# General Description

The geometric modeler ROCAD3D allows the modeling and association of simple primitive objects to create more complex objects. These modules allow creating wireframe models of robots, positioners, cell components, tools and parts. The ROCAD3D module can also be used separately for 3D geometric modeling.

The mode of operation of RoCAD3D is identically to ROBMOD. The operation is based in commands and menus.

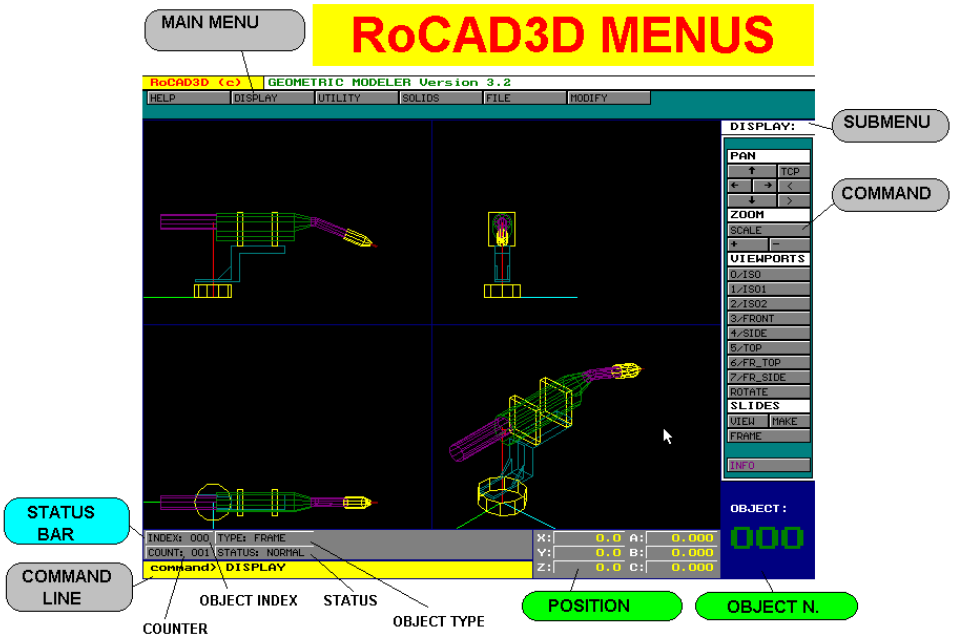



*Fig. 3-1. RoCAD3D screen areas..*

The screen is divided in the following strips:

- In the upper strip is the main menu.
- In the right lateral strip there is the submenu is active and the corresponding commands. There is also the object indicator and the visualization of directories for certain function calls.

- In the Lower strip there is the *Status* and command line and also information about the position and orientation of current object in RPY system (*Roll, Pitch Yaw*).

- The center of the screen is the visualization of the viewports of graphical display.

ROCAD3D is not a powerful CAD system. Is use is only to support the modeling for ROBMOD Offline program. To complement the use of ROCAD3D is possible to convert files to DXF format and work in a major software program like AUTOCAD. ®.

For the conversion of DXF there are in the package the programs DXF2GEO.EXE and GEO2DXF.EXE. The conversion can be done without leaving RoCAD3D or externally. The entities that the conversion programs can use are *3dline*, *3dface* and *3dpoly*. The maximum number of vertexes The maximum number is 20 for the polygons defined in AUTOCAD.

To create a DXF file from an AUTOCAD drawing use the command *dxfout* and select ENTITIES. To close polygons use the utility POLY.EXE (obsolete).

# Geometric Modeling

The geometric modeler basically uses 3 types of files with extensions <.CAD>, <.GEO>, <.ROB> and <.POS> (last two are equal). Apart from the fact that the description of the objects is identical in these files data structure is slightly different.

## Data Structure

The data structure of the objects is described by the following lines in the indicated order:

- T,object_code
- F,X_frame, Y_frame, Z_frame, Rz_frame, Ry_frame, Rx_frame
- C,comment
- Q,I_points, J_poligons
- N,X_node1, Y_node1, Z_node1
- ...
- ...
- N,X_nodeI, Y_nodeI, Z_nodeI
- P,K1_poligon1 vertx1_1, ..., vertexK1_1, color_1
- ...
- ...
- P,KJ_poligonJ, vertex1_J, ..., vertexKJ_J, color_J

The first line with a T in the beginning indicates the object type according an internal code.

The second line with an F in the beginning indicates the position and orientation associated with the object frame in the following order X, Y, Z, rotation by Z, rotation by Y and rotation by X.

The line with a C in the beginning is a comment and can have arbitrary location.

Fourth line beginning with a Q is the number of nodes and polygons the form the object.

Following are the lines beginning with N of the node coordinates X, Y, Z that form the object

Following are the lines beginning with P of the several polygons that form the object by the order K – number of vertexes of the polygon, index of vertex 1,…index of vertex K, color of the polygon.

As an example we have a file representing a box with 100x200x300 mm, of color 2 (green).

This box has code number 1, 8 vertexes and 6 polygons.

```
T,1
F,    0.0,    0.0,    0.0,    0.000,    0.000,    0.000
C,no_comment
Q,8,6
N,0.000000,0.000000,0.000000
N,100.000000,0.000000,0.000000
N,100.000000,200.000000,0.000000
N,0.000000,200.000000,0.000000
N,0.000000,0.000000,300.000000
N,100.000000,0.000000,300.000000
N,100.000000,200.000000,300.000000
N,0.000000,200.000000,300.000000
P,5,0,1,2,3,0,2
P,5,4,5,6,7,4,2
P,2,0,4,2
P,2,1,5,2
P,2,2,6,2
P,2,3,7,2
```

First line with P in the beginning corresponds to the first polygon that has 5 vertexes, namely 0,1,2,3 and 0 (close polygon) and has color 2.

## Simple Objects Models

### CAD Files

The files of extension CAD can include several objects with a data sequence identical to the previous file. The objects following ones each other's in the file.

The vertexes index refers always to the objects for what have been defined.

To each of the objects are associated a frame.

This representation allows modifying the position and orientation of any object, as they are separated.

### GEO Files

In this representation the objects are mixed forming a single object. The vertexes of this new object are calculated using the position and orientation of the frame of each individual original object.

The file <BOX_WED.CAD>, formed by a box of 100x200x300 mm, and a wedge of 50x150x250 mm and color 5 (magenta), with a displacement of 100 mm in X direction of 100 mm, will have initially these contents:

```
T,1
F,     0.0,     0.0,     0.0,    0.000,    0.000,    0.000
C,no_comment
Q,8,6
N,0.000000,0.000000,0.000000
N,100.000000,0.000000,0.000000
 N,100.000000,200.000000,0.000000
N,0.000000,200.000000,0.000000
N,0.000000,0.000000,300.000000
N,100.000000,0.000000,300.000000
```

```
N,100.000000,200.000000,300.000000
N,0.000000,200.000000,300.000000
P,5,0,1,2,3,0,2
P,5,4,5,6,7,4,2
P,2,0,4,2
P,2,1,5,2
P,2,2,6,2
P,2,3,7,2
T,6
F, 100.0, 0.0, 0.0, 0.000, 0.000,
0.000
C,no_comment
Q,8,6
N,0.000000,0.000000,0.000000
N,50.000000,0.000000,0.000000
N,50.000000,150.000000,0.000000
N,0.000000,150.000000,0.000000
N,0.000000,0.000000,250.000000
N,50.000000,0.000000,0.000000
N,50.000000,150.000000,0.000000
N,0.000000,150.000000,250.000000
P,5,0,1,2,3,0,5
P,5,4,5,6,7,4,5
P,2,0,4,5
P,2,1,5,5
P,2,2,6,5
P,2,3,7,5
```

After compilation it generates the file <BOX_WED.GEO> with the following structure:

```
Q,16,12
* T,1
* F, 0.0, 0.0, 0.0, 0.000, 0.000,
0.000
* C,
* Q,8,6
N,0.000000,0.000000,0.000000
N,100.000000,0.000000,0.000000
N,100.000000,200.000000,0.000000
N,0.000000,200.000000,0.000000
N,0.000000,0.000000,300.000000
N,100.000000,0.000000,300.000000
N,100.000000,200.000000,300.000000
N,0.000000,200.000000,300.000000
* T,6
* F, 100.0, 0.0, 0.0, 0.000, 0.000,
0.000
* C,
* Q,8,6
N,100.000000,0.000000,0.000000
N,150.000000,0.000000,0.000000
N,150.000000,150.000000,0.000000
N,100.000000,150.000000,0.000000
N,100.000000,0.000000,250.000000
N,150.000000,0.000000,0.000000
```

```
N,150.000000,150.000000,0.000000
N,100.000000,150.000000,250.000000
P,5,0,1,2,3,0,2
P,5,4,5,6,7,4,2
P,2,0,4,2
P,2,1,5,2
P,2,2,6,2
P,2,3,7,2
P,5,8,9,10,11,8,5
P,5,12,13,14,15,12,5
P,2,8,12,5
P,2,9,13,5
P,2,10,14,5
P,2,11,15,5
```

Please node that there isn't the line corresponding to the frame in these files.

## Complex Object Models

### ROB and POS Files

These files have an identical structure to the files with extension <.CAD> except they don't have the lines corresponding to the individual frames. Each pre-compiled object corresponds to a link in the kinematics chain of the robot and positioner.

When we compile a file with <.ROB> or <.POS> extension this structure is automatically created.

We present next the model of a SCARA robot very simplified - file <SCARA4.ROB>.

```
* C,_______ROBOT FILE_______
* T,12
* F,      0.0,      0.0,      0.0,     0.000,     0.000,     0.000
* C,FRAME
Q,6,3
N,0.000000,0.000000,0.000000
N,0.000000,0.000000,100.000000
N,0.000000,0.000000,0.000000
N,100.000000,0.000000,0.000000
N,0.000000,0.000000,0.000000
N,0.000000,100.000000,0.000000
P,2,0,1,12
P,2,2,3,10
P,2,4,5,11
* T,12
* F,      0.0,      0.0,      0.0,     0.000,     0.000,     0.000
* C,BASE
Q,8,6
N,-150.000000,-150.000000,0.000000
N,150.000000,-150.000000,0.000000
```

```
N,150.000000,150.000000,0.000000
N,-150.000000,150.000000,0.000000
N,-150.000000,-150.000000,1200.000000
N,150.000000,-150.000000,1200.000000
N,150.000000,150.000000,1200.000000
N,-150.000000,150.000000,1200.000000
P,5,0,1,2,3,0,1
P,5,4,5,6,7,4,1
P,2,0,4,1
P,2,1,5,1
P,2,2,6,1
P,2,3,7,1
* T,12
* F,     0.0,     0.0,     0.0,    0.000,    0.000,    0.000
* C,INTERMEDIATE ARM
Q,16,4
N,100.000000,60.000000,-80.000000
N,99.999992,60.000000,80.000000
N,-550.000000,80.000031,79.999969
N,-550.000000,80.000031,-80.000031
N,99.999992,-60.000000,-80.000000
N,99.999985,-60.000000,80.000000
N,-550.000000,-79.999969,79.999969
N,-550.000000,-79.999969,-80.000031
N,99.999992,-60.000000,-80.000000
N,99.999985,-60.000000,80.000000
N,99.999992,60.000000,80.000000
N,100.000000,60.000000,-80.000000
N,-550.000000,-79.999969,-80.000031
N,-550.000000,-79.999969,79.999969
N,-550.000000,80.000031,79.999969
N,-550.000000,80.000031,-80.000031
P,5,0,1,2,3,0,2
P,5,4,5,6,7,4,2
P,5,8,9,10,11,8,2
P,5,12,13,14,15,12,2
* T,12
* F,     0.0,     0.0,     0.0,    0.000,    0.000,    0.000
* C,UPPER ARM
Q,8,6
N,-440.000000,40.000000,-60.000000
N,-440.000000,-40.000000,-60.000000
N,59.999996,-40.000023,-60.000000
N,60.000000,39.999977,-60.000000
N,-440.000000,40.000000,60.000000
N,-440.000000,-40.000000,60.000000
N,59.999996,-40.000023,60.000000
N,60.000000,39.999977,60.000000
P,5,0,1,2,3,0,3
P,5,4,5,6,7,4,3
P,2,0,4,3
P,2,1,5,3
P,2,2,6,3
P,2,3,7,3
* T,12
* F,     0.0,     0.0,     0.0,    0.000,    0.000,    0.000
* C,ROTATION OF FLANGE
Q,24,14
```

```
N,20.000000,0.000000,-60.000000
N,17.320509,10.000000,-60.000000
N,10.000000,17.320507,-60.000000
N,0.000000,20.000000,-60.000000
N,-10.000000,17.320509,-60.000000
N,-17.320507,10.000000,-60.000000
N,-20.000000,0.000000,-60.000000
N,-17.320509,-9.999999,-60.000000
N,-10.000001,-17.320507,-60.000000
N,-0.000001,-20.000000,-60.000000
N,9.999999,-17.320509,-60.000000
N,17.320507,-10.000001,-60.000000
N,20.000000,-0.000001,60.000000
N,17.320509,9.999999,60.000000
N,10.000001,17.320507,60.000000
N,0.000001,20.000000,60.000000
N,-9.999999,17.320509,60.000000
N,-17.320507,10.000001,60.000000
N,-20.000000,0.000001,60.000000
N,-17.320509,-9.999999,60.000000
N,-10.000001,-17.320507,60.000000
N,-0.000002,-20.000000,60.000000
N,9.999998,-17.320509,60.000000
N,17.320507,-10.000002,60.000000
P,13,0,1,2,3,4,5,6,7,8,9,10,11,0,4
P,13,12,13,14,15,16,17,18,19,20,21,22,23,12,4
P,2,0,12,4
P,2,1,13,4
P,2,2,14,4
P,2,3,15,4
P,2,4,16,4
P,2,5,17,4
P,2,6,18,4
P,2,7,19,4
P,2,8,20,4
P,2,9,21,4
P,2,10,22,4
P,2,11,23,4
* T,12
* F,     0.0,     0.0,     0.0,    0.000,    0.000,    0.000
* C,DISPLACEMENT OF FLANGE
Q,24,16
N,10.000000,0.000000,-230.000000
N,0.000000,10.000000,-230.000000
N,-10.000000,0.000000,-230.000000
N,0.000000,-10.000000,-230.000000
N,10.000000,0.000000,350.000000
N,0.000001,10.000000,350.000000
N,-10.000000,0.000001,350.000000
N,-0.000001,-10.000000,350.000000
N,30.000000,0.000000,-240.000000
N,21.213203,21.213203,-240.000000
N,0.000000,30.000000,-240.000000
N,-21.213203,21.213203,-240.000000
N,-30.000000,0.000001,-240.000000
N,-21.213203,-21.213203,-240.000000
N,-0.000001,-30.000000,-240.000000
N,21.213203,-21.213203,-240.000000
```

```
N,30.000000,-0.000001,-230.000000
N,21.213205,21.213202,-230.000000
N,0.000002,30.000000,-230.000000
N,-21.213202,21.213205,-230.000000
N,-30.000000,0.000002,-230.000000
N,-21.213205,-21.213202,-230.000000
N,-0.000003,-30.000000,-230.000000
N,21.213202,-21.213205,-230.000000
P,5,0,1,2,3,0,5
P,5,4,5,6,7,4,5
P,2,0,4,5
P,2,1,5,5
P,2,2,6,5
P,2,3,7,5
P,9,8,9,10,11,12,13,14,15,8,5
P,9,16,17,18,19,20,21,22,23,16,5
P,2,8,16,5
P,2,9,17,5
P,2,10,18,5
P,2,11,19,5
P,2,12,20,5
P,2,13,21,5
P,2,14,22,5
P,2,15,23,5
```

After running ROBMOD (and connection with corresponding Denavit-Hartenberg parameters) it generates the figure

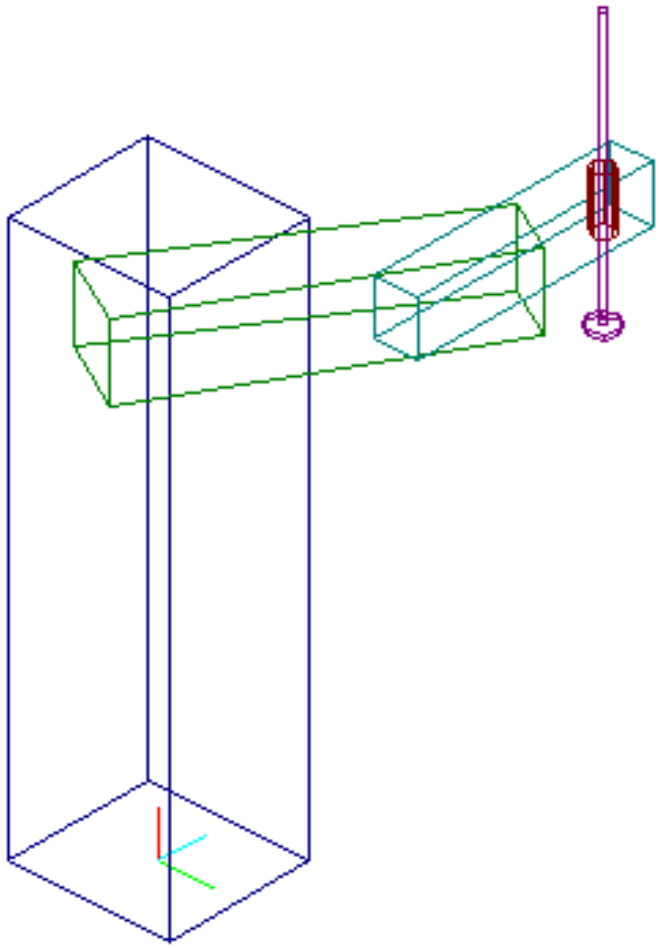


*Fig. 3-2. SCARA4.ROB model after running ROBMOD.*

# Commands and Menus

The principle of working of the ROCAD3D module is identical of the ROBMOD module:

Clicking the right button of the mouse or pressing the initial of the command activates each menu or command. In some cases where commands start with the same key it may be necessary to press additional keys.

Mouse right button emulates ENTER and left button emulates ESC. Arrow keys and PgUp/PgDn also have special meanings.

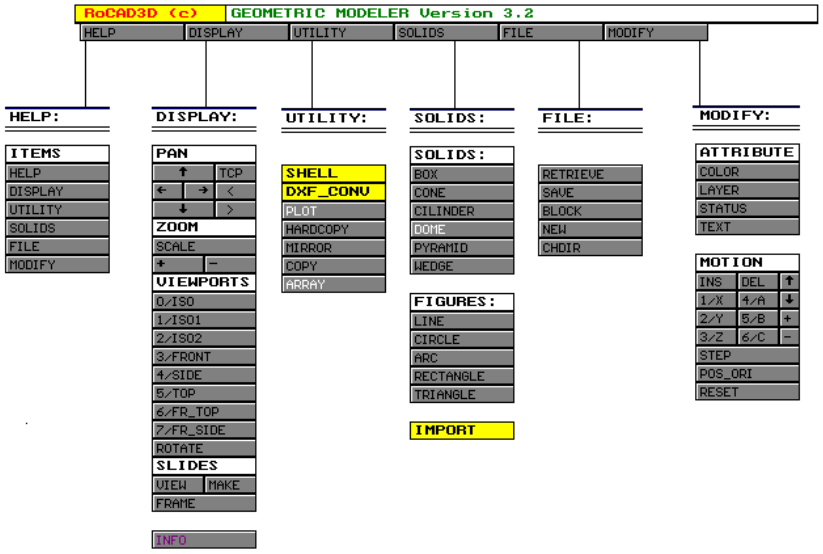



*Fig. 3-3. RoCAD3D Menus.*

The ROCAD interface uses the following menus:

DISPLAY – Display Menu
Views, zoom, pan, rotation by Z, slides, etc.

UTILITY – Utilities Menu
DOS shell, mirror, copy, array, plotting, hardcopy, DXF conversion, etc.

SOLIDS – Object Primitive Menu
Box, cone, cylinder, dome, pyramid, wedge, line, circle, arc, rectangle, triangle. Import.

FILE – File Access Menu
Retrieve, save, block, new, chdir, etc.

MODIFY – Edit Menu
Attribute - color, layer, status, text. Displacement by increments and coordinates, etc.

## Getting Help

It's possible to get help pressing F1 in each screen. The type of help depends of the current menu..

## DISPLAY Menu

The display menu provide a series of functions to change the display:

<n> VIEWPORTS
Change of the views. Multiple or single views can be used.

- 0/ISO - Isometric view
- 1/ISO1 - Isometric + projection (small windows)
- 2/ISO2 - Same. Windows of the same size
- 3/FRONT - Front view
- 4/SIDE - Side view
- 5/TOP - Top view
- 6/FR_TOP - Front/ Top view
- 7/FR_SIDE - Front/ Side view

The display of the views depends of the rotations that are made by Z.

SCALE
Change of the scale of the image. The scale can be modified by the keys + and - or introducing the scale factor.

PAN
The displacement (pan) of the image it is effectuated using the arrows and the factor (keys <and>). The view can also be cantered in the tool point (TCP - tool center point) of the robot

ROTATE
Rotation of the views according to the axis Z. If this function is active the keys + and - they allow to do to vary the value, and SCALE to attribute a specific value. Note: function ON/OFF.

SLIDES
Slides can be made, retrieved or used to produce an animation effects.

FRAME
This function toggles frame display

INFO
Program information and Copyright notice.

## UTILITY Menu

The utility menu provides utility functions:

SHELL
Calls DOS shell. ROCAD3D will stay resident. Use Exit to return to ROCAD3D. The amount of memory that is occupied is about 250 KB.

DXF_CONV
This function translates DXF files to [.GEO] format and inverse. The user as also the external utilities DXF2GEO.EXE and GEO2DXF.EXE to perform the same task.
NOTE: The DXF file can only have the ENTITIES part. Only 3DPOLY, 3DFACES and LINE (3dline) are translated.

HARDCOPY
This function makes a hardcopy of the cell display in EPSON FX-80 format. Please ensure that a printer is connected and ON-LINE.

PLOT
This function not yet available will produce a plotting of the cell.

MIRROR
Makes a mirror of the selected object relative to the planes XY, XZ or YZ. The external utility GEOSIM.EXE allows performing the same function.

COPY
Makes a copy of the selected object.

ARRAY
This function not yet available will produce an array of objects identical to the selected object.

NOTES:
AutoCad and EPSON FX-80 are registered trademarks of AUTODESK, AG. And EPSON.

## O Menu SOLIDS

This menu is used to create the object primitives (WIREFRAME models).

BOX
Creates a box of dimensions DX * DY * DZ. The user inputs the three borders and the color

CONE
Creates a cone or cone section. The user inputs the base and top radius (R1 e R2), weight (H), node number and color.

CILINDER

Creates a cylinder. Input are: radius, weight, number of nodes and color (R, H, Nodes, Color).

DOME
Spherical dome (not implemented).

PYRAMID
Creates a pyramid or pyramid section. Data: edge dimension, weight, number of sides and color (L1, L2, H, Nodes, Color).

WEDGE
Creates a wedge. The used inputs the three dimensions and color (Dx, Dy, Dz, Color). The slope is relative to plane XY.

LINE
Creates a line or line sequence. The inputs are the three displacements and color (Dx, Dy, Dz, Color).

CIRCLE
Creates a circle. Data is radius, weight, number of nodes and color (Identical to *CILINDER*)

ARC (Shape)
Identical to *CIRCLE*. Input also of the center angle and weight.

RECTANGLE
Creates a rectangle. Data input is the three dimensions and color. The rectangle is slopped relative to XY depending of Dz..

TRIANGLE
Not available

IMPORT
Gets an existent block <.GEO>. Appends to existent objects.

## FILE Menu

File menu allows to save and retrieve of files with geometric data of objects and corresponding locations. Several file types can be used <.CAD>, <.ROB> or <.POS> (kinematics chain object file), <.CEL> (cell file), <.TL0...TL3> (tool files), <.GEO> (compiled file - block-basic geometric entities).
The DXF uses the <.GEO> extension so the user has to rename the block files to use the converters.

The functions of these menus are:

SAVE
Recording of collection of objects and respective locations. <.CAD> extension. If the extensions <.ROB> or. <.POS> are used is created a special file for the kinematics chain of a robot or positioner. In this case the frames of each object shall have null values. The first object to include is a FRAME (to allow to manipulate the robot base) and the following the robot links by the order they appear. Note that each link (individual object file) shall be positioned according to rotational or prismatic axis of the robot Z oriented.

RETRIEVE
Retrieves files of extension <.CAD>. Is also possible to load files of types <.GEO>, <.CEL>, <.TL0...TL3>, <.ROB> and <.POS> if the right mouse button is pressed as the directory appears. This command makes a reset of the database of objects.

BLOCK
Saves objects as blocks. Objects can no longer be exploded. A file of extension [.GEO] is created. The location off the components is recalculated. The block is set at frame 0. GEO files are object files to manipulate in the ROBMOD Offline and Simulation Module.

NEW
Erases objects from memory.

CHDIR
Changes the [.CAD] and [.GEO] directory. Directory is recorded in the ROCAD3D.CFG file and default is *c:\robot3d\cell*

## MODIFY Menu

The *MODIFY* menu has an identical interface of the ROBMOD module to motion of objects.

The motion can be done with absolute or incremental values of coordinates.

This menu has function to change the location and attributes of objects.

Functions:

COLOR
Modifies the selected object color. The value (-1) corresponds to original color.

LAYER
Modifies the select object layer (not implemented).

STATUS
Changes the *Status* of the selected object. Choose between *Normal*, *Hide* and *Delete*. If the status is *Delete* the object is not recorded if *SAVE* is used.

TEXT
Changes the text attributes of an object.

1/X, 2/Y, 3/Z, 4/A, 5/B, 6/C
Selects for the current object the axis to move. The displacement is made by Cartesian coordinates increments. Orientation is based in Roll, Pitch, Yaw (RPY).

+, -
Increments position or orientation.

STEP
Increment value for linear or angular. Default 100 mm for linear and 15 degrees for angular.

POS_ORI
Absolute coordinate input of the location to place the object.

RESET
Go to the initial frame.

INS e DEL
Reorder of objects (not implemented).

UP and DOWN (arrows)
Selection of objects.

## Exit the Program

To shut off the program please press Q in the main menu of click in QUIT with the right button off the mouse.

# Building a Model

In the next pages we will show how to create two distinct model:

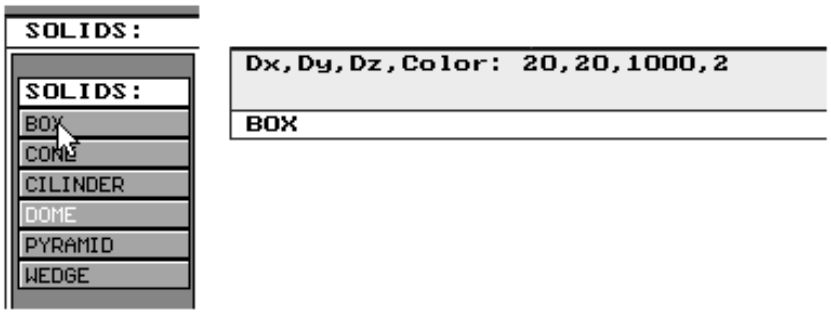
- Work table
- Gripper with two states

## Work Table

In this example we will show how to model a simple object a table with a top plate BOX of 1000x1000x20 mm green color, and four legs in the extreme edges of the plate each one made by a BOX of 20x20x1000 mm with *cyan* color,

Click with the right mouse button in the *SOLIDS* Menu.

Click with the right mouse button in *BOX*, and input >20,20,1000,2




The object will be placed in the screens as in figure 3.4

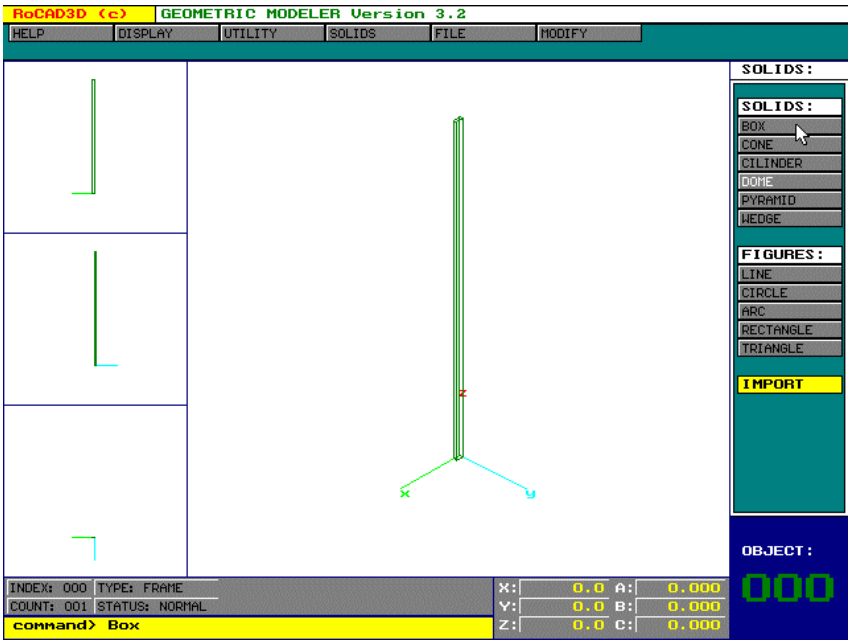
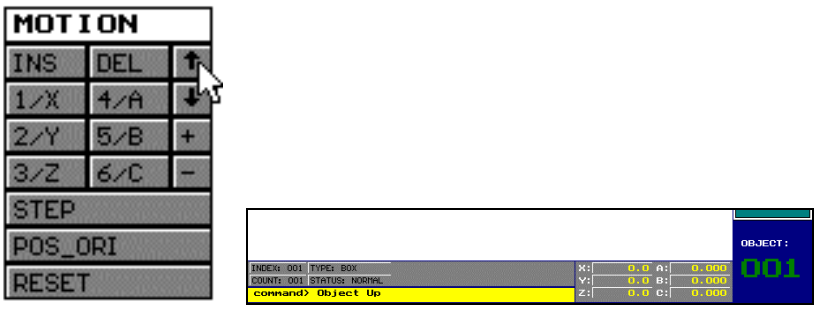



*Fig. 3-4. Building the Object (Leg).*

Press the right button of the mouse to return to the main screen and press the menu *MODIFY* with the left mouse button.

Click the up-arrow of corresponding key in the keyboard to select object 001.




In the lower right strip appear the value 001 indicating that the object 001 is selected.

In the *Status* Strip we can look of the object characteristics

Return again to the main screen to select the UTILITY menu.

Repeat three times the *COPY command*. We create three identical objects to object number 001. In the *Status* line we have now COUNT: 004, which indicates that we have now four objects.

To create the plate we select *SOLIDS* and *BOX* and input >1000,1000,20,3.

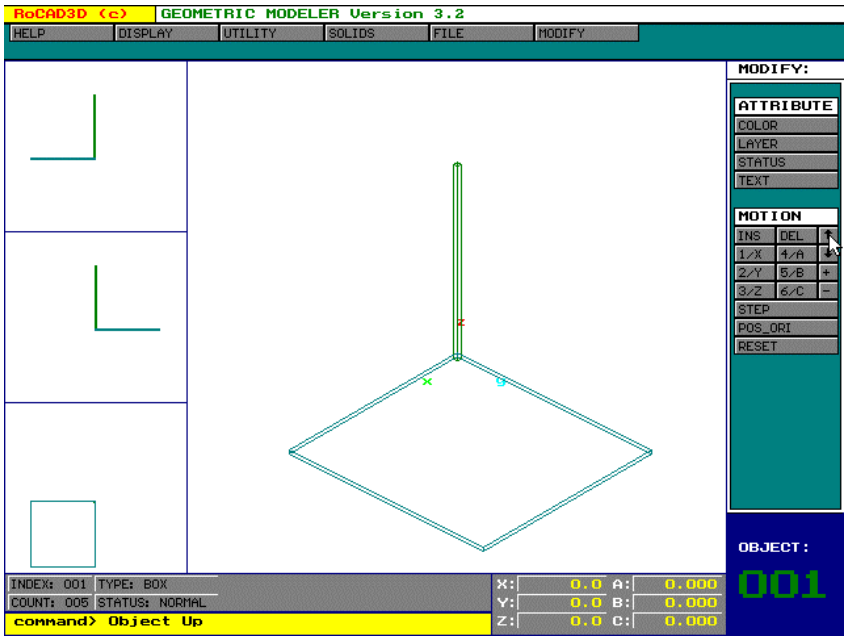



*Fig. 3-5. Plate Construction.*

To conclude the Work Table we will have to move the four legs and plate to their final positions. We will start by object 005 the plate.

Select the *MODIFY* menu. Use the up arrow to select object number 005.

Press 3 click in *3/Z*, e one time in +. The plate moves up 100 mm.

Press S or click in *STEP* e input > L. We select this way the linear step. Input >900. We have changed the linear step value to 900.

Click or press in +. The plate move up 900 mm. In total the plate has moved 1000 mm in Z direction.

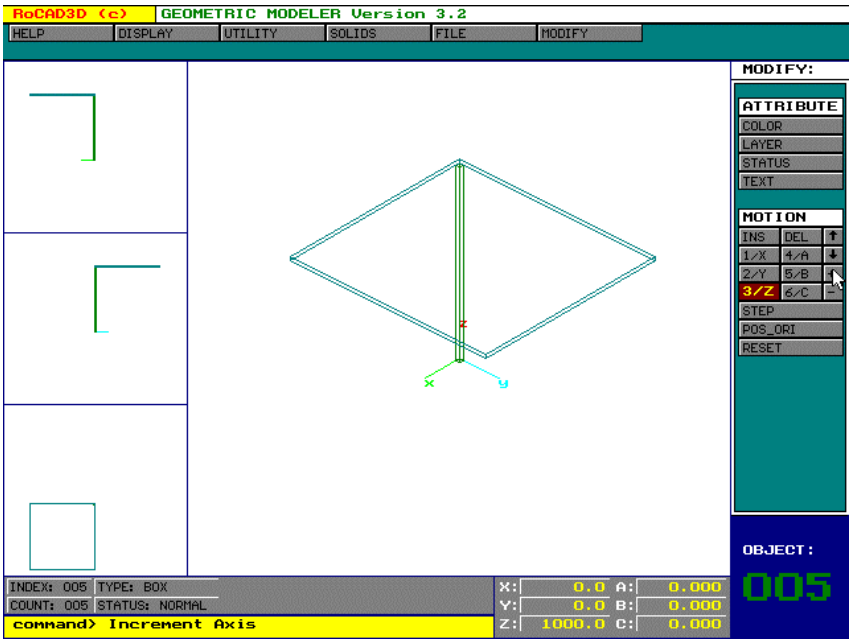



*Fig. 3-6. Modifying an Object Position.*

In the coordinate box we see Z: 1000.0.

Click *STEP* and L (linear) and input >980.

Select object 001 and axis *1/X* and press +.

Select object 002 and axis *2/Y* and +.

Select object 003 and +. After select *1/X* and +.

We have placed the legs of the table in the correct position getting the following figure:

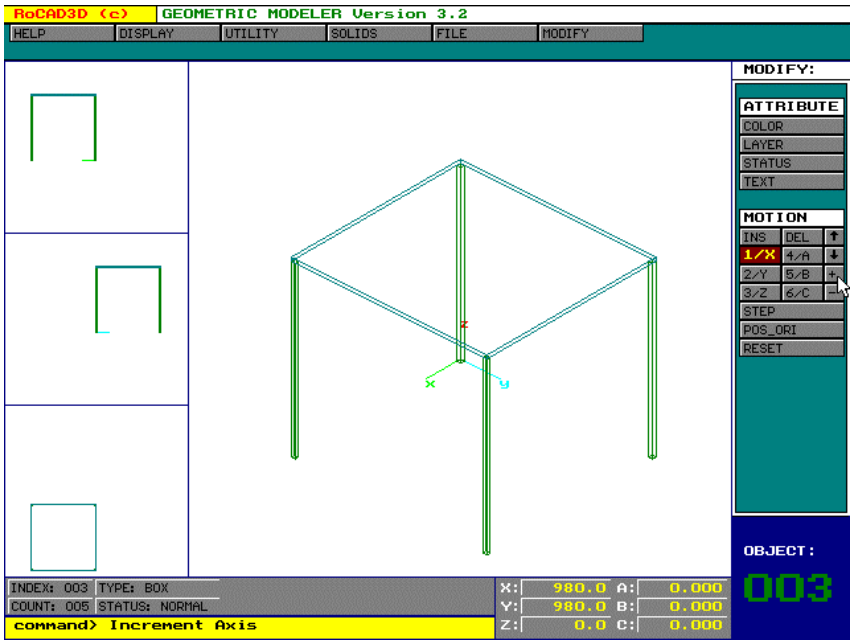



*Fig. 3-7. Complete Table.*

At last we shall save our work.

Select *FILE* menu and click *SAVE*. Input >table. By default it will be create the file <TABLE.CAD>.

## Robot Gripper

In this example we will see how to crate a robot gripper made by a cylinder and three box placed at 120º. The cylinder has a radius of 32, weight 42 mm, 12 nodes and color magenta (5). The fingers will have 20x10x10 mm and brown color (6).

Press *DISPLAY and 2* to have four viewports of equal size.

Select *SOLIDS* and *BOX* 20,10,10,6.

Select *MODIFY* and *UP* (up-arrow) to select object 001.

Select *STEP* and L (linear) 5 to have a linear increment value of 5 mm.

Select *1/X* +++ and *2/Y* – to center the finger in the axis X with an offset of 15 mm.

We get the following figure:

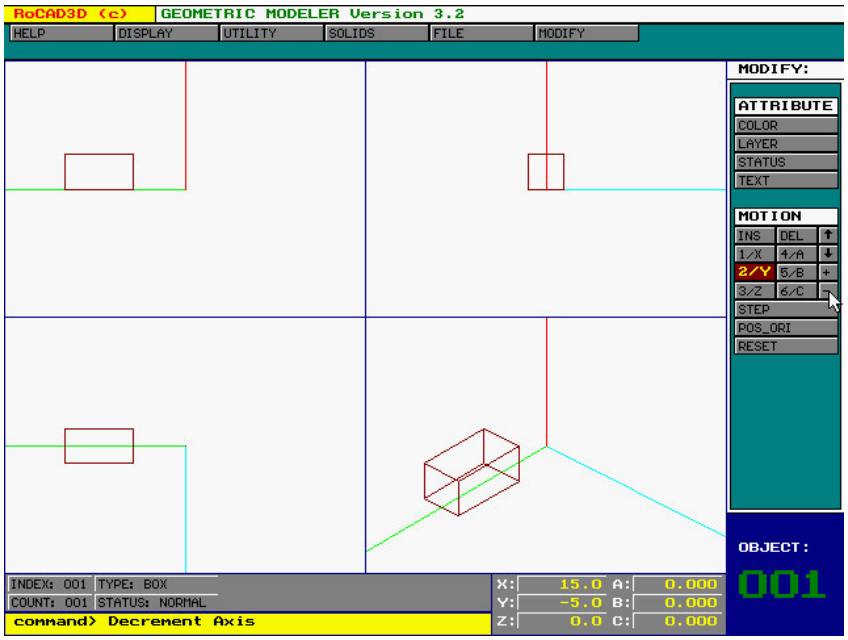



*Fig. 3-8. Finger for the Gripper.*

Select *FILE* menu and *BLOCK* <FINGER.GEO>.

Select again *MODIFY* and *1/X +++*. The object moves another 15 mm in axis X. Select again *FILE* and *BLOCK* using the file name <FINGERA.GEO>.

Select *NEW*. The object is cleared from the screen.. Select the *SOLIDS* menu and *CILINDER* 32,42,12,5. Click *IMPORT* and use the file <FINGER>.We get the figure:

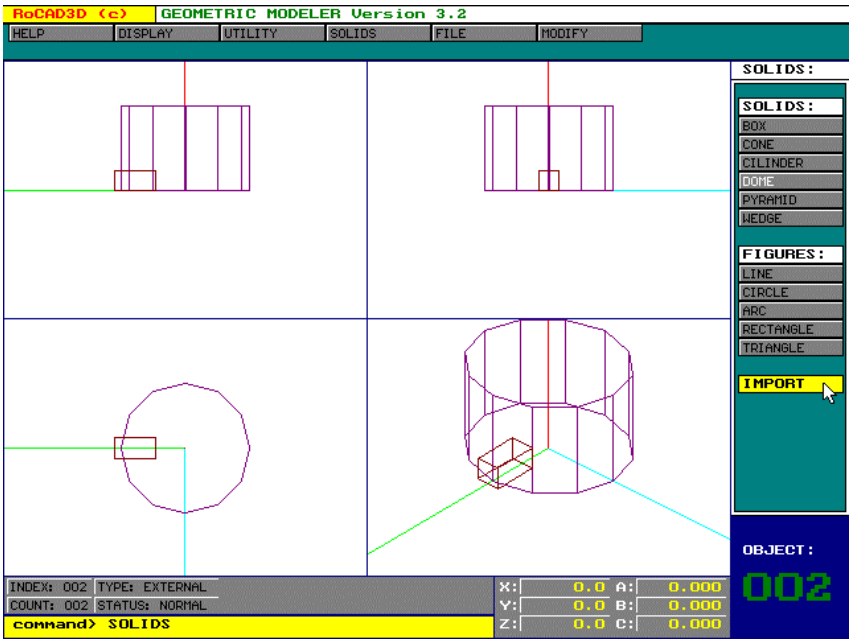


*Fig. 3-9. Primitive Objects.*

Select the *MODIFY* menu and object number 002.

Go to *UTILITY* menu and repeat *COPY* twice.

Return to *MODIFY* menu and click *STEP* A (angular) 120, to change the angular increment value to 120º.

Select axis *4/A* for rotation by Z. Select object 003 and +. Object 003 rotates 120º.

Select object 4 and -. Object 004 rotates -120º. We change the color of the objects number 003 and 004 to *COLOR* 6.

We will get the following figure:

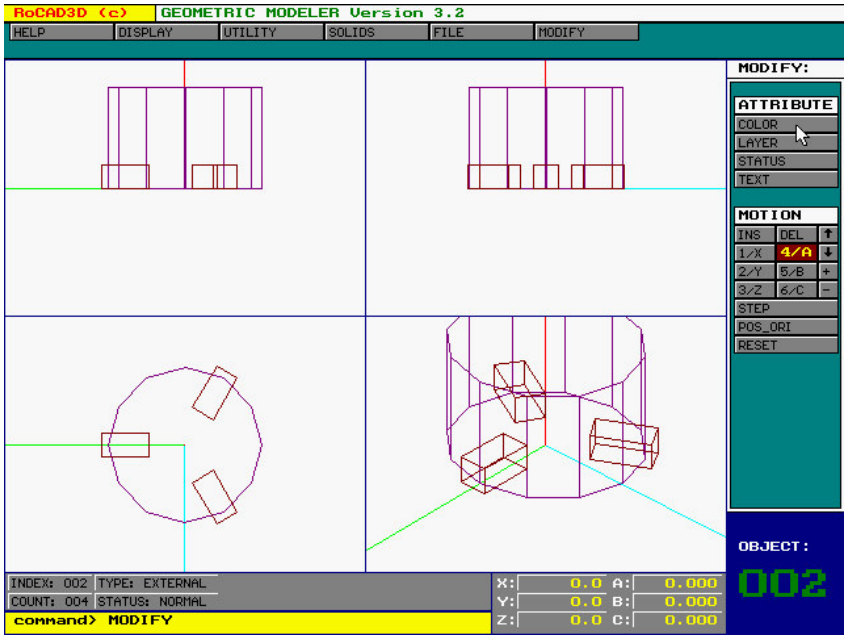



*Fig. 3-10.Gripper construction.*

At last we select axis *3/Z* and move up the objects 002, 003 and 004 by 32 mm. We get the figure:

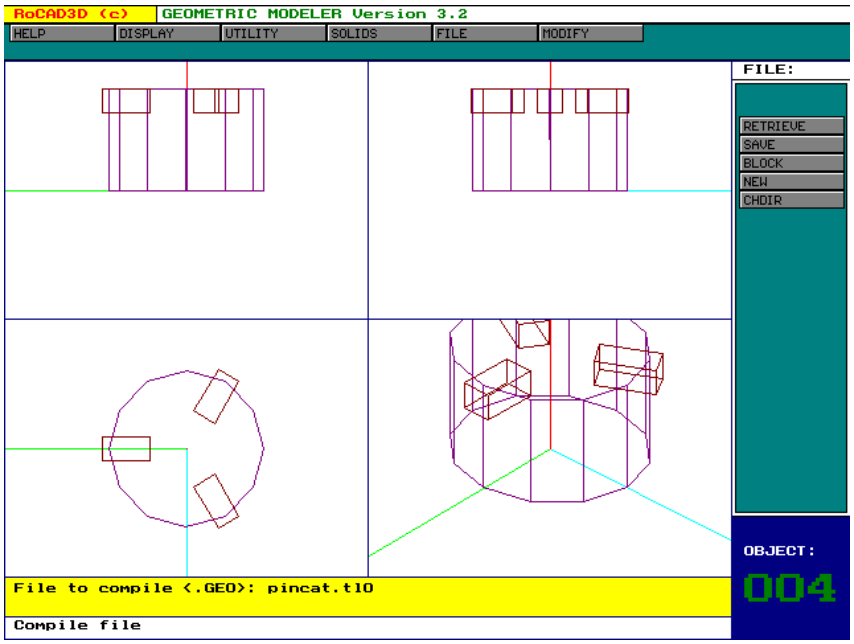



*Fig. 3-11. Complete gripper.*

We save the object with *FILE SAVE* <PINCAT>. Compile the object with *BLOCK* <PINCAT.TL0>. We have just made a tool for a robot.

To create the open gripper we would repeat the previous steps with the block <FINGERA.GEO> and we would give the name to the opened gripper <PINCAT.TL1>.

## SCARA Robot Modeling

To model a robot we have to create the objects corresponding to the links of the kinematics chain, orient them according the frames associated with each link (Z oriented) and compiled (Block) it separately.. We illustrate this process with a SCARA model of a robot as the one in the following figure:

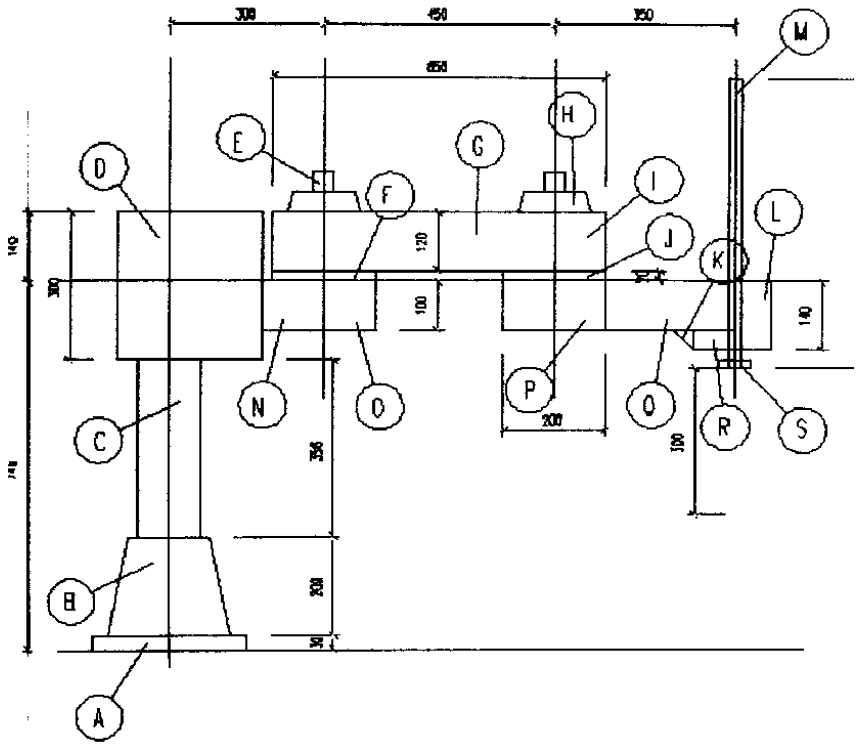



*Fig. 3-12. AX801Robot.*

Geometric Primitives for Robot Axis AX801

A) BOX,X=300,Y=300,Z=30,CYAN
B) CONE,R1=120,R2=80,H=200,N=10,GREEN
C) CILINDER,R=60,H=356,N=10,YELLOW
D) BOX,X=280,Y=200,H=300,CYAN
E) CILINDER,R=20,H=40,N=6,RED
F) CILINDER,R=100,H=20,N=10,GREEN
G) RECTANGLE,X=450,H=120,MAGENTA (2)
H) CONE,R1=70,R2=60,H=40,N=8,RED
I) ARC,R=100,H=120,N=5,180 degrees,MAGENTA
J) CILINDER – equal to F)
K) WEDGE,X=40,Y=140,H=40,YELLOW
L) ARC,R=70,H=140,N=8,180 degrees, YELLOW
M) CILINDER,R=12.5,H=585,N=6,BLUE
N) RECTANGLE,X=120,H=100,CYAN (2)
O) ARC,R=100,H=100,N=5,180 degrees, CYAN
P) BOX,X=100,Y=140,Z=100,YELLOW
Q) RECTANGLE,X=250,H=100,YELLOW (2)
R) BOX,X=80,Y=140,Z=40,YELLOW
S) COLINDER,R=30,H=15,N=8,WHITE

## Kinematics Chain

The kinematics chain of a SCARA robot is represented in the following figure:

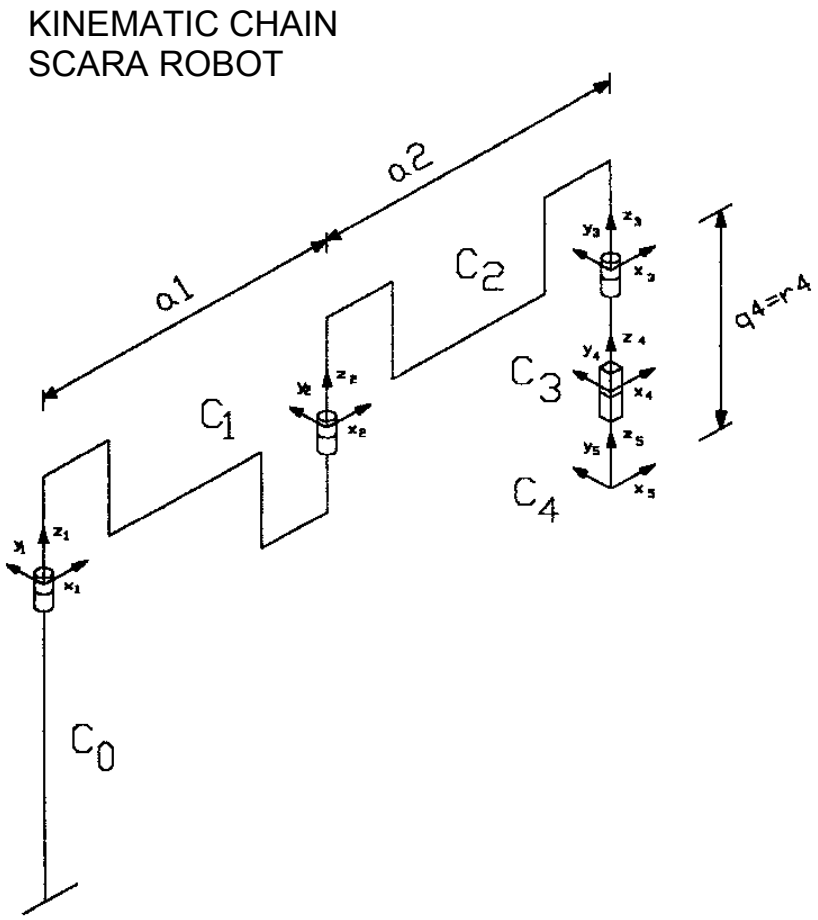



*Fig. 3-13. SCARA Robot – Kinematics chain.*

# Building the different links

## Base

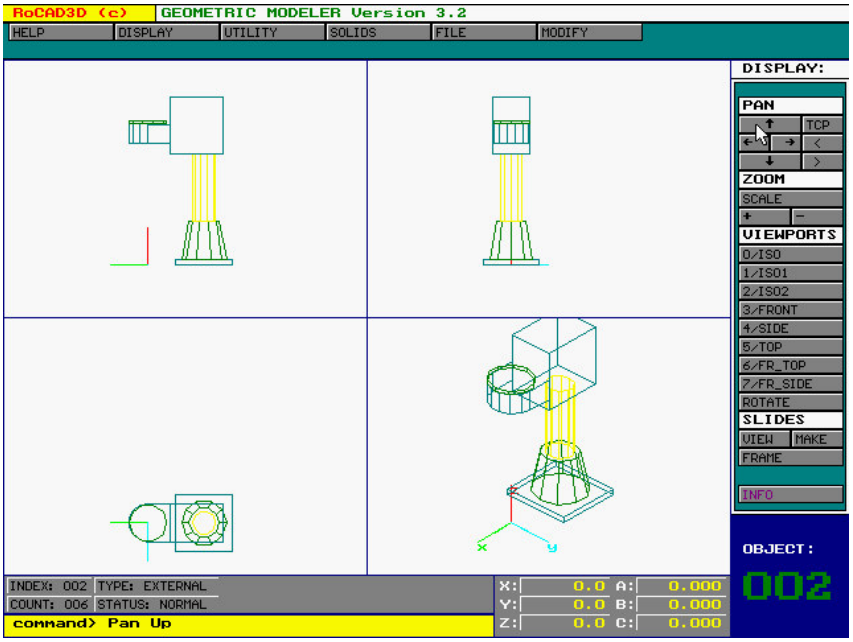



*Fig. 3-14 SCARA. Robot -Base (file AX801_C0.GEO>*

## Intermediate Arm

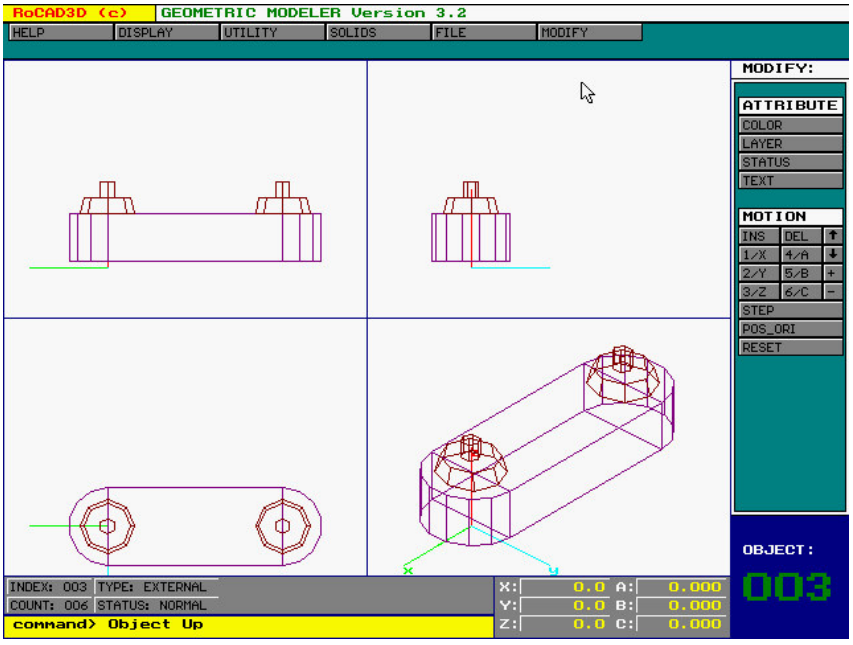



*Fig. 3-15. SCARA Robot – Intermediate Arm (fileAX801_C1.GEO>*

## Upper Arm

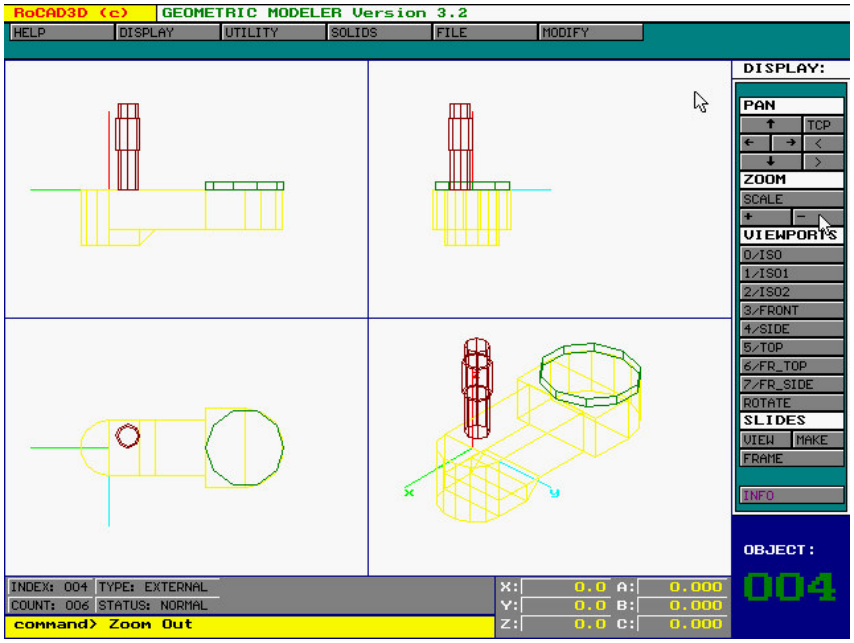



*Fig. 3-16. SCARA Robot –Upper Arm (file AX801_C2.GEO>*

## Rotation of flange

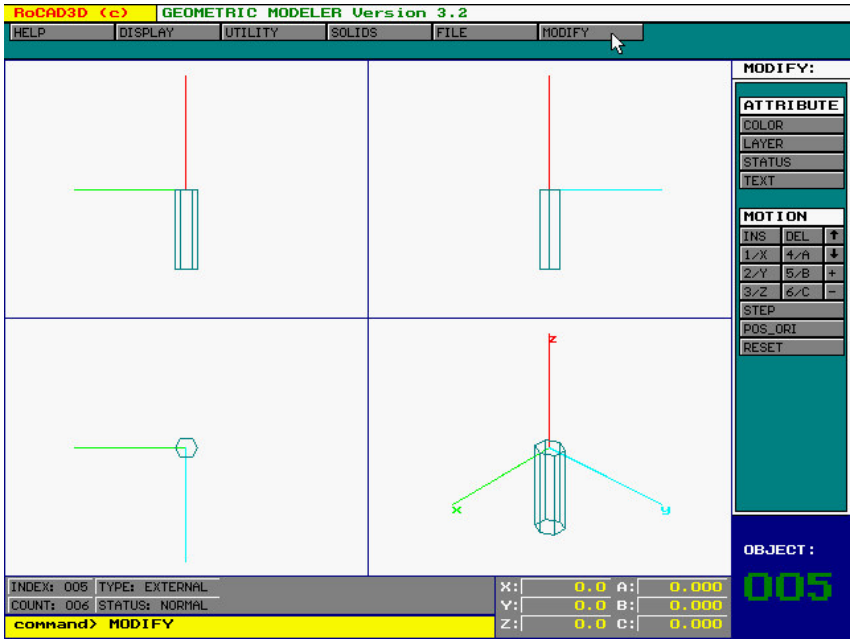



*Fig. 3-17. Robot SCARA –Rotation of flange (file AX801_C3.GEO>*

### Vertical Axis

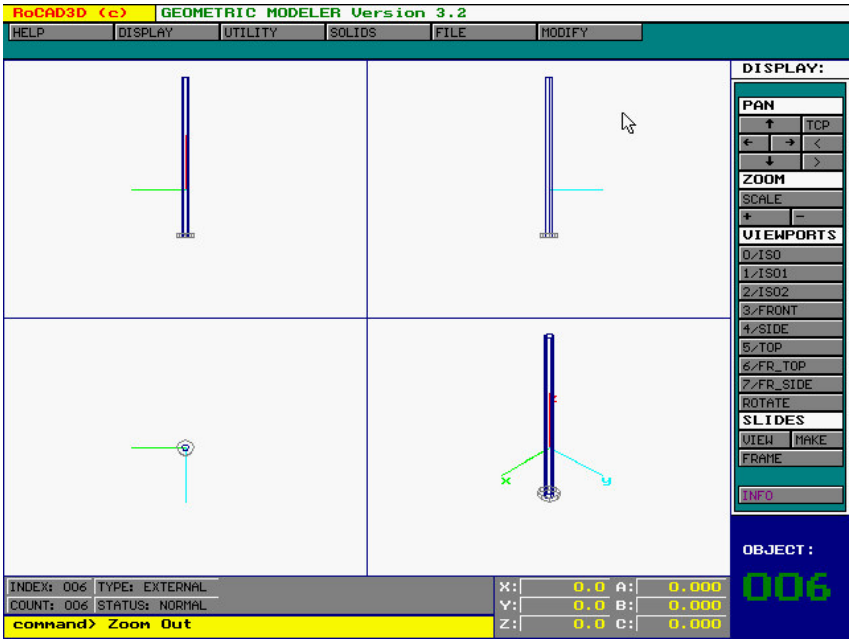



*Fig. 3-18. SCARA Robot – Vertical axis (file AX801_C4.GEO>*

## Building the Model

Select *FILE NEW*.

Select *SOLIDS IMPORT <FRAME> IMPORT <AX801_C0> IMPORT <AX801_C1> IMPORT <AX801_C2> IMPORT <AX801_C3>* e *IMPORT <AX801_C4>*.

### Joining the Links

Select *SAVE <AX801.ROB>*. The program recognizes the extension *<.ROB>*, building a file ready to be used by the module ROBMOD.

To complete the process of construction of the model we would have to create the files corresponding to the Denavit-Hartenberg parameters a other corresponding to the kinematics.

contents of AX80I.DH

```
F,   300.0,     0.0,     0.0,   0.000,   0.000,   0.000
R,   450.0,   746.0,     0.0,     0.0
R,   350.0,     0.0,     0.0,     0.0
R,     0.0,     0.0,     0.0,     0.0
P,     0.0,     0.0,     0.0,     0.0
N,     0.0,     0.0,     0.0,     0.0
N,     0.0,     0.0,     0.0,     0.0
```

The model after conclusion and together with the gripper and work cell would have the following aspect in ROBMOD:

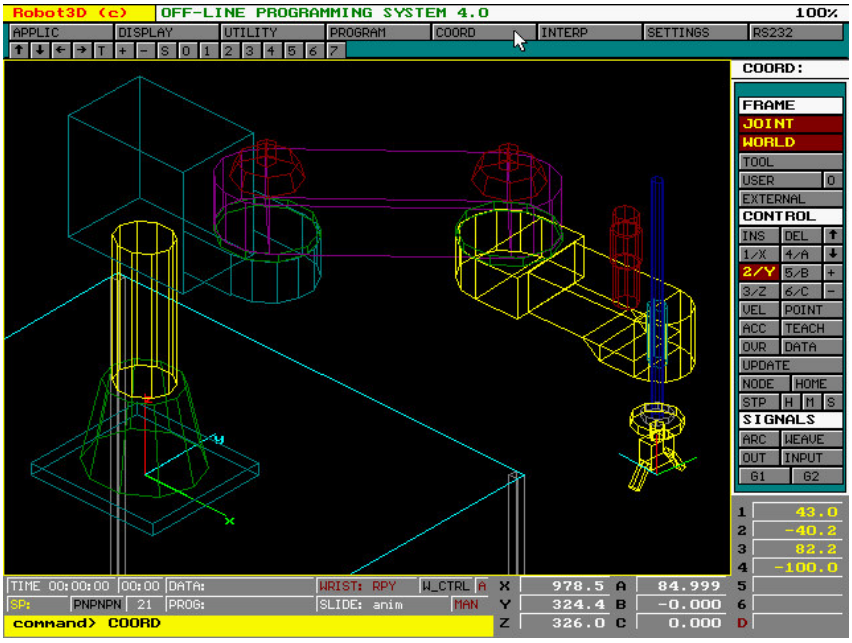



*Fig. 3-19. SCARA AX801 Robot*