Abstract Submission for the Paper Entitled:

Using AutoCAD's 3D Studio Import Feature to Expedite Model Building in Thermal Desktop

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Thermal Desktop's capability for rapid model turnaround makes it an extremely effective tool for the concurrent design environment. However, there has been some debate as to which conversion file format is the most powerful when working with multiple mechanical design applications. Given that Thermal Desktop is integrated with AutoCAD there are several geometry import options (outside of those listed within the thermal menu) that are viable for use in thermal analysis. One such option allows users to import 3D Studio (*.3DS) files into AutoCAD, which can then be easily converted to Thermal Desktop surfaces. This report summarizes the steps involved in importing 3D Studio geometry into Thermal Desktop, and covers some of the advantages and disadvantages of this approach from a general users perspective.

After a CAD package such as Mechanical Desktop, SolidWorks, or Inventor is used to successfully create the geometry it can be exported as a 3D Studio file, imported into AutoCAD, and converted to Thermal Desktop entities. Given its convenience this process has been employed by the Jet Propulsion Laboratory's Center for Space Mission Architecture and Design (CSMAD) and Team-I, JPL's concurrent design environment. Within both CSMAD and Team I, a large emphasis is placed on real-time multi-disciplinary problem solving using a common CAD generated geometry; hence, the traditional methods of geometry creation offered by several thermal programs has been deemed impractical for these particular efforts. Furthermore, as many thermal tool users are aware, the geometry creation aspect of the model is generally the lengthiest portion, so when it's alleviated a large timesaving is incurred.

In a real time mission design demonstration offered by CSMAD the integrated use of Thermal Desktop with a 3D Studio imported file was highlighted as an effective means for the completion of time critical thermal trade studies. In Team-I, Thermal Desktop is routinely used to perform quick thermal trade studies using 3D Studio models exported from Mechanical Desktop. This procedure has reduced model turnaround time so significantly that analytical results can now be returned to the customer in a matter of hours! However, experience has proven that unless care is taken when importing geometry, using this method could potentially result in overly complex thermal models that cannot be exercised in a meaningful manner.

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Thermal Desktop has become a very effective tool in the concurrent design environment due to its contribution to rapid model turnaround. However, there are several conversion file formats available for use and consequently there has been debate as to which is most effective when working with multiple mechanical design applications. This paper seeks to describe the reasoning behind using a third party file conversion format for real-time CAD model sharing, and also to describe the process by which a model can be imported into Thermal Desktop. Finally two examples of the use of this process in concurrent design at the Jet Propulsion Laboratory (JPL) will be briefly discussed. For the purposes of brevity, it is assumed that the reader has at least a working knowledge of AutoCAD 2000 and Thermal Desktop.

At JPL, members of concurrent design teams in the Center for Space Mission Architecture and Design (CSMAD) and Team-I have found the AutoCAD 2000 3D Studio file import option to be quite effective. During CSMAD and Team-I design sessions, a great deal of the work is centered about the Computer Aided Design (CAD) file. The CAD file offers, a graphical representation of the spacecraft from a conceptual standpoint. However, limitations of traditional mechanical CAD packages are such that detailed optical geometry and temperature maps can be extremely difficult to render on a model in pseudo real-time. Hence the ability to port CAD geometry to other, more specialized engineering design packages like ZeMax/Code V (for detailed optical design), NASTRAN (for structural dynamics), and ADAMS (for rigid body dynamics) is key to the success of the concurrent design environment. Since thermal analysis also plays an important role in this process, it was deemed vital that an interface between the CAD file and a thermal tool exist.

Given Thermal Desktop's integration with AutoCAD, it was believed to offer the highest potential for success. As it stands, Thermal Desktop offers several model import options and its integration with AutoCAD widens this range. After some experimentation, it was determined that CAD geometry exported as a 3D Studio file could be imported by AutoCAD 2000 and very easily converted to Thermal Desktop surfaces.

The benefits of working with 3D Studio geometry include the speed and simplicity in which very complicated models can be imported into other CAD applications. 3D Studio geometry is imported to AutoCAD 2000 by way of a translator (which is included as part of the standard installation of AutoCAD 2000); hence, it is not necessary to have 3D Studio installed in order to take full advantage of this technique. In its most basic form, the import process uses only the following two steps:

1) In AutoCAD 2000, select "3D Studio" from among the file types listed under the *Insert* menu.

2) From the popup dialog, select the 3D Studio filename and the pertinent file import options depending on the complexity of the geometry.

Depending upon the file being imported, the geometry may arrive in individual layers or may present itself as a single object. In the latter case, the object can be reduced to individual elements by using AutoCAD's *Explode* command. From this point, layers, thermophysical and optical properties, as well as orbital parameters, can be assigned. However, the user is advised to exercise caution since CAD geometry imported using this method will be meshed, and even the most simple models can get extremely large, very quickly. During the period in which the method has been used at JPL, it has not been an uncommon occurrence to have simple geometry yield total Thermal Desktop node counts of greater than 10,000. In these instances, one of three approaches has been taken. The first approach has been to reduce the file by the deletion of inconsequential geometry prior to importing, while the second and third approaches have involved deleting and replacing geometry with Thermal Desktop primitives, and utilizing the "Super Node" capability. The first and second approaches were exercised in a demonstration offered by CSMAD.

CSMAD, one of JPL's Centers of Excellence, has been assigned the task of enabling the practical application of advanced process technologies in JPL's mission architecture process. During a real time mission design demonstration offered by CSMAD, the integrated use of Thermal Desktop with a 3D Studio imported file was highlighted as an effective means for the completion of time critical thermal trade studies. Prior to importing the 3D Studio file, objects, such as fasteners, struts, and power source fins, were removed in order to simplify the analysis since they were not significant to the trade studies. The imported file appeared in Thermal Desktop as shown in Figure 1.

Since the model arrived as a single object, it was subdivided and layers were assigned. The layers were very useful, because as the trade studies moved towards waste heat analysis, external science and avionics equipment were removed simply by the deletion of their layers. Steady state temperature results as shown in Figure 2 were returned for several different orbital trajectories in a matter of hours. Compared to traditional thermal analysis tools (like TRASYS, SINDA, and TSS), using the 3D Studio import method has saved literally hundreds of hours of extra analysis time! Team-I, another of JPL's concurrent design environments, has seen similar results.

Team-I functions as an incubator for projects that are in the Discovery, and even pre-Discovery proposal stages. Since time and funds are nearly always limited for these projects, rapid but accurate model creation techniques are critical for a project's early success. In the Team-I concurrent design cycle, which usually takes place in three to four sessions of three hours each over the course of four weeks, CAD geometry is generated using Mechanical Desktop. In order to have a relatively complete engineering analysis of a mission, engineers representing each of the subsystem disciplines work concurrently on each of their subsystems. Since having each of these engineers recreate geometry in their respective applications would be a significant waste of time, the CAD geometry created in Mechanical Desktop is exported in formats that can be easily converted by the respective engineering applications. For the thermal engineering subsystem, the 3D Studio import method is the method of choice.

Although the geometry is imported, users still have the option to add geometry using AutoCAD operations and/or the primitives provided. Alternatively, the user can delete elements and layers as needed. In addition to saving engineers time, this technique for importing CAD geometry is perfect for users who are not proficient in the creation of complex geometry from scratch.

The integration of design tools will become more important as organizations strive to produce smaller less expensive spacecraft over a shorter time span, and as engineers continue to spread their time among many different projects. The ability to import CAD geometry will be a major contributing factor to the successful adoption of Thermal Desktop in organizations that employ mixed design tools.

The design process is truly accelerated when a thermal engineer is not required to recreate existing geometry for the purpose of analysis. Since time equals money, tools that shave several hours (or even days) off the design cycle of a project not only save engineers' time, but have the potential to save companies many thousands of dollars in the long term.

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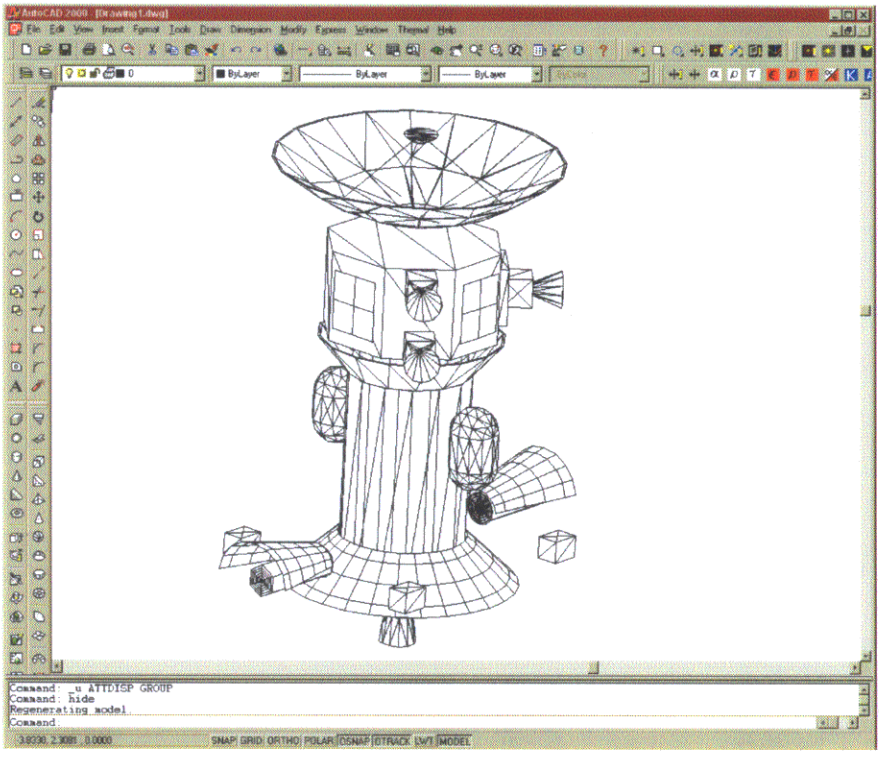

Figure 1. Imported 3D Studio file as it appeared in Thermal Desktop.

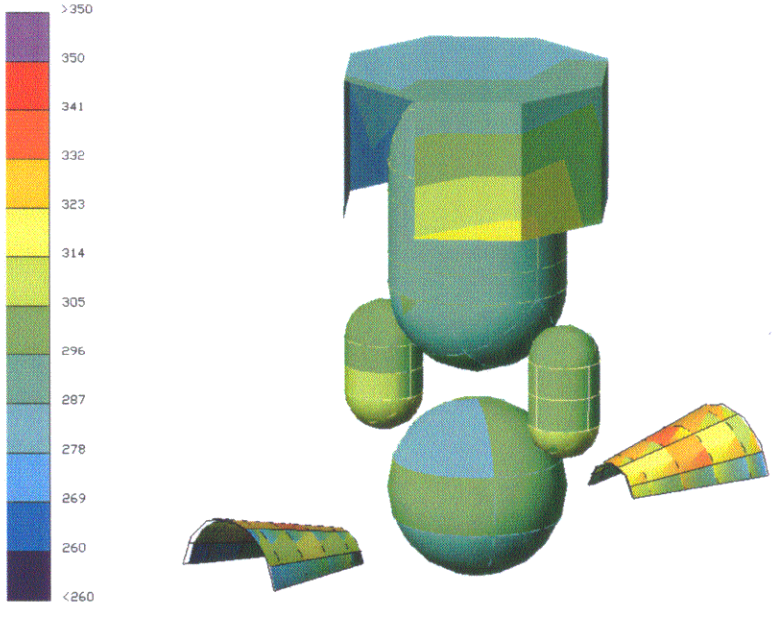

Figure 2. Steady state results from the imported model shown in Figure 1.