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CONVERSION OF COMPUTER AIDED DESIGN (CAD) OUTPUT FILES TO MONTE CARLO N-PARTICLE (MCNP) INPUT FILES

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ABSTRACT (Abstract Head)

MCNP[1-3] is used throughout the world to perform complex particle transport calculations for a number of different applications. One tool that is commonly used to create and view MCNP input files is the MCNP Visual Editor [4]. A new feature has been added to the MCNP Visual Editor that will allow the user to convert 2D "dxf" files and 3D "sat" files to an MCNP input file.

The 2D CAD conversion reads in a CAD Drawing eXchange Format (DXF) file. The contents of the DXF file are then displayed prior to converting it to a Monte Carlo N-Particle (MCNP) format. The user can modify the CAD data prior to converting it to MCNP. Once the modifications are complete, the user can convert it to MCNP and optionally include an upper and lower boundary to bound the axial extent of the 2D DXF data.

The 3D CAD conversion reads a Standard ACIS Text (SAT) file, which can be exported by most CAD packages. After the file is read in, it can be viewed using a 3D geometry viewer built into the Visual Editor. This geometry can then be converted to an MCNP input file.

This new feature will enable users to use a CAD package to model the geometry and then convert the geometry to MCNP for performing the transport calculation.

Additionally, once the model has been converted to an MCNP input file, it can be viewed using a 3 D viewer that has been added to the MCNP Visual Editor for viewing MCNP geometries.

Key Words: CAD, MCNP, conversion, SAT, DXF

1 CONVERSION OF A 2D CAD DXF FILE

Fig. 1 shows an example of a 2D geometry created in TurboCAD® Professional showing a number of complex 2D geometry objects including circles, ellipses and polygons. To convert this file to an MCNP input file, the drawing is saved using a DXF format. The saved file is then read into the MCNP Visual Editor

To read the DXF file into the MCNP Visual Editor, the user selects "CAD Import->2D Import" to bring up the panel shown in Fig. 2. The user can then select the "Import" option to

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display the file selection panel. The selected file is read in by the MCNP Visual Editor and can then be displayed in the plot windows which are part of the MCNP Visual Editor.

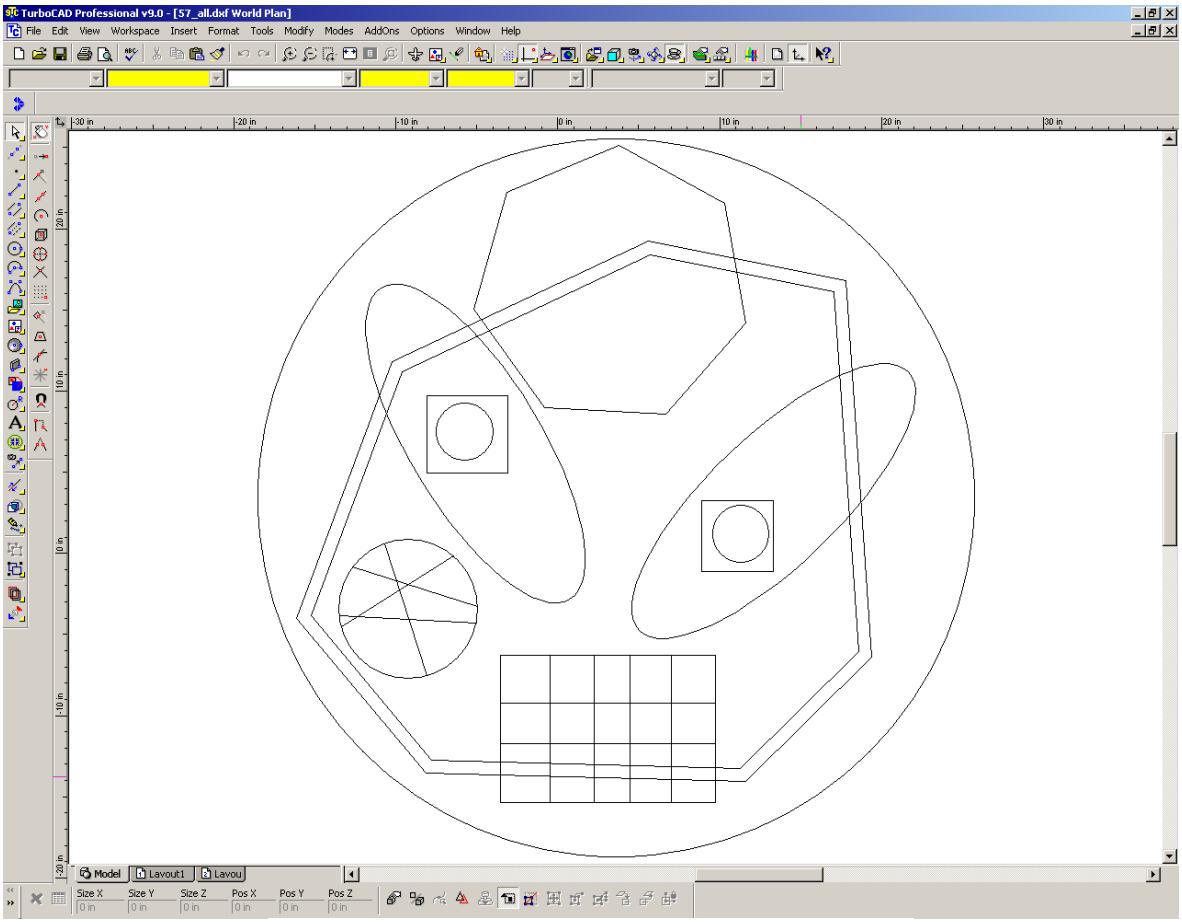

Figure 1: 2D CAD file in TurboCad Professional

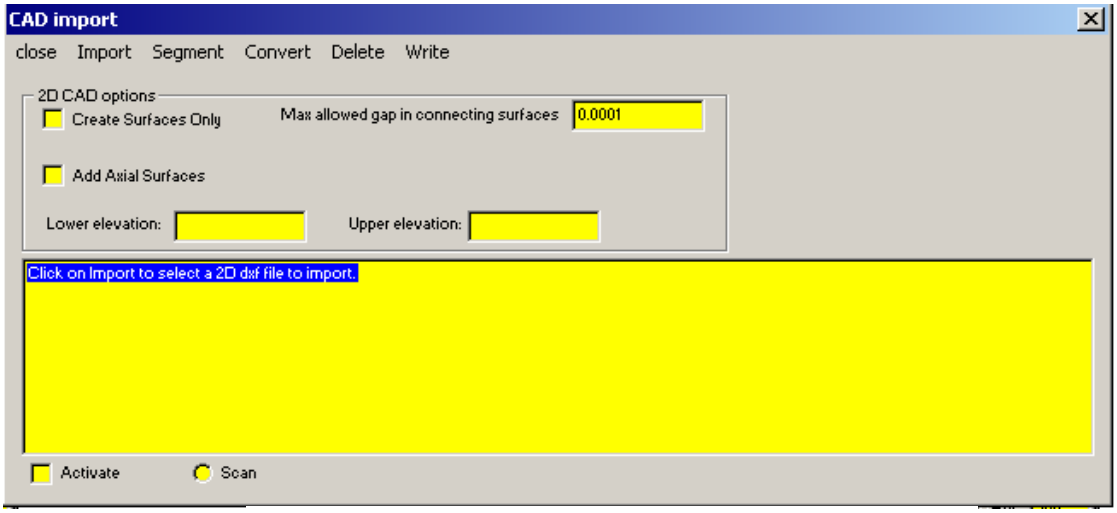

Figure 2: 2D CAD Import Panel in the MCNP Visual Editor

Fig. 3 shows the geometry that is displayed in the MCNP Visual Editor after the DXF file is imported. When the "surf" checkbox is selected, from the options to the left of the plot, the CAD surface numbers are displayed. The surfaces are numbered according to the order in which they appear in the DXF file.

The user can now choose to remove surfaces from the geometry so that they will not be included in the final MCNP input file that will be generated. For example, surface 54 (see arrow in Fig. 3) can be removed by selecting "Scan" (shown at the bottom of the panel in Fig. 2) and then dragging the mouse across surface 54. It can then be deleted by selecting "Delete" from the same panel.

Fig. 4 shows the geometry after surface 54 has been deleted. Because the file has not yet been converted to an MCNP format, all of the surfaces above 54 are renumbered.

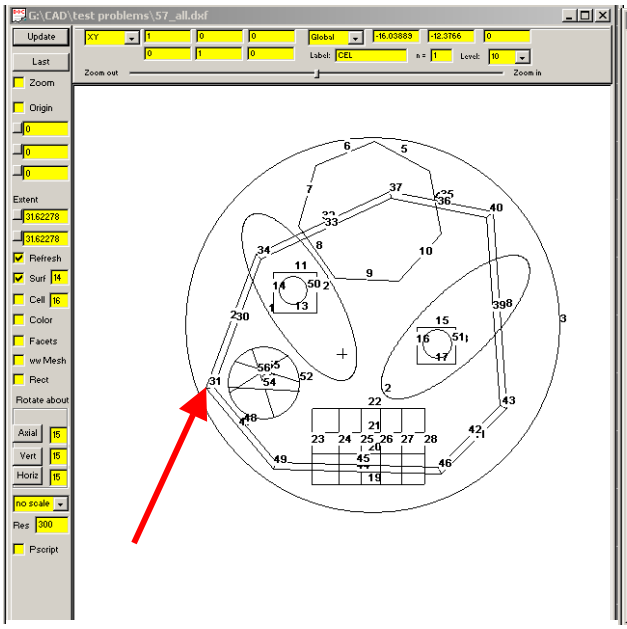

Figure 3. Display of the DXF CAD Geometry in the MCNP Visual Editor (arrow shows surface to

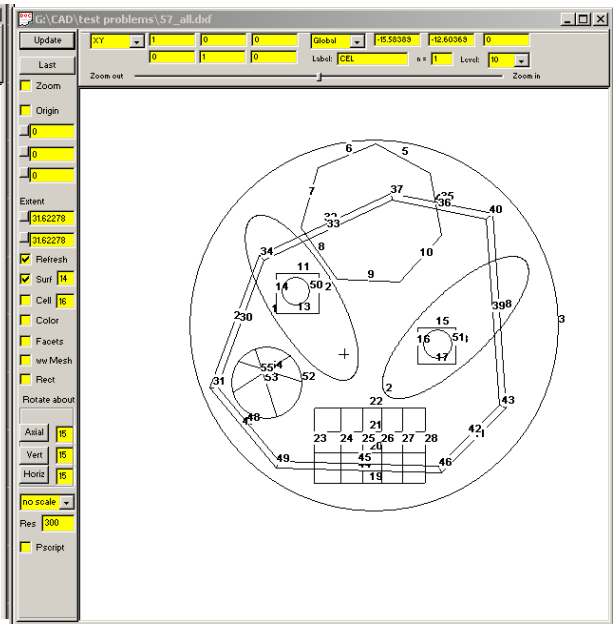

Figure 4. Display of the DXF CAD Geometry with Surface 54 Removed

Prior to converting the geometry to an MCNP format, the lines are segmented so that every line that crosses another line is broken into segments to enable the efficient conversion of the line segments to MCNP cells. This segmenting is done, by selecting "Segment" from the menu in Fig. 2. Fig. 5 shows the geometry after the geometry has been segmented. Notice that segments are formed at any location where two lines cross. Also notice that elliptical surfaces are segmented at every location that a line crosses the ellipse.

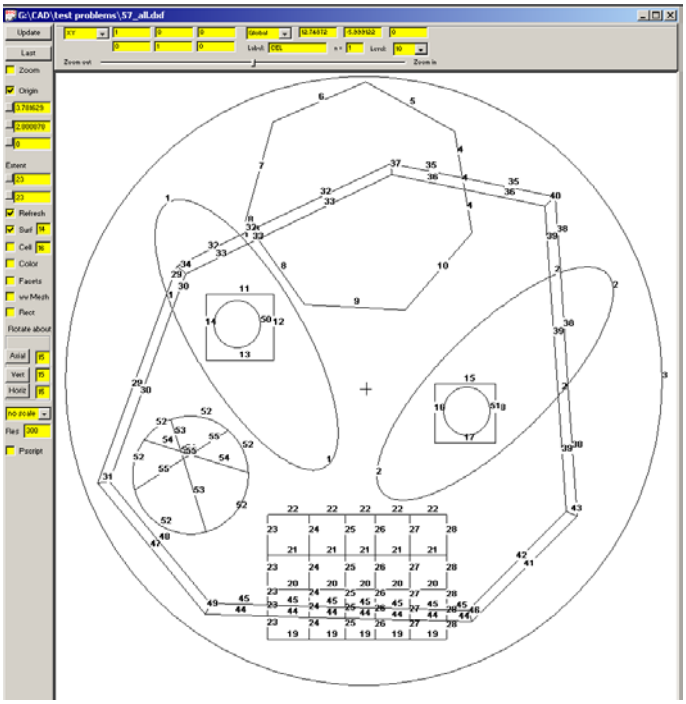

Figure 5: 2D CAD Geoemtry After Segmenting.

When converting the geometry to MCNP, the user has the option of adding an upper and lower axial extent. Axial extents are included by selecting the "Add Axial Surfaces" check box in Fig. 2 and then indicating an upper and lower axial coordinate. For this example we will set the lower coordinate to –50 cm and the upper coordinate to +50 cm. Finally, select "Convert" from the panel in Fig. 2 to create the MCNP geometry.

Fig. 6 shows the resulting MCNP geometry that is created. The axial view shows the 2D geometry has been terminated at the top and bottom with surfaces that have the requested axial values. Included in Fig. 6 is the top portion of the MCNP input file that is created.

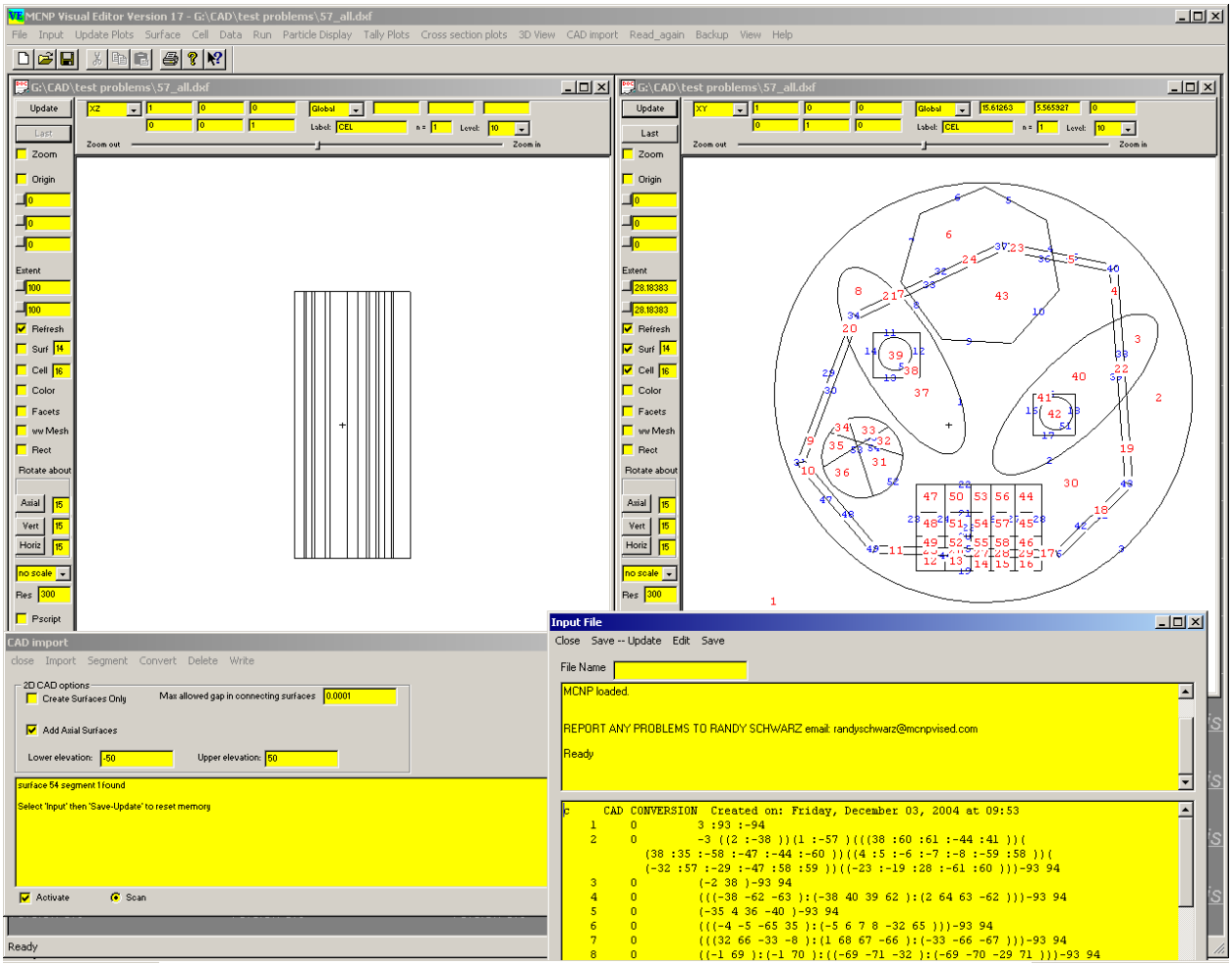

Figure 6. MCNP Geometry Created from 2D dxf File.

2 CONVERSION OF A 3D CAD SAT FILE

The 3D CAD conversion program is designed to read in a SAT file exported from a CAD package and then convert this SAT file to a MCNP geometry. It is necessary to make some observations about the geometry to be imported because the CAD program has fewer restrictions on the geometry than the MCNP program. The most significant of these restrictions is the requirement that all space be defined in the MCNP geometry. To deal with this, there are two different algorithms to convert CAD files.

The first algorithm handles solids that are entirely contained inside each other. This is the type of geometry that would be created if the CAD program is being used as a front end to generate the MCNP geometry. The Visual Editor will then do the needed subtractions or unions in creating the MCNP geometry.

The second type of file consists of a fully defined solid geometry model where all space is defined. The CAD files of this type were often developed to be used with manufacturing or simulation packages and generally meet all or most of the MCNP constraints because the programs they were developed for have similar restrictions. Individual MCNP cells (initial CAD bodies) should be relatively simple to enable rapid random walk tracking.

Fig.7 shows an example of a simple radiation facility consisting of a rectangular waste container in the center of the building. There is a shield wall with a rectangular duct with a bend going through it that is also modeled. Figure 7 shows the geometry as modeled in TurboCAD. The geometry consists of solid objects completely contained inside each other. There is no subtraction or addition in this model. A subtraction occurs when a body is created and a second created body is cut from it. An addition occurs when two bodies are unioned together.

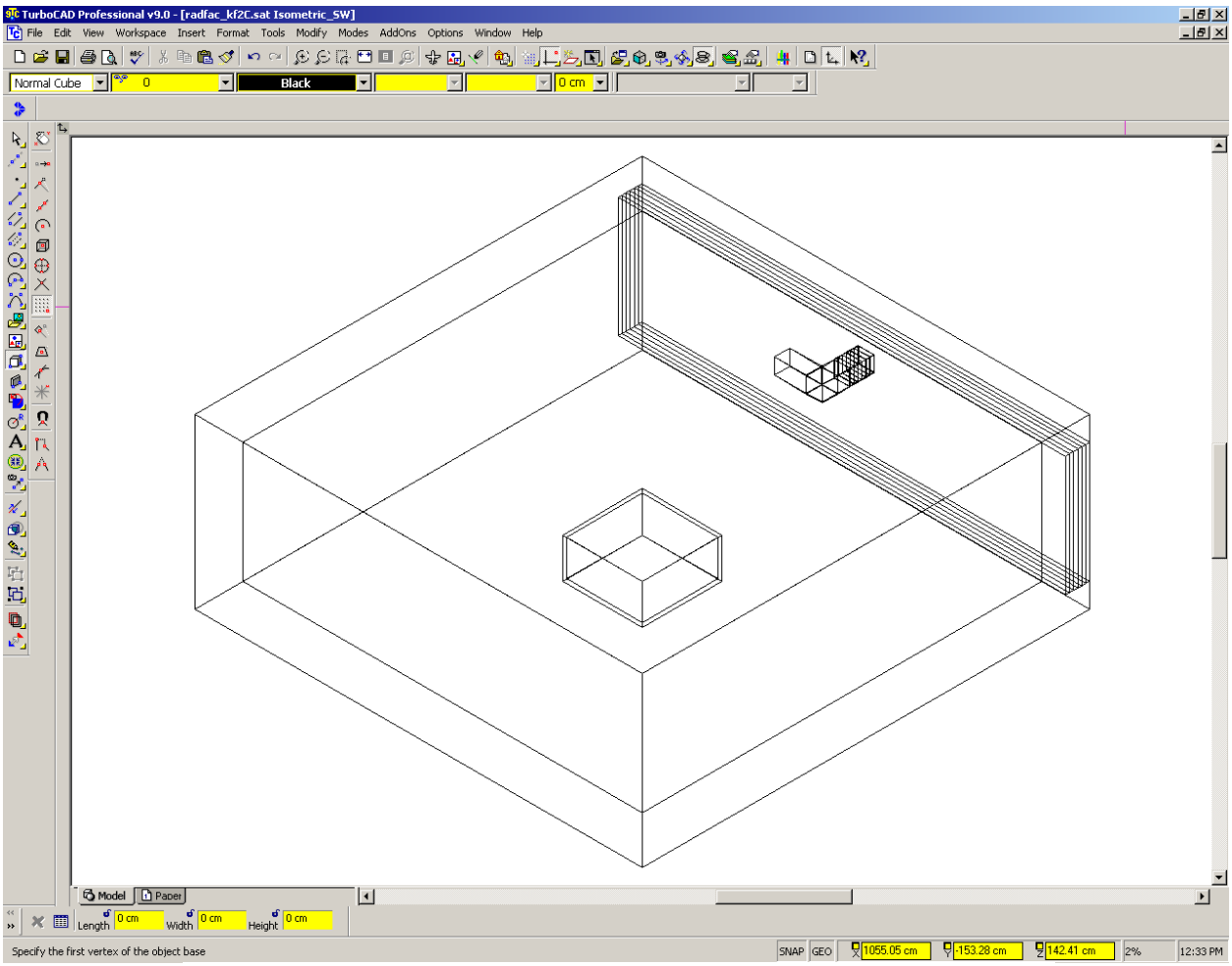

Figure 7. CAD geometry of a radiation facility.

This CAD file is then saved as a SAT file. The Visual Editor reads in this file and generates a 3D display of the geometry. Fig. 8 shows the CAD geometry after it has been read in by the Visual Editor.

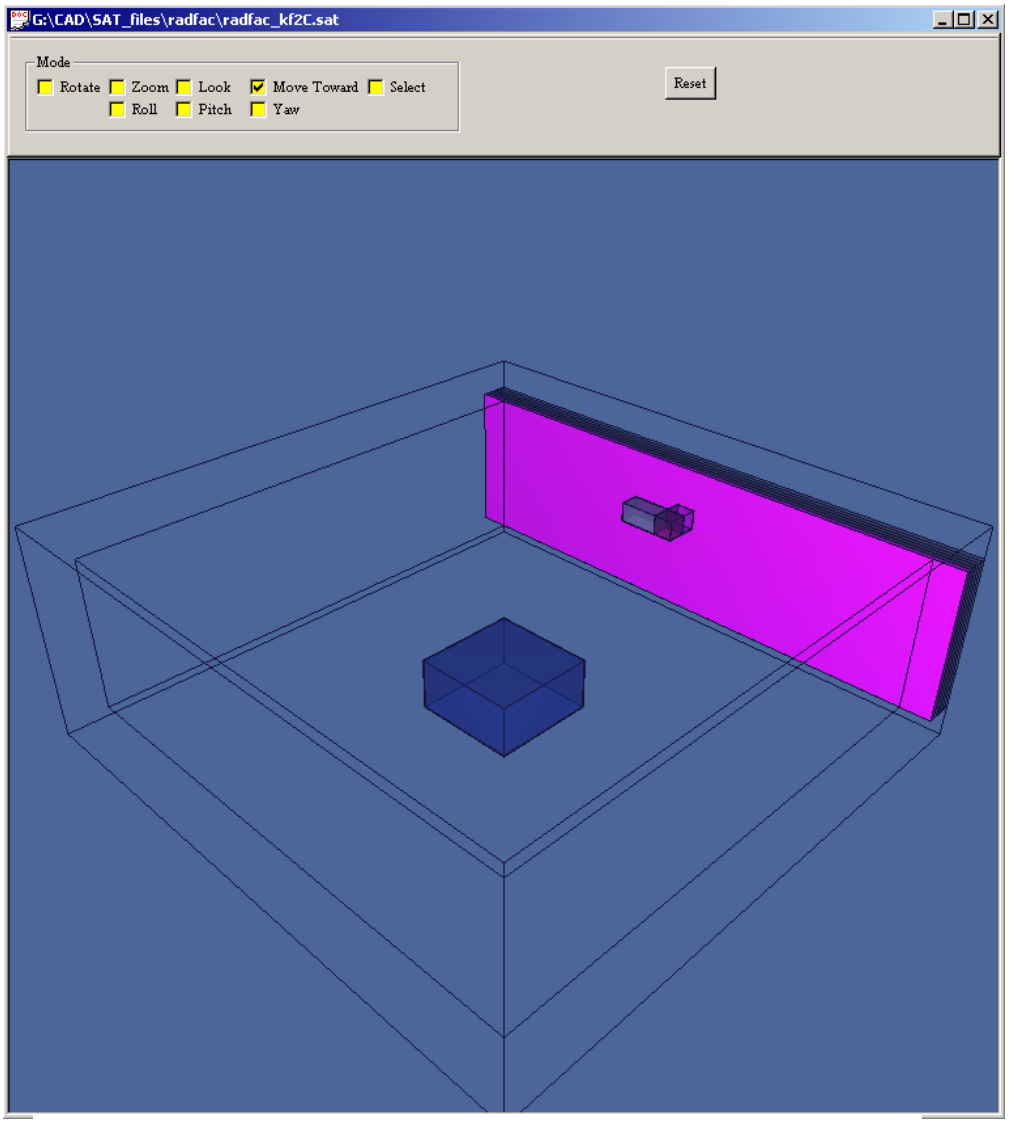

Figure 8: CAD Geometry Display in the Visual Editor.

There are a number of options available in the Visual Editor for viewing the geometry. Individual bodies can be made solid, transparent, wireframe or can be removed completely from the display.

For example, in Fig. 8, the outside of the room is shown in wireframe, the objects inside the room are transparent and the shield wall is solid. Additional options are available to allow the user to change the view, by using the standard “roll”, “pitch” and “yaw” features common to many flight simulators. The graphical interface also includes a trackball feature to rotate the geometry with the mouse.

Fig. 9 shows the geometry after it has been converted to MCNP. A close up view of the duct can be seen in the plot on the right side. A portion of the resulting input file is also shown in Fig. 9.

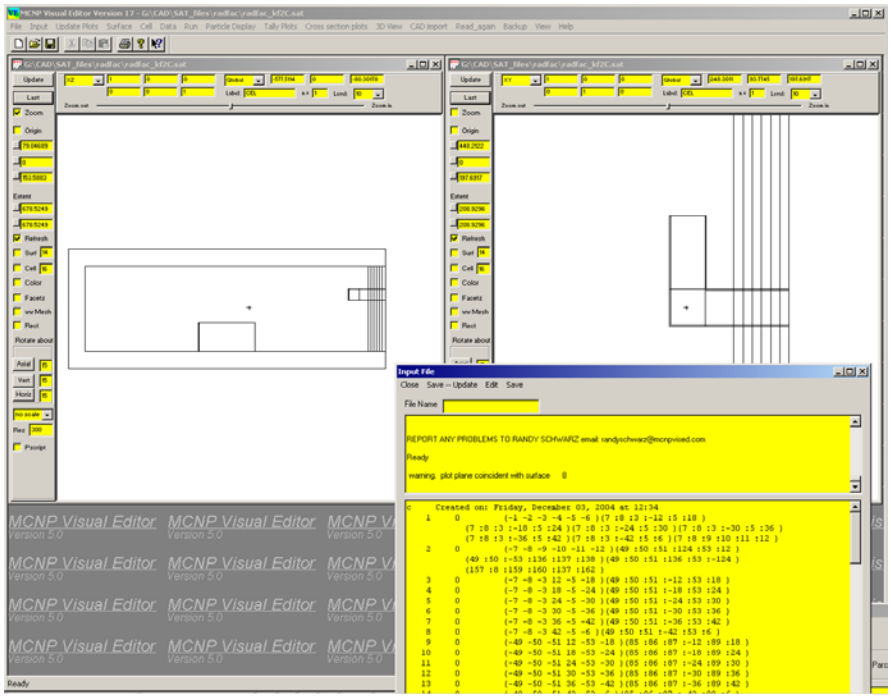

Figure 9. MCNP Geometry from Converted CAD File.

The same 3D viewer that is used to view CAD geometries is also available for viewing the MCNP geometry. Fig. 10 shows the geometry again in 3D, only this time it is using the MCNP description of the geometry to generate the 3D model.

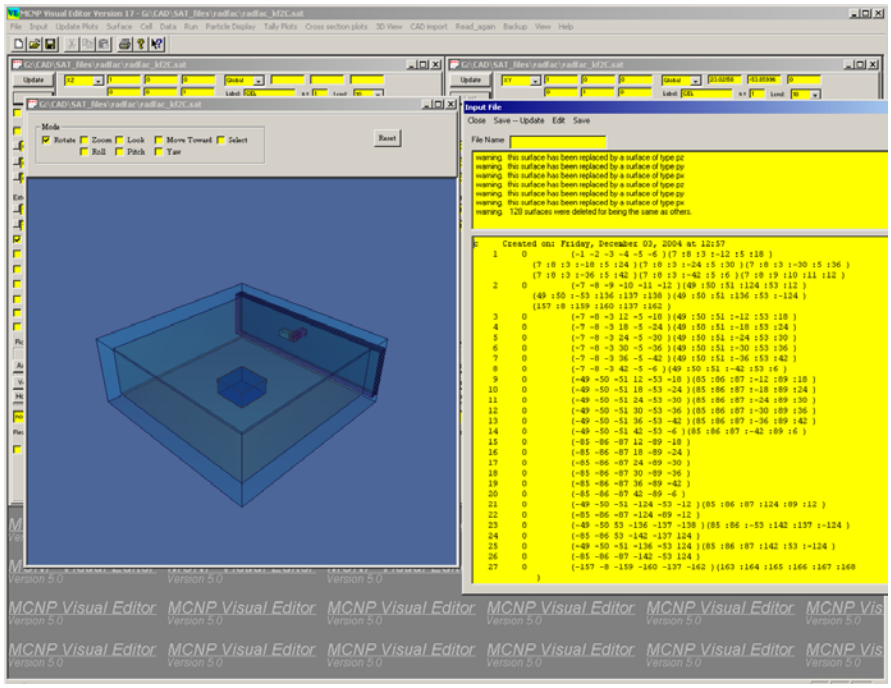

Figure 10. 3D Display of the MCNP Geometry.

The MCNP Viewer is capable of displaying a wide array of MCNP geometries as demonstrated in Fig. 12.

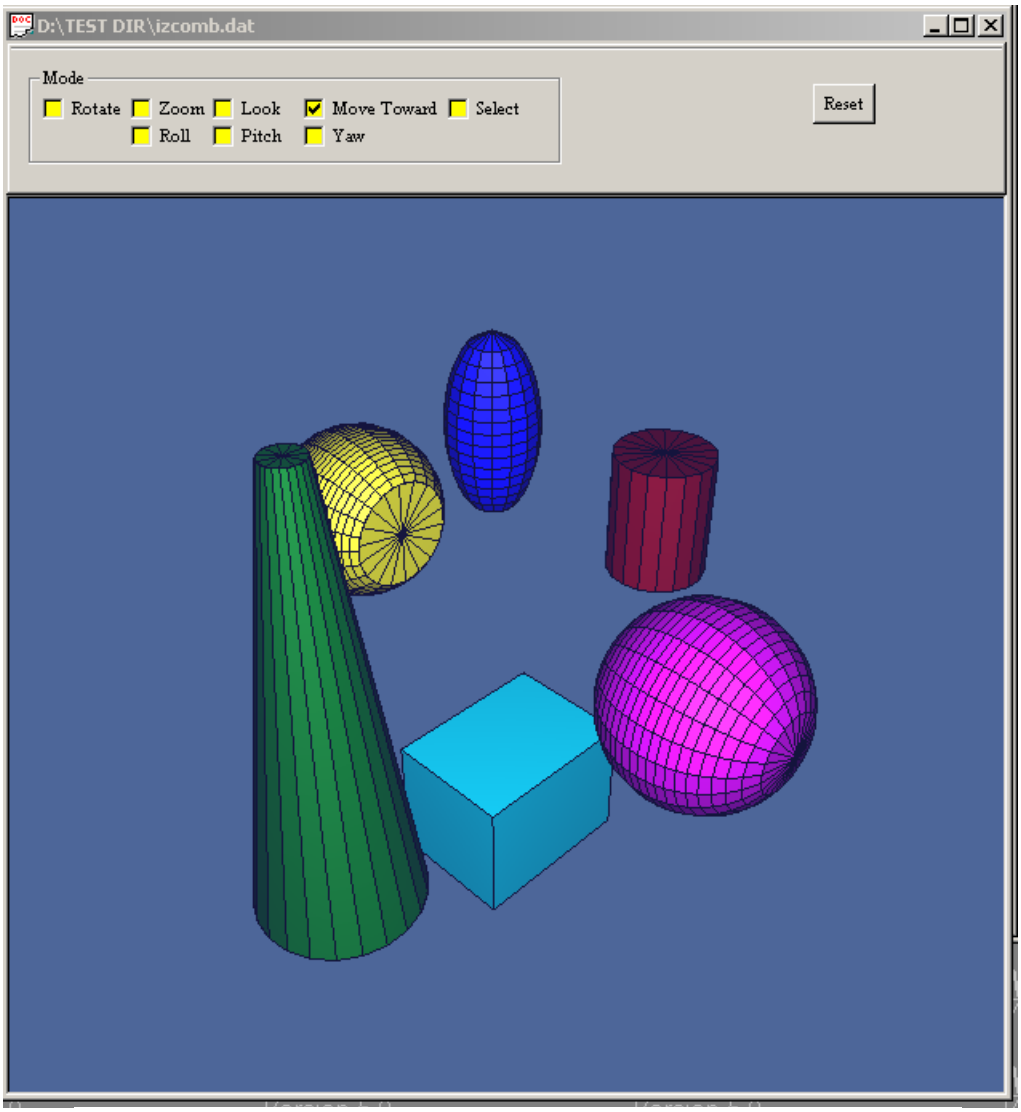

Figure 12. MCNP Cells that can be Displayed in the Visual Editor.

Fig. 13 shows an example of a fairly complex MCNP input file that has been displayed in 3D with all of the cells set to be transparent.

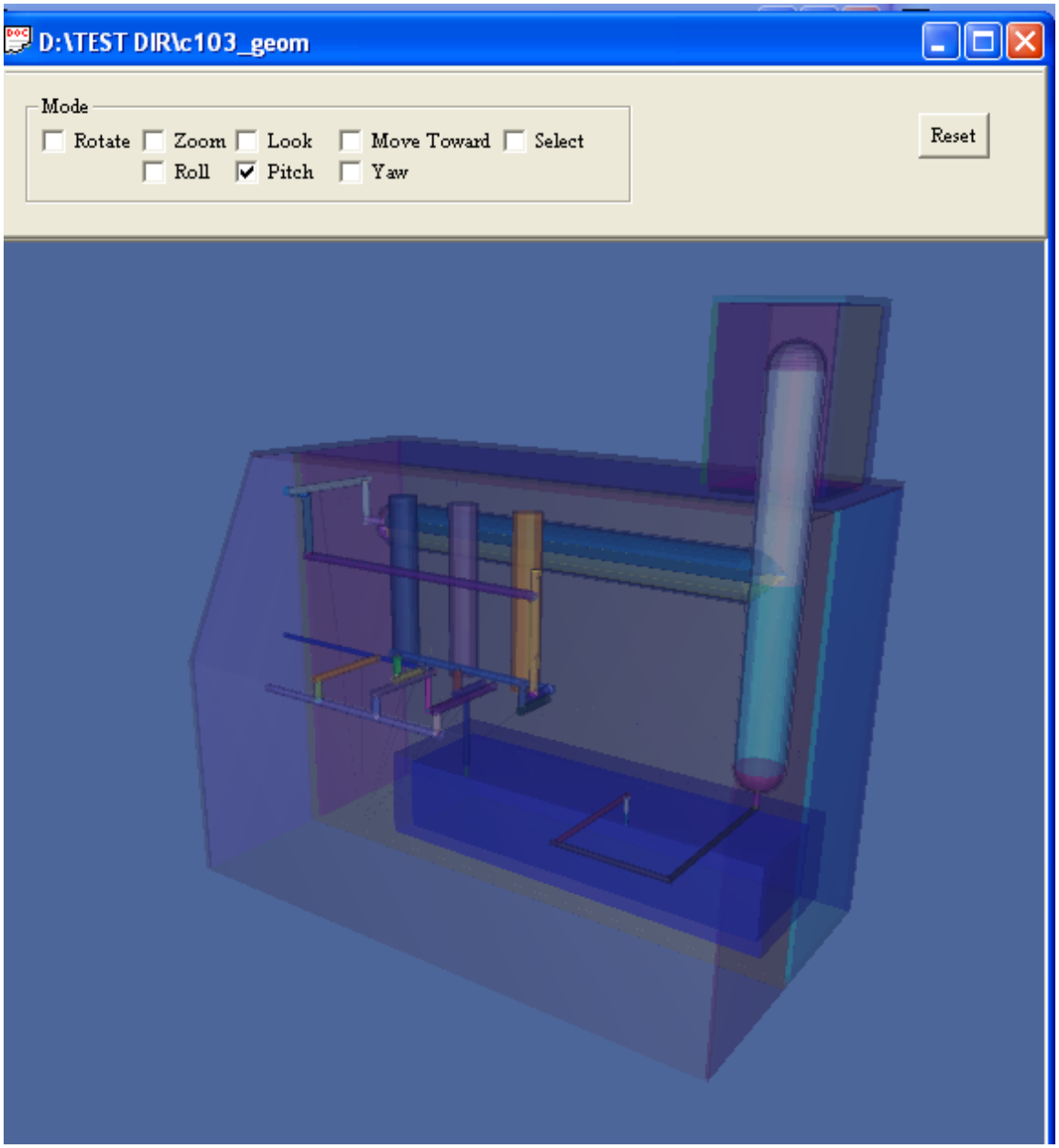

Figure 13. Transparent MCNP Geometry.

3 CONCLUSIONS

The Visual Editor has been modified to include the capability to read in 2D and 3D CAD files and convert them to a valid MCNP geometry. Once the geometry is read in, it can be displayed in 3D. Additionally, once the geometry has been converted, it also can be displayed in 3D. This feature allows for the 3D display of any MCNP geometry.

4 ACKNOWLEDGMENTS

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5 REFERENCES

1. X-5 Monte Carlo Team, "MCNP-A General Monte Carlo N-Particle Transport Code, Version 5 - Volume I: Overview and Theory," LA-UR-03-1987, April, 2003 revised September, 2003, distributed with RSICC package C00710.
2. X-5 Monte Carlo Team, "MCNP-A General Monte Carlo N-Particle Transport Code, Version 5 - Volume II: Users Guide," LA-CP-03-0245, April, 2003, distributed with RSICC package C00710.
3. X-5 Monte Carlo Team, "MCNP-A General Monte Carlo N-Particle Transport Code, Version 5 - Volume III: Developers Guide," LA-CP-03-0284, April, 2003, distributed with RSICC package C00710.
4. L.L. Carter and R.A. Schwarz, "MCNP Visual Editor Computer Code Manual," 2004, distributed with RSICC package C00710 http://www.mcnpvised.com/.