EQUINOX-3D™

v0.9.8

User's manual v0.9.8.85 - updated 2018-04-01

http://www.equinox3d.com

Help with the manual, as well as EQUINOX-3D, is greatly appreciated.
It doesn't yet cover every feature of EQUINOX-3D, but it should give you a solid place to start.

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1. Introduction

EQUINOX-3D is a powerful 3D modeling / CAD (computer aided design), animation and rendering software suite.
It allows you to create stunning, photo-realistic pictures and movies, to design complex mechanical parts and intricate shapes for 3D printing, laser cutting, or other types of manufacturing, and to test mechanical designs, to build 3D worlds for virtual reality, or for many other applications, and so on.
The possibilities are endless!
EQUINOX-3D also has a powerful application programming interface (API), so entire new functionality may be added from “plugins”.

Font conventions

When referring to a menu item or a button / icon on a panel, or in a dialog box, bold, italic sans-serif font is used, with the following conventions:

- Menu->File->Open file means the “Open file” menu button in the horizontal menubar's "File" menu.

- Menu->Transform->Reset means the “Reset” menu button in the vertical menubar's "Transform" menu.

- ***Tool->Surface->Revolve*** means the “Revolve” button / icon in the tool panel's (toolbar) "Surface" folder.

Ctrl+S (bold, sans-serif) means a keyboard shortcut.

3DWindow, Spline, Mesh etc.: fundamental types are capitalized and contracted into a single word.
For those of you, interested in developing plugins for EQUINOX-3D: these also refer to actual data types in the API (E3dWindow, E3dSpline, E3dMesh etc.).

Helpful tips are marked with ***Tip:*** (bold italics, serif).

1.1. User inteface basics

EQUINOX-3D starts up with a traditional 4-view look, which may be customized later.

All buttons, sliders etc. have tool-tips. These help messages pop up if you rest the mouse pointer on the button for 2 seconds or longer.

Tip: Reading the tool-tips is a quick and easy way to get started with EQUINOX-3D!

There is also a vertical menu panel on the left, a “Transformation and search” panel on the right and 3 horizontal panels on the bottom.
Each of the above may be turned on or off, from the ***View*** menu, or via the function keys **F1**-**F5**.

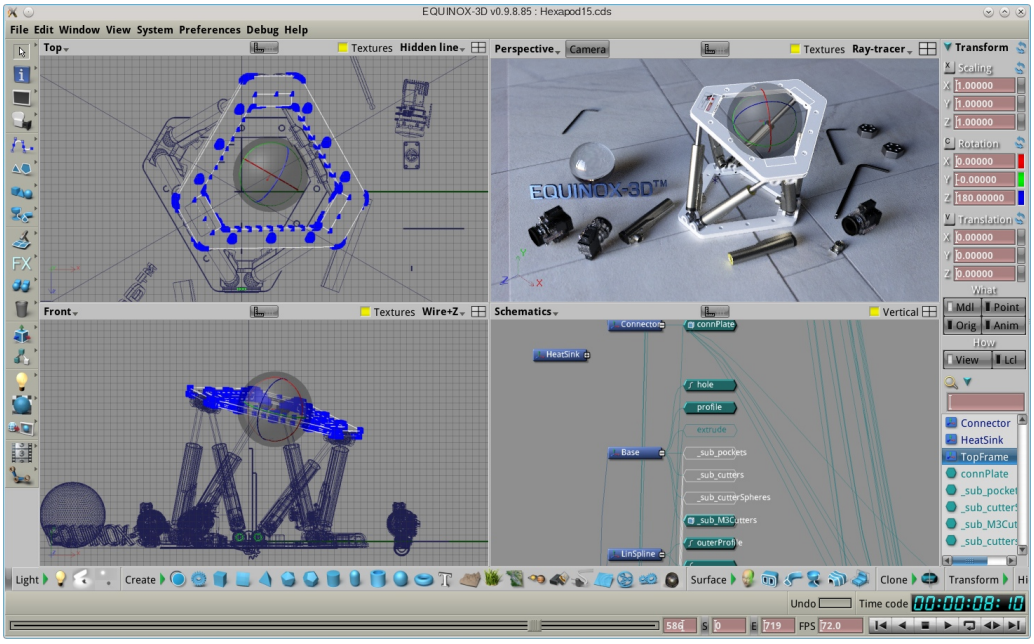


Figure 1.1.: the main window of EQUINOX-3D

1.1.1. 3D windows

Each 3D window (3DWindow) has a header with some controls and a main part with the 3D display. You can turn this header on/off via the **H** key.

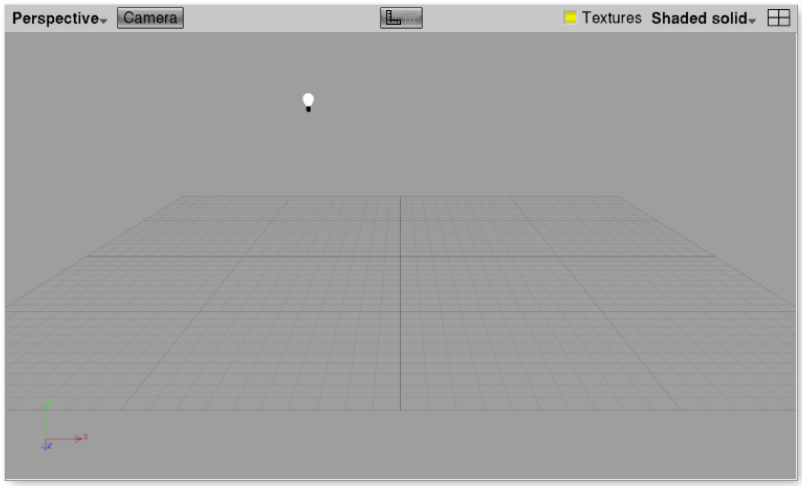


Figure 1.1.1: a 3DWindow with *Perspective* **view** and *Wireframe* **display mode** (renderer).

The active 3DWindow is where the mouse pointer is. Keyboard input for camera control, selection etc. will apply in the active window.

Each 3DWindow may be minimized / maximized either horizontally, vertically, or in both directions, by clicking the window icon on the righ side of the header (see the tool-tip).
You can also change the size of each window by pressing the **F8** key.

New, “detached” 3DWindows may also be opened via ***Window->New 3D window***, or with **Shift+Ctrl+N**.
Detached 3DWindows will have their own Cameras. When you create a detached 3DWindow, a new Camera is created for it, called “Detached-Camera”, but you can also share any other cameras between 3DWindows.

Both the main 3DWindow and detached ones may be switched to full-screen mode via the ***View*** menu, or with **Ctrl+F**.

1.1.1.1. 3D Window settings

To change the settings for a 3D Window, click on the button in the middle of the header of the Window:

Figure 1.1.2: 3D Window header with View-mode selector, camera picker, settings button, Textured mode, Rendering-mode selector, and window size button.

This will bring up a dialog box that allows you to change everything from grid displays, to renderer settings:

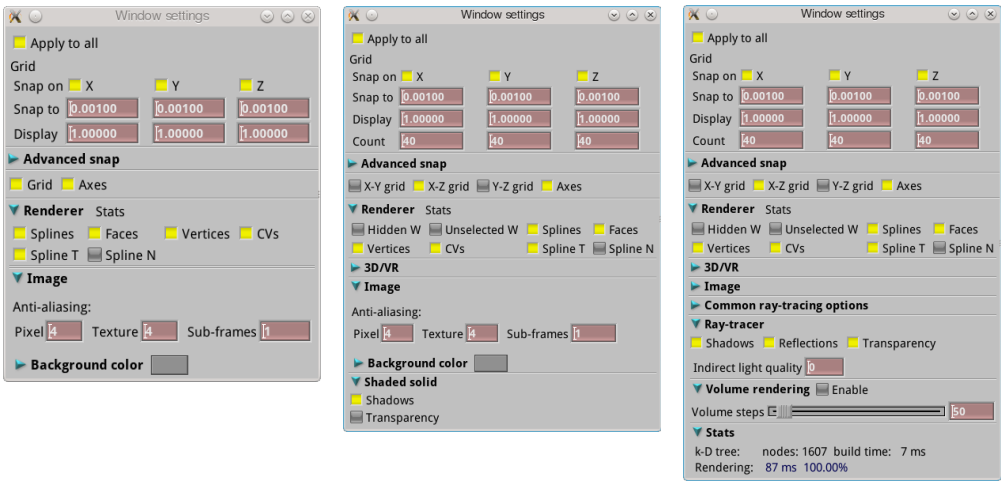


Figure 1.1.3: 3D Window settings dialog boxes. Left: 2D view (“Front”), Middle: 3D view, with “Hidden Line” rendering mode Right: 3D view with “Ray-tracer” rendering-mode.

1.1.1.2. Using VR or AR headsets with EQUINOX-3D

EQUINOX-3D supports VR (virtual reality), and AR (augmented reality) headsets. You may set up any detached 3DWindow, as your VR headset display.
To do this, make the 3DWindow full-screen with **Ctrl+F** and simply move it over to the headset's screen (e.g. drag with Alt+left mouse button, depending on your computer's desktop settings). See your graphic card's settings (e.g. nvidia-settings) for using multiple display setups, such as connecting a VR headset.

Headset-specific parameters (split-screen horizontal stereo 3D, eye distance, lens correction etc.) can be adjusted in the 3DWindow's settings. These will be saved and restored when you save a 3D scene to a file, so you don't need to set them up again.

The headset's tracking sensor (or any 3D sensor) can be connected to the 3DWindow's Camera. You can turn any Model into a 3DSensor from ***Constraints->Make a Model a 3D sensor***. This Model will be able to drive either Cameras, or any other 3D Models, via transform constraints (see later). Multiple 3DSensors allow you to track your hands as well, or even your entire body (sensor support is still under development).
This setup is saved into Scene files as well and sample setups will be provided.
Headset tracking / Camera control may be turned on / off by pressing **Ctrl+Enter** while the pointer is on the given 3DWindow (other sensors will have their own settings under the appropriate 3DSensor object).
When tracking / Camera control is turned off, the usual Camera controls will work instead (see 1.2.1).

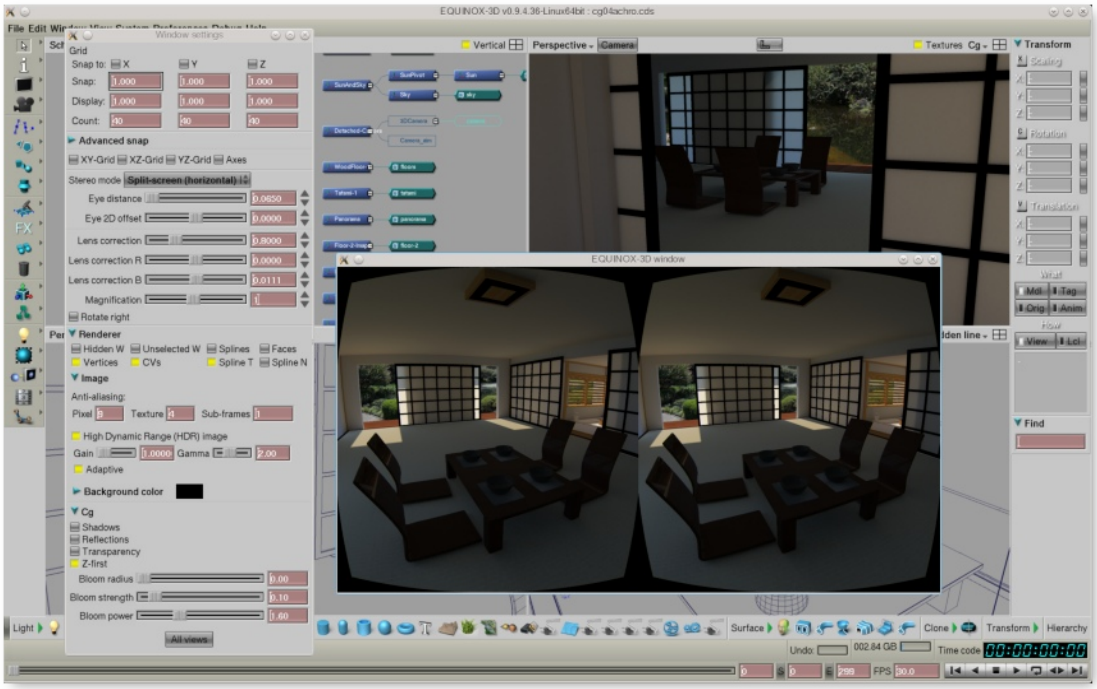


Figure 1.1.1.1 using EQUINOX-3D with a VR headset.

1.1.1.3. Selecting a View-mode and a Rendering-mode

The top-left button of each 3D window activates a pull-down menu of choices for the **view-mode**.

Any of the 3DWindows may be set to one of these view-modes:
- Perspective - standard 3D view with a perspective or custom projections
- Top, Front, Right - “orthographic” projection
- Schematics - shows the relationships between objects as a graph
- Animation - animation curves
- Texture - texture-mapping view
- Any other custom views that may be implemented by plugins

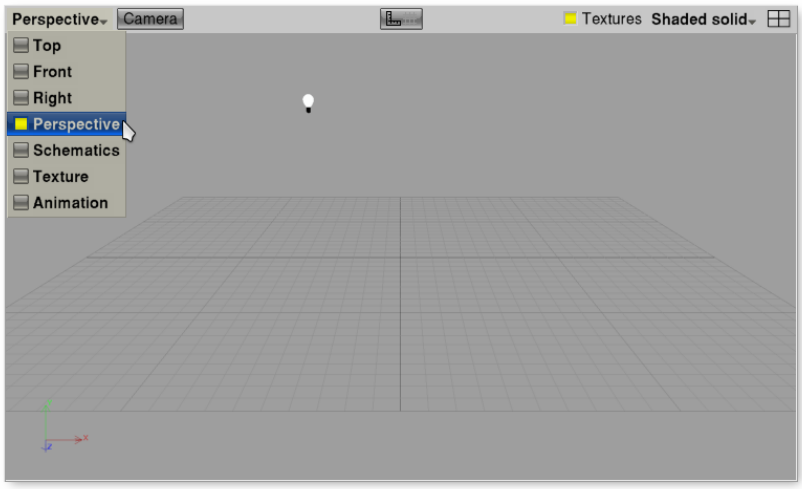


Figure 1.1.1.1a view-modes in a 3D window

The second button from the right activates the menu for selecting the **rendering mode**, such as *Wireframe* (*Wire+Z*), *Hidden line*, or *Ray-tracer*, etc.

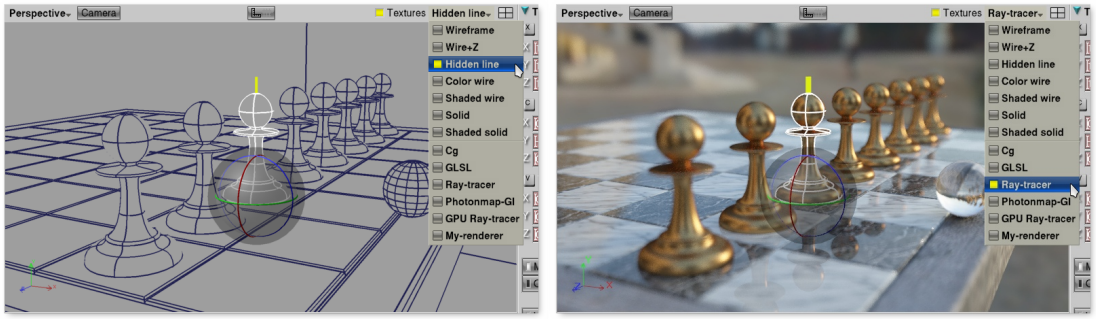


Figure 1.1.1.1b different rendering-modes in a 3DWindow

EQUINOX-3D has a unique and very powerful *deep-integration* renderer infrastructure. Plugins can implement new renderers and any 3D window can then use those renderers while still displaying selections, wireframe, 3D controls etc. and allowing editing in that window.
In other words, plugins can add *fully integrated* renderers to EQUINOX-3D.
Yes, you can edit your 3D model right on a photorealistic, ray-traced view!

For example “Cg” and “Ray-tracer” renders are implemented by plugins, while “Wire-frame, Hidden-line etc. are built in.

Also, EQUINOX-3D has a fast interactive ray-tracer, so you can edit your 3D models directly in a ray-traced window with physically correct shading, reflections, refractions etc. changing as you change a shape!

Tip: clicking the the Middle Mouse Button (MMB) on either the view-mode or the rendering mode buttons will toggle between the two most recent modes. This makes switching back-and-forth super quick!

1.1.2. Bottom panels

On the bottom of the main window, there are 3 panels (bars). These panels can be turned on and off from ***Menu->Panels*** or via the keys **F1**-**F5**.

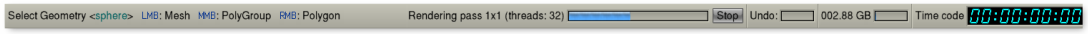
1.1.2.1. Toolbar

The Toolbar is organized into folders. (Light, Create, Surface etc.). The folders can be opened and closed by clicking on the little green arrow after the folder's name:

Clicking on an icon with the **LMB** (Left Mouse Button) will activate a tool, while the **RMB** (Right Mouse Button) will bring up the tool's dialog box, if that particular tool has one (and possibly activate the tool).
For example: **LMB** on the Tube icon will simply create a “default” Tube, while **RMB** will also pop up the “Create Tube” dialog box and let you interactively change the parameters of the Tube (inner radius, outer radius, height etc.).

1.1.2.2. Status panel

The Status panel has a message label, undo-stack indicator bar and a time code display for animaton.
The message label indicates the status of EQUINOX-3D, the function of the mouse buttons, it can display messages and/or a progress-indicator bar.



Tip: The Status panel is the primary source of feedback to the user. regarding the current status / mode EQUINOX-3D and what the mouse buttons will do.
When in doubt, read the status panel!

In this manual, and in EQUINOX-3D in general (e.g. on the Status panel),
LMB, or just **R** means Left Mouse Button
MMB, or just **M** means Middle Mouse Button
RMB, or just **B** means Right Mouse Button

1.1.2.3. Time panel

The Time-panel includes the main time slider with the current-, start- and end-frame fields and the usual playback buttons (rewind, stop, play etc).
This panel is used for controlling and displaying (playing) animations.

1.1.3. Menus

There are two menu-bars in EQUINOX-3D. The horizontal one on the top has the standard "File" menu, user interface options, preferences etc.

The vertical menu-bar on the left has the 3D modelling, rendering and animation menus:

This menubar is configurable in the Preferences settings. The buttons can be displayed either with Icons only, Text only or both Icons and Text.
You can find the setting for this, under ***Menu->Preferences->Edit***, ("Menubar buttons" under the User interface drop-down folder):

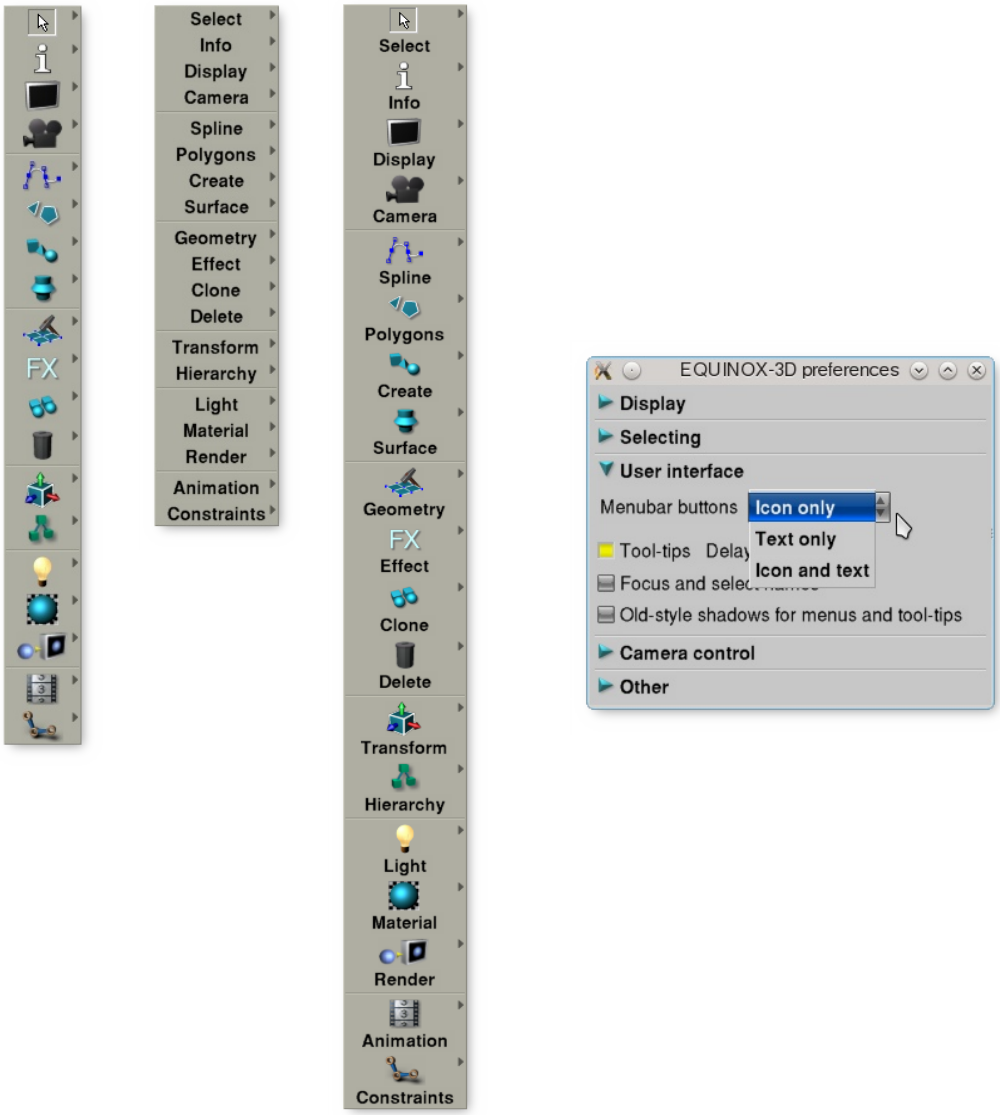


Figure 1.2.1. Vertical menu bar with **Icon only**, **Text only**, and **Text and icons** setting.

Buttons in these menus may have an "options" "sub-button". This pops up the a dialog box for a particular tool (similarly to "right-clicking" on a ToolPanel icon).
The ***Clone->Immediate*** button is an example of this. See Figure 1.2.2.

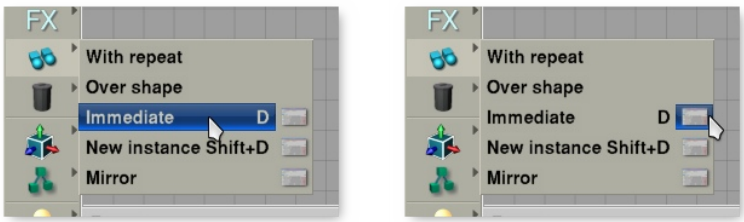


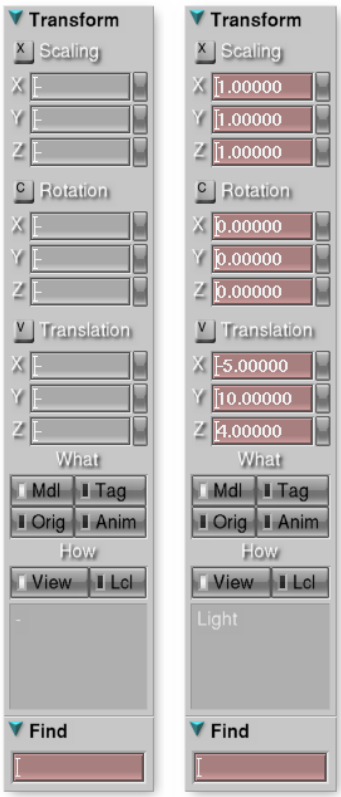
Figure 1.2.2. Menu button with options (dailog box) “sub-button”

Tip: Clicking on any menubar button (***File***, ***Display*** and so on) with the Middle Mouse Button, will activate the last function again. This can really speed up your workflow.

Note: plugins can add buttons in either the menus and / or the Toolbar. You can unload, modify / rebuild (if you can code in C/C++) and reload a plugin without exiting EQUINOX-3D. When a plugin is unloaded, those buttons are removed, when it's reloaded, the buttons are added back.

1.1.4. Transform Panel

This vertical panel is used for interactive transforming (scaling, rotating, moving etc.) objects or components of objects.
It controls the way objects are manipulated with the mouse.



This panel is inactive (left image) when there are no objects selected.
If an object is selected, the panel becomes active (right image) and shows the current transformation values as well as the name of the selected object(s).

You can enable/disable interactive transformations per coordinate axis (X, Y, Z) with the little buttons right to the number fields.
You can also turn them on/off simultaneously by clicking on the “Scaling”, “Rotation” or “Translation” buttons, or hitting the 'X', 'C' or 'V' keys.

Under the label “What”, you can select what will be transformed with the mouse (“transform target”):
- **Mdl**: whole object(s) (Models), or
- **Tag**: tagged points of objects

Under the “How” label, you can select how the interactive translating will work (“transform mode”):
- **View**: drag objects or components along the view
- **Lcl**: move along X, Y or Z axis of an object

There is also an interactive finder tool on this panel. If you type in a name, or a partial name using the “*” wildcard character, it will select objects that match that name.

If the transform target is **Tag**, but there are no tagged points on the selected objects, it will temporarily switch to **Mdl** (while the transforming is taking place; holding down a mouse button).
This allows for quick switching between transforming objects or points, just by tagging and un-tagging points.

1.2. User interaction

1.2.1. Transient modes

Many modes in EQUINOX-3D are only active while you are holding down a key. When you release that key, it will go back to the previous mode.
This greatly speeds up your work flow, as you don't have to run back-and-forth between the menu and 3DWindows.
The status panel will always tell you what mode is active.

For example, holding down the **M** key allows you to move points, such as Mesh Vertices, or Spline CVs, holding down the **Ctrl** key allows you to move the Camea, and so on.
When you let go of the key, it will go back to whatever mode you were in.

1.2.2. Context-sensitivity

EQUINOX-3D is very powerful, with a *lot* of functionality. Don't let the relatively simple-looking user interface deceive you!
It looks simple, because most functionality is *context-sensitive*, meaning that you are only offered options that make sense, in any given situation.
For example, when you activate the ***Edit Polygons*** tool, you can do all your editing very quickly and efficiently without using any menus.
As you move the mouse pointer over the Mesh or PolyGroup you have selected, the Status-panel will show you options, based on where the mouse pointer is, and the active component will be highlighted.
For example, if it's above a Vertex, the Vertex will be highlighted (it will turn yellow), and it will let you delete that Vertex, start a new Polygon, or a new Edge at that Vertex, etc.
If the pointer is above an Edge, the Edge will be highlighted (it will turn yellow), and it will allow you to add a new Vertex on the Edge (“split Edge”), delete the Edge.
And so on...
This speeds up the work flow even more and it keeps the user interface simple and easy to learn (much simpler than a bunch of pop-up menus, to show all the options).

1.3. 3D interaction

1.3.1. Cameras

The first and most important thing to learn in any 3D software, is controlling the Camera. When you connect a VR headset to EQUINOX-3D, the virtual Camera in EQUINOX-3D, will simply follow your head movements.
On a traditional monitor, however, you will be looking at a 2D screen, so you need to control the Camera with the mouse (or other device).
Each 3DWindow's has its own, independent Cameras for each view-mode (Top, Front, Perspective, etc.).
The “Perspective” view Camera of each 3DWindow is shown in the schemaitics view, as a simple hierarchy, with the Camera's transform-node, an aim-point, and a common parent node.
You can create any number of Cameras, you can switch any 3DWindow to use any Camera, by clicking the “Camera” button in the 3DWindow's header.
You can even share Cameras between 3DWindows. For example, you may want to see the Scene from the same Camera view, in wireframe mode and ray-tracer mode, side-by-side, in two separate 3DWindows.
You can also see the Cameras themselves in the 3DWindows, if you select the appropriate node in the schematics view, and un-hide it (e.g. via ***Menu-Display->Un-hide selected***).

1.3.2. Camera control

To ease the transition from other 3D packages, EQUINOX-3D implements the camera control of some popular 3D programs, as well as its own.
All the modes below are transient modes. Releasing the given key will put EQUINOX-3D back in the previous mode (e.g. rotating objects).

Orbit: While holding down the **O** key on a perspective view, you can 'orbit' the Camera around its aim point, with the mouse.
LMB: longitude+latitude **MMB**: longitude **RMB**: latitude

Dolly: While holding down the **P** key on a perspective window, you can move the Camera along the line-of-sight with the mouse (see the Status panel indications for the mouse button functions).

Track/Zoom: While holding down the **Z** key on a perspective view, you can move the Camera and its aim-point parallel to the view plane (tracking) or you can change Camera's field-of-view (zoom).
On an orthographic view (Top, Front, Right, Schematics, Animation, Texture etc.), holding down the **Z** key will activate Scroll / Zoom mode.

Zoom into region: While holding down the **Z** key on a non-perspective view, you can

select a rectangular region with the right mouse button. When you release the mouse button, the Camera will 'fly' into that region.
If you accidentally activate this, just release the **Z** key before releasing the mouse button, to cancel this action.

1.3.1.2. Single-key camera control

Orbit/Dolly/Track: on a perspective view, while holding down the **Ctrl** key, you can 'orbit', 'dolly' or 'track' the Camera by moving the mouse while holding down one of its 3 buttons.

Scroll/Zoom/Zoom: on an orthographic view, while holding down the **Ctrl** key, you can 'scroll', 'zoom' or 'zoom into a region', by moving the mouse while holding down one of its 3 buttons.

Orbit/Track/Dolly: hold down the **Alt** key and see the Status panel...

1.3.2.3. “Fly to” / Framing things

When working on an object, we usually need to move the Camera, so the object is in the middle of a window and zoom in on it: i.e. "frame" the object.
EQUINOX-3D has a sophisticated automatic framing feature. In a perspective window, it can frame an object or objects by not just putting it in the center of the window and getting close enough to it, but it also places the camera's aim point at a reasonable center point around which you can orbit the camera and keep the object(s) in the center.
This allows you to easily examine the object from different angles.

EQUINOX-3D takes this feature a step further: instead of immediately placing the cameras to their new positions and orientations, it smoothly “flies” them there.
The framing/fly-to function works in any view (3D, schematics, animation curcves etc.).
This helps you maintain a sense of relative location of objects and it provides a more pleasant user experience.
Similar techniques are common in video games, but EQUINOX-3D is the only modeler to support it (since the last edition of this manual, some modelers partially copied this feature, but only for 3D views).

You can adjust the duration of the fly-to under ***Menu->Camera->Settings***.

Pressing the **F** key will frame the camera to the selected object(s) in the active 3DWindow.
A will frame the camera to all objects in the Scene.
F or **A** with **Shift** will perform the fly-to in all 3DWindows simultaneously.

"Frame selection" works for Models (transform Nodes), Geometries (Meshes, Splines etc.), PolyGroups or even for a group of selected Polygons.

2. The 3D world

2.1. Objects and Models

EQUINOX-3D has two fundamental 3D elements: ***Object*** and ***Model***

Objects represent:
- Lights
- Cameras
- Geometries (3D shapes)
- Special elements defined by plugins. For example: force-fields

Models "bring" Objects into the 3D scene, at a specified position, orientation and size (scale). The 3D industry calls this *instantiating* or *instancing Objects.*
Models define the *transformation* (scaling, orientation (rotation) and position) of Objects, so they are also called *transformation-nodes*, or *transform-nodes*.
On the schemaitics view, Models are shown as blue boxes with a coordinate-system icon. Objects are shown as a torqoise box with angled sides and a little icon.

When you create an Object (e.g. by clicking on an icon on the tool panel), EQUINOX-3D will automatically create a Model for it and place it at the origin.
It will also name them: the Model will have the name of the tool that created it, starting with a capital letter and the Object will have the same name starting with a lower-case letter:

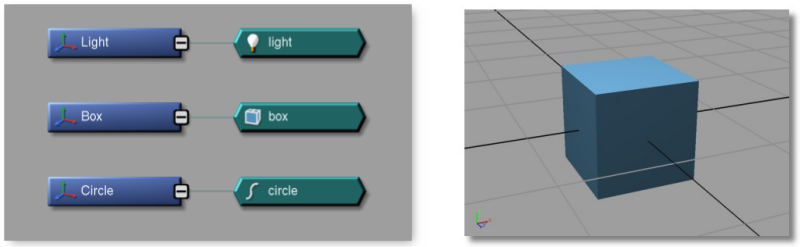


Figure 2.1. Schematics-view and 3D-view of a Model with an Object (torquoise box).
Note the coordinate system icon on the Models (blue boxes), representing transformation and the wireframe cube icon on the "box" Object, indicating a Polygon Mesh.
Similarly, the "light" Object has a light bulb icon and the "circle" Object has a curve, indicating a Spline Geometry (not shown on the 3D view).
By default, EQUINOX-3D uses Capitalized names for Models and names starting with lower-case for Objects (e.g. "extrudeAlongSpline").

2.1.1. Multiple instances of an Object

An Object might be added to multiple Models and these Models may be placed, oriented and scaled differently in the Scene.
This is a powerful and commonly used technique, called “instancing”.
Imagine that you want to build a long hallway with 20 identical columns. If you create 20 duplicates of your column, when you edit one of them, only that one will change.
Instancing it, on the other hand, will create “links” to the same Object from multiple Models, so if you change one, all instances will change simultaneously.
This will allow you to see your hallway with all 20 columns while you are refining your column model, but save you the repetitive work of applying every change to all copies.
Instancing is also more efficient because EQUINOX-3D will only have to keep one copy of the Object in memory, so you can use a lot less memory, if you have many instances of a complex Object.

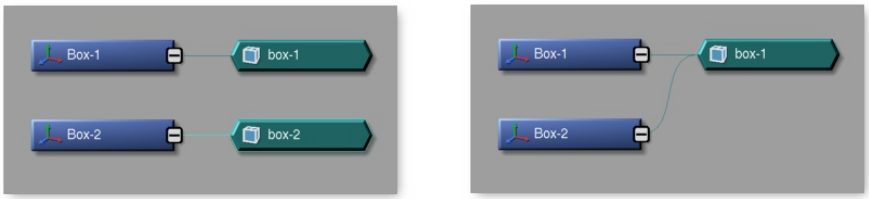


Figure 2.2. Schematics view of a duplicated (left) versus instanced (right) Object.
The two situations will look identical on a 3D view, except when you edit the Mesh called “box-1” in the second case, both of its instances of it will change.

2.2. Hierarchies

Models may be connected together to form hierarchies. Hierarchies allow for relative transformations, which means that each Model is scaled, rotated and moved ***relative to its "parent"***.
This makes it easy to have a person's upper arm rotate relative to the torso (at the shoulder joint), the lower arm rotate relative to the upper arm (at the elbow joint) etc.

A hierarchy is sometimes referred to as a “tree”, because its representation on the Schematics view resembles an upside-down tree. Sub-trees are also called *branches*.

Figure 2.2. shows an example for a hierarchy.
Note that the branch containing the Models named “Tube”, “Sphere” and “Capsule” is selected (the edges of the Models are highlighted with white lines).
“Tube” is the root of that branch, while “Box” is the root of the whole hierarchy (tree).

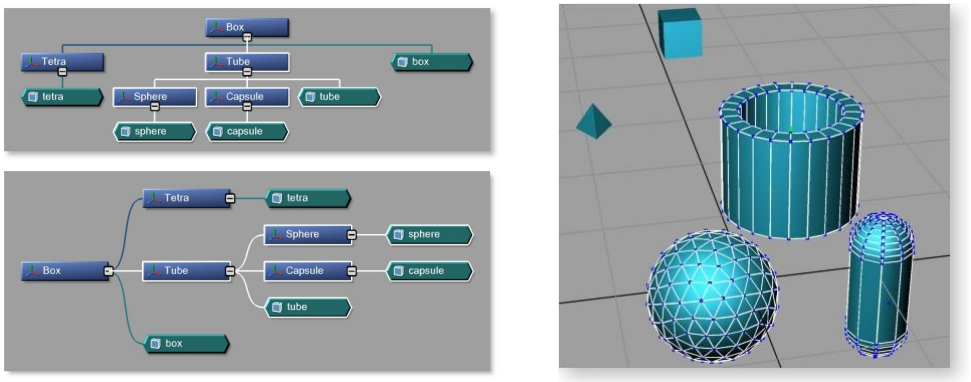


Figure 2.2. representations of a hierarchy on the Schematics view with vertical and horizontal layout and different connector types (left) and the actual 3D shapes (right).

2.3. Geometries

A Geometry is a type of Object that describes a 3D shape, such as a line, a set of 3D points (particles), a surface or a volume of a solid, liquid etc.
EQUINOX-3D allows for multiple Geometries (Mesh, Spline etc.) per transform-node (Model), so unlike in many other 3D programs, there is usually no need for 'empty' Models to group Geometries.
This simplifies hierarchies and avoids performing the extra transformations, leading to faster rendering. At the same time, it still allows you to easily select and edit Geometries.

2.3.1. Meshes, PolyGroups and Polygons

A Polygon Mesh is a type of Geometry. It is a surface, described by Polygons.
A Mesh has groups of Polygons that share a Material (a.k.a. Shader). These are called *PolyGroup*s, or *shading-groups*.

PolyGroups within a Mesh can share Vertices.
If a Model or a Mesh is selected, its Vertices are shown with little blue rectangles (see Figure 2.3.1.). If only a Geometry of a Model is selected (not the whole Model), the edges will be highlighted with cyan, instead of white.
If only a PolyGroup is selected in a Mesh, the Vertices of the Mesh will not be shown.

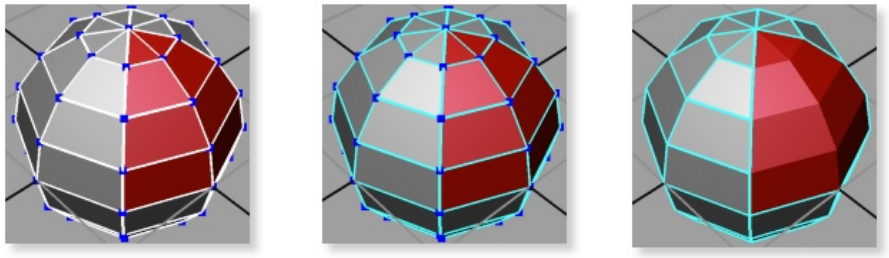


Figure 2.3.1. A Polygon Mesh with 2 PolyGroups (Grey and Red Polygons).
The Model selected (left), the Mesh selected (midle), the gray PolyGroup selected (right).

To create a Mesh, you can start from any of the primitives in the Toolbar (Box, Sphere etc.), then you can use the powerful Polygon editing tools under ***Menu->Polygons->Edit Polygons***.
This is a context-sensitive tool that allows you to add/remove Edges, Vertices, Polygons, split Edges etc.
Once you activate this tool, just move the mouse over an Edge, Vertex etc. and look at the Status-panel for instuctions! To exit the Polygon editing too, press the **Esc** key.

2.3.2. Subdivision surfaces

Subdivision surfaces are a powerful extension of Polygon Meshes. They are the state-of-the-art way of modeling complex shapes.
They are perfect for modeling 3D characters, environments, or for the state-of-the-art form of CAD (computer aided design), called free-form CAD.
If you watch a Pixar movie, or shop around for amazingly complex 3D printed objects, you will see subdivision surfaces in action.

A subdivision surface takes a low-resolution Polygon Mesh as its input and it smooths the surface, by applying a subdivision and interpolation process that you can adjust.
As the input is a Polygon Mesh, this allows for any shape (without having to “stitch” together pieces), unlike modeling with parametric sufraces, such as NURBS “patches”.
Subdivision surfaces essentially make NURBS patch-based modeling obsolete.

EQUINOX-3D has powerful support for the most advanced form of subdivision surfaces, called Catmull-Clark subdivision. These allow for nearly any types of Polygons as their input, unlike other methods, that can only accept triangles.

EQUINOX-3D has robust handling of boundary Edges and Vertices, Edge sharpness and more. The subdivision “levels” are accessible to the user as separate Meshes under a Model and each level may be instantiated and/or moved around to other Models.
This is great, if you want to work on the low-res Mesh in one 3DWindow, while seeing the smooth surface in another window.

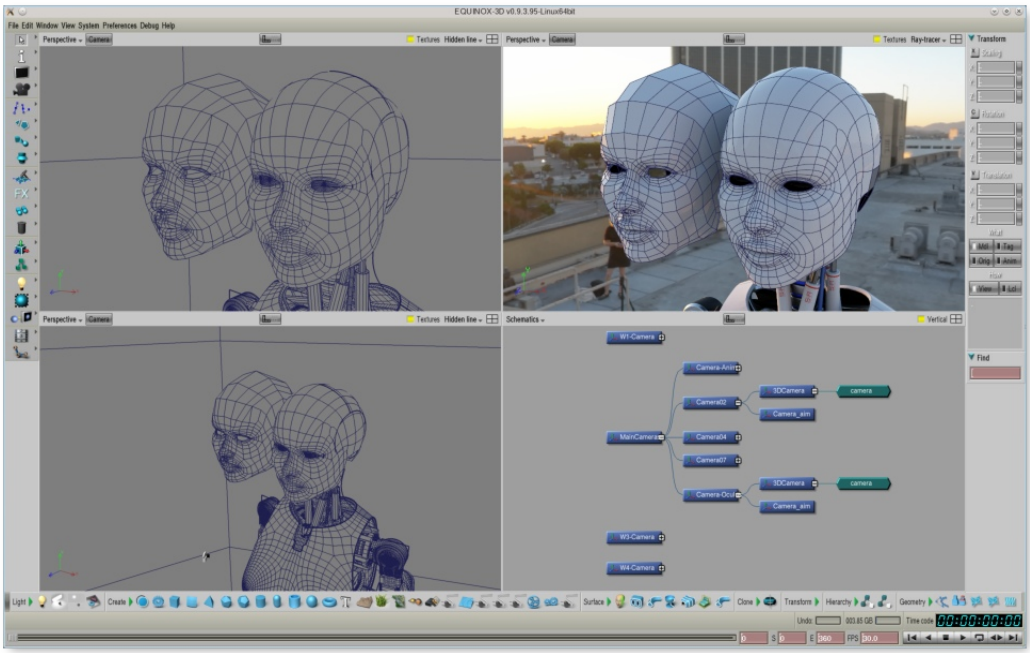


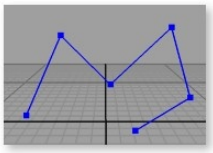
Figure 2.3.2. Smooth subdivision surface (right) with its low-resolution input Mesh (left).

2.3.2. Splines, Spline Segments and CVs

A Spline is a (usually) curved line that is described by a mathematical formula, using a parameter, hence their other name: parametric curve.
Splines are usually made of multiple segments. The shape of the segments is determined by points, called Control Vertices, or CVs.

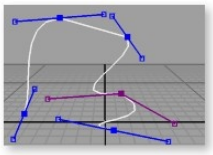
Interpolating Splines - These Splines go through their control points.

- **Linear**: Continous segments of straight lines going from one CV to the next:

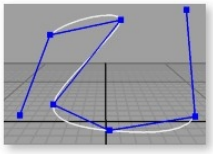


- **Bezier**: A very versatile Spline that goes through all of its CVs and the type of the segments (linear or curved) may be changed individually.
There are 4 CVs for each segment. These are usually represented by 2 lines ("*handles*" or "*tangents*"). These are parallel with the tangent of the curve.

The CVs may have different editing constraints:
- C1-continuity (mirrored handles: **blue**). When you move one end of such a handle, the other side will have the same direction (tangent continuity) and length.
- G1-continuity (direction-mirrored handles: **purple**). The other side will keep the same direction, but not the lenght..
- C0-discontinuity (independent handles: **cyan**)

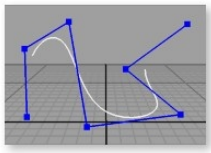


- **Cardinal**: A simpler type of Spline that goes through its CVs and has only two CVs per segment (no "handles").



Approximating Splines - These Splines don't necessarily go trhough their CVs.

- **B-spline**: This Spline might not go through its CVs, instead the CVs "pull" on the curve, like magnets:



2.3.3. Parametric Faces

The next type of Geometry is called a Parametric Face, or just Face. It is a surface, defined by closed Splines. Each Spline defines a *contour* of the Face.
The first Spline defines the *exterior contour*, while the rest define (optional) holes.
Creating a Face is easy. Just make a Spline, close it and activate ***Menu->Spline->Convert to face***. See Figure 2.3.1.
Then, you can add further Splines to "cut" holes in the Face, using ***Menu->Spline->Attach hole to Face.***
You can keep editing the Splines, or you can remove holes, in the *Face attributes* dialog box (select the Face Geometry and press the E key). You can even instantiate the contour Splines separately ("Split contours" in the *Face attributes* dialog box).

You can mix any types of Splines within a Face. For example, the exterior contour might be a Bezier Spline, one of the holes a Linear Spline, another one, a B-spline and so on.
Note that the Spline and Face-related functions are all in the Spline menu and there is a separator before the Face functions.
Faces are very useful,especially when combined with Exture tools.
Appendix A describes all the tools with examples.

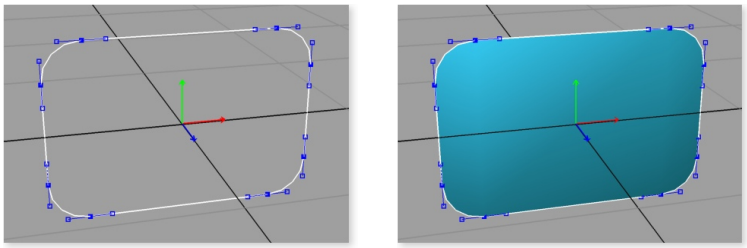


Figure 2.3.1. Converting a Spline to a Face

Faces with holes are essential for shapes like letters, such as "A", B", "D" etc., because these letters have enclosed holes. See the 3D Text tool in EQUINOX-3D.

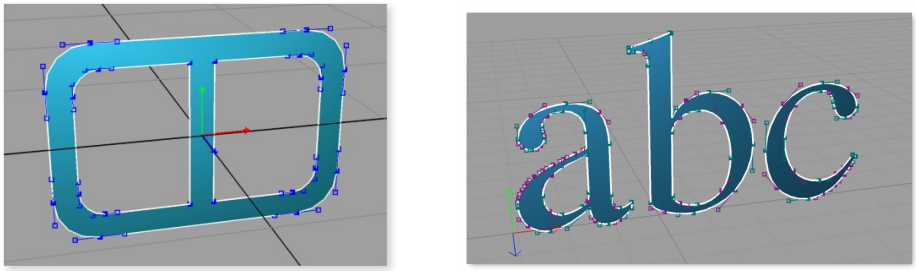


Figure 2.3.2. Faces with holes. Note the Bezier curves that specify the contours.

3. Selecting

EQUINOX-3D has *context-sensitive* selection and three main selecting modes:
- Model selecting
- Object / Geometry selecting
- Point selecting

3.1. Model selecting

Hold down the **SPACE** bar:
Information will be displayed in the Status-panel about the Model under the mouse pointer and the functions of the 3 mouse buttons will be shown (Left button: select Node (single Model), Middle button: select Branch, Right button: select whole tree (hierarchy)).

To select multiple Models, hold down the **Shift** key simultateously with the **SPACE** bar.

Clicking on 'nothing' while in single selection mode (no Shift key) will unselect everything in the Scene.
Selected Models are shown with a white wireframe and with points visible (Mesh Vertices, Spline CVs etc.).

You can also “drag-select” Models, by holding down the **SPACE** bar, holding down a mouse button and moving the mouse to select a rectangular area.

Figure 3.1.1. Status-panel when the pointer is “hovering” over an object, while the **SPACE** bar is held down.

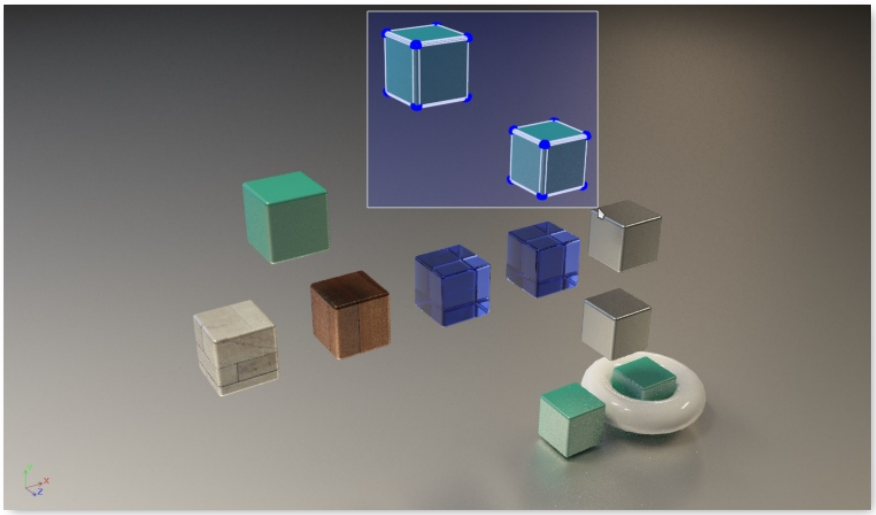


Figure 3.1.2. Drag-selecting Models (white wireframe shows that Models are selected).

3.2. Object / Geometry selecting

Hold down the **G** key:
Information will be displayed in the Status Panel about the Object under the mouse pointer.

Figure 3.2.1. Status-panel while the pointer is “hovering” over an object and the **G** key is held down. The Object / Geometry type is identified and options displayed.

To select, *click* with the indicated mouse button.
Selected Objects / Geometries are shown with torquoise (green-blue) wireframe and with points visible (Mesh Vertices, Spline CVs etc.).

You can also “drag-select” Objects, by holding down the **G** key, holding down a mouse button and moving the mouse to select a rectangular area.

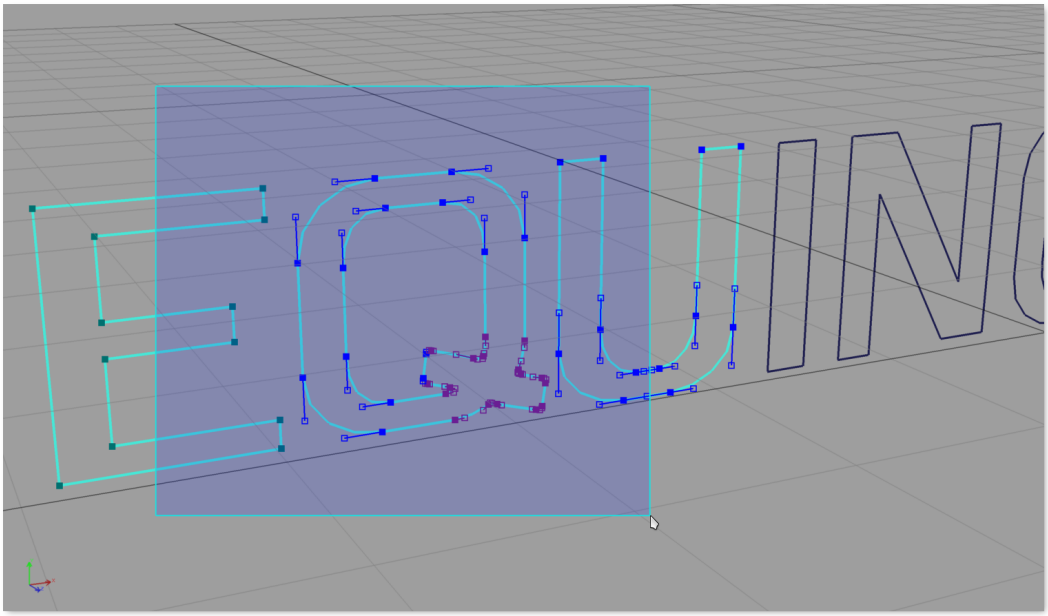


Figure 3.2.1. Drag-selecting Objects (Spline Faces, in this case). Torquoise wireframe shows that Objects of a Model are selected (vs. white wireframe for selected Models).

If the Object under the pointer is a Camera or a Light, you are only offered one option: to select the Object.

If the Object under the pointer is a Mesh, you can select either:

- The entire Mesh
- The PolyGroup under the pointer.
- The Polygon under the pointer. In this mode, holding down the right button while moving the pointer will “paint-select” (or unselect, if started on a selected Polygon) the Polygons under the pointer.
- The Edge under the pointer. “Paint select” also works for Edges.

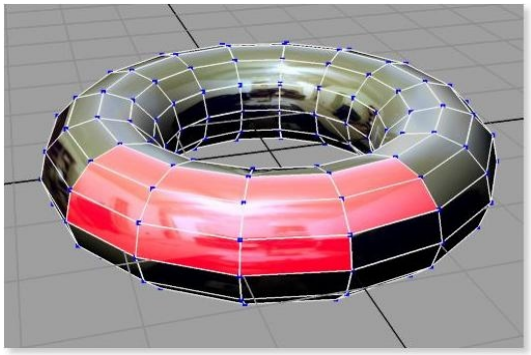


Figure 3.2.2. Polygons selected with "Paint-select".
Note that selected Polygons are highlighted with red, but the original surface will show through (including textures and reflections).

When PolyGroups of a Mesh is selected (vs. the entire Mesh), the Vertices of the Mesh are not shown (unless you are in “Edit Polygons” mode). This is how you can tell the difference!

In 'Solid' display modes (as opposed to wireframe), when selecting, a ray is cast through the scene, and the intersection between this ray and the closest surface (closest "hit") is selected.

In the preferences dialog box, an option can be set to limit ray-intersect testing to the selected objects when performing this kind of selecting. This can be useful for example to select Polygons on an object behind an unselected object. It could also mean a significant speedup when selecting Polygons in "Polygon paint-select" mode.
Selected Polygons are highlighted in "solid" display modes (this is optional, see "Display controls").
The highlight is blended with the surface, so shading and textures show through as fig. 3.2.2. illustrates.

3.2.1. Polygon “fill-select”

Hold down the **L** key and move the pointer over a Mesh. You will be able to select all Polygons that are *connected* to the one under the pointer, within the PolyGroup, or in the entire Mesh, or all PolyGroups connected to the one under the pointer.
A Polygon is considered connected to another, if it is reachable via shared Edges.

This tool is incredibly useful when you have Meshes with large numbers of Polygons.
For example, you may get a Mesh from someone, that has thousands, or millions of Polygons, containing several parts, all merged into a single PolyGroup, and you want to split them apart, so you can assign different Materials to them.
Selecting Polygons one-by-one, or even via paint-select, could be extremely tedious. With fill-select, it will take a single click.
See also:
Menu->Geometry->Separate Polygons
Menu->Geometry->Separate PolGroups
etc.

If the Geometry under the pointer is a Spline, you can select:
- the Spline itself (Geometry), or
- the Spline Segment under the pointer

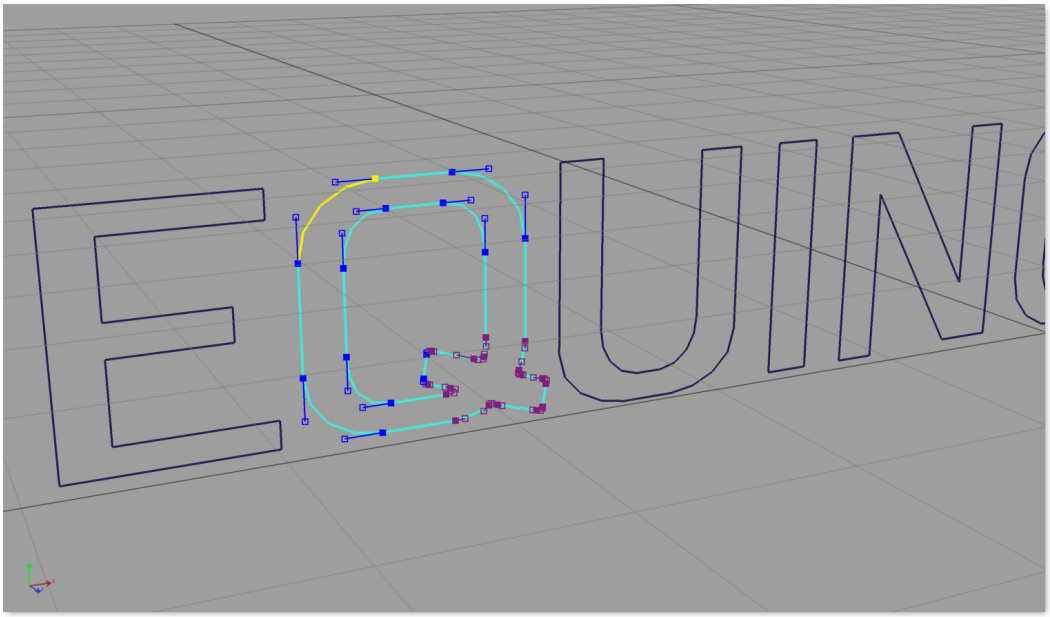


Figure 3.2.2. Splines with one segment selected

Multiple Geometries or sub-geometries (PolyGroups or Spline Segments) may be selected by holding down **Shift+G**.
Clicking on 'nothing' while in single Geometry selection mode (no **Shift** key) will unselect every Geometry or PolyGroup in the Scene.

3.3. Selecting Points

Hold down the 'T' key and drag the mouse with one of its 3 buttons pressed. This will draw a rectangular area in which points are tagged (selected), un-tagged or the tags are inverted when you release the mouse button.
The Status Panel will explain the function of each mouse button.

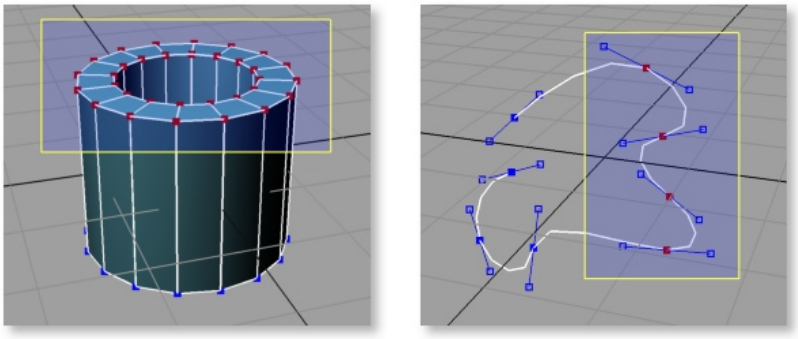


Figure 3.3.1. Tagging points of a Mesh and a (Bezier) Spline

Another way to select points:
- select Polygons on a Mesh/PolyGroup as described before
- go to: ***Menu->Select->Tag Vertices of selected Polygons***.

To un-tag all points of the selected objects, go to: ***Menu->Select->Un-tag all vertices***.

Once points are tagged, you can transform them by selecting "**Tag**" in the Transform panel. and activating Scaling, Rotation or Translation. See figure 3.3.2.

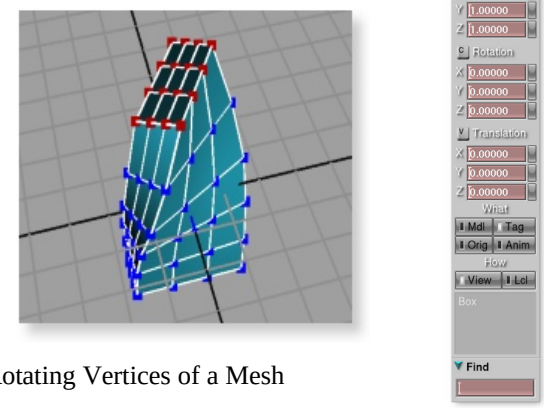


Figure 3.3.2. Rotating Vertices of a Mesh

4. Basic Geometry editing

4.1. Undo / redo

EQUINOX-3D has unlimited, comprehensive undo and redo, so you can experiment freely!
You can use the common key combinations:
- **Ctrl-Z** : undo last operation
- **Ctrl-Y** : redo last operation
Or, you can go to ***Menu->Edit->Undo*** / ***Menu->Edit->Redo***.
There's also a “trademark” undo stack indicator in the StatusBar. Empty means there, nothing to undo, full blue means you have reached the user-settable maximum undo steps, so the oldest operations will get deleted as you go.
You can set this maximum to anything. The only limitation is how much memory your computer has.

4.2. Construction history

In EQUINOX-3D, Geometries, Models etc. can "remember" how they were created. This is called *construction history*. This information is kept when you save a Scene into a file.
For example: create a torus and close the Torus dialog box.
This torus is represented as a Polygon Mesh, but EQUINOX-3D will remember that it was created by the 'Torus" plugin. This plugin can re-build the torus with different parameters.

If you want to, say change the main radius of the torus, just:
– select the torus Geometry (**G** key + Left Mouse button)
– press **E** to edit the parameters again (radius, number of subdivisions etc.)

Construction history may have other Objects as *inputs* and *multiple levels / steps.*
For example, you may build the profile shape of half of an object as a Spline, extrude that Spline to create a Mesh, then Mirror the resulting Mesh, to create the other half.
If you modify the Spline, it will make the extruded Mesh update, which will make the mirrored Mesh update, and so on.

This is an incredibly powerful system. It allows you to set up “dependencies” only once, then, when you edit the input shapes, all the dependent shapes will be rebuilt automatically.
It makes advanced 3D design and CAD work easy and thousands of times faster than modifying everything by hand.
It also allows you to match / fit parts perfectly.
For example, you can use the *same* Spline both for extruding a shape, and for creating a rim for a rubber seal on it. Or you can use a Spline to cut a hole in a shape, then place screws around the hole along a Spline offset from the original Spline by an *exact and constant* distance along the curve.
The possibilities are endless!

4.2. Editing shapes

The easiest way to edit Geometries is to move their points (the control-vertex of a Spline or a Vertex of a Polygon Mesh).
To move a single point, activate the "Move point" tool by holding down the **M** key.
This is also a transient mode tool. As soon as you release the **M** key, it deactivates and goes back to the previous mode, so you can quickly select an object, move a few points on it, select another one etc.
The point being moved becomes active which is indicated by a yellow highlight.

When you create a Bezier spline, its "Previous" and "Next" sub-keys will be at the same position as the CV itself, so all segments of the Spline will appear linear.
However, when you start moving a point with the Move point tool, it first "pulls apart" the Previous sub-key, so the segments around the key will become curved.
See Appendix A4: Spline menu for details on creating and editing Splines.

To scale / rotate / move multiple points, you can select the points and use the TransfomPanel. See *3.3. Selecting points*, for more details.

4.3. Editing the attributes of a Mesh

Select a Mesh by holding down the **G** key and press the **E** key, to bring up the Mesh atrributes dialog box.

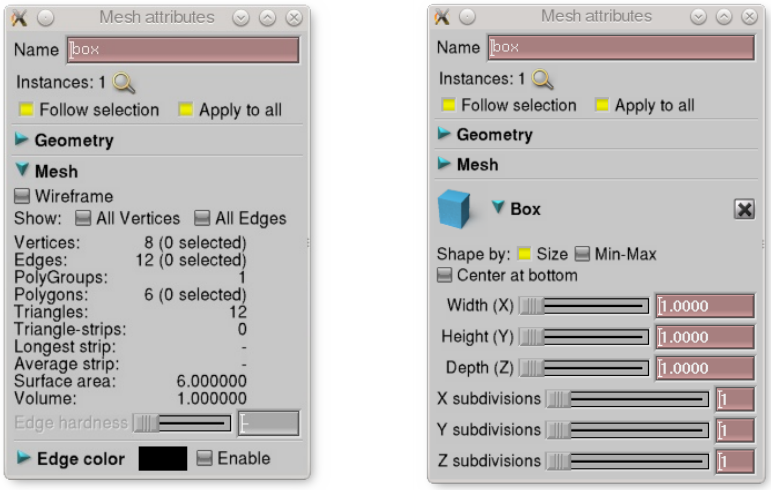


Figure 4.3.1 Mesh attributes. Note that the Mesh on the right has a “Box” construction history. It “remembers” that it's a box. Changing the box parameters will modify the Mesh.

You may delete the construction history, by clicking the “X” in the top-right corner of the “Box” drop-down folder.

This will make the Mesh “forget” how it was created, turning it into a plain Mesh.

4.4. Editing the attributes of a Subdivision surface

To turn a Mesh into a subdivsion surface, select the Mesh and click **Tool->Surface->Subdivision surface**. If you right-click, it will also bring up the settings dialog box.

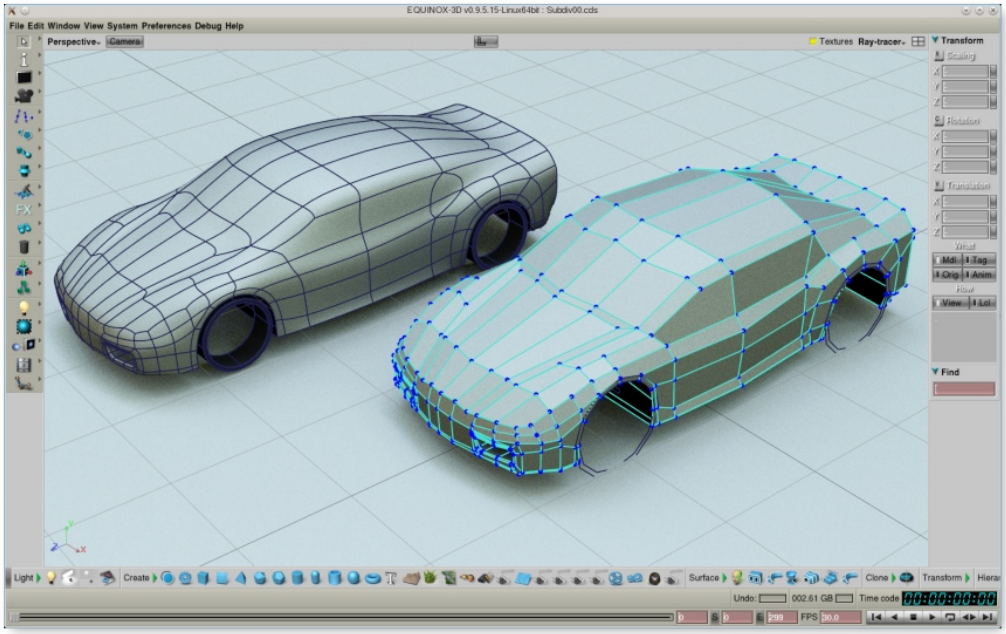


Figure 4.4.1. Subdivision surface. Note the the low-res input Mesh on the right. It is instantiated under a separate Model, so it can be moved away from the smoothed Mesh (left).

If you already have a subdivision surface set-up, select a subdivision level Mesh and press the **E** key, to bring up the Mesh attributes dialog box.
If a Mesh is a Subdivision surface level, it will have a “Subdivision surface” drop-down panel. The input Mesh (subdivision “level 0”, also known as the “control Mesh”), will also have a slider that specifies the number of subdivision levels.

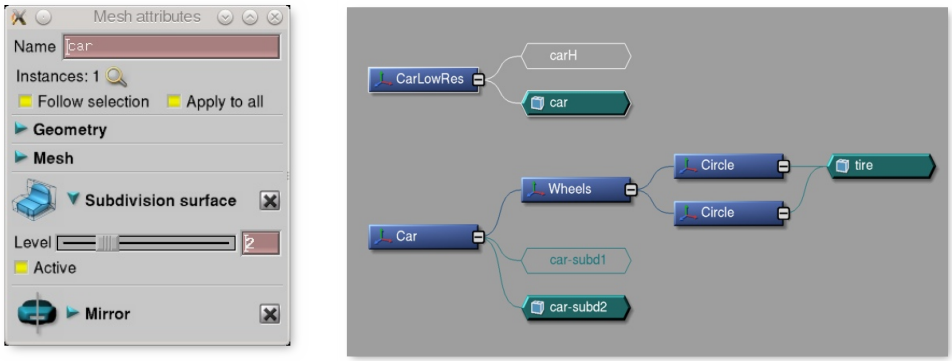


Figure 4.4.2. Subdivision surface attributes on the input Mesh. Note the “Mirror” construction history. Only half of the low-res Mesh was hand-built, it was then mirrored and smoothed / subdivided by EQUINOX-3D.

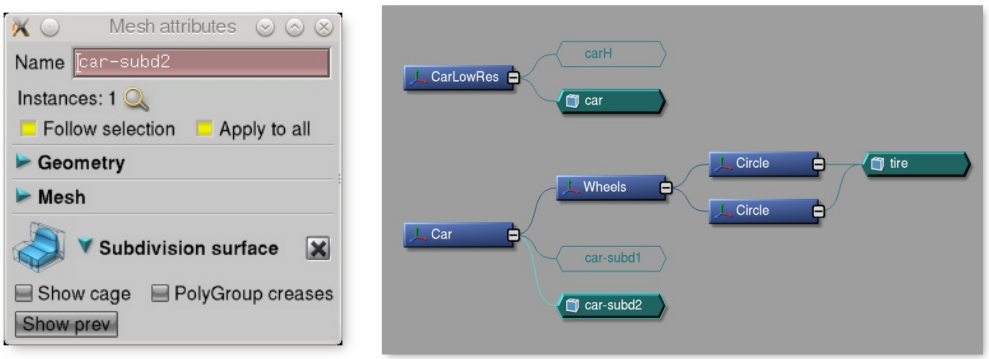


Figure 4.4.3. Subdivision surface attributes on the level-2 Mesh. Note that EQUINOX-3D automatically names the subdivision levels as inputMeshName-subdX, where X is the level of subdivision.

4.5. Editing the attributes of a Spline

Select a Spline, or one of its Segments by holding down the **G** key. The Spline will turn torquiuse color. Selected segments turn yellow, as seen on Figure 3.2.2.
Now, go to ***Menu->Info->Edit on selection***, or just press the **E**' key.
This should bring up the dialog box shown below:

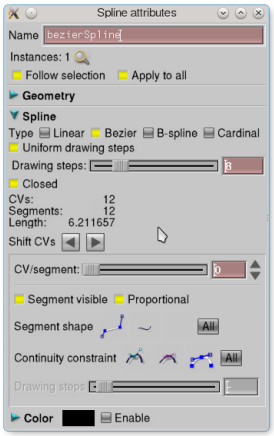


Figure 4.5. Spline attributes dialog box.

If a Spline segment was selected, the current CV (Control Vertex) will be the one at the beginning of that selected Segment.
Selecting a different segment while the dialog box is up, will automatically update the "CV and segment information" and it will make the current CV yellow in the 3D views.
This dialog box shows allows you to change attributes of the Spline, such as tesselation (piecewise-linear approximation) settings and segment types.
EQUINOX-3D lets you change the tesselation *per segment*. This is very useful when you use a Spline to create a surface (e.g. with the “Revolve” tool) because it lets you finely control the number of Polygons in the resulting surface.

There is also a very useful function, called “Shift CVs”:
Often, when you create a Spline, you might not start with the CV you will want to be the first one.
Sometimes, this does not matter. For example, when a *closed* Spline is used for modeling.
However, when you want to use a Spline to move the camera along a path, the start and end points matter, even if the Spline is closed.
The “Shift CVs” tool allows you to “move” the CVs around, forward or backward.
Each CV will preserve its attributes, so the shape of the Spline will not change (unless the Spline is open, in which case the “gap” between the last and the first CV will move around).

4.6. Editing the attributes of a Face

Select a Face by holding down the **G** key and press **E**:

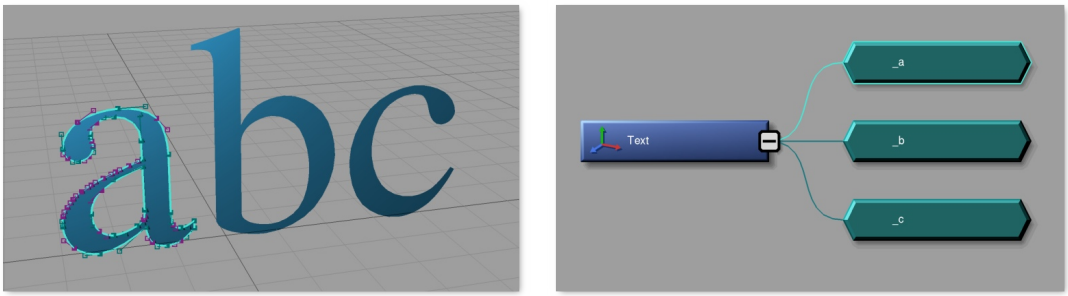


Figure 4.6.1. Selecting a Face out of 3 Faces on a Model.

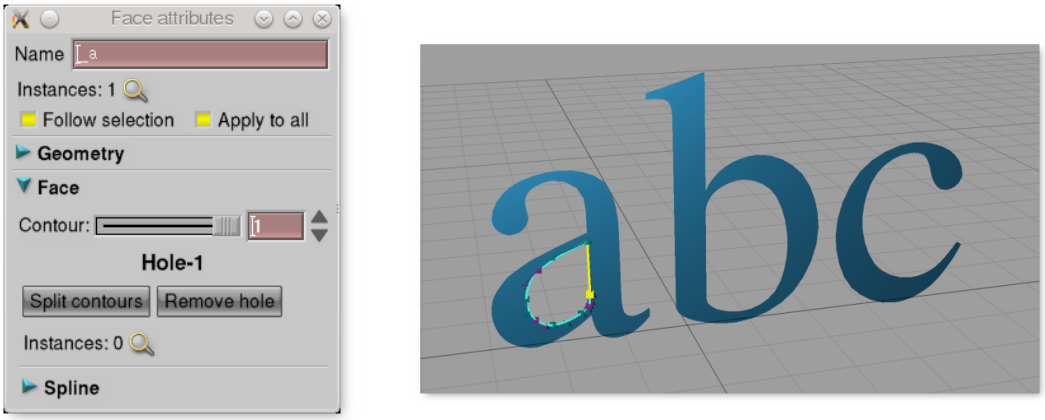


Figure 4.6.2. Selecting a hole contour of a Face. Note that the Face has one instance, but the hole Spline has no instances under Models. it is only stored on the Face. You can instantiate the contours of a Face, by clicking “Split contours”.

4.7. Deleting

Delete selection (**Delete** key) will:

- Delete selected Polygons in a Mesh/PolyGroup if they are selected as a Geometry or a PolyGroup.
- If there are no selected Polygons in a (selected) PolyGroup, it will remove the Polygroup from its Mesh.
- Deleting a single Model, or a Branch of a hierarchy also works.
- **Ctrl + Delete** will delete selected points (Mesh Vertices, Splinec CVs)
- **Shift + Delete** will delete selected Edges on selected Meshes

5. User preferences (settings)

The preferences files are located either in: /usr/local/equinox/.equinox or in .equinox/ from the user's home directory.
The main preferences file is called: .EQUINOX-3D. It stores the global settings for EQUINOX-3D, as a user-readable text file.

The default settings for each 3DWindow are stored in separate files, named .EQX3DWindow-00, .EQX3DWindow-01 etc.

Plugin preferences are saved in separate files, specified by the plugins. These files are saved in the same directory where the main prefs file was found when EQUINOX-3D was started.
Plugins can define a list of "Resources" (variables with type information) and these are all automatically saved into the appropriate files when the user selects "Save preferences".

Appendix A - summary of menus

A.1. Select

Selection functions

This menu contains several functions, such as Select All Models, all Meshes, Eges with selected Vertices, and so on. The names are self-explanatory.

A.2. Information

A.2.1. Edit selection (hot key: 'E'):

Finds the first selected object in the Scene and pops up a dialog box, to edit the attributes of that object.
This may be a Model, a Geometry (Mesh, Spline etc.), a PolyGroup or many other things.

Remove attributes (hot key: 'Alt+Del'):
Remove extra information, such as construction history from the selected Geometries and Models.

A.3. Camera

Zoom into region

Select a rectangular region on a 2D view (top, front, right, schematics, etc.) to zoom into.
Also, see camera controls.

Add Camera-dependence to Model

Allows you to make a Model only visible to a particular Camera, or sub-camera (left / right eye for 3D stereo).
This is very useful for VR. For example, if you want to feed live 3D video into EQUINOX-3D and you want to display it in your VR headset, mixed with virtual 3D objects (augmented reality, or remote reality, if you are using EQUINOX-3D to drive a robot with 3D vision).

Add / edit background image

Allows you to add an image file as the background for a particular Camera, for example if you want to use a reference image while building a 3D model.

Reset

Resets / flies the Camera of the current 3DWindow, or all windows to the default position.
Also, see camera controls.

Frame all

Moves / flies the Camera into a position that allows convenient viewing and orbiting around all visible objects in the Scene.
Also, see camera controls.

Frame selection

Moves / flies the Camera into a position that allows convenient viewing and orbiting around the selected objects.
Also, see camera controls.

A.4. Spline / Face

Close and Open

Close or open the selected Splines.

Draw Linear

Create a Linear Spline by adding CVs. When a new CV is created, it can be moved right away without releasing the mouse button.
A new CV can be added after the last one, before the first one or between two existing ones (the tool finds the closest point on the Spline).
For a description of the different Spline types, see section: 2.1.2.

Draw Bezier

Create a Bezier Spline by adding CVs. When a new CV is created, the handles can be pulled apart right away without releasing the mouse button.
A new CV can be added after the last one, before the first one or between two existing ones (the tool finds the closest point on the Spline).
If you add a new CV before the first one, this will pull out the "Previous" side of the handle. For "after" and "between" CVs, it pulls out the "Next" side.
This also works in the "Add point" tool.

Draw BSpline

Create a B-Spline by adding CVs. When a new CV is created, it can be moved right away without releasing the mouse button.
A new CV can be added after the last one, before the first one or between two existing ones (the tool finds the closest point between the CVs).

Draw Cardinal

Create a Cardinal Spline by adding CVs. When a new CV is created, it can be moved right away without releasing the mouse button.
A new CV can be added after the last one, before the first one or between two existing ones (the tool finds the closest point on the Spline).

Edit points

Add new CVs to an existing Spline and delete CVs. You need to select a Spline before activating this tool. When a new CV is created, it can be moved right away without releasing the mouse button. A new CV can be added after the last one, before the first one or between two existing ones (the tool automatically finds the closest point on the Spline).
See the Status-panel for details.

Edges to Splines

Takes a Mesh as an input and for every edge of that Mesh, it creates a linear Spline. This may be useful for extruding a shape (Spline) along those edges to create a manifold shape.

Linearize

Convert the selected Splines to linear type, by sampling points on curved segments.

Offset Spline

Creates a Spline that is offset from the selected Spline by a *constant and exact distance*, through the curve. The new Spline will have construction history and it may be snapped to / offset from a surface as well.
This is a very powerful tool. It allows, for example, to cut a “window” on a complex surface and place screws along the edge of the window, an exact distance away from the edge, to create an internal part that fits perfectly on the inside of another part.
And so on...

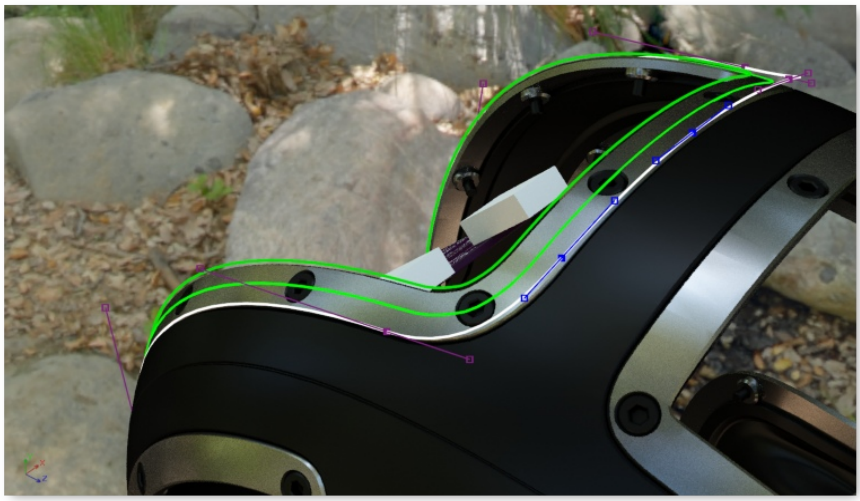


Figure A.4.1. **Offset Spline** tool. The original Spline (selected, white with CVs visible) was offset into 2 additional Splines (green). The middle Spline was used to place the screws, while the other green Spline was used to cut out the inside of the maintenance door on the robot's skull (the original, white Spline was used to cut the outisde of the silver bezel).
The screws were placed, using the **Constrain along Spline** / **Constrain along surface** tool, to constrain them both to the surface and to the Spline. This tool also oriented the screws automatically, so they all point outward from the surface.
The Splines, and extruded cutting shapes were also snapped to the surface, with the Snap to surface option, in the **Extrude along Spline** tool.

Convert to Face

Convert the selected Spline or Splines into Face(s). The Splines must be closed. The resulting Face will have its own copy of the Spline, but the original Spline will be kept as well.
See Figure A.4.3.

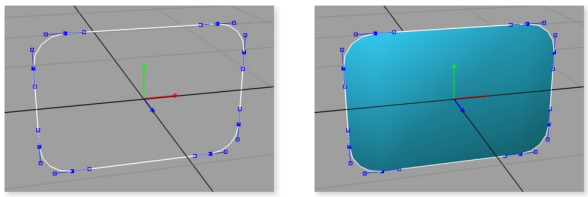


Figure A.4.2. Converting a Spline to a Face

Attach hole to Face

Attaches the selected Spline(s) to the selected Face(s) as hole(s). The Splines must be closed.
The resulting Face will have its own copy of the Spline(s), and the original Spline(s) will be kept as well. See Figure A.4.2 for an example.

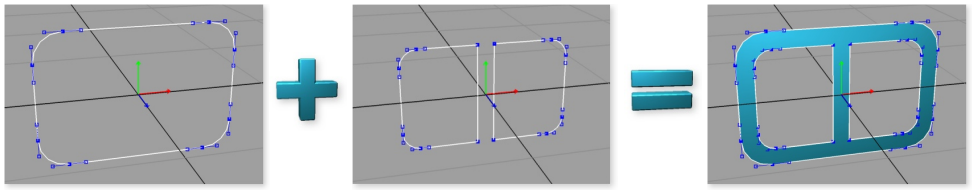


Figure A.4.3. Adding holes to a Face

Convert Face to Polygon

Converts the selected Face into a Polygon. This tool creates a new Model, Mesh and Polygroup for this Polygon.

A.5. Polygon

Edit Polygons

This is an interactive tool. Before activating it, select a PolyGroup to be edited. This tool lets you perform different operations, incuding:

- Adding new Polygons to a PolyGroup / Mesh
- Adding Vertices on Edges (splitting Edges)
- Adding Edges (splitting Polygons)
- Deleting Edges (merging Polygons)
- Deleting Vertices

This tool is context-sensitive, so the type of applicable operations will depend on what is under the mouse pointer.
The Status-panel will indicate the valid operations.

Fix Polygon directions

This is an incredibly useful tool for fixing “messy” Meshes with inconsistent Polygon directions.
Polygon direction matters for several reasons, such as rendering efficiency (back-face culling), fast closedness and containment tests (e.g. for boolean operations), solid rendering (effectively ray-tracing transparent objects), 3D printing and so on.
A Polygon is considered facing toward you, if its Vertices are in counter-clockwise order, as seen by you.
Unfortunately, many 3D applications don't enforce consistency, so you'll probably see Meshes with some Polygons facing outward, some inward, often in a seemingly random way.
This tool will bring all Polygons within connected surfaces (see Polygon fill-select) to the same orientation.
Once the Polygon directions are consistent, you can easily invert all Polygons, if they are not facing in the right direction:
- Select a Mesh or PolyGroup and do ***Menu->Geometry->Invert***, to invert them, or:
- Fill-select Polygons and do ***Menu->Geometry->Invert Polygons***

A.6. Create

Various primitives, such as Circle, Box, Grid, Sphere etc.

These tools create Splines, Meshes etc. with construction history, so you can edit them interactively.

A.7. Surface

Extrude

This tool takes a “profile” Geometry that is either a Spline or a Face and extrudes it along a straight line, creating a surface (e.g. a Polygon Mesh).

The construction history on the resulting surface allows you, for example to change the Shape of the profile Spline / Face and the extruded surface will change interactively.
The depth and direction of the extrude can be specified, the front and back faces can be beveled, the profile may be scaled and rotated through the extrusion (“Twist”), etc. See settings dialog box below.

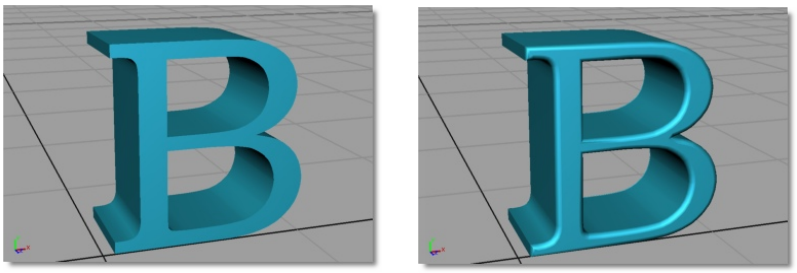
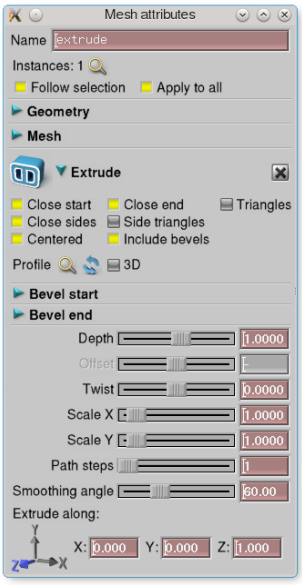


Figure A.7.1. Extruding a Face with holes. Without bevel and with bevel.



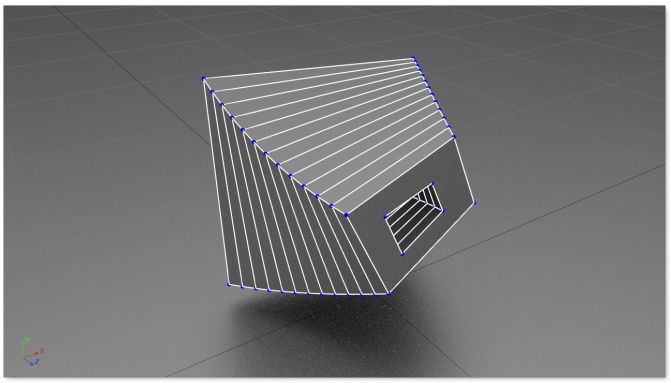


Figure A.7.2. Extrude tool dialog box and an extruded object with Twist and Scale..

Extrude Mesh

This tool takes a a Mesh as its input and creates a new Mesh that has a “wall thickness”, instead of just a surface.

It properly handles boundary Edges and Polygons with holes. The construction history allows you to change the thickness, to create only the inside, or the only the sides, to put either of those in separate PolyGroups and so on. This tool is fundamental for solid modeling. It is essential for creating designs that can be 3D printed, or manufactured in any other way. This tool is activated by the same button as Extrude. If you have a Mesh selected when you click that button, it will do an Extrude Mesh. If you have Splines and/or Faces selected, it will extrude those.

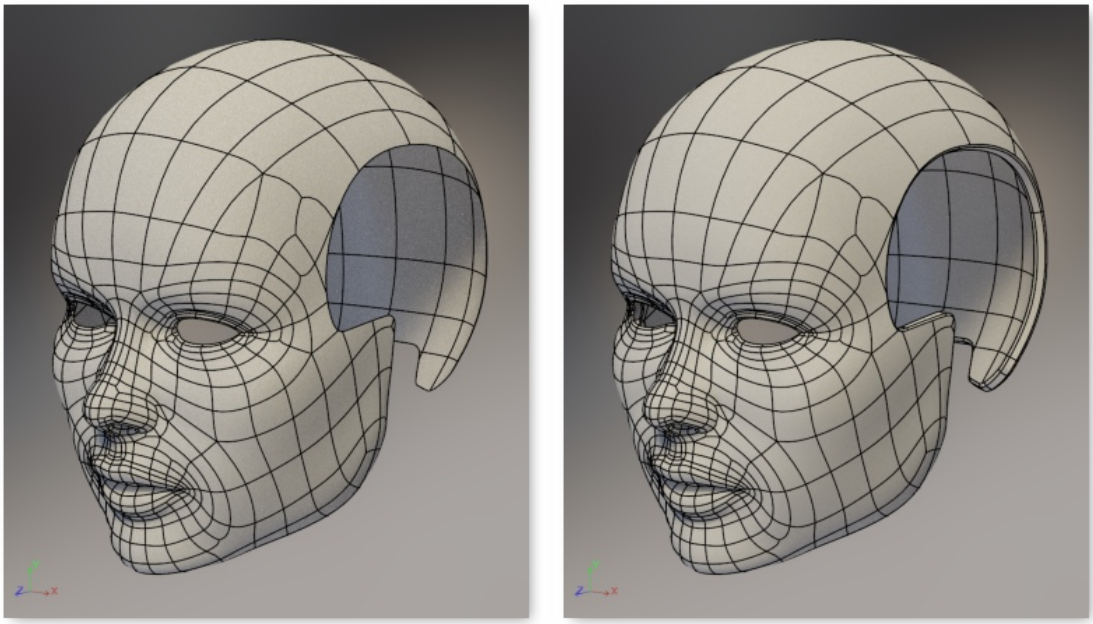


Figure A.7.3. *Extrude Mesh*. Before (left) and after (right). Note the wall thickness in the right image. The left image has “Double sided” rendering enabled, otherwise the inside of the Polygons would not be visible (due to back-face culling).

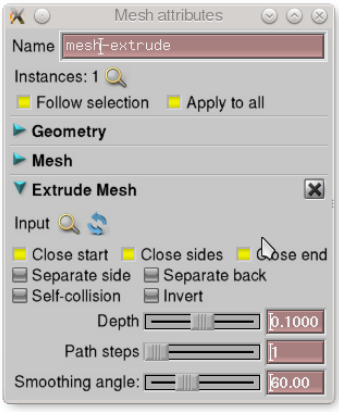


Figure A.7.3. Extrude Mesh settings dialog box.

Extrude along Spline

This tool takes a “profile” Geometry that is either a Spline or a Face and extrudes it along a “path” Spline, creating a surface (e.g. a Polygon Mesh).

This a very powerful modeling tool that allows you to create complex surfaces from a couple of Splines. The construction history on the resulting surface allows you to change the shape of the profile Spline / Face or the path Spline and the extruded surface will change interactively.
You can also go back and change the options of the tool by selecting the surface Geometry and pressing the **E** key (***Menu->Info->Edit on selection***).
Figure A.7.2. and A.7.3. show examples of extruding a Spline and a Face along a path Spline.

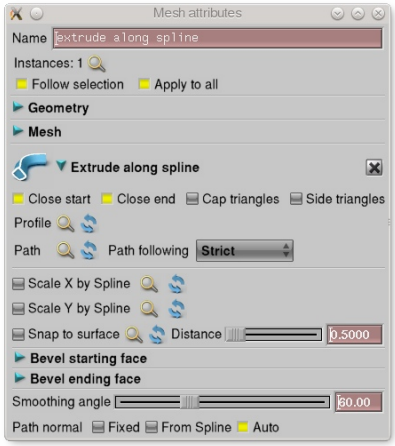


Figure A.7.1. Extrude along Spline (“loft') dialog box

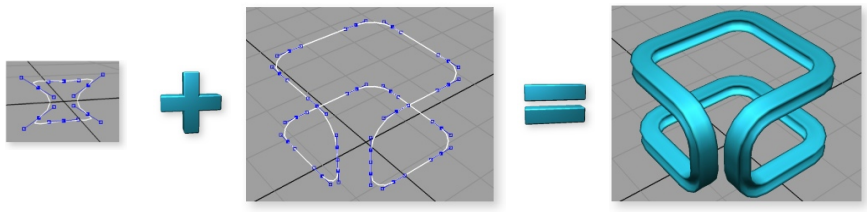


Figure A.7.2. Extruding a Spline along another Spline

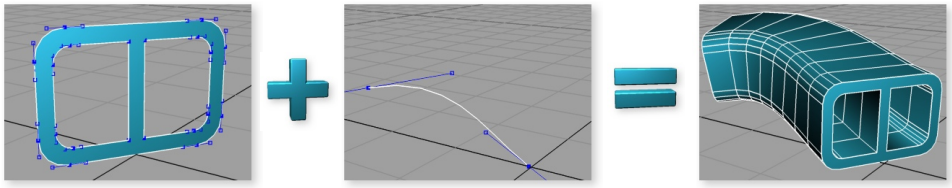


Figure A.7.3. Extruding a Face with holes along a Spline

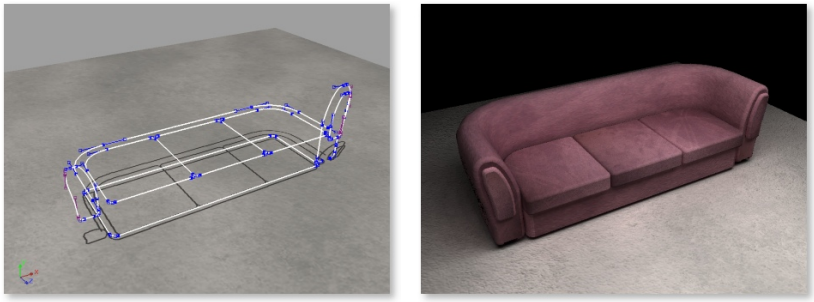


Figure A.7.4. *Extrude* and *Extrude along Spline*, with the optional bevels are very powerful modeling tools. For example, they allow you to quickly build a couch just from a few Splines.

Extrude along Spline also allows you to vary the size of the cross-section along the path, by using two “guide” Splines. A 3rd guide Spline allows you to vary the spacing between the cross-sections.

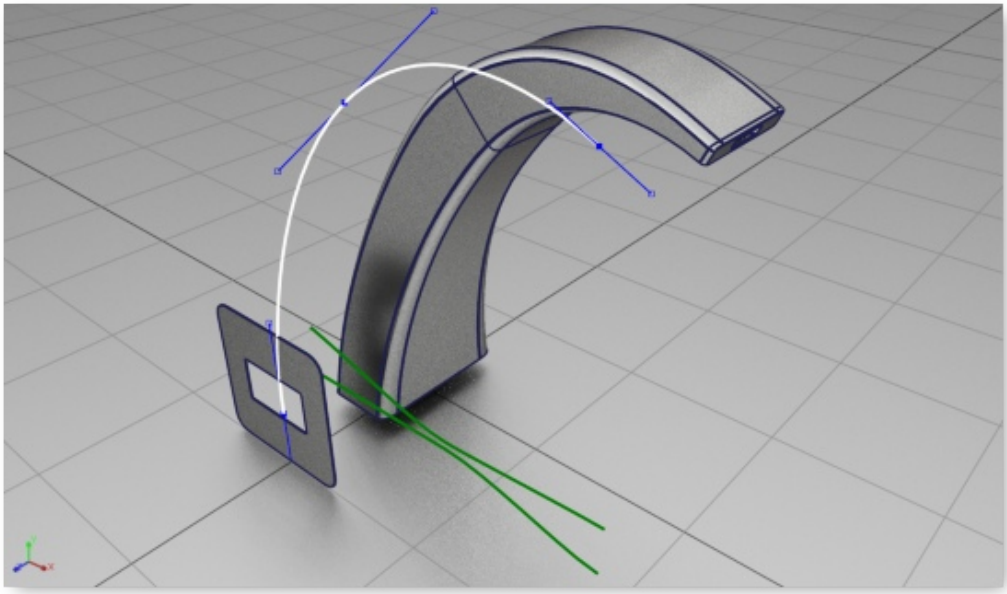


Figure A.7.5. *Extrude along Spline* with scaling “guide” Splines (green), path Spline (white, selected) and profile Face with a hole.

Extrude along Spline also allows you to “snap” the resulting shape to a surface.
These features allow for advanced CAD work. For example, you can **exactly** place cutting shapes on surfaces, to cut out the hole for the windshield of a car, or the doors on a robot's skull, add rims for placing rubber seals and so on.

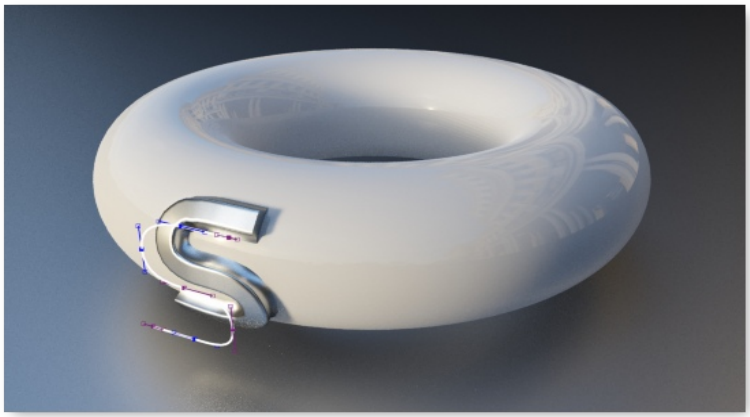


Figure A.7.6. *Extrude along Spline* with “Snap to surface” option enabled.

Revolve

This tool revolves a Spline (the “profile”) around an arbitrary axis to create a surface (e.g. a Polygon Mesh).

Typical use:

- Create a Spline and make sure it's selected
- Click on the Revolve icon on the Tool Panel: (left button: no dialog box, right button: dialog box.), or
- Select ***Menu->Surface->Revolve*** either the main button or the little dialog box icon besides it.

Dialog box options:

- Triangles: the resulting surface will be made of triangles or rectangles
- Smoothing angle: average the normal vectors at the Polygon Vertices to create a smooth surface appearance
- Start and End angle: it allows for a non-complete (less than 360°) revolution.
- Sides: the number of sides on the surface

The tool maintains a construction history, so you can change the shape or the parameters of the profile Spline at any time and the surface will change interactively.
You can also go back and change the options of the tool by selecting the surface Geometry and activating ***Menu->Info->Edit on selection***.

Note: make sure that the contour Spline is drawn counter-clockwise and to the right of the Y axis, as seen on the Front view, otherwise the revolved surface will be inside-out.

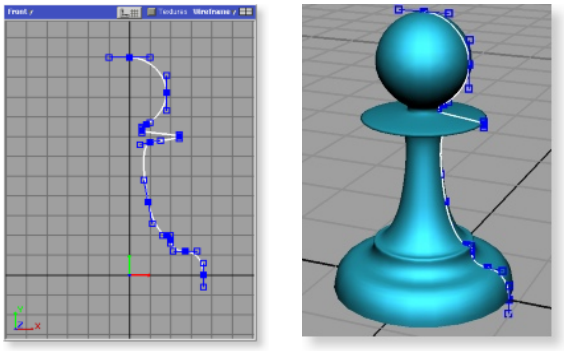


Figure A.6.1. Revolving a Spline

Skin

This tool "stretches" a surface on a set of a Splines (the "cross-sections"), much like the skin of an airplane wing covers the "ribs".

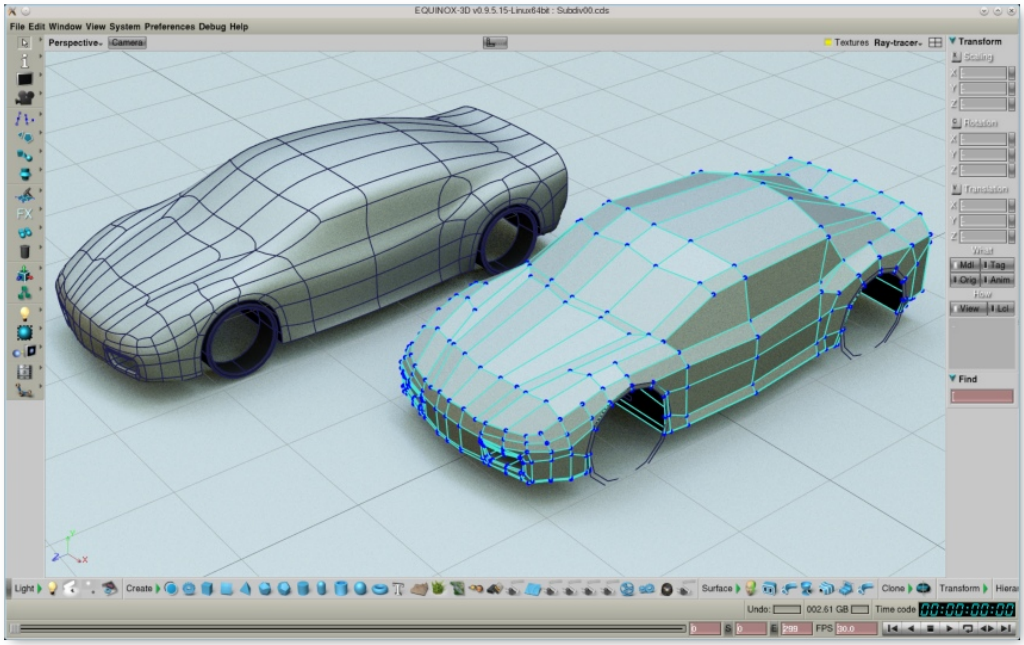
- Create a set of Splines and make sure they are selected
- Click on the Skin icon on the Tool Panel: (left button: no dialog box, right button: dialog box.), or
- Select ***Menu->Surface->Skin*** either the main button or the little dialog box icon besides it.

Dialog box options:
- Triangles: the resulting surface will be made of triangles or rectangles
- Smooth: average the normal vectors at the vertices to create a smooth surface appearance
- Weld closed cross-section ends: merge the two Vertices on the surface that correspond to the beginning and the end of a closed Spline cross-section
- Sides: the number of steps along the cross-section Splines

The tool maintains a construction history, so you can edit the cross-section Splines, change the Skin parameters etc., and the surface will change interactively.
You can also go back and change the options of the tool by selecting the surface Geometry and activating ***Menu->Info->Edit on selection***.

Subdivision surface

Converts a Mesh to a subdivision surface. For details, see:
2.3.2. Subdivision surfaces, and
4.3. Editing the attributes of a Subdivision surface



A.8. Geometry

Tesselate

This tool converts all "complex" Polygons in the selected Meshes into triangles. A complex Polygon is one that is either concave or has holes in it.

Triangulate

Converts all Polygons in the selected Meshes into triangles. This might be necessary when using a 3D object in a real-time renderer (such as in a 3D video game), as most of those renderers only support triangles.
In EQUINOX-3D, Polygons can have any number of sides, they can be concave or even have holes on them.

Un-triangulate

Merges triangles of the selected Mesh, by automatically finding Edges that could be deleted. This tool only selects those Edges, so you can see them select/unselect further Edges, before deleting them.
To delete the selected Edges, press **Shift + Delete**.
This tool is incredibly useful, if you get some 3D models as triangle Meshes, but you want to edit them (e.g. turn them into subdivision surfaces). Editing models as triangle Meshes is very tedious, and this tool makes it much easier for you to convert them to quad, or n-gon Meshes.

Separate Geometries

Collects all the selected Geometries (Meshes, Splines etc.) and move them into a newly created Model.

Separate PolyGroups

Collects all the selected PolyGroups within a Mesh and move them into a newly created Mesh.

Separate Polygons

Collects all the selected Polygons within a PolyGroup and move them into a newly created PolyGroup.
This allows for assigning and changing a common Material on these Polygons.

A.9. FX

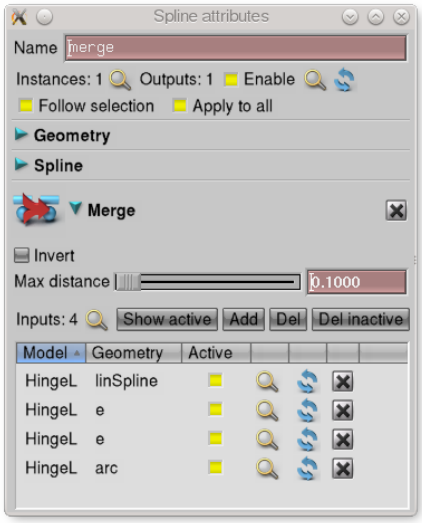
Merge Splines

Merge selected instances of Splines into a single Spline, by automatically finding the closest points between them.

This tool is essential for a lot of 3D modeling and CAD operations. For example, you may want to merge exact circular arcs, with straight lines and Bezier curves. Construction history allows you to change the radius of the arc later, or edit any of the other input Splines while the merged result will change interactively.

You can use multiple instances of the same Spline, as inputs.
For example, you only have to create the Spline profile of a single step, in flight of stairs, duplicate / instance them with the **Clone with repeat** tool, then you can merge the results into a single Spline, to create the stairs with the **Extrude** or **Extrude along Spline** tool (use the latter, if you want curved stairs, such as at the entrance of an opera house).

You can add / remove input Splines later, temporarily deactivate some of them (so you can see things more clearly), sort the inputs by Model or Spline, etc.



A.9.1. Merge Splines dialog box.

Merge Meshes

Create a single Mesh from instances of multiple Meshes.

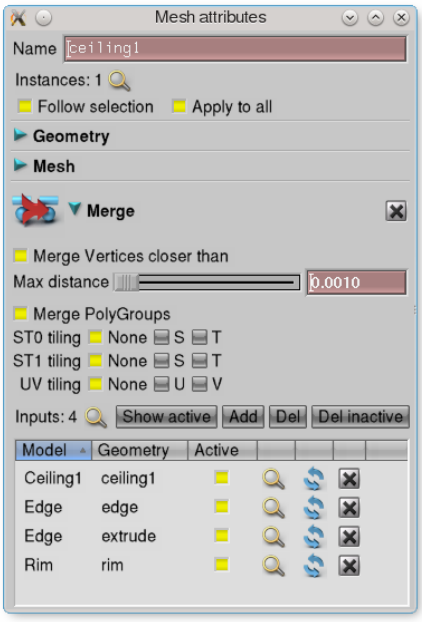
This tool is extremely useful, for many purposes, such as for building a single Mesh, to be used for 3D printing, or other forms of physical prototyping / manufacturing.

It's also great for simplifying your Scene and speeding up some operations. For example, if you want to cut multiple pieces from a shape (say, 10 screw holes) with the **Boolean** tool, as long as the pieces don't intersect, you can merge them and perform only a single Boolean operation.
This will keep your hierarchies simpler (only one Boolean result Mesh vs. one for each cutting piece) and make the boolenan operations faster. This is because merging Meshes is a lot simpler and faster than a Boolean operation (no intersection tests etc.).

You can also merge any Vertices that are within a given distance, and / or merge PolyGroups that use the same Material.
This is very useful for optimal content video game / VR scenes etc. Merging many parts into a single PolyGroup, and doing a single, optimized texture layout (see Edit PolyGroups dialog box), allows you to render a single light map texture for the merged models.
This will allow you application to draw all of these models with a single API call, greatly improving rendering performance.

You can use multiple instances of the same Mesh, as inputs.

You can add / remove input Meshes later, temporarily deactivate some of them (so you can see things more clearly), sort the inputs by Model or Mesh, etc.



A.9.2. Merge Meshes dialog box.

A.10. Clone

Immediate

Create a clone (copy) of the selected Models, including their Geometries.
If only Geometries are selected on a Model, this tool creates a new Model and adds a duplicate of each selected Geometry to this new Model.
If only PolyGroups are selected, new Meshes and Models will be created accordingly.

Options

Duplicate shares Materials If this option is selected (default), the new Geometries will share Materials with the originals, so the Materials can be edited simultaneously.
Otherwise each new Geometry will have its own copy of the Materials it is using.

Clone construction history If this option is selected (default), the new Geometries will have a copy of the construction history of the originals.

New instance

Create copies of the selected Models, but instead of making copies of their Geometries, those will be *shared* between the original Model and the new one.
When a shared Geometry changes (e.g. when you move a Vertex of a Mesh), all of its instances will change simultaneously.
This allows for creating copies of objects, placing and orienting them and later editing their shape all at once without having to copy and position them again.
Instancing can also save a significant amount of memory, as only one copy of the instanced Geometry will need be stored.

Duplicate with repeat / Over shape

Create copies or instances of Models / Objects with incremental transforms, or along a shape, like a Spline or the surface of a Mesh.
There are separate menu buttons, for “With repeat” and “Over shape”, but it's the same tool. You can, in fact switch back-and-forth in the dialog box.
For example, make 5 copies, each rotated by 20 degrees and moved by 0.5 units along the X axis.
When duplicating along a Spline, you can also scale the copies and control the distribution of the copies, via additional “guide” Splines, similarly to the **Extrude along Spline** tool.
This tool is essential for modeling anything repetitive, such as a spiral staircase, a space station hallway, made of blocks, for placing, say 10x10 holes on in a grid for a speaker, and so on.
For example, it allows you to create the tracks for a bulldozer, or the metal chain wrist band of a watch.

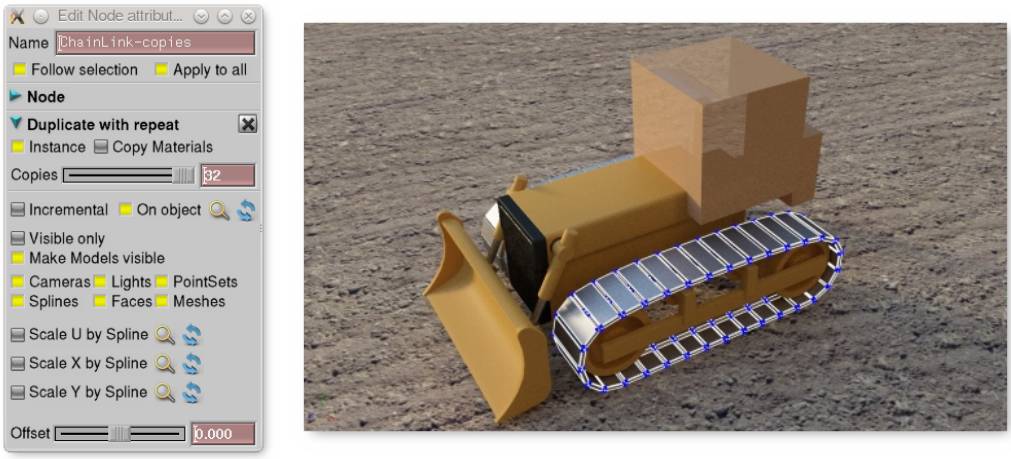


Figure A.10.1 **Duplicate with repeat**, along a Spline. The tracks' overall shape was modeled with a Bezier Spline and a model of a link was cloned 33 times, along this Spline.

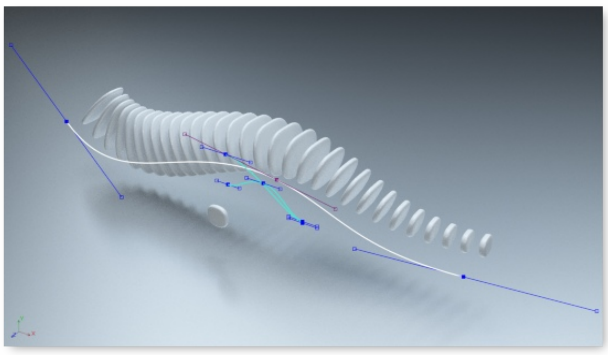


Figure A.10.2 **Duplicate with repeat**, along a Spline, with X and Y scaling guide Splines. The path Spline is shown as Model-selected (white) and the guides are Objec-selected

(torquoise). You can also see the original shape, next to the copied ones.

Mirror

This tool is essential for building anything symmetrical (cars, airplanes, people etc.). It will literally cut the work you have to do in half!
You only need to model one side of a Spline, or a Mesh and this tool will build a mirrored version, with both sides.
As you edit the original side, it will interactively rebuild the mirrored side.
It can also merge or remove points on the seam, creating a smooth / seamless shape.

A.11. Delete

Deleting tools

Tools for deleting Models, Objects, Animations etc. Live (almost) everything else, deleting is, of course, undoable.

A.12. Transform

Reset

Set the transformation values of the selected Model(s) to:

Scaling:	1.0, 1.0, 1.0
Rotation	0.0, 0.0, 0.0
Translation:	0.0, 0.0, 0.0

Freeze to world

Perform the local-to-world transformation of every Geometry in the selected hierarchies and reset the transformation values of the Models in those hierarchies.
This effectively puts the origins of the local coordinate systems of every affected Model into the world origin. The position of the objects will remain the same.

Freeze branch to its parent

Perform the local-to-branch-parent transformation of every Geometry in the Models of the selected branches.
This puts the origins of the local coordinate systems of every affected Model into the origin of the parent of the branch root, and resets their local transformations.
If the branch-root has no parent (it is the root of the hierarchy), this operation is equivalent to "**Freeze to world**".

Freeze branch to its root

Perform the local-to-branch transformation of every Geometry in the descendant Models in the selected branches.
This puts the origins of the local coordinate systems of every affected Model into the origin of the branch root, and resetting the local transformations.

Freeze scaling on branch

Perform the local-to-branch scaling of every Geometry in the descendant Models descendant Models in the selected branches.
This operation is similar to "**Freeze branch to its root**", but it only affects the scaling values.
All the affected Models will have a scaling of: 1.0, 1.0, 1.0, but will retain their original shape.

Snap tagged points to grid

Move all tagged points to the closest grid cell. The grid settings used are of the main 3D window (usually top-right).

A.13. Hierarchy

Connect

Connect a Model or a branch to a parent Model to make a hierarchy. You need to select a Model or a hierarchy branch before activating this tool.

You can pick a parent or a child for the selected Model. You can connect multiple selected Models to a parent at once. Of course, if you pick a child for a 'parent to be' Model, you should have only one Model selected.

Disconnect

Disconnect the selected Model(s), branch(es) or Objects from their a parents.

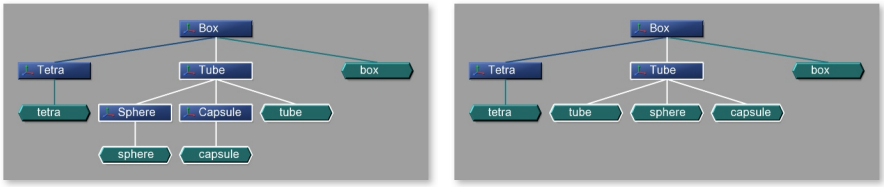
Move (reparent)

Move Models, branches of a hierarchy, or Objects to under a new parent.

Collapse branch

Collects all the Objects from the Models in a branch (hierarchy sub-tree), then
- performs the appropriate transformations on them
- adds the Objects to the root Model of the branch-
- then removes all descendant Models from the branch root

Example:



The Model, called “Tube” will contain the *tube*, *sphere* and *capsule* Objects. The 3 Objects will now all use the same transforms, defined by “Tube”.
However, their shape was modified by the collapse tool to compensate for the different transforms (the Vertices of the Meshes were transformed the “opposite way”), so the 3D view will look the same after the operation.

A.14. Material

Add / edit on selection

Edit the Material of the selected objects (Models, Geometries etc.). This tool first checks if any of the selected PolyGroups / Meshes, or Models have a Material. If they do, it assigns the Material from the first such object, to all selected ones, then pops up the dialog box.
If none of the selected objects has a Material, the tool creates a new Material and assigns that to all selected objects, before poping up the dialog box.
If an object has no Material of its own, but is in a hierarchy, it will inherit a Material from its parent or its parent's parent etc. This inheriting is automatically updated when a Model is connected or disconnected from a hierarchy.

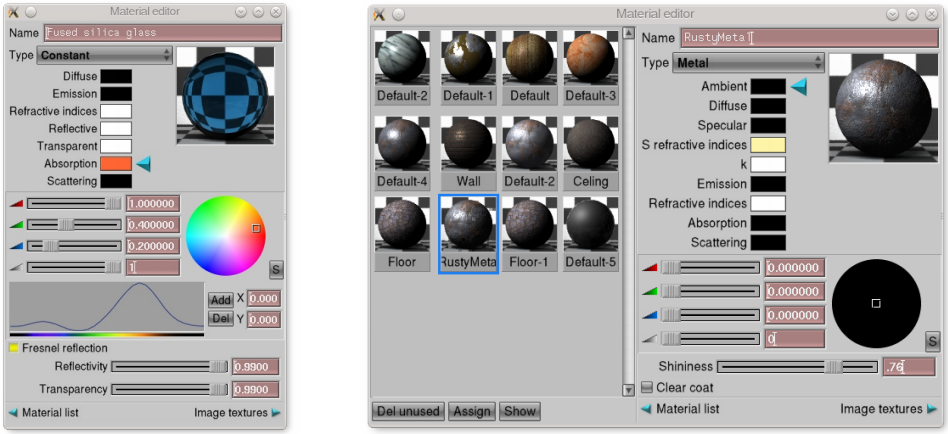
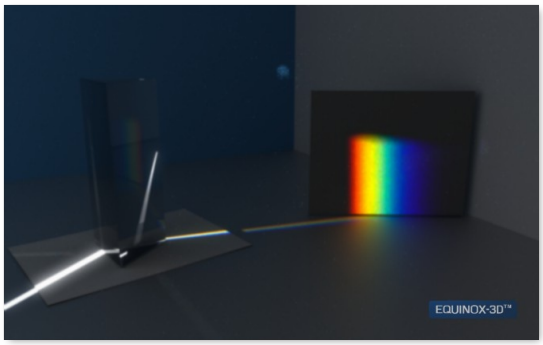


Figure A.14.1. Material dialog box. with the spectral color graph (left) and wih the Material list panel panel open (right).

EQUINOX-3D has a **physically-based**, **photorealistic renderer** and it comes with several physically-based Materials (metals, dielectrics etc.).
Materials are fully programmable and plugins may implement new types of Materials.
Material colors may be specified either as RGB, or in a hyper-spectral form, that allows for more accurate, full spectral rendering. For example, it allows for simulating diffraction in a prism and the resulting “rainbow” spectrum (the hyperspectral renderer is not released yet).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Texture editing

Textures may be image files, movie files, or even live video from a camera.
Multiple Textures may be used on each Material (up to 8, at the moment). Each Texture may have different functions, from changing the Difuse, Specular etc. color, to adding “bumpiness”, displacement, and so on.
Texture mapping is stored on the Geometry, so multiple Meshes, Faces etc. may share a Material with the same Textures, but have different mapping on the 3D shape.

Tip: In “Solid” and “Shaded solid” rendering modes, only one texture is shown per PolyGroup. You can select which one, by setting the texture index, in the Material dialog box (open “Image textures”). See “2 of 2” with left and right arrows in Figure A.14.2.

An even more powerful “shade graph” editing tool is coming...

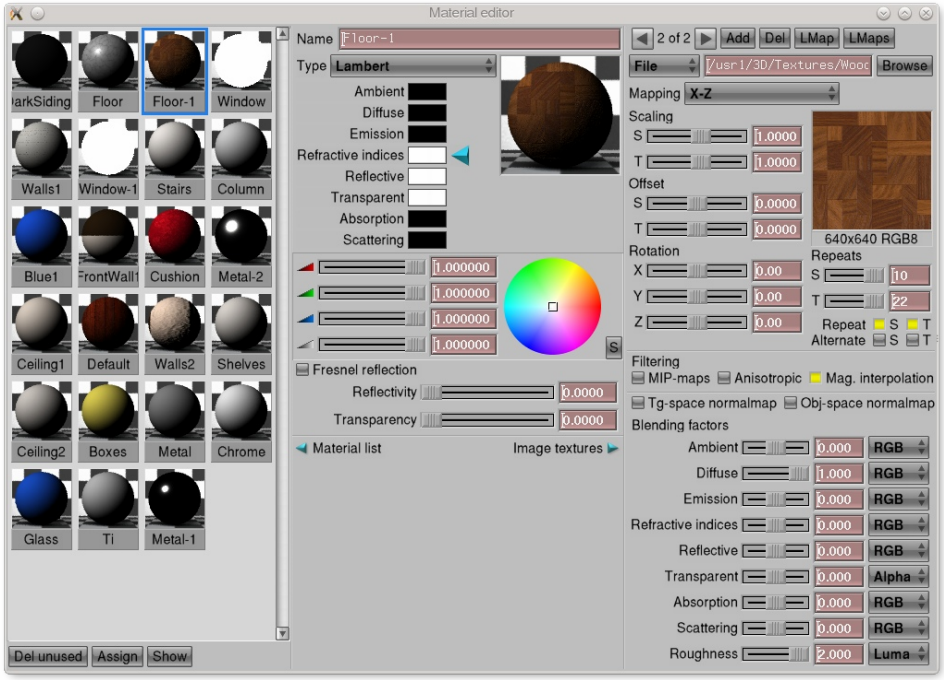

Figure A.14.2. Material dialog box with “Material list” and the “Image textures” panels open.

Assign from another object

Assign (share) the Material of another object to all selected PolyGroups. You can also pick the Material to be shared from the Material lister.

Copy from another object

Copy the Material of another object to all selected PolyGroups.

A.15. Render

Rendering tools

While EQUINOX-3D allows you to switch any 3DWindow into any rendering-mode, including full global-illumination ray-tracing, you can also open a separate rendering window and set up rendering of movies here (start frame, end frame, output file name etc.).

A.16. Animation

Path animation

Animate an object along a path defined by a Spline.
Example:
- Create a Spline (for this tool, only Bezier or Linear are supported at the moment).
- Create, say a cube
- Select the cube
- Activate ***Animation->Simple path animation***
- The message on the Status Panel will ask you to pick a path, click on the Spline
- Hit PLAY on the Time Panel

If you close the spline and turn on looping in the Time Panel, the cube will keep flying around the closed path.
Since there is no function-curve editing yet, this tool simply assigns the start and end frame set in the Time Panel for the starting and ending point of the path.
For a closed path, you can try the example file:
`Examples/Animation/Path/FunkyPath.hrc`

For the technically inclined: this tool uses correct *arc-length parameterization* on the Spline, so objects will move at an even speed regardless of the shape of the Spline.

Appendix B

Glossary

Construction history	A high level description of a Geometry, Model etc.. It describes how that object was created, potentailly depending on other objects. This lets the user edit a Geometry at a higher level than its physical representation (e.g. a Polygon Mesh). For example, simply changing the radius of a sphere (e.g. by moving a slider), the user can have the "Sphere tool" re-build a different polygonal approximation of a sphere.
CV	Control Vertex, also known as Spline Key. A point of a Spline that affects the shape of that Spline.
Geometry	A type of point-list, line, surface or volume that represents a shape. EQUINOX-3D supporst the following Geometry types: – Point set – Spline (Linear, B-Spline, Bezier and Cardinal) – Face (flat surface defined by Splines) – Polygon Mesh
Material	The description of a surface and internal properties of an Object that (along with the shape) makes it possible to render an image of that Object, or for other Objects to interact with this Object (physics simulation). Material descriptions may range from a single color, or the traditional Ambient/Diffuse/Specular colors (plus transparency, refractive index etc.) to complex, physically-based models that describe how light interacts with a certain Object. Materials may contain *textures* and *shaders*.
Mesh	Also called Polygon Mesh. A type of Geometry that has an array of points (Vertices) and Groups of Polygons (PolyGroups). The Polygons index the Vertices from the array on the Mesh.
Model	Also called *transformation-node* or *transform-node*: the element that "brings" (instantiates) Objects into the scene and defines their size, orientation and location in *world-space*.
Object-space	Also called *local-space*: the coordinate system in which the shape of an Object is defined. The relationship between the *local-space* of that Object and *world-space* is specified by the Model(s) that instantiate that Object, via coordinate-system transformations (scale, rotate, translate).
PolyGroup	A group of Polygons in a Mesh that share a Material (and its Textures).
Plugin	A piece of software (program and data) that can be inserted and

	removed from an application while the application is running. Plugins allow anyone with programming knowledge and familiarity with the API (Application Programming Interface) of a particular application to add custom functions without needing to re-build the whole application. EQUINOX-3D has a relatively small core and a large number of plugins, providing flexibility and scalability.
Shader	A mathematical model that simulates a light-surface or light-volume interaction and its program implementation. Shaders are associated with Materials. In addition to the built-in shaders, such as “Lambert”, “Phong”, “Blinn”, “Ward's anisotropic”, EQUINOX-3D also has a programmable shader interface. People familiar with basic computer rendering can implement their own shaders in a plugin and use them in the ray-tracer (you don't need to understand how the whole ray-tracer works). For example: a physically correct skin or hair shader.
StatusPanel	A horizontal bar that displays information about the current state of EQUINOX-3D. These include the function of the mouse buttons, undo stack indicator and the time code for the current frame.
Transformation	An operation to convert an Object from one coordinate-system to another. Usually consisting of scaling, rotating or translating (moving). See: Model. EQUINOX-3D supports an arbitrary list of transforms per Model.
World-space	Also called *global-space*: the **common** coordinate system that defines a 3D scene. See local-space.

Appendix C

Abbreviations

LMB	- Left Mouse Button
MMB	- Middle Mouse Button
RMB	- Right Mouse Button