas of 3D modelling is found in every project: visualizing small objects as monuments with complicated shapes; situation of 3D model in Google Earth environment on additionally modelled platform, choosing of suitable symbol system, including 2D symbols. The realization of such topics is not difficult if we have enough good and expensive techniques, hardware and software. Very often we need to find cheap and easy decision being part of diploma theses. Several decisions have been discussed in the paper.

The aim of the projects is to find more workable applications, for example:

- in the field of early warning and crisis management;
- programming and describing automatic solutions of 3D models and maps;
- find more graphical applications on the base of measurements in 3D maps;
- propose different research and proposals for best and fast solutions in 3D map making.

As final step of visualization of 3D maps, students present animated models of the represented region. This fact gives of their diploma theses presentation finalization of their work.

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