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A SINDA THERMAL MODEL USING CAD/CAE TECHNOLOGIES

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SUMMARY

The approach to thermal analysis described by this paper is a technique that incorporates Computer Aided Design (CAD) and Computer Aided Engineering (CAE) to develop a thermal model that has the advantages of Finite Element Methods (FEM) without abandoning the unique advantages of Finite Difference Methods (FDM) in the analysis of thermal systems. The incorporation of existing CAD geometry, the powerful use of a pre and post processor and the ability to do interdisciplinary analysis, will be described.

INTRODUCTION

Since the birth of the Chrysler Improved Numerical Differencing Analyzer (CINDA), a tool widely used in the aerospace industry, many improvements to the code have been made. Lately, the advances have been dramatic, starting with the rewrite of the Systems Improved Numerical Analyzer (SINDA) to what is now known as SINDA '85, to the addition of fluid analysis and the creation of a graphical interface, SINDA Application Programming System (SINAPS). Most of the progress has concentrated around the Finite Differencing methods, with very slow progress in the graphical end of the analysis.

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Computer aided Engineering (CAE) have revolutionized the analytical world. Most of the advances have taken place in the field of Finite Element Methods (FEM). FEM, an ideal tool for structural analysis, is not well suited for thermal analysis yet, specially, when the problem is radiation dominated . FDM because of its particular characteristics to handle nonlinear systems, has been the method of preference in the analysis of thermal systems. The advantages of CAE created an interest in the thermal analysis discipline that gave way to translators that can convert FEM format to FDM format, thus creating a unique opportunity for the thermal analyst.

This paper concentrates on the methodology of using CAD generated geometry in a CAE environment to develop a thermal model. The format and mathematics used on both, CAD and CAE platforms, is different requiring therefore a translator to share the information. The Initial Graphics Exchange Specification (IGES) version 5.0 translator was selected due to its availability on both platforms.

THERMAL MODEL UPDATE FOR THE AEROASSIST FLIGHT EXPERIMENT (AFE)

The thermal model of the AFE had reached a level of obsolescence and a major update with required. As the design matured, there was a need to update the model to include all design reviews. The structural design had major changes, but it was still in the evolution stage. To update the model, a major undertaking was necessary, but there was still the question of how to keep up with the changes, especially, how to respond to the "what if" questions that were being posed as changes in the design were taking place? There was a choice of doing the update the traditional way and lag behind or investigate the avenue of using the CAD generated geometry to create the model and to incorporate updates of components as they change, without affecting the rest of the model.

A NEW APPROACH IN THERMAL ANALYSIS

The incorporation of CAD generated geometry to create a thermal model in a CAE environment, is an avenue that will complement established practices and it will also allowed the analyst to do the following:

- Use the same geometry generated by the designer

- Eliminate design mis-interpretation
- Avoid dimensional errors
- Maintain model fidelity
- Update design changes only on the affected areas
- Share the model with other disciplines
- Share results with other disciplines
- Promote concurrent engineering

The design of the AFE was done using the Intergraph Graphics Design System (IGDS) and the Intergraph Engineering Modelling System (I/EMS) packages. Use of the CAD data required transferring it to the CAE platform, where the actual modelling would take place and finally to a platform where the conversion to a SINDA model is done. Following are the steps taken to create a thermal model using CAD data.

- Compress the boolean trees of the CAD file
- Using the I/IGES translator, translate the I/EMS file to an IGES file
- Using the CADPAT, IGES-to-PATRAN translator, translate the IGES file to a PATRAN neutral file.
- Prepare the model in PATRAN by defining the nodal network, physical properties and material properties.
- Translate the model (a PATRAN neutral file) to a FEM/SINDA file, using the FEM-to-FDM translator FEM/SINDA.
- Using FEM/SINDA, convert the FEM/SINDA file to a Finite Difference file.

Table 1 shows the geometry entities I/GES version 5.0 and CADPAT release 4.0, can support.

Table 1. **IGES Entities Supported by I/GES and CADPAT**

I/GES	CADPAT	IGES Entity & Number
Circular arc or circle	Parametric cubic line	Circular arc, 100
Composite curve	Parametric cubic line	Composite curve, 102
B-Spline curve	Parametric cubic line	General conic, 104
Points	Parametric cubic line	Data points, 106
B-Spline curve	Parametric cubic line	Parametric spline curve, 112
B-Spline surface	Parametric cubic patch	Parametric spline surface, 114
Point	Grid	Point, 116

B-Spline surface	Parametric cubic patch	Ruled surface (arc length),118
B-Spline surface	Parametric cubic patch	Surface of revolution, 120
B-Spline surface	Parametric cubic patch	Tabulated cylinder,122
Transformation matrix	Coordinate system	Transformation matrix,124
B-Spline curve	Parametric cubic line	Rational B-Spline curve,126
B-Spline surface	Parametric cubic patch	Rational B-Spline surf.,128
B-Spline surf. boundary	Primitive parametric surface curve	Curve on parametric surface, 142
B-Spline surface	Primitive face	Trimmed parametric surface, 144

The I/EMS model of the AFE, figure 1, is composed of many components, due to its massive size, it was necessary to separate each component in individual files, making the translation process less cumbersome. Once the files were translated, figure 2, and modeled individually as a component, they were merge to form the complete model. Figure 3 depicts a flowchart of the translation process.

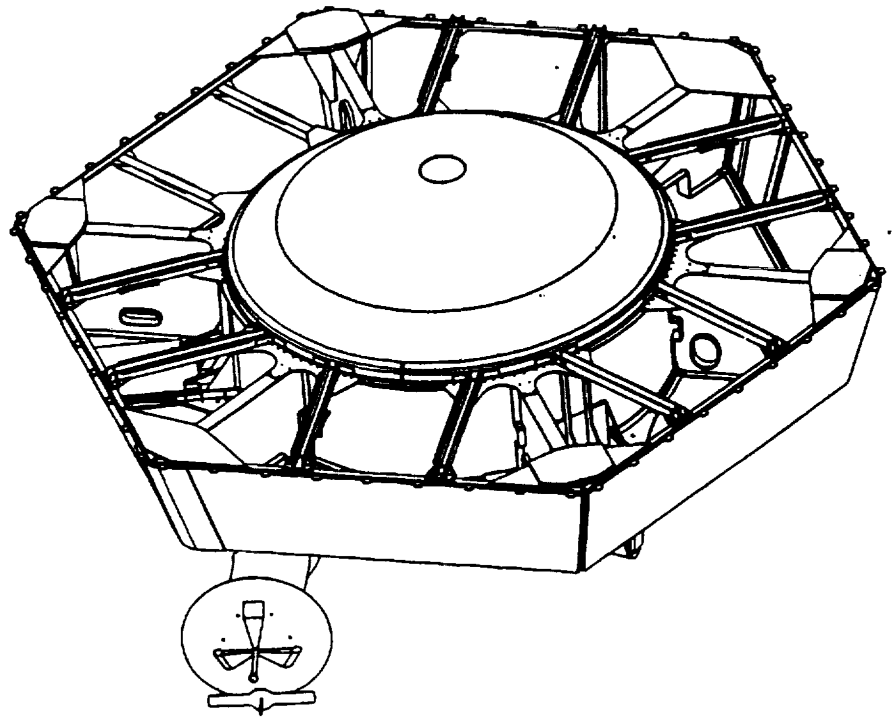

Figure 1. Aeroassist Flight Experiment CAD drawing

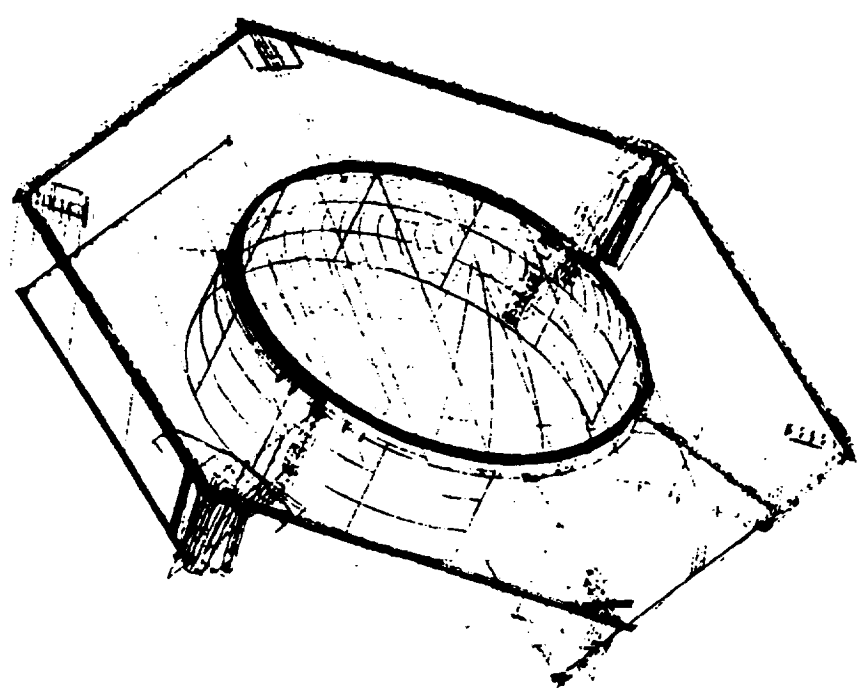

Figure 2. Aeroassist Flight Experiment translation from CAD to CAE, without modifications

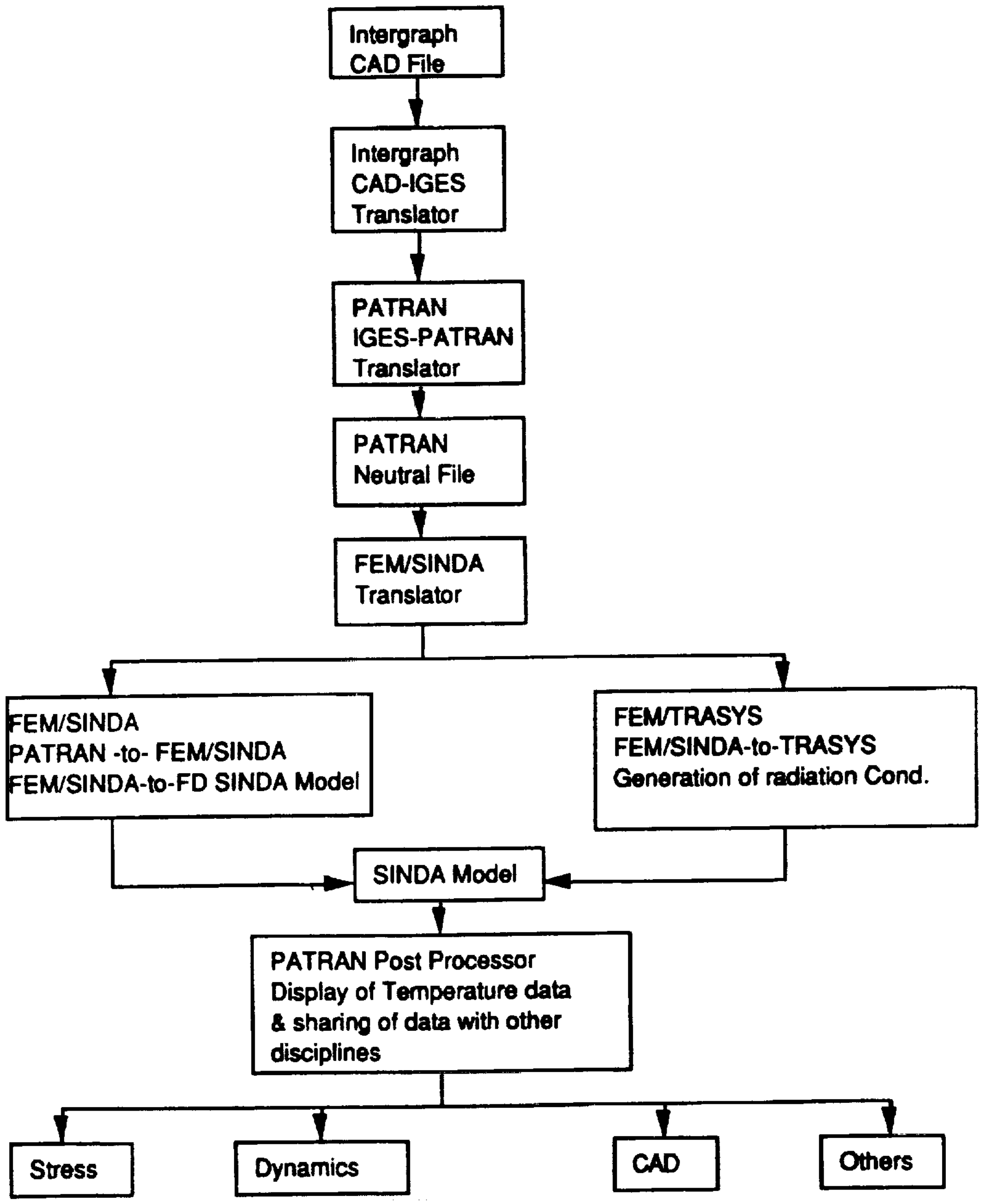

Figure 3. Thermal Analysis CAD/CAE Interdisciplinary Illustration For The AFE Experiment

CONCLUSIONS

The process of using CAD/CAE technologies is not a substitute for the traditional thermal analysis, but merely a complement to the task of analyzing thermal systems. It is a process that can be applied when dealing with large and complicated structures, when hand inputs can take several months. This process goes beyond thermal analysis, this process encourages the members of all disciplines working in a project, to work together, the results of such cooperation are unlimited, with sharing of models and results being just a few.

Due to cancelation of the AFE project, the complete modelling of the AFE using this process was not possible, but the major components were incorporated in the model. Further work is progressing through other projects. Presently this process is being applied to the creation of SINDA and TRASYS models from the same CAD/CAE file, as well as creating geometry from TRASYS models that were written by hand and needed updating. New technologies and cooperation between CAD and CAE vendors will expedite this process.

ACKNOWLEDGEMENTS

The present process investigation would not have been posssible without the support of the AFE thermal analysis project manager, Mr. Patrick Hunt of NASA Marshall Space Flight Center, who encouraged the investigation of another avenue for the model update, Dr. W. Randolph Humphries of NASA Marshall Space Flight Center, whose interdisciplinary charter help us investigate the process with different structures and our supervisor, Dr. Alok Majumdar, who kept on encouraging us throughout the investigation.

REFERENCES

1. Initial Graphics Exchange Specification, version 5.0, U. S. Department of Commerce.

2. CADPAT, release 4.0, PDA Engineering.

3. FEM/SINDA User's manual, version 2.0, Martin Marietta Corporation Missile Systems., Orlando, Florida.