Readme

COLLABORATORS			
	TITLE : Readme		
ACTION	*NAME*	*DATE*	*SIGNATURE*
WRITTEN BY		August 24, 2022	

REVISION HISTORY			
NUMBER	DATE	DESCRIPTION	NAME

Contents

Chapter 1

Readme

1.1 Readme.guide

```
                REAL 3D V.2.48
--------------
```

Thank you for purchasing Real 3D, the fastest and most impressive ray tracing, modelling and animation software in the Amiga market.

This file contains information not included in the manual.

1.2 environments

Environments

The 'Environment' saving has changed in Real 3D v.2.45. Now Project/ Environment functions load and save all project information which is related to working environment itself. This information includes all data sections except objects and materials, which are clearly project specific.

In earlier versions, the Environment concept included only Window and Screen data sections.

Saving Environments

The first thing many users attempt when they start Real 3D for the first time is to configure the environment. For most, the default HiRes-Non-interlaced screen is simply not desirable. The manual provides a thorough explanation of the Open Screen requester features; unfortunately, it never relates a clear step-by-step example of opening a new environment. The following example demonstrates how to open a new screen and close the default one. The screen type, depth, name, etc. may be modified accordingly.

To open a new environment screen:

1) Select Project/Environment/Open Screen from the pull-down menus.

Choose a HiRes-Interlaced screen with a depth of four and click on OK to accept the settings.

When a new screen opens, it is totally blank except for the title bar and a Real 3D Screen window. The Screen window provides several gadgets for manipulating AmigaDOS screens, including 'Hi-jack' and 'Close' gadgets. The features of this window are fully explained on page REFERENCE 1.16. For now, the most important feature of this window is that it delivers access to Real 3D's pull-down menus from any screen.

2) While the Screen window is selected (the default when a new screen opens), select Project/Windows/View to open a Real 3D View window on the new screen.

Actually, the type of window chosen is irrelevant. A Select or Tool window works just as well. There merely needs to be a Real 3D window open to claim this new screen as a Real 3D environment.

3) Once there is a window open, the Screen window is closed using the top-left window close gadget (NOT the button labelled 'Close'). Or, to close the old environment screen, the 'Jump' button is used to transfer the Screen window to the next screen. When the Screen window lands on the old environment screen, the 'Close' button will close the current environment and the Screen window.

NOTE: Each time the 'Jump' button is clicked, the Left-Amiga-M key combination will cycle through the AmigaDOS screens until the Screen window is found on the next screen.

4) Open any other windows that are desired (i.e. Select, Tool, other Views, etc.).

View windows are fully configurable to help new users get a feel for the Real 3D universe. For instance, an X-Y-Z axis and coordinates give real-time feedback as well as a representation of the current view angle. An added virtual ground can enhance the sense of perspective views. Both of these functions are located in the View/Drawing Set requester (Right-Amiga-D) as Coordinates and Abs Grid, respectively.

In addition, icons are added to a Tool window by selecting the desired sets from the Tools/Icons... pull-down menu.

5) Specify a new environment as the default by saving it to the startup directory of Real.

Save the project to the "R3D2:Environments/" directory as a file called "real-startup" using the Project/Environment/Save menu function. Then copy this file to the "R3D2:s" directory using a directory utility program, or from the AmigaDOS shell type:

```
copy R3D2:Environments/real-startup R3D2:s
```

You may also save the environment directly to the "R3D2:s" directory,
but this has a side effect of setting the default environment directory
path to "R3D2:s" instead of "R3D2:Environments", which is a more
appropriate alternative.

1.3 periodic evaluation

Periodic Evaluation

Control of periodic evaluation has been extended from the path method
to all methods.

Periodic evaluation means, that the program takes care of making a
closed motion cycle to repeat smoothly. If evaluation is non-periodic,
the method evaluates the parameter object 'all the way', and if the
parameter object is a closed curve or a circle, the first and last
frames will be identical. When this kind of motion is repeated, the
target object appears to stop for a moment whenever it reaches the end
point of the curve.

Normally, periodic evaluation is desirable whenever a motion loop
should be repeated continuously.

Periodic evaluation can be selected from the requesters opened by the
Animate/Create menu functions. Also Animate/Edit requesters display
this option.

Note that the Key framing editor (which can be opened by selecting
either of the Morphing methods and the menu Animate/Edit) also contains
a gadget for controlling periodic evaluation.

The evaluation type is stored to a tag labelled as ITRF. If ITRF=1,
the evaluation is periodic, and the value zero selects non-periodic
evaluation. In other words, you can control the evaluation manually by
adding the ITRF tag with an appropriate value to any animation method.

1.4 key frame editing

Editing Key Frame Animations

When you use the key frame editor window, the following things should
be taken into account:

- The key frame editor window now includes a gadget for

periodic evaluation
.

- B-spline interpolation is possible even with two and three key
objects. An intelligent extrapolation system handles these cases

automatically.

- When you insert new objects under a MORPHING OPEN or CLOSED method, old FKNO tag values, which define the key positions in time, may overlap with the new keys. In such a situation, separate the identical FKNO tag values using the Modify/Properties/Tags function, or by picking the overlapping knots one by one. You can also delete all FKNO tags, and the program will automatically redistribute the knots evenly in time.

1.5 material window

Material Window
---

1. The material editor window contains one new gadget, 'EXTRAS'. The purpose of this gadget is to invoke custom material editors defined by external material classes. When editing normal built-in materials, this gadget is disabled. It becomes enabled as soon as an external material is loaded to the editor.

For further details, consult the the documentation of such material extension kits.

2. Material preview system has been added to the material editor. Previewing is started from the material window menu Preview. Preview system is closed when the material window is closed or the preview menu is selected again. Real 3D updates the preview window whenever the APPLY button is pressed.

The window which renders the preview image is a normal view window. Therefore, you may freely define its render settings, size, output target (e.g. an external screen) and other properties. This makes the previewing system very flexible. Also the object and mapping type used in previewing can be defined by the user as presented below.

The preview system may be customized in the following way:

Create a view window. Use View/Window Size to change the size to be the preview size. Use Project/Windows/Window Name to change the name of the view window as 'Preview' (without quotes). Move the window to a suitable place, for example the top left corner of the Real 3D screen. Define suitable render settings for the view.

Create an object to be used in the preview and apply a mapping to it. The name of the mapped material isn't important. You may use e.g. a parallel mapping from the front.

Select the root object and add SPRV tag to it. You can use Modify/ Properties/Tags to add the tag. The value of the tag is not important, only its existence. This tag is needed because the 'Preview' view window renders only the first object it finds having this tag.

Close other Real 3D windows leaving only the 'Preview' view window open. Choose Project/Project/Save sections. Check Windows and Objects only.

Choose OK. Save as PREVIEW.PRJ in the PROJECTS directory under
the Real 3D installation directory.

3. Relative bitmap-size indipendent texture coordinates have been implemented.
They can be accessed from RPL and formula handlers using variables 'relx',
'rely' and 'relz'.

Relative coordinates have the following ranges:

Parallel mapping:
Horizontal mapping edge corresponds interval [0,1] in relx.
Vertical mapping edge corresponds interval [0,1] in rely.
Mapping plane normal whose length is the average of mapping edges
corresponds interval [0,1] in relz.

Cylinder mapping:
Circumference of cylinder corresponds interval [0,2¶] in relx.
Axis corresponds interval [0,1] in rely.
Radial distance from axis to circumference corresponds interval [0,1] in relz.

Sphere mapping:
Circumference of sphere corresponds interval [0,2¶] in relx.
The arc between the poles corresponds interval [0,¶] in rely.
Radial distance from center to circumference corresponds interval [0,1] in relz.

Disk mapping:
Circumference of disk corresponds interval [0,2¶] in relx.
Radial distance from the center to the circumference corresponds
interval [0,1] in rely.
Mapping plane normal whose length is the radius of the disk corresponds
interval [0,1] in relz.

Default mapping:
relx, rely, and relz are the absolute space coordinates.

Spline mapping:
relx and rely are the 'natural' surface parameters: the edges of the mesh
correspond interval [0,1] in relx and rely. relz is always zero.

4. A new scope handler called 'Depth' added. It limits the material scope
in 'z' (depth) direction to the interval specified by 'a' and 'b' scope
handler parameters. For example, if a=0 and b=0.1, a parallel mapping
maps the material 0.1 abs. space meters deep into the target objects from
the mapping rectangle level to the direction specified by the small peak.
This handler can be used for example to map a texture to one side of
a cube only.

5. Another new scope handler is 'Angle'. It defines the scope of the material
as a function of the viewing angle to the surface. The angle is described
using a value from -1 to 1. -1 and 1 correspond directions perpendicular
to the viewed surface, and 0 corresponds viewing along the surface.
The parameters 'a' and 'b' specify the range, inside which the scope is
unchanged. Outside the interval, scope is set to zero. Typically, this
handler can be used to create 'one-sided' textures. For example, a texture
map on a rectangle can be set to paint only one side of the rectangle by
selecting Angle handler with a=0, b=1.1 (the extra 0.1 is for eliminating
accuracy problems). If a=-1.1, b=0, the opposite side will become textured.

1.6 tool types

```
Tool Types
----------

Real 3D v.2.4x main program supports the following icon tool types:

LACED=TRUE/FALSE            (default false)
SCREEN=HAM/WORKBENCH/HIRES          (default hires)
DEPTH=2/3/4/5/6/7/8             (default 3)
PROJECT=R3D2:S/REAL-STARTUP           (default R3D2:S/REAL-STARTUP)
TEXTURES=R3D2:Textures;R3D2:Bumpmaps    (default R3D2:Textures)
DONGLE=PARALLEL

The first three define the default screen type, which is used, if no
real-startup is found or if it does not include any screens.

PROJECT definition specifies the name of the startup file.

TEXTURES definition can be used to set default paths for texture
map files.

DONGLE=PARALLEL definition instructs Real 3D to look the parallel port
first when examining the dongle protection (2nd mouse port is checked
first by default). This prevents unnecessary interference with mouse
port devices when a parallel port dongle is used.
```

1.7 changes in rpl

```
Changes in RPL
--------------

The new version includes some new RPL words.  Also, the locking
protocol has been modified.

For further details, see  RPL Guide/New Features
```

1.8 ham8 screens

```
HAM8 Screens
------------

A HAM8 screen is created by using the Project/environment/Open Screen
menu.  This choice will be available to you automatically if you have
an AGA equipped machine.  Simply choose the desired resolution, a depth
of 8, and click on the HAM gadget.  When the settings in the Open
Screen requester are accepted, a new HAM8 screen is created with a
Screen window on it.
```

Using the Screen window's access to the pull-down menus, open a Project/Windows/View Borderless window. This opens a backdrop window which fills the entire screen. The Render Settings and Drawing Set for this backdrop window are modified just like any other Real 3D View window. This HAM8 screen may remain open simultaneously with the main modelling and animation environment, and renders on this screen can be saved to disk as animframes by simply choosing the new screen name from the animation window, then select raytrace and check the save box, and hit the play button.

The new screen name is shown in the 'Current' text gadget of the screen window when the screen is first opened. If you are unsure of what name a screen has, use the menu Project/windows/screen, and when the window opens, the screen name is shown in the 'Current' text box.

1.9 loading examples

Loading Example Projects

Many of the example projects were saved in PAL environments. Unfortunately, not all AmigaDOS environments are configured to display anything more than NTSC screens. When a sample project fails to load due to a "Monitor Not Available" error, the Project/Project/Replace Sections menu function can load all project information except the screens.

When selected, this function provides a requester with a list of items that may or may not be loaded from a project. Just place a check next to all items except for the screens and click on OK. A file requester will then allow a project file to be selected. When the project is loaded the screen information is ignored and the current screens are used, instead.

1.10 color problems

Color Problems

On page TUTORIAL 1.11 at the bottom of the first column, the manual describes how to change the color of the table object. Some users click on the brown color, the third row down on the left of the Palette window. This makes the wireframe of the object a very dark gray, almost the color of the background. Others click on the first color (color register #0) and then move the sliders to the desired color. This will produce an invisible object on the environment screen.

The reason for this is that each color register in the Palette window corresponds directly to the color registers in a 16 color environment screen. The wireframe display colors are taken from these registers. For instance, if the first color register (#0) in the Palette window is

selected and then changed to 255 0 0 (red) using the sliders, the object's rendered color would be red but its wireframe color would be the same as the environment's background color - effectively making the object invisible. This is because the background color of the environment is also defined by color register #0. If color register #2 (white) is selected and then changed to red, the object is still rendered as red, but its wireframe is now white because color register #2 on the environment screen is also white.

For a visual comparison of the color registers, select Project/Windows/ Palette and then Project/Environment/Screen Palette. The Screen Palette on the environment screen will show the corresponding wireframe colors to the registers in the Palette window.

1.11 rpl stack problems

RPL Stack Problems

If you encounter an error message 'Stack Full' when loading large RPL files (or when executing them using Macro system), do the following:

1). Replace the current environment with your 'real-startup' file using Project/Environments/Replace, if your current working environment requires cleaning before saving it as a new real-startup. If you are not sure what this means, just exit the program and re-start it.

2) Select Settings/RPL and double all the values displayed in the RPL setting requester. Then select OK.

3) Save the modified environment as specified in the Miscellaneous/Environments guide section.

4) Exit the program and restart it. This guarantees that the modified settings will be used by all RPL related functions.

5) If the problem does not disappear, repeat the steps until the stack is large enough.

1.12 skeletons

Skeletons

Skeletonal control methods in Real 3D v.2.40 use a new skeleton primitive as a parameter. A secondary skeleton is no longer necessary. It is still possible to use any evaluable primitive (line, curve, mesh, etc.) as a skeleton, but the special skeleton primitive offers friction control which is not possible with other primitives.

When creating a skeleton primitive, the program first reads the points from <LMB> clicks. A <RMB> click ends the definition. Then Real 3D

opens a skeleton editor, where the following attributes can be defined:

- A friction value for each joint separately: select a joint from the list selector and then adjust the friction.

- A 'Fidelity' value. It can be used for controlling the orientation of skeleton targets with respect to the direction of the skeleton. The value of 0 causes the orientation of target object match exactly the orientation of the corresponding bone of the skeleton. The higher the value the more the orientation is determined also by the next and previous bones of the skeleton. This can be, for example, used for simulating skin behaviour when using skeletons for character animations. The higher the fidelity value, the smoother the skin bends at the joints.

- A Fixed/Free setting for the whole skeleton. If the skeleton is of type 'Free', Inversed Kinematics modification moves the whole skeleton in order to reach the indicated point, if the length of the skeleton is not sufficient otherwise.

A skeleton can be edited using Modify/Properties/Skeleton attr. function. This opens the same skeleton editor as the creation function.

A new tag 'FSKF' is used by the SKELETON method. FSKF defines the same 'fidelity' property as the value in the skeleton attributes requester, but the tag defines it for each target separately, thus allowing more accurate control. The value range of the tag is from 0 to 1, 0 corresponding a situation where the orientation of the target follows the bone totally.

For example, a spline-modelled arm, subdivided into cross-sections which are controlled by a SKELETON method, can be made bend smoothly at elbow by adding the tag 'FSKF=0.5' to the cross-sections at both sides of the elbow joint.

For additional skeleton examples, see the directory 'examples/skeleton'.

In order to convert an old, skeletonally controlled object to the new version, do the following:

- Create a skeleton primitive, which matches the old primary skeleton line, under the skeleton method level.

- Delete the secondary skeleton parameter.

- Delete the tag ISKE from the Skeleton method.

- Delete the MCOG, DDIR, DDIV and VPHS tags from the target objects of the skeleton method.

- Refresh the animation system using Animate/Control/Refresh.

1.13 links

Bi-directional Links

Link objects created by Create/Structure/Link menu are bi-directional in the new version. This means, that it is not only possible to read object properties through a link, but also modify the target of the link via the link. For example, if you create a sphere and a link referring to the sphere, moving the link will move the sphere.

When bi-directionality is undesirable, it is possible to make the link as 'read-only' by setting the Protected attribute flag of the link (use Modify/Properties/Attributes function).

1.14 measuring window

Measuring Window

The following two examples demonstrate using the measuring window.

1) Creating a polyhedron using the measuring window. This example shows how to handle some problematic steps of the process, like changing the active Window.

- Select Create/Visibles/Polyhedron.

- If you have multiple View windows, click the first point on a View window, which defines a suitable viewing direction for creating the object. You may then use <Del> key to remove the first point before entering accurate coordinates from the measuring system. If you use only one View window, you can directly start using the measuring window.

- Click the X gadget of the measuring window, enter the value, press <TAB> key, enter Y and press <TAB>, enter Z and press <RETURN>. Then Press <Left-Amiga>A to accept the first point (or click 'ACCEPT').

- Now X gadget is automatically activated, so you can enter the second point in a similar way.

- When all points have been defined, Activate the 'N' gadget and enter a suitable depth for the polyhedron.

- In order to end the definition, Activate the View window by clicking its top border. You can also use <F1> to activate the first View window. If both of these do not work (because of a borderless View type, for example), just click the View with <LMB>, then press <Del> key to remove the extra point, and finally press right mouse button to end the definition.

2) Rotating an object accurately.

- Select the objects to be rotated

- Select Modify/Linear/Rotate.

- Define the rotation center (e.g. by a left mouse click)

- Grab the object by a second mouse click.

- Activate the N field of the measuring window, enter a desired angle,
  and press RETURN. Note, that if the measuring window was closed, you
  may easily open it at this point by pressing <F9> key.

- Click the ACCEPT gadget (or <LAM> key).

1.15 miscellaneous

1. Project/Windows/Window Name function added.

2. Create/Freeform/Triset From Mesh added. Useful only for data export purposes.

3. View/Render/Export DXF added. Exports polygonal objects and freeforms, quadric primitives are exported as curve data corresponding the wireframe representation.

4. Inversed kinematics modifies skeletons primarily in the plane in which the skeleton was created. This makes the modification behave more consistently.

5. Animate/Create/Morphing now creates a new level object for the created morphing hierarchy when necessary.

6. The function Animate/Edit can now be used for specifying 'Periodic/Non-periodic' and 'Interpolative/Extrapolative' information for all animation methods where these attributes make sense.

7. ICNT tag added for CREATION method. The tag can be used for specifying maximum number of objects that can be created. This provides the user with easy way to make sure that the creation method won't eat all the memory.

8. Cross-platform binary compatibility fully implemented. Binary files can be exchanged between Amiga and Windows versions (starting from Real 3D for Windows v.2.47).

9. A built-in key binding for showing selected objects by flashing their wireframe implemented. The hot-key is '0'.

1.16 Online Access to Real 3D resources

The BBS numbers listed below give information and support related to Real 3D v.2. Note that some of these numbers give extensive support only for registered customers of the local distributor.

```
  Activa International,       31 2153 80126
  The Netherlands

  Activa GmbH,                49 40 642 4092
  Germany

  Activa UK,                  44 81 986 5964
  UK

  Realsoft International      1 519 436 0140
  USA

  Karlberg&Karlberg           46 611 277 94
  Sweden

  FAMO                        47 226 87176  and  47 226 87557
  Norway

  Digipix                     61 2 970 6444
  Australia

  Realsoft                    358 71 2626775
  Finland         358 71 2626751   16.8 HST/v.32 bis
```

1.17 menu list

```
MENU ITEM                                  RPL Menu word   Hotkey
-------------------------------------------------------------------
                  * = Toggle

Project

     Objects
                  Insert                        0 0 0
                  Save                          0 0 1
                  Replace                       0 0 2
                  ----------------------------------
                  Font Loader                   0 0 4

     Project
                  New                           0 1 0
                  ----------------------------------
                  Insert                        0 1 2
                  Save                          0 1 3
                  Replace                       0 1 4
                  ----------------------------------
                  Insert Sections               0 1 6
                  Save Sections                 0 1 7
                  Replace Sections              0 1 8

     Materials
                  Window                        0 2 0     <RAM>M
                  ----------------------------------
                  Delete                        0 2 2
```

```
              Delete All                    0 2 3
              ----------------------------------
              Insert                        0 2 5
              Save                          0 2 6
              Replace                       0 2 7

Macros
              * Record                      0 3 0
              ----------------------------------
              Execute Current               0 3 2
              Execute Named                 0 3 3
              Repeat Current                0 3 4
              Spread Current                0 3 5
              ----------------------------------
              Current to Named              0 3 7
              Named to Current              0 3 8

Named Colors
              Select                        0 4 0
              Create                        0 4 1
              Modify                        0 4 2
              Delete                        0 4 3
              ----------------------------------
              Insert                        0 4 5
              Save                          0 4 6
              Replace                       0 4 7

Windows
              Select                        0 5 0
              View                          0 5 1
              View Superbitmap              0 5 2
              View Borderless               0 5 3
              View DBuffered                0 5 4
              RPL                           0 5 5
              Tool                          0 5 6
              Animation                     0 5 7     <RAM>A
              Palette                       0 5 8     <RAM>P
              Measuring                     0 5 9
              Screen                        0 5 10
              Color Wheel                   0 5 11
              External Classes              0 5 12
              ----------------------------------
              Close                         0 5 14
              * No Gadgets                  0 5 15
              Window Name                   0 5 16

Environment
              Open Screen                   0 6 0
              Make Def.Pub                  0 6 1
              Close Screen                  0 6 2
              Close Current                 0 6 3
              ----------------------------------
              Insert                        0 6 5
              Save                          0 6 6
              Replace                       0 6 7
              ------------------------------------
              Save Screen                   0 6 9
```

```
                Screen Palette                  0 6 10

     External Screen
                Open                            0 7 0
                Close                           0 7 1
                Set Modes                       0 7 2
                Settings                        0 7 3
                Save                            0 7 4

     Exit Real                                  0 8 0


Create

     Visibles
                Polygon                         1 0 0
                Polyhedron                      1 0 1
                Polymid                         1 0 2
                Cut polymid                     1 0 3
                -----------------------------------
                Rectangle                       1 0 5
                Cube                            1 0 6
                Pyramid                         1 0 7
                Cut pyramid                     1 0 8
                -----------------------------------
                Reg.polygon                     1 0 10
                Reg.polyhedr.                   1 0 11
                Reg.polymid                     1 0 12
                Reg.cut.plmd                    1 0 13
                -----------------------------------
                Circle                          1 0 15
                3P Circle                       1 0 16
                Cylinder                        1 0 17
                Cone                            1 0 18
                Cutcone                         1 0 19
                -----------------------------------
                Sphere                          1 0 21
                Ellipsoid                       1 0 22
                Ellipsegment                    1 0 23
                Cut ellipseg                    1 0 24
                -----------------------------------
                Hyperbol                        1 0 26
                Cut hyperb.                     1 0 27

     Sectors
                Circle                          1 1 0
                Cylinder                        1 1 1
                Cone                            1 1 2
                Cut cone                        1 1 3
                -----------------------------------
                Ellipsegment                    1 1 5
                Cut ellipseg.                   1 1 6
                -----------------------------------
                Hyperbol                        1 1 8
                Cut hyperbol                    1 1 9

     Structure
```

```
              Level                          1 2 0
              Link                           1 2 1
              Group                          1 2 2
              Method                         1 2 3

Light-sources
              Point                          1 3 0
              Line                           1 3 1
              Wall                           1 3 2
              Spot                           1 3 3
              Beam                           1 3 4

Controls
              Attribute                      1 4 0
              Offset                         1 4 1
              Axis                           1 4 2
              Coordsys                       1 4 3
              -----------------------------------
              Open Line                      1 4 5
              Closed Line                    1 4 6
              Circular Line                  1 4 7
              -----------------------------------
              B-Spline Ctrlp                 1 4 9
              B-Spline Knot                  1 4 10
              B-Spline Curve                 1 4 11
              B-Spline Closed                1 4 12
              B-Spline Cir.                  1 4 13
              B-Spline Helix                 1 4 14
              -----------------------------------
              Skeleton                       1 4 16

Mapping
              Default                        1 5 0
              Parallel                       1 5 1
              Cylinder                       1 5 2
              Sphere                         1 5 3
              Disk                           1 5 4

Compound Tools
              Lathe                          1 6 0
              -----------------------------------
              Circular Subdivided            1 6 2
              Rounded Circ. Subd.            1 6 3
              Sharp Circular                 1 6 4
              Rounded Circular               1 6 5
              -----------------------------------
              Conical                        1 6 7
              Conical Subdivided             1 6 8
              -----------------------------------
              Rectangular                    1 6 10
              Rectangular Subdiv.            1 6 11
              Rectangular Conical            1 6 12
              Rect.Conical Subd.             1 6 13
              -----------------------------------
              Rounded Polygon                1 6 15
              Rounded Polyhedron             1 6 16
              Ellipsed Polygon               1 6 17
```

```
                Ellipsed Polyhedron          1 6 18
                -----------------------------------
                Join Primitives              1 6 20
                Object-Pixel Tool            1 6 21

     Freeform
                Mesh                         1 7 0
                Torus                        1 7 1
                -----------------------------------
                Coplanar                     1 7 3
                Orthogonal                   1 7 4
                Rotate                       1 7 5
                Swing/Move                   1 7 6
                Swing/Size                   1 7 7
                Build from Curves            1 7 8
                Mesh-Pixel Tool              1 7 9
                Skin Curve                   1 7 10
                Parallel C/S                 1 7 11
                Extrude                      1 7 12
                Triset from Mesh             1 7 14

     Fractals
                Landscape                    1 8 0
                Tree                         1 8 1

     Boolean
                OR                           1 9 0
                AND                          1 9 1
                AND NOT                      1 9 2
                AND with Paint               1 9 3
                AND NOT with Paint           1 9 4
                -----------------------------------
                Rethink                      1 9 6
                Rethink All                  1 9 7
                Unthink                      1 9 8
                Unthink All                  1 9 9

     Particles
                Skeleton                     1 10 0
                Volume                       1 10 1


Modify

     Linear
                Move                         2 0 0
                Move COG                     2 0 1
                Size 2D                      2 0 2
                Size 3D                      2 0 3
                Stretch                      2 0 4
                Extend                       2 0 5
                Rotate                       2 0 6
                Mirror                       2 0 7
                Shear                        2 0 8
                Rot&Ext                      2 0 9
                Deform                       2 0 10
```

```
Structure
             Cut                          2 1 0
             Copy                         2 1 1
             Paste                        2 1 2
             Delete                       2 1 3
             Duplicate                    2 1 4
             Swap                         2 1 5

Properties
             Color                        2 2 0
             Name                         2 2 1
             Attributes                   2 2 2
             Alpha Channel                2 2 3
             Tags                         2 2 4
             Animation                    2 2 5
             Replace Tags                 2 2 6
             COG                          2 2 7
             Direction                    2 2 8
             Velocity                     2 2 9
             Spin                         2 2 10
             Size                         2 2 11
             Physical Attr.               2 2 12
             Lighting Attr.               2 2 13

Bend Local
             Move 2D                      2 3 0
             Move 3D                      2 3 1
             Move Radial                  2 3 2
             ---------------------------------
             Size 2D                      2 3 4
             Size 3D                      2 3 5
             Size Radial                  2 3 6

Bend Global
             Move 2D                      2 4 0
             Move 3D                      2 4 1
             Move Radial                  2 4 2
             ---------------------------------
             Size 2D                      2 4 4
             Size 3D                      2 4 5
             Size Radial                  2 4 6

Bend Endp.
             Move 2D                      2 5 0
             Move 3D                      2 5 1
             Move Radial                  2 5 2
             ---------------------------------
             Size 2D                      2 5 4
             Size 3D                      2 5 5
             Size Radial                  2 5 6

Bend Linear
             Move 2D                      2 6 0
             Move 3D                      2 6 1
             Move Radial                  2 6 2
             ---------------------------------
             Size 2D                      2 6 4
```

```
              Size 3D                       2 6 5
              Size Radial                   2 6 6

Bend Circular
              Move 2D                       2 7 0
              Move 3D                       2 7 1
              Move Radial                   2 7 2

Non-linear
              Move                          2 8 0
              Size                          2 8 1
              Stretch                       2 8 2
              Rotate                        2 8 3
              Twist                         2 8 4
              ----------------------------------
                Parabola                    2 8 6
              * Linear                      2 8 7
                Circle                      2 8 8
                Sine                        2 8 9
                Curve                       2 8 10
              ----------------------------------
              Set Tool                      2 8 12

Special
              Inverse Kinematic             2 9 0
              ----------------------------------
              Parallel Shrink               2 9 2
              Cylindrical Shrink            2 9 3
              Spherical Shrink              2 9 4
              Normal Shrink                 2 9 5

COGs
              Size 2D                       2 10 0
              Size 3D                       2 10 1
              Stretch                       2 10 2
              Extend                        2 10 3
              Rotate                        2 10 4
              Mirror                        2 10 5
              Shear                         2 10 6
              Rot&Ext                       2 10 7
About COGs
              Size 2D                       2 11 0
              Size 3D                       2 11 1
              Stretch                       2 11 2
              Extend                        2 11 3
              Rotate                        2 11 4
              Mirror                        2 11 5
              Shear                         2 11 6
              Rot&Ext                       2 11 7
Freeform
              Reparametrize                 2 12 0
              Move Knotpoint                2 12 1    <RAM>K
              Concatenate                   2 12 2
              Swap Direction                2 12 3
              Open/Close                    2 12 4
              Type                          2 12 5
              Invert                        2 12 6
```

```
                Remap                          2 12 7
                Surf.to curves                 2 12 8
                Distribute                     2 12 9
                Assign                         2 12 10
                Exchange u & v                 2 12 11
                Snap to                        2 12 12
                Delete                         2 12 13
                Insert                         2 12 14
                Break                          2 12 15
                Set start                      2 12 16
                Triple ends                    2 12 17

                ------------------------------------
    Draw Mode
                * Accurate                     2 14 0
                Bounding box                   2 14 1

View

    Type
                * Parallel                     3 0 0
                  Perspective                  3 0 1
                ------------------------------------
                * Separate IO                  3 0 3
                * ViewCam Motion               3 0 4     <RAM>L
                  ViewCam Pos.                 3 0 5     <RAM>,

    Input Plane
                Set XY                         3 1 0     <RAM>1
                Set YZ                         3 1 1     <RAM>2
                Set XZ                         3 1 2     <RAM>3
                Object->IPlane                 3 1 3     <RAM>N
                ViewCam->IPlane                3 1 4     <RAM>Q
                Roll XYZ                       3 1 5     <RAM>4
                * Horiz. Lock                  3 1 6     <RAM>5
                * Vert. Lock                   3 1 7     <RAM>6
                Reset Hot Point                3 1 8     <RAM>7
                Hot Point Forwards             3 1 9     <RAM>8
                Hot Point Backwards            3 1 10    <RAM>9

    ViewCam
                Reset all                      3 2 0     <RAM>E
                Reset Scale                    3 2 1     <RAM>0
                Position                       3 2 2     <RAM>`
                Pos&Zoom In                    3 2 3     <RAM>I
                Pos&Zoom Out                   3 2 4     <RAM>O
                Center                         3 2 5     <RAM>>
                Auto Focus                     3 2 6     <RAM><
                Set XY                         3 2 7     <RAM>X
                Set YZ                         3 2 8     <RAM>Y
                Set XZ                         3 2 9     <RAM>Z
                Set Custom                     3 2 10    <RAM>C
                Define X                       3 2 11    <RAM>F
                Define Y                       3 2 12    <RAM>B
                Camera->ViewCam                3 2 13    <RAM>W
                IPlane->ViewCam                3 2 14    <RAM>J
                ViewCam Control                3 2 15
```

```
     Camera
                 ViewCam->Camera                3 3 0     <RAM>V
                 Create Camera                  3 3 1
                 Define Camera                  3 3 2
                 -----------------------------------
                 * Camera View                  3 3 4
     Grid
                 Select                         3 4 0
                 Create                         3 4 1
                 Modify                         3 4 2
                 Reposition                     3 4 3
                 Delete                         3 4 4
                 -----------------------------------
                 * Visible                      3 4 6
                 * Snap to Grid                 3 4 7
     Render
                 Window                         3 5 0     <RAM>R
                 Boxes                          3 5 1     <RAM>T
                 -----------------------------------
                 Greyscale                      3 5 3     <RAM>G
                 HAM                            3 5 4     <RAM>H
                 -----------------------------------
                 Selected                       3 5 6
                 Settings                       3 5 7     <RAM>S
                 -----------------------------------
                 Export RPL                     3 5 9
                 -----------------------------------
                 Render Hierarchy               3 5 11
                 Export DXF                     3 5 12

     Drawing Set                                3 6 0     <RAM>D

     Boxes
                 Define                         3 7 0
                 Modify                         3 7 1
                 Delete                         3 7 2
                 Delete All                     3 7 3
                 Show All                       3 7 4

     Window Size                                3 8 0

     Control Window                             3 9 0


Animate

     Create
                       Path                     4 0 0
                       Direction                4 0 1
                       Rotation                 4 0 2
                       Sweep                    4 0 3
                       Stretch                  4 0 4
                       Size                     4 0 5
                       Morphing                 4 0 6

     Forces
                       Radial                   4 1 0
```

```
                    Directed                4 1 1
                    Tangential              4 1 2
                    Friction                4 1 3
                    Noise                   4 1 4

                    ----------------------------
     Control
                    Play Forwards           4 3 0
                    Play Backwards          4 3 1
                    Go to Beginning         4 3 2
                    Go to End               4 3 3
                    Go to ?                 4 3 4
                    Step Forwards           4 3 5
                    Step Backwards          4 3 6
                    ----------------------------
                    Refresh                 4 3 8

     Time Line                              4 4 0

     Edit                                   4 5 0


Extras

     Vectors
                    Push                    5 0 0
                    Pull                    5 0 1     <RAM>.
                    Enter                   5 0 2
                    Clear                   5 0 3
                    ----------------------------
                    Subtract                5 0 5
                    Average                 5 0 6
                    Average All             5 0 7
                    Cross Product           5 0 8
                    ----------------------------
                    Eval. Current           5 0 10
                    Define & Eval.          5 0 11
                    Length evaluate         5 0 12
                    ----------------------------
                    Lasso Select            5 0 14    <RAM>[
                    Lasso Deselect          5 0 15    <RAM>]
                    Push Selected           5 0 16    <RAM>*
                    Pull All                5 0 17    <RAM>/

     Undo                                   5 1 0     <RAM>U

     Statistics                             5 2 0

     Refresh All
                    Wire-frame              5 3 0
                    Ray Trace               5 3 1

     Cancel All                             5 4 0

     Evaluate
                    Curve Length            5 5 0
                    Parameter               5 5 1
```

```
     Select Objects                          5 6 0     <RAM>space

     Free Images                             5 7 0


Settings

     Clip Boxes
                       Active                6 0 0
                       ----------------------------
                       Select                6 0 2
                       Deselect              6 0 3

     General                                 6 1 0

     Refresh
                         None                6 2 0
                         Current             6 2 1
                       * All                 6 2 2
     Oper.Level
                       * Active              6 3 0
                       ----------------------------
                       Depth                 6 3 2
     Creation
                       * Qry. Level Name     6 4 0
                       * Qry. Prim. Name     6 4 1
                       * Auto Current        6 4 2
                       * Auto Selected       6 4 3
                       * Auto Index          6 4 4

     Paths                                   6 5 0

     Alpha Channel                           6 6 0

     Attributes                              6 7 0

     RPL                                     6 8 0

     View Resolutions
                       Rotation              6 9 0
                       Position              6 9 1
                       Zoom                  6 9 2
     Undo
                       * Active              6 10 0
                       Set depth             6 10 1
                       Clear                 6 10 2

     File Icons                              6 11 0

Tool

                       Icons                 7 0 0
                       Create Icon           7 1 0
                       Delete Icon           7 2 0
```