

## **APPLICATION AND LIMITS OF STANDARD SOFTWARE FOR 3D-MODEL BASED VISUALISATION, EXTENSION STRATEGIES, ESSENTIAL PROPRIETARY APPLICATIONS**

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### **ABSTRACT:**

This document delivers insight into the creation of 3d-visualisations based on survey and planning data using standard hard- and software. It shows possibilities to extend standard software and demonstrates the limits of existing systems. At first, common software systems are compared and evaluated according to their performance features. Using Maxon Cinema 4D as an example, the creation of a visualisation is depicted. Some necessary proprietary applications for tasks like data conversion and 3d-model processing are introduced and integrated into the creation process. Finally, specific problems are analysed, for example low rendering speed, missing interactivity and high memory demand, and associated solutions are developed and explained using the A+S-3D-Engine and the Survey-Viewer.

### **KURZFASSUNG:**

Dieses Dokument vermittelt einen Einblick in die Erstellung von 3D-Visualisierungen basierend auf Vermessungs- und Planungsdaten unter Verwendung von Standardhard- und software. Es zeigt Möglichkeiten zur Erweiterung von Standardsoftware und demonstriert die Grenzen der existierenden Systeme. Zunächst werden dazu einige verfügbare Softwaresysteme verglichen und anhand ihrer Leistungsparameter bewertet. Am Beispiel von Maxon Cinema 4D wird dann die Erstellung einer Visualisierung veranschaulicht. Die dazu notwendigen Eigenentwicklungen, wie etwa eine automatische Datenkonversion und Hilfsmittel zur Bearbeitung des 3D-Modells, werden vorgestellt und im Erstellungsprozess eingeordnet. Schließlich werden bestimmte Probleme analysiert, zum Beispiel niedrige Darstellungsgeschwindigkeit, fehlende Interaktivität und hoher Speicherbedarf, zugehörige Lösungen entwickelt und anhand der A+S-3D-Engine und dem Vermessungsvviewer erklärt.

## **1 INTRODUCTION**

### **1.1 Motivation**

For projects concerning infrastructure design, especially road design, it is particularly essential to have a visualisation before, during and after the planning. It conveys an impression of the newly planned road even before preliminary design and it helps to gain more public acceptance.

The design of such constructions makes high demands on geometry and planning technology. The construction project, as a 3D object, must therefore be assessed in whole and only this leads to a comprehensive evaluation of routing and road safety. On the basis of surveying and planning data, a 3D model is needed that should be designed with standard hard- and software to keep costs low.

### **1.2 Selection of a Software System**

The available software systems do not differ very much in performance. But in visualisation the small differences are of vital importance. Parameters like processing speed, learnability and extension possibilities were consequently the most important criteria when choosing a system. In addition, the costs of a licence influenced the decision for or against a system.

A few well-known programs were tested. In particular: Discreet 3D Studio Max, WaveFront Maya, Softimage XSI and Maxon Cinema 4D.

Tests on processing speed did not show large differences between the systems and did always produce acceptable figures. The memory demand of all systems was relatively high, Cinema 4D was the only system though which could process very big models with several million polygons acceptably. Discreet's 3D Studio was not able to even open models of this size. WaveFront Maya and Maxon Cinema 4D convinced with a simple and easy to configure user interface. Discreet 3D Studio appeared to be complicated and was obviously designed for experts who have already worked with the system for some time. All tested systems were easily extendable, but Maxon's script language was, because of its flexibility and simple integration into the system, a strong argument for this system.

Costs for program licences were nearly the same, but Maxon's package included a network renderer which allows to calculate animations on several computers of a network.

After this preliminary test Maxon Cinema 4D was selected as the software system for visualisation projects and it proved successful so far.

### 1.3 Selection of the Hardware

The selection of the hardware is vitally important for the realisation of visualisation projects. Costs for hardware are relatively small compared to the costs for software. Cinema 4D supports multiple processors and therefore several systems with two processors are used. It would be possible to even use computers with more than two processors, but it is difficult to acquire such hardware. On principle, systems with several processors are of great advantage because they show faster response times. Furthermore, such a system may be used for other tasks as well while continuing to render.

Our hardware systems contain a two gigabyte DoubleDataRate memory which provides a relatively high bandwidth and by this it guaranties a high data flow. The selection of the memory modules is very important because the expected amount of data will need a lot of memory very fast. Processor speed also plays a part, but it is subordinate compared to memory speed. It is to be expected that the RAM will not be sufficient for the processing. All modern operating systems support virtual memory (memory blocks not in use are stored on the hard drive). On the one hand this compensates the shortage of available RAM, but on the other hand it makes high demands on the hard drive. Therefore, all visualisation systems have several hard drives that are organised as a RAID. As a result the data gets distributed onto the hard drives in such a way that the possible data flow is greatly improved.

The graphics performance of the computer systems is another important feature for the realisation of visualisation projects. That is why only graphics cards were used which are able to do 3D calculations like lighting and transformation of the models independently of the main processors.

Modern electronic components produce a lot of heat which has to be carried off effectively. The cooling system greatly affects the stability of modern computers, consequently efficient water cooling systems are used for the computer systems. This method of cooling guaranties a stable flow of work. And as a pleasant side effect, this system runs very quietly.

As mentioned above, it is very important to be able to use several computers to work on an animation at the same time. A standard network with a transfer rate of 100 mbit per second is quite sufficient.

## 2 VISUALISATION WITH CINEMA 4D

### 2.1 Data Foundation and Conversion

The data placed at our disposal for visualisation has to be converted for the use in Cinema 4D most of the time. A big part of the formats delivered can be converted by existing conversion tools, but this leads to a loss of much information which is needed for further processing. To counter this kind of loss special conversion modules have to be developed which enable Cinema 4D to use these information.

Road planning data normally has to be exported in OKSTRA or CARD/1 format. An A+S conversion module is able to transform this data into a format which can be used by Cinema 4D. During the process lines for each axis and transverse profile

are created which can be combined to form a wireframe profile. This generates several sub-models that have to be united later.

The surveying data normally exists as SHP (3D Shapefiles, customary for geoinformation systems), DEM (Digital Elevation Model) or as CARD/1 surveying. These formats are well documented and can be read and converted easily and fast. In photogrammetric surveying even Orthophotos are available, but their resolution is too high to integrate them directly as texture material. It is however rather simple to split them up and to transform them into a normal texture format. Orthophotos are extremely well suited to convey a realistic impression of the landscape.

Autocad drawings normally used, for example, in landscaping and road marking plans can easily be exported in DXF format and then used in Cinema.

### 2.2 Working with Cinema 4D

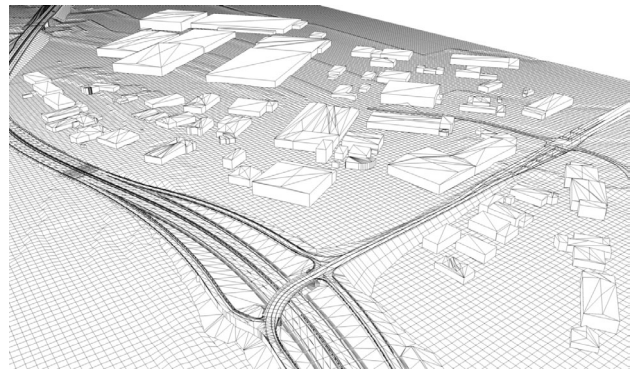


Figure 1: Wireframe Model

At first, the sub-models mentioned above have to be combined to form an extended model. To achieve this they are imported one by one and combined to a wireframe model of the surveying and planning data. Elements that have not been surveyed can be integrated manually using Cinema 4D's functionality for positioning and creation of objects. Even though this takes a lot of effort and is heavily restricted because normally the time to finish a model is rather limited.



Figure 2: Aerial Photograph-Texture

Now textures are added to this extended model, to achieve a most realistic impression of the scenery. For this example, Orthophotos from photogrammetric surveying were available which were prepared as mentioned above to be used in Cinema 4D. The material definitions needed for this have to be generated manually, but the procedure can be made easier with

a plugin. The lighting has to be configured to match the conditions when the aerial photographs were taken. Otherwise, the shadows of buildings and vegetation would not be convincing. After covering the terrain model with the aerial photographs it is possible to get a good impression of the layout of the planned object in combination with the existing landscape.



Figure 3: Complete Landscape Model

The next step consists of covering the buildings generated from surveying data with terrestrial photographs to enhance the impression of reality even more. This is a lengthy procedure because each building has to be textured separately. The surveyed vegetation can now be added and completed with the data from the landscaping plan. The landscaping data is a problem because normally it has no data on heights, but Cinema 4D has the possibility to generate these missing heights by a projection onto the terrain model. In addition it is difficult to position the single plants because only areas of planting are shown in the landscaping plan which have to be planted following certain rules. Therefore, Cinema 4D has to be extended to diminish the amount of work needed.

The model formed by those procedures is now rendered from the desired perspective and the results are presented to the client. At this point it is possible to emphasis special planning aspects and to correct errors. If needed even animations can be generated to illustrate for example an expert report on traffic flow.

### 2.3 Extension of the Functionality of Cinema

In the preceding paragraph it was made clear that Cinema is missing some special functionalities for the positioning of objects. To place objects on given points Cinema has to be extended and there are two possible ways of doing so. The first method is to use a plugin written in C++, but this is rather a lot of work for a simple functionality as this and therefore unacceptable.

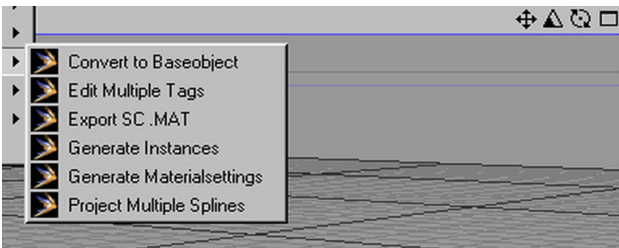


Figure 4: Integrated Plugins in Cinema

This is why a second method was used, the creation of a script. Starting with Cinema line objects a menu item was integrated that set a certain object down on all points of this line. The available script language commands were powerful enough to solve this task with just a few lines of code. This pays off even when just a few objects have to be positioned because it diminishes the amount of needed time immensely, because each object takes about one minute to position manually. Doing this it is nearly impossible to create a forest within an acceptable time. By using the script this is no problem and it takes about half a minute to place 1000 objects.

Another task is to assign textures to certain objects according to their name. Again, a script was written which creates material definitions from object names and links them to the corresponding texture files. In this context it had been difficult to position the textures correctly because information on georeferences have to be taken into account and Cinema cannot process this data without problems. The solution was to develop a C++ plugin that generates those texture coordinates automatically and enables a realistic and precise representation of the terrain. Using this script it is also possible to cover the roofs of buildings with textures which enhances the impression of the visualisation even more.

### 2.4 Problems

When creating pictures and animation some problems occur that cannot be solved by extensions. Above all clients criticize the lack of interactivity. Especially the residents would like to see how the construction will look from the perspective of their houses when the plan is presented to them. But this is not possible because of the long rendering times. Even interactive working on the models is very difficult and that slows down the progress of drawing up the models.

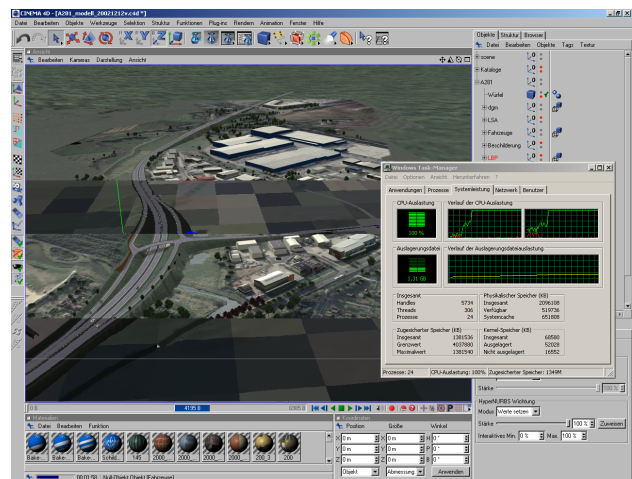


Figure 5: Cinema renders

Internally the immense memory need of Cinema 4D is critical. Even relatively small models require several hundred megabytes of RAM. Bigger models with dense vegetation or animations with high traffic flow are nearly impossible to be transferred into pictures or videos. The memory need can be reduced by skillful segmentation of the model, but not significantly.

The conversion of raw data is relatively lengthy and should therefore be automatised to achieve shorter finishing times. Combining the sub-models and the creation of road markings

and crossings could be done nearly completely automatic as well.

These problems can be solved by our own special developments. Today's standard hardware is fast enough to allow interactive representations with the desired quality to be possible with moderate requirements on memory.

### 3 PROPRIETARY APPLICATIONS

#### 3.1 Automatised Processing of Raw Data

As mentioned above the Orthophotos have to be splitted up and converted into a texture format for the texturing of the landscape model. This can be done automatically because the photos are normally geo-referenced. The terrain model is divided into smaller parts as well to fit texture and part of the model together. The material definitions are generated automatically. Therefore this whole work circle is abolished.

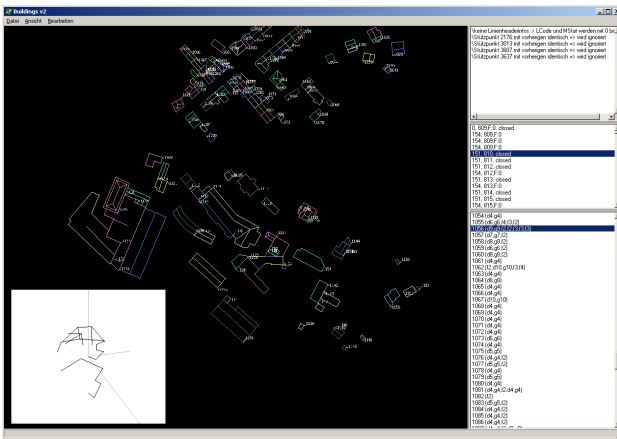


Figure 6: Automatically generated Houses

House models as well can be generated automatically if the surveying is adequately encoded. The requirements on the encoding correspond largely with the normal standards, extended by the required data for automatic processing. From this data houses can completely be generated automatically by an A+S's own converter. Modelling the houses manually is a time-consuming work, the additional work while surveying however is relatively small. It is therefore worthwhile for the client to carry out the surveying following the additional requirements.

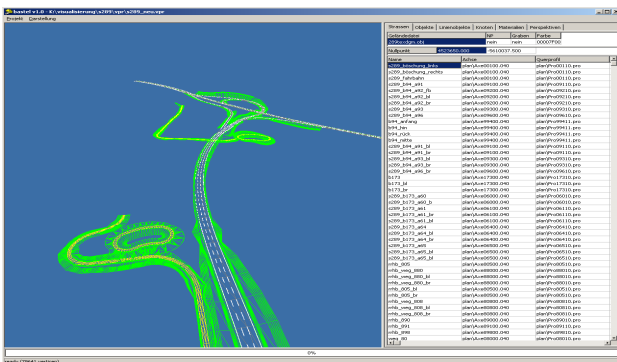


Figure 7: Automatically generated Traffic Facility

Traffic facilities are normally described in their complex form in the corresponding planning system. During the export into a standard format, most information needed for the generation are lost. For this reason, A+S has developed a program that uses exactly these information to independently generate a textured model of the traffic facility. This 3D model can be integrated into the terrain model textured with Orthofotos with only slight changes on the generated materials.



Figure 8: Integrated Expert Report on Traffic Flow

Expert reports on traffic flow cannot be integrated into an animation without automatised assistance. To do this manually would cost not just time but a lot of money as well. A+S therefore developed in cooperation with the PTV AG a program system that is able to transfer data generated by PTV's Vissim (microscopic simulation of dynamic transport demand) into a Cinema format which can be inserted directly into the existing model of the plan. This way it is possible to get a detailed picture of the expected traffic and its consequences.

#### 3.2 The A+S 3D Engine

The amount of needed memory and the speed for representation of Cinema 4D for big models is not acceptable, but this could not be solved with another extension. Therefore, an independent program system was developed that is able to show nearly all Cinema models very fast. This 3D Engine was designed as a module and can be integrated into any other program without much effort.

Technically the material definitions were a problem, especially reflecting and heavily structured surfaces. But modern graphics cards are able to generate these effects in acceptable quality and speed. The fact that the 3D Engine does not have to offer any editing functionalities helped to optimise storage structures and by that it was possible to reduce the amount of needed memory to about 10%. Only visible objects or those potentially visible are held in memory. It has to be noted that the objects are not stored as polygon objects as in Cinema, but only as simple descriptions of the objects that can be used to generate a model very fast. In addition, the complexity of the generated model is related to visual aspects like the size of the object on the screen. That is why it is possible to generate a picture much faster than before and this leads to a better interactive access where the visualisation can be seen from any position immediately.

The 3D Engine as a module cannot be used directly, it has to be integrated into a program system.

#### 3.3 The interactive Survey Viewer

Based on the A+S 3D Engine, a presentation software was developed in cooperation with Hansa Luftbild which offers the clients the possibility to look at a survey 3-dimensionally from any chosen point of view. The survey viewer offers a clear

representation of the survey data that is understandable even for non-experts. Planning data can be integrated as well to allow residents, at a presentation, to have a look at planning projects from their chosen point of view. In addition the viewer surface can easily be adjusted to the special uses of each client.



Figure 9: Survey Viewer

Objects can be faded in or out during a presentation to illustrate special planning aspects like plantings and noise protection installations. Furthermore the viewing mode can be selected for special object groups. When presenting a project to an audience of professionals the wireframe mode will be most interesting.

The survey viewer has been successfully used by Hansa Luftbild on several occasions.

## 4 CONCLUSIONS

### 4.1 Applicability of Standard Software

In the previous paragraphs it was shown that it is possible to use standard software successfully for the design of visualisations. It is important to carefully adjust hard- and software to avoid troubles later.

The open structure of the available software allows an extension of its functionalities and makes it easier to use the system for unusually complex tasks. Even though, there are still problems that can only be solved by our own developments.

### 4.2 Effort Consideration

Without doubt, the development of new software has its risk, especially the amount of time needed can hardly be calculated. Therefore A+S carried out the development while working on visualisation projects to cover costs and to minimise the risk.

In time, a collection of tools was assembled to make the designing of a visualisation easier. With each project, the tools were refined, extended and more and more integrated into the designing process. By this we were able to reduce the needed amount of time to less than 25%.