

A Comparison of 3D Modeling Programs

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I. INTRODUCTION

There is a wide variety of 3D modeling programs available on the market today, ranging from simple home-brew systems to high-end professional packages. Our goal in this task is to find a robust, easy-to-learn, scalable model-building environment to develop virtual world models for use with the DIVE[11] virtual environment (VE) system. Several criteria are used in this comparison; to be of use to us, a model-building program must:

- be able to export models to VRML files,
- have an easy to use and efficient interface, and
- enable precise positioning of polygons.

This report bases its findings solely on these criteria. This is not a comprehensive comparison of 3D environments. Many aspects of 3D development that are crucial to most projects are ignored here, including the rendering engine, speed, animation interface, NURBS support, lighting models and many other features that do not concern us in our application.

II. BACKGROUND

The multi-media task (MMTASK) of the ATON-project [12] focuses on the problems that exist in today's VE systems. These problems include the lack of support for different I/O devices (e.g. head-mounted displays, gloves, wands), difficulties navigating in and interacting with the virtual world, lack of 3D sound-renderers and integration with real-world data. The MMTASK is multifaceted in many ways and one of the research thrusts involves the creation of a 3D environment representing a college campus.

This document compares programs that can be used to create the elements of the 3D environment. This comparison focuses on features that make the creation of accurate models of arbitrary objects easy.

For this particular thrust, only a low level of detail is necessary because ultimately the objects will be used in a real-time environment. A reasonable degree of accuracy is needed because the models will be based on real world objects (i.e., the buildings on the campus).

III. BASIS OF COMPARISON

Each software package we evaluated was judged and rated on a scale of 1 to 10 (10 being the best) in each of the categories described below. The tests were carried out on an NEC PC with a 450 MHz Pentium-II with 128Mb of RAM and a Diamond Multimedia Viper V7xx video card. An evaluation version of each program was used to conduct the tests. Most programs included full functionality with limited or disabled save/export function. We describe each of the criteria of the comparison below.

A. Views/Ease of Use

This category compares how easy it is to see the object and to manipulate the view panes. Can each view be easily zoomed, rotated and moved? Are these controls intuitive? Can additional views be defined?

B. Primitives/Polygon Creation Tools

Every 3D modeling program allows the user to create primitives (basic shapes, sphere, cone, etc.). This category compares how easily each program lets the user accurately place and size these primitives. Can coordinates be typed in? Are the coordinates shown onscreen? Are there snap grids?

C. Editing Polygons

Developing an interface to work in 3D on a 2D screen is a daunting task that has taken years to perfect. There are different paradigms that can be used in order to make sense of this. The main thrust of this category is in judging how intuitive the interface is. How easy it is to select, move and edit

polygons after they have been created. When an object is clicked, does the program select as expected? Does the object move in the expected plane? Can objects be snapped to a grid or other objects?

D. Complex Surface and Volume Operations

In this category, the operations that can be used to transform surfaces from simple objects to more complex volumes and surfaces are compared. Can lines, polygons or surfaces be extruded and lathed? Can curves or surfaces be joined? Can a union or subtraction of a volume be performed?

E. Texture Maps

Applying texture maps will be an important part of this project. A sense of realism will be achieved by using very simple objects with few polygons and vivid texture maps. This makes real-time processing possible. The paradigms used to apply texture maps can be confusing. This category compares the flexibility and understandability of the program's texture mapping functionality. Can the placement of the texture be controlled? Is there a preview? How does the user control tiling and the way that the texture wraps around an object?

F. Materials

Applying material properties to an object is another step in making it look real. This category compares the functionality of each program's material interface. This category varies widely. Can the diffuse, specular and color properties be controlled separately? Can reflectivity, transparency, index of refraction and other such properties be defined? Note that the material support in DIVE (our primary run-time environment) is actually very limited. DIVE's material support is equal to a rating of 4 by the scale used in this report.

G. VRML output

Output to VRML is a prerequisite for consideration in this project. All objects will have to be put into VRML to be translated into a run-time environment. This category compares the program's flexibility and support for VRML.

IV. COMPARISON

We undertook an exhaustive search for all the currently available 3D modeling environments. Programs that were designed for more limited tasks (simple flying logos, 3D paint programs and virtual environment programs that lack model development

capabilities [such as DIVE]) were excluded, since these programs do not fit our requirements.

Two categories of programs were found: professional level and consumer level programs. The evaluated professional level programs are:

- Maya[1] by Alias|Wavefront
- 3Dstudio MAX[2] by AutoDesk
- LightWave[3] by NewTek

The consumer level programs are:

- SoftF/X[4] by Byte by Byte
- TrueSpace 4.2[5] by Caligari
- Simply 3D 3.0[6] by Micrografx
- Rhino[7] by Robert McNeel & Associates
- MultiGen[8] by MultiGen-Paradigm
- AC3D[9] by Andy Colebourne
- FormZ[10] by auto•des•sys inc

All of the above programs were tested according to the criteria discussed in the previous section. We will now discuss each program separately with respect to these criteria of comparison. For each package, we also represent our "grading" with a simple graph of the evaluation for the seven main criteria.

A. 3DStudio MAX by AutoDesk

	1	5	10
Views	[Progress bar from 1 to 9]		9
Primitives	[Progress bar from 1 to 8]		8
Editing	[Progress bar from 1 to 8]		8
Complex	[Progress bar from 1 to 9]		9
Texture	[Progress bar from 1 to 7]		7
Materials	[Progress bar from 1 to 9]		9
VRML	[Progress bar from 1 to 10]		10

Even though this product has been around for a couple of years, it has still maintained its position as one of the most preferred programs by 3D artists.

1) Views/ Ease of Use

The default view uses four different viewports: top, front, left and perspective. The viewports can be controlled individually and even change to another viewtype (camera, light) independently of the others. The views can be manipulated using the mouse and ctrl-, shift- and alt-keys.

Most tools are accessible from the different toolbars. These toolbars can be customized in order to suit everyone. 3DStudio Max has its own scripting language which allows users to modify their work using a shell or record different actions and thus create new, customized tools.

2) Primitives/Polygon Creation Tools

The most common primitives can be created in 3DStudio Max: 2D-shapes and 3D-objects. Cameras, lights, and particles are also easily created and manipulated. All objects have their own set of parameters that can be altered anytime.

3) Editing Polygons

Unwanted objects can easily be hidden which is really helpful. It is possible to select a single point, a face, an entire object etc. It is fairly intuitive to select, deselect and manipulate existing objects.

4) Complex Surface and Volume Operations

3DStudio Max has numerous tools for creating and manipulating surfaces. From the basic extrusion and twisting to advanced tools like softness (less impact on control points far from the selection).

5) Texture Maps

Good but too many options, which makes it a bit complicated to apply the texture as intended. But it is probably just a matter of getting used to the program.

6) Materials

3DStudio Max lets the user control everything he/she could possibly want. The main difference from the texture mapping is that fact that the material editor has several default materials that can be used and modified.

7) VRML output

One problem with many programs is the lack of good VRML output, but 3DStudio Max really is an exception. It lets the user suppress objects and only export those and the exported VRML-file is clean and straightforward.

8) Summary

Most of the programs tested have specialized in one or two areas within 3D-graphics (e.g. animation, editing, rendering), but 3DStudio Max contains a complete set of tools (and sub-tools) for all purposes. Perhaps Autodesk's ability to create new useful tools along with its ability to maintain an "up to date" interface is the reason why 3DStudio Max is so popular among 3D artists.

B. AC3D by Andy Colebourne

	1	5	10
Views			7
Primitives			6
Editing			7
Complex			3
Texture			5
Materials			6
VRML			9

AC3D is a shareware program developed by Andy Colebourne at Lancaster University, England. The program is a mixture between a modeler, an object-manipulator and a file-converter, and it is available for several hardware-platforms.

1) Views / Ease of use

The viewports are the regular ones; front, left, top and perspective. The orthogonal views can only be moved (not rotated) by the keyboard but the perspective view can be controlled by the mouse to zoom, rotate and so forth. It takes a while to get used to the different mouse-actions but once it is learned, it works fine.

2) Primitives / Polygon Creation Tools

There exist only a few basic shapes in AC3D. The objects can be modified after creation by typing in dimensions into a dialog box (including rotation).

3) Editing Polygons

It is very easy to select individual vertices, a group of vertices or complete objects. Each selection can easily be moved and rotated.

4) Complex Surface and Volume Operations

Several tools are available to manipulate vertices and surfaces, although only the basic extrude has been helpful to us. There exist other tools for surface manipulation but their usefulness is very limited.

5) Texture Maps

AC3D supports texture maps and it is very easy to understand how the textures are applied on different surfaces. The only options available control which plane the texture should be applied on the surface and how many times the texture will be repeated over the surface (tiling).

6) Materials

The material-editor in AC3D does not consist of anything out of the ordinary but since it supports the

properties that are implemented in DIVE, it is enough for our purpose.

7) *VRML output*

The VRML-output works really well. It is possible to switch output of normals and textures in a 'settings' window. The only negative is that it is only possible to export the entire world (not possible to select objects only).

8) *Summary*

AC3D is a great shareware with lots of functionality. It works really well on all the platforms we have tested. It is not easy to create objects with AC3D but it works fine to import and manipulate existing objects.

C. *Rhino by Robert McNeel & Associates*

	1	5	10	
Views				9
Primitives				9
Editing				5
Complex				10
Texture				3
Materials				4
VRML				9

Rhino is basically a modeling-program; it is obviously designed to be easy to learn and to use.

1) *Views/Ease of Use*

The default views are, as in most programs, front, right, up and perspective. Each viewport can be moved, rotated, zoomed independently of the others by using either keyboard shortcuts or by different mouse-buttons. Rhino is very intuitive to use; it does as intended.

2) *Primitives/Polygon Creation Tools*

Objects can be created either by click and dragging the mouse, or typing the coordinates into a command line. Most basic objects can be created; 1D shapes (points, lines), 2D shapes (rectangles, circles) and 3D objects (cubes, cones and spheres).

3) *Editing Polygons*

It is easy to manipulate whole objects in Rhino, but it takes a lot of practice to edit single points of a polygon. Two snap-techniques can be used. Grid-snap is the regular snap-tool while object-snap snaps to a point on an object. The object-snap is really useful but it is difficult to master. Selecting objects, lines, curves or points is really nice, e.g. if several line-segments are shown in the same location in a

viewport, Rhino displays a list of the line-segments at that location.

4) *Complex Surface and Volume Operations*

There are many useful operations in Rhino, from simple move- and rotate-operations to more complex operations such as Booleans and fillet. But it is not the amount of operations that is great about Rhino; it is the fact that most operations are really easy to use.

5) *Texture Maps*

Rhino has limited support for textures. It is unclear how a texture will be applied to a face and there exist no tools that can manipulate the position and behavior of the texture (e.g. wrapping, tiling).

6) *Materials*

Even if Rhino has more support for materials than textures, it is not very advanced. Only basic-components (diffuse, specular, etc.), transparency and 'highlight' can be used.

7) *VRML output*

Rhino can import and export several file-formats and is excellent at exporting VRML. The user can control the number of polygons exported and choose individual objects to export. The materials and textures part of the VRML-code works perfectly.

8) *Summary*

This program is really great for creating models. The user-interface is quite intuitive and easy to use. Rhino has a large set of tools for creating and manipulating objects.

D. *SoftF/X by Byte by Byte*

	1	5	10	
Views				2
Primitives				7
Editing				3
Complex				4
Texture				7
Materials				5
VRML				n/a

SoftF/X is a basic modeling and animation program. The modeling, animating and batch rendering components are separate. No information is available on educational discounts.

1) *Views/Ease of Use*

Sizing, focusing and the four-panel view are good but zooming, rotation and moving are very bad. It is difficult to manipulate any view. There are no

shortcuts for the mouse and objects are easily lost due to the unpredictable zooming tool. The orthogonal view has no axis to orient the user. Generally, navigation is frustrating with this program.

2) Primitives/Polygon Creation Tools

A primitive is basically selected and created in the center with default values and it is difficult to change. But the user can also bring up a dialog box, type in coordinates and sizes and accurately create primitives that way. This is a pretty good interface, better than the 'point and hope'-method, but not very convenient. Also, there is no mouse tracking in the normal views.

3) Editing Polygons

It is difficult to near impossible to even select an individual object. This is frustrating since you click and click but never get anywhere. Selecting a single point and moving was easy but there is no way to do it accurately. Snap features are not intuitive.

4) Complex Surface and Volume Operations

There are some basic operational tools but that is about it. And the existing tools are difficult to use because selecting objects is really difficult.

5) Texture Maps

This program has one of the best texture-mapping interfaces the authors have seen. It is very clear about creating surface, reflection, bump or texture maps and it provides an easy way to see the way your texture wraps around the object. Lots of properties are editable and textures can be added in several layers.

6) Materials

The materials properties are a bit limited. It does include transparency and reflectivity but direct control of luminosity and specular power are missing.







7) VRML output

SoftF/X includes a VRML export along with DXF but the export functionality is disabled in this demo version.

8) Summary

There is no real usefulness in this program, since it is so difficult to work with objects. There may be some compelling features, but these were not found. As far as model creation is concerned this is not the program for the job.

E. trueSpace 4.2 by Caligari

	1	5	10
Views			3
Primitives			5
Editing			6
Complex			8
Texture			3
Materials			2
VRML			n/a

TrueSpace seems to be one of the few 3D programs that escaped the 3D-acquisition craze of 1997. Developed by Caligari Corporation, trueSpace was one of the earliest modeling programs in existence. They took a unique approach to the paradigm of working in a 3D space on a 2D screen. Also, they took their own approach to buttons, tools and menus, since they predated the Windows standardization. In fact, their system with a small menu on the bottom of the screen, pop up buttons and pop up icons from objects is still innovative to this day. But, it does not quite jive with the behavior that we have come to expect because of the ubiquitous Microsoft interface.

1) Views/Ease of Use

TrueSpace tries to present all the needed information from one orthogonal view. This has proven to be difficult to ineffective for modeling. Panning and zooming are near impossible and getting the world to orient the way you want it is difficult. A neat tool is used to rotate in any direction you want, but that is the only type of motion that is easy to do. Selecting objects is difficult. When clicking on an object you get a pop of menu of icons that are all quasi intuitive. These icons are similar to the ones on the menu bar that are all kind of mysterious. There seem to be a good variety of features but they are difficult to use because you do not know what type of object the features will work on and you are not given any hints.

2) Primitives/Polygon Creation Tools

The usual primitives are given in trueSpace but there is no way to accurately determine the dimensions. Coordinates of a primitive can be typed in after the primitive has been created.

3) Editing Polygons

It is easy to select objects, rotate and move them. Although the mechanism to do so is abstract. Object dimensions can only be scaled.

4) Complex Surface and Volume Operations

There are lots of good 3D object deforming, shaping and combining tools. However, they are very artistically oriented. They are great for experimentation and can create some neat effects. But it is difficult to create anything really accurate with them.

5) Texture Maps

The texture mapping features are somewhat unclear. It was difficult to control the way that a picture is texture mapped. It is the frustrating click and hope method that must be used.

6) Materials

A material-editor could not be found.

7) VRML output

VRML output is documented but it could not be tested due to limits in the demo-version.

8) Summary

TrueSpace is a great program for people who are just playing around or people that just want good-looking model. But as far as creating an accurate model of anything, this is not the program

F. Simply 3D 3.0 by Micrografx

	1	5	10	
Views				5
Primitives				4
Editing				6
Complex				7
Texture				6
Materials				8
VRML				n/a

By Micrografx, Simply 3D is among the easiest to use programs tested. Its \$200 price tag makes it among the most affordable programs in this report. A collection of already created objects, textures and lights make it feel easy to create good-looking scenes. It includes several wizards that make it easy to create commonly used animations. At first glance this program seems to be the “photodelux” of the 3D world, just giving idiot proof commands to do generic tasks while hiding the truly useful features completely. But this is not the case. Behind the pre-made objects and wizards are decent 3D creation tools and a nice animation and basic reverse kinematics interface. Upon deeper inspection it becomes apparent that this program is the descendent of Infini-D, a program by Specular which was acquired by Fractal Design in 1997 and who’s

fate became unclear once Fractal merged with Meta-Tools to become MetaCreations. Apparently it was sold to Micrografx at some point.

1) Views/Ease of Use

Simply 3D uses a standard four pane view. These views are a bit difficult to manipulate, there is no zooming or panning using mouse keys. There is only a basic zoom button, but the auto zoom is fairly intelligent. The perspective view is actually a camera view. To change the perspective, the camera is moved. This is a change from the standard but it is intuitive and provides the power to easily create multiple perspective views. The camera remains pointed toward the center of the scene, which makes it easier to use but difficult to do anything but the simplest fly through.

2) Primitives/Polygon Creation Tools

A basic set of primitives is included but the size and position of the primitives cannot be controlled upon creation. These can be set after they are created. These properties, which include translation, 3D scaling and rotation, can be altered after they are created.

3) Editing Polygons

Objects can be easily selected and moved, scaled or rotated. But changing individual points is difficult. The <x y z> positions are given but there is no grid to orient to or snap to.

4) Complex Surface and Volume Operations

Simply 3D includes lots of neat tools and presets for twisting, bending and generally morphing objects in interesting ways. Most of these tools are pretty abstract and not really useful for creating real world effects. But they sure look cool.

5) Texture Maps

The texture-mapping interface gives lots of good options to help control how to apply textures. It is a little difficult to tell which way a texture will orient on an object but this is a by-product of the flexibility offered by the interface.

6) Materials

Simply 3D offers good a good materials properties interface. It includes settings for color, transparency, index of refraction, shine, and more.

7) VRML output

This is documented but the option could not be found.

8) Summary

Simply 3D is a poor choice for creating real world scenes. The lack of accurate tools and difficulty navigating views make it almost impossible for this task. But for creating simple 3D scenes and animations this program is strongly recommend. It comes with a very good looking ray tracer and an intuitive animation interface. Breathtaking scenes can easily be created. It is a bit slow, but the results are stupendous. For the price, this program is a steal. If you just need to create flying logos and text that looks really good this is a very good buy.

G. MultiGen by MultiGen-Paradigm

	1	5	10
Views			9
Primitives			8
Editing			7
Complex			6
Texture			7
Materials			5
VRML			8

MultiGen is an expensive package that has met the needs of several vertical markets. It is particularly designed for creating real-world simulations, such as urban planning, complex terrains, and real-time simulation. The price tag is a bit high

1) Views/Ease of Use

MultiGen's views are easily manipulated. Mouse modifier keys can be used to change the perspective view. There are many options for changing the view including precise controls of position, pitch, yaw and roll. Each of the four panes are equally flexible.

2) Primitives/Polygon Creation Tools

The primitive creation paradigm is a bit different from other programs. But it lends itself well to precise world creation. Coordinates for position and size can be typed, but they do not quite act as expect.

3) Editing Polygons

Objects, vertices and points can be easily selected and translated accurately. There are plenty of grid options and the snaps work well.

4) Complex Surface and Volume Operations

Even though there do not exists so many interesting tools for polygon editing, MultiGen creates polygons really flexibly so extra tools are unnecessary.

5) Texture Maps

The texture mapping tools are clear. These are among the easiest to understand but they are not that flexible.

6) Materials

Material-options are limited, e.g only colors chosen from a list can be used (rather than defining each one). There are just enough options to get by.

7) VRML output

Successful translation to VRML was achieved.

8) Summary

MultiGen is a very strong program that is flexible and has many features. It is not quite intuitive, this means there is a bit of a learning curve. MultiGen is the program for modeling large-scale geographic sites but for our purposes it is not worth the cost.

H. Lightwave

	1	5	10
Views			8
Primitives			8
Editing			6
Complex			8
Texture			7
Materials			9
VRML			n/a

LightWave just barely makes the professional list. At a price of \$2500, \$900 educational, you would expect that LightWave offers more than the programs at the consumer level. And this it does, at very least LightWave offers a well thought out interface, solid modeling features, a good animation interface and a strong rendering interface. All the professional level programs in this report received very favorable ratings and LightWave is no exception. What makes the difference between LightWave and the other professional programs are high level features like scripting.

1) Views/Ease of Use

It is a bit disappointing that LightWave does not let the views be controlled using mouse modifier keys, but the smooth on screen controls make the views easy to work with. The views are flexible and setting up a snap grid is easy.

2) Primitives/Polygon Creation Tools

LightWave has a control window so that the position, orientation and every other aspect of any

object can be controlled. It is also possible to create objects from by using this control window.

3) Editing Polygons

Selecting objects is a bit difficult but there are plenty of options for moving and rotating objects.

4) Complex Surface and Volume Operations

LightWave offers lots of interesting options for manipulating 3D objects. Using these tools is particularly easy.

5) Texture Maps

LightWave's texture mapping interface is good, but like many others it is complicated and difficult to figure out what the results will actually be.

6) Materials

As expected, LightWave offers thorough materials options and it is easy to apply materials to objects.







7) VRML output

It is hard to believe that a program such as LightWave would not include a VRML exporter, but this feature could not be found. In a pinch, AC3D can import LightWave files and convert them to VRML.

8) Summary

LightWave is a strong contender in the middle of the road 3D modeling market. It offers a thorough and mature interface and many of the features found only in the highest level packages for a reasonable price (particularly for educational). The interface is much easier to use than other professional level packages. It gives the ease of use of a consumer level package with much of the functionality of the pro packages.

I. FormZ

	1	5	10	
Views				6
Primitives				10
Editing				7
Complex				8
Texture				6
Materials				5
VRML				n/a

For \$975 (educational) formZ is a strong addition to the field of 3D modeling. It includes an impressive array of features. When first started up, the collection of toolboxes is a bit intimidating. But after a bit of work with the program everything becomes intuitive quickly.

1) Views/Ease of Use

This is most likely the weakest part of formZ. It only offers a single view, although it can easily be changed to other presets, this involves selecting a new view from the menu bar. The view cannot be manipulated with the mouse and the right mouse button has no functionality.

2) Primitives/Polygon Creation Tools

In formZ objects are placed on the screen using the mouse or their position and dimensions can be typed into the prompts box. There exist many options for creating primitives depending how they are placed.

3) Editing Polygons

There are lots of options in formZ for editing objects. Whole objects can be moved and rotated and points or any part of an object can be transformed. But, some of the tools get a bit complicated and you loose track of what the end result will be.

4) Complex Surface and Volume Operations

FormZ includes many options for manipulating 3D objects. Along with the usual extrude and lathe tools there are options for deforming, adding, subtracting and many other options.

5) Texture Maps

There are lots of options in formZ's texture map interface. This offers a lot of flexibility in applying texture maps but it also makes it difficult to figure out what the result would be.

6) Materials

All the basic materials features are there. Transparency is supported but there is no index of refraction setting. The interface is a bit weird, the properties are set to several presets rather than directly on objects.

7) VRML output

A VRML exporter is documented but the demo did not allow exporting.

8) Summary

FormZ comes with a lot of features compared with some of the other programs in the report but it is also a bit pricey. Although the features are quite thorough, the look and feel is a bit immature. The tool bars look like they come from an old DOS program, the lack of features for the right mouse button and long lists under each menu are a bit disturbing. Finally, although this program offers strong features that meet our needs, the lack of a

four-pane view, difficulty manipulating views and high price forced us to look elsewhere.

J. Maya

Maya is one of the big guns of the 3D animation world. Maya has a long and colorful history, starting as Alias and being married to Wavefront under the struggling SGI umbrella. After melding the best features of these programs, enhancing them even more, redesigning the interface and producing an awesome set of documentation (the set of books that comes with Maya stacks about a foot and a half high) Maya emerged. Maya is now in version 3.0. It offers many features that are well beyond the scope of this report. Everything is scriptable and everything is treated as an object.

V. CONCLUSIONS

It should be obvious by now that there is no one "best" 3D modeling program for all model-building applications. There are programs that are more suited to some tasks than others, and each of the programs we evaluated handled different sets of tasks. In fact, inertia is actually the most compelling factor in choosing modeling programs. LightWave and trueSpace are examples of programs that will continue to thrive simply because so many people use them and do not want to change. Maya will continue to be the software of choice for many studios because this is where they've invested training and hardware dollars. 3D Studio Max tends to be the choice of engineering modelers and some researchers due to its inverse kinematics features. 3D Studio was also one of the first 3D programs for the PC platform, so many early adopters still use it.

For the ATON project, Rhino was recommended for use in creating the objects and AC3D as a translation tool. Rhino's CAD-like interface lends itself well to this project and AC3D is a tool that one should always have on hand.

At this point we have actually completed the modeling project. These two programs have met our needs quite well. They were inexpensive and easy to learn. Rhino's ability to import CAD files and preserve layers was invaluable. This coupled with Rhino's robust snap features allowed us to make a rough model of several buildings and about 100,000 square yards of the grounds of the University of California, San Diego in just a few days. Textures were applied in AC3D and compiled into a VRML world. A description of our model-building task, including several screenshots and QuickTime fly-

through movies can be found on our project web site: www.create.ucsb.edu/ATON/.

VI. FUTURE WORK

Next step in our research in VE would be to try different distributed real-time VE-engines/renderers. We are not certain whether or not the current DRIVE-system [13] is the most suitable for the project. We are now starting an evaluation of virtual environment rendering and interaction systems based on the requirements of the ATON applications. Such requirements will include ease-of-use, world-distribution, real-time rendering, user-interaction, open source, spatial sound output and support for different hardware-platforms. Parallel to the rendering tests, we are also working with several different input devices in order to interact with the virtual worlds.

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