

CyberCity Modeler, Generation, Updating and Continuation of 3D-City models with on-line-Editing – Visualization with TerrainView 2.0

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1 INTRODUCTION

Because of the new technology and the herewith lack of data, updating and continuation of 3D-city models was not a big issue in the past. Municipalities and other organizations have been satisfied with collecting 3D-data for selected areas. While more 3D-data becomes available, the updating and continuation of data has to be considered more seriously. Because of this reason CyberCity Modeler was extended by a new tool to an efficient updating by comparing existing 3D-city models with new aerial photographic information. Updating a city model means deleting of no longer existing buildings, adding of new constructed buildings and modifying of changes in existing objects. A new software module VisualStar was developed as a photogrammetric workstation with special functionality for data continuation and 3D measuring. The 3D-data is managed in a GIS database like ESRI's ArcGIS and ArcSDE or C-Plan's Topobase.

For interactive visualization ViewTec improved TerrainView (version 2.0), which includes additional sophisticated functions for on-line visualization. One of the most important requirements was the possibility of moving, deleting and importing objects. New objects can be taken over from various formats and combined to complex sceneries. Another important issue is the web streaming of landscape and city models, where TerrainView offers the possibility of viewing large data sets with very high speed.

2 VISUALSTAR: UPDATE AND CONTINUATION OF 3D-CITY MODELS

CC-Modeler is a software tool for generation of 3D-city models. It was described in several papers (see www.cybercity.tv) and presented e.g. at Corp 2003. The amount of existing data is rising and therefore the necessity of updating and continuation of the data is required. Additionally the data must be handled within GIS databases. Following points are important for actualization:

- Comparison between existing 3D-city models and actual status.
- Deletion of objects which do not exist anymore
- Edit of objects which have changed between the different status
- Add new objects by direct modeling
- Management of the actual city model in a GIS database (incl. attributes)

To perform these tasks, CC-Modeler was extended by a new tool called VisualStar. VisualStar is a digital photogrammetric station, which was especially developed for 3D-city modeling. It requires a PC with a stereo-capable graphic card and monitor. With a shutter glass the stereo viewing is performed. VisualStar also has standard photogrammetric features like stereo-model orientation, automatic and semi-automatic measurement of aerial triangulation, DTM and DSM, orthophoto computation including mosaicking.

For working with 3D-models existing data is imported from a GIS database or file system and is displayed together with the aerial stereo model. This means that the old city model is overlaid with the new image information and differences and changes are visible immediately. Buildings, which do not exist anymore, can be deleted from the database. New buildings can be recognized because they are visible in the stereo model and not yet represented by the necessary vectors. These buildings can be measured and modeled directly. The modeling is performed automatically after measurement of the polygons of the boundary points and the inner points of the roof. The operator just measures points, the lines and vectors are created automatically. The modeling is performed without knowing about the roof structure. E.g. it is not necessary to tell the program if it is a saddle-, tent- or other roof.

The 3D-data can be managed in commercial databases with ESRI's ArcGIS, ArcSDE or C-Plan's Topobase.

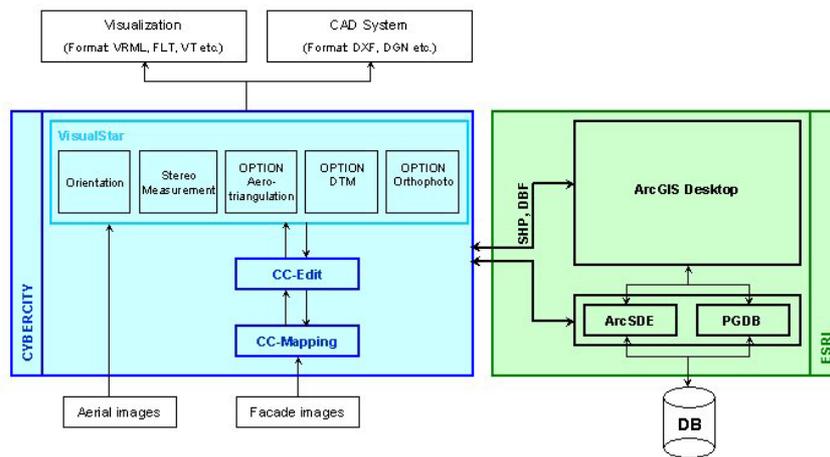


Figure 1: Workflow for Updating of 3D-city models in CyberCity processes and the management with ESRI's Arc products

CC-Modeler is an automatic topology generator for 3D-objects. The main components of the system are shown in Figure 1. The first obligatory step is preprocessing, which includes the checking of the measurement order of the boundary points (BP), detection of redundant points, and determination of the possible groups of faces, based on sets of adjacent (BP) point pairs.

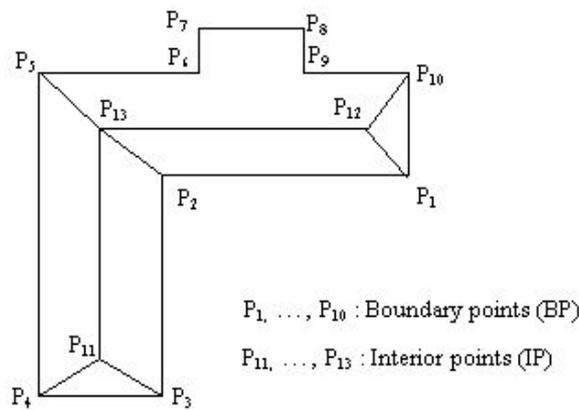


Figure 2: Data capturing procedure with CC-Modeler

The next step is to build the face model of the 3D-object, i.e. to determine how many faces the 3D-object has, which points define an exact face and the spatial relations between the faces. This is implemented through a *Consistent Labeling* algorithm by probabilistic relaxation operations, in which two procedures are involved, the initial probability determination and the relaxation processing. The result of *Consistent Labeling* is the face definition for every face. Then, least squares adjustment is performed for all faces simultaneously, fitting the individual faces in an optimal way to the measured points and considering the fact that individual points are usually members of more than one face. This adjustment is amended by observation equations that model orthogonality constraints of pairs of straight lines between boundary points. Finally, a vector description of 3D-objects is obtained.

This procedure allows the operator just to measure points, the vectors of faces and lines are generated automatically which means a distinctly more efficient data capturing procedure.

3 AUTOMATIC GENERATION OF FACADE TEXTURE

A software tool was especially defined to optimize texturing of facades. The goal was to reach a high degree of efficiency for big city areas. With CC-TLSAutotex or CC-Autotex, facade textures, which are taken from aerial images, can be put automatically on wall facades. This software module is an addition to CC-Mapping, where manually taken terrestrial pictures are handled or pictures within a library are used as generic texture.

CC-TLS Autotex allows to map images, which are taken by helicopters. TLS stands for Three-Line-Scanner, a digital camera system developed by Starlabo, Tokyo and equipped with software developed by ETH Zurich and CyberCity AG. The principle is shown in figure 3.

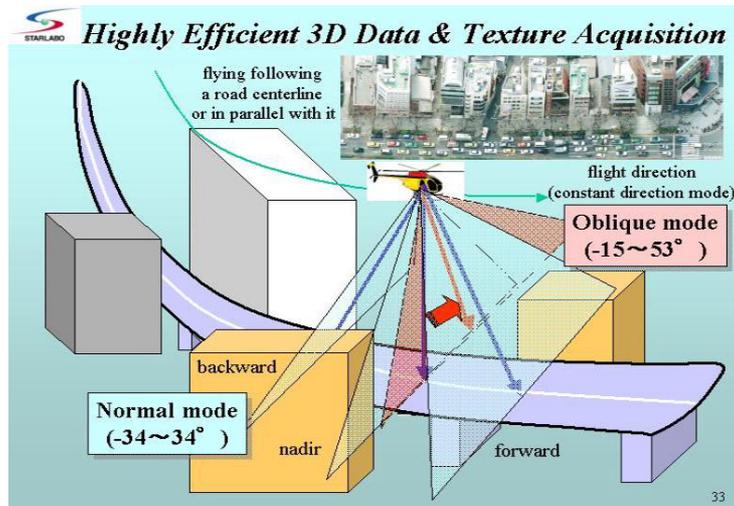


Figure 3: TLS data taken by helicopter for facade mapping

With CC-TLSAutotex the texturing of facade images is performed automatically for all non-hidden planes of the walls. The program detects occluded facades and textures all visible facades automatically. In case of occlusions the operator has to decide, if he will manually map this part or copy parts of the wall. An editing functionality for manual improvement of the image is included in the package. The 3D-model must exist either as v3d (Format of CyberCity) or dxf object. At the automatic procedure the quality of the different picture is analyzed and the best in respect to resolution, brightness and contrast is selected.

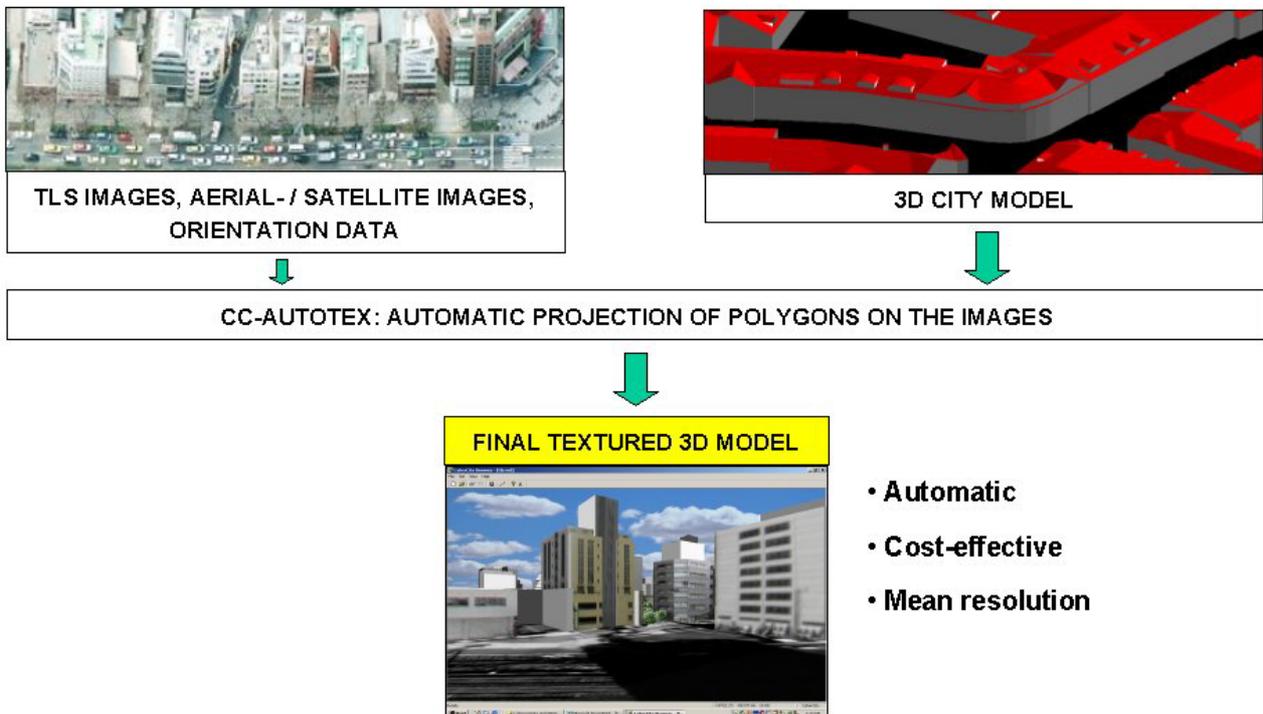


Figure 4: TLS results by CC-TLSAutotex

CC-Autotex is used for photos taken by planes. Starting with a 3D-city model in v3d or dxf format, the polygons within the images are computed and then textured to the object face. A projective transformation is applied for rectification. A special procedure for

deriving the facade texture was developed and will be published later. Using this procedure we can generate about 90% of the facades automatically. If required, retouching must be done manually. This is only necessary for a smaller number of images, because there is less occlusion in images taken from planes than in terrestrial photographs.

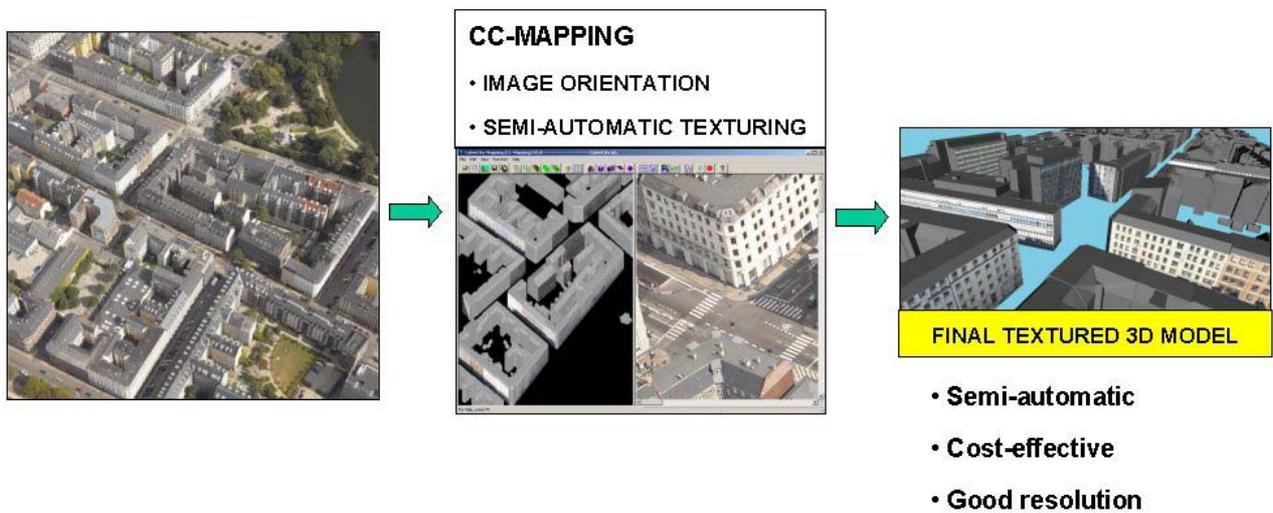


Figure 5: Aerial image data taken by plane for facade mapping

4 VISUALIZATION WITH TERRAINVIEW 2.0

The **TerrainView** application is a state of the art Virtual Reality based software solution that facilitates the interactive visualization of high-resolution 3D-terrain data over the **Internet and Intranet**. Due to ViewTec's advanced software technology and innovative data management concepts, large amounts of data may be processed in real-time. Digital elevation models, high resolution orthophotos, satellite images, 3D-buildings and vector data provide the real time application with the information to display excellent high quality representations of complex terrains and landscapes. It was described in several papers (see www.viewtec.ch). Spatial planning, works premises and city visualization, TerrainView gives benefit by visualizing present or future building projects in a most attractive way. TerrainView can include the corresponding information into the terrain model of your site, to visualize any preferred number of textured buildings. Optimization of production sites, marketing and public relation strategy can now be improved.

Main features of TerrainView are:

- Web streaming support
- Import of 3D-models of different formats
- Manipulate objects
- Various modes of navigation
- Points of interest editor
- Advanced flight path editing
- Terrain paging
- Weather visualization
- Arbitrary resolution screenshots
- Stereo support
- Generation of digital video
- Information tree

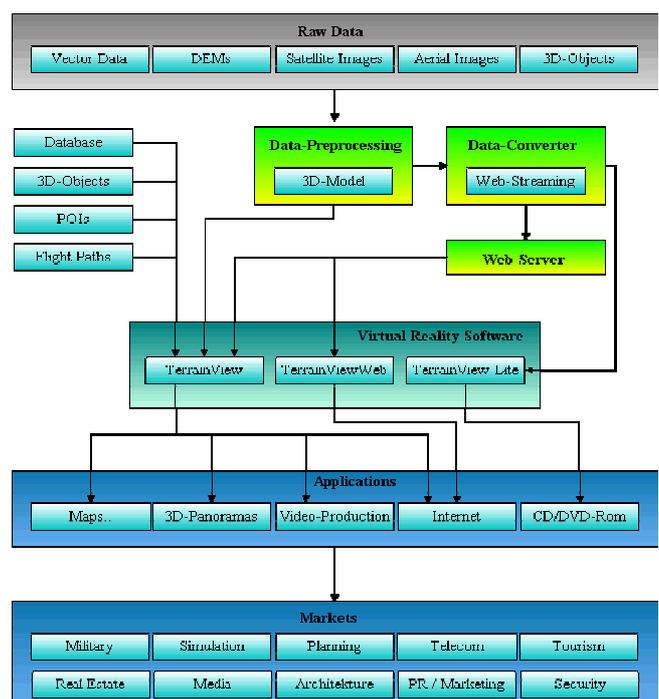


Figure 6: Workflow of Visualization

Web Streaming Support

With TerrainView you are able to connect 3D-terrain databases through Internet. Cities like Munich and Berlin with more than 500'000 buildings can be streamed. The 3D-terrain data size is only limited by the available disk space. TerrainView runs in conjunction with proxy servers and firewalls. All data streams are compressed and heavily encrypted. A standard Web Server delivers and manages the 3D-terrain data and orthophotos for the TerrainView application over the Internet or private computer networks. While using standard server technology, the user has access to large sized databases that can be viewed over low-bandwidth networks in real-time.

The TerrainView-Web ActiveX component/plugin for Microsoft Internet Explorer is also available free of charge (see www.viewtec.ch/techdiv/terrainviewwebplugin_e.html). City planners and architects have now the possibility to visualize big cities, import planned 3D-building models and show the results within one hour. TerrainView can visualize building blocks from vector data, texture the roofs with geospecific orthophotos and the walls with generic and geotypical textures. Landmark buildings can be imported as textured CyberCity or 3D-studio models. Urban planners can also access the whole Switzerland in 2m-resolution and cultivate this Internet model with their own buildings.

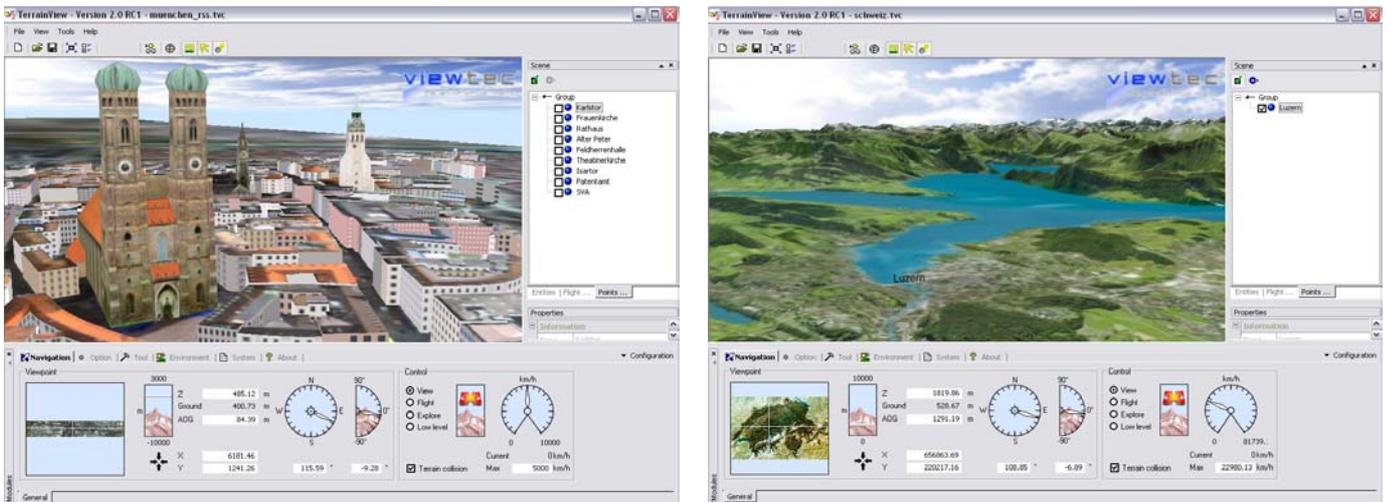


Figure 9: City of Munich with integrated landmark buildings and Switzerland with 2m-resolution

Supports Industry Standard Formats

Models such as buildings, billboards, and points of interest can be imported to enhance the realism of the terrain. Currently the supported data formats are Multigen OpenFlight, Terrex TerraPage, Quantum3D VT, Carbon Graphics geo, CyberCity v3d, Autodesk 3ds, Discreet 3D Studio Max (MAX), VRML 1 and 97, Design Workshop dw, Wavefront obj and NewTek LightWave 3D lwo. TerrainView rendering is accelerated through OpenGL, the industry standard for high-speed 3d graphics programming and takes full advantage of leading-edge OpenGL features.

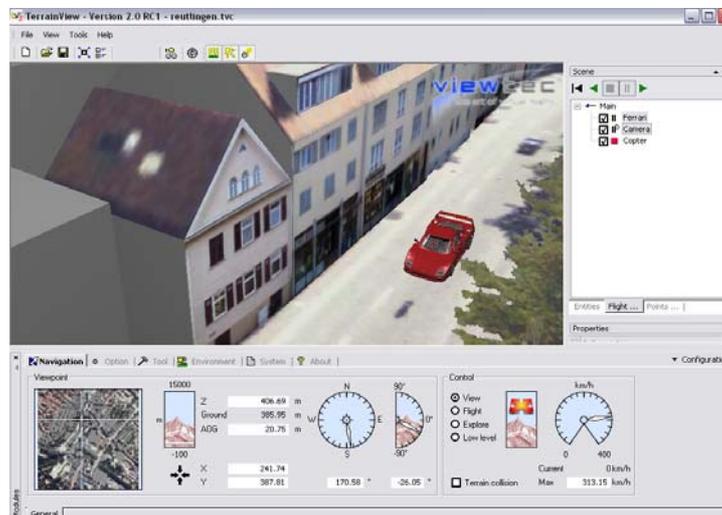


Figure 7: TerrainView scene with different 3D-models

3D-Object Manipulation

The imported 3D-data can be manipulated and adjusted to the customer’s needs in an easy and comprehensive manner. The user may merge and group multiple 3D-objects of different formats together. TerrainView can change between presentation and modify mode. If in modify mode, selected 3D-models can be moved, rotated, and scaled by the user. It is also possible to select, group and manipulate several objects at once.



Figure 8: City of Hamburg with selected and manipulated building

Flight Paths Editor

Flight paths are smoothly interpolated curves between a series of user-defined control points. TerrainView flight paths can interpolate positions and orientations.

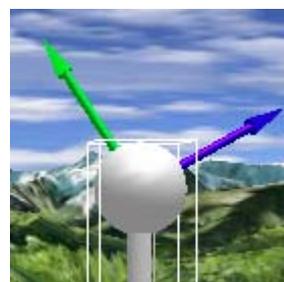
The flight paths in TerrainView use cubic interpolation what guarantees that every control point will be actually positioned on the calculated curve. TerrainView offers two vector interpolation methods:

- Catmull-Rom* This is a specialized cubic interpolation method, creating nicely curved paths. Apart from the control points’ position no further input is needed.
- Viewing Direction* This interpolation method uses the control points’ orientation vectors as tangents for the cubic interpolation. I.e. the user must set not only the control points’ position, but their orientation, too.

By using natural parameterization for the calculated curves, TerrainView achieves constant speed during motion along the flight paths.



Control point for Catmull-Rom interpolation



Control point with orientation information. The green arrow represents the forward direction, the blue one the upward direction.

Figure 9: Different interpolation methods

The green and blue arrows which are visible for spline interpolation represent the orientation at the control point and are called the frame vectors of the control point.

In TerrainView it is also possible to attach any object to a flight path. Furthermore, the camera can be attached to a flight path as well, and can be pointed at any other object that has been loaded, including any object currently flying along a different flight path.

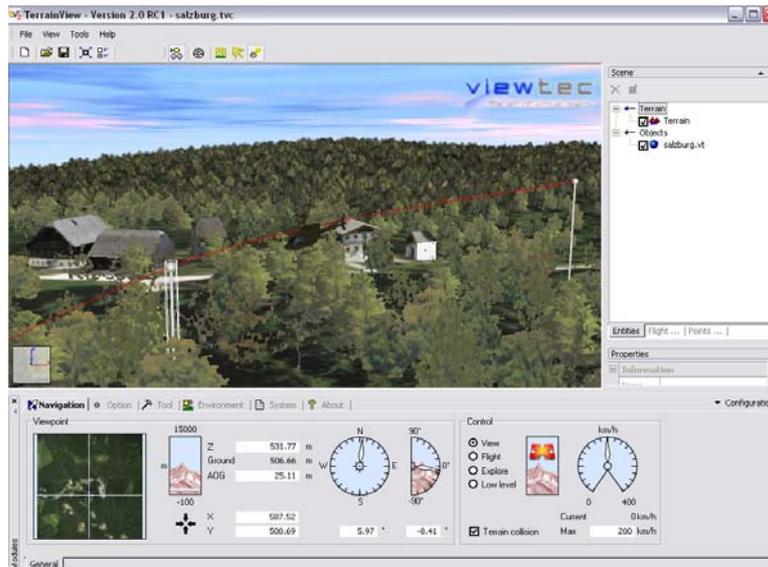


Figure 10: A helicopter is attached to a flight path

Generation of Digital Video

TerrainView offers the functionality to create video files in the AVI format using various encoders/decoders e.g. MPEG4. TerrainView offers two possible modes to create a video, "Interactive", or "Flight path". In the interactive mode, the currently rendered view is written to the video stream while the user navigates across the terrain, whereas in flight path mode one or more previously defined flight paths are started and the one with the active camera provides the images for the video.

5 CONCLUSION

CyberCity and ViewTec offer together new modules needed for updating and high-end visualization through Internet. CyberCity's VISUALSTAR allows online updating and editing, AutoTEX the efficient mapping of façade textures with high quality and low cost. TerrainView now allows modification of 3D-objects online and permits the visualization of complex landscape and 3D-city models. Flight paths can be generated in a very sophisticated manner. CyberCity Modeler and TerrainView together are highly developed tools for most ambitious 3D-model applications.

6 REFERENCES

Publications, references and detailed information may be found at

www.cybercity.tv

www.viewtec.ch