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# The Use of Cosmic Nastran in an Integrated Conceptual Design Environment

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Conceptual engineering is increasing with the advent of the engineering workstation as a viable platform for numerical analysis, including finite element analysis. Traditionally, engineers have used finite element analysis after the detailed design stage had begun. There were exceptions in the area of load path models which were used early in the design process. New hardware platforms and software techniques now bring tools for finite element analysis into the mainstream conceptual design phase. A survey by a major British aerospace firm determined that the first five percent of design time dedicates an astounding eighty percent of the project cost. By using COSMIC NASTRAN early in the design phase, the total project cost can be reduced. The development of automated meshing routines that work within COSMIC NASTRAN pre processors also reduce the cost associated with finite element analysis and helps bring this tool into the conceptual design environment. Even though specialized finite element analysis should be reserved for professional engineers, there is a place for less experienced users in this area. The development of advanced meshing routines also allow the user to have confidence in the finite element mesh. Many systems also optimize the element shapes. Other features that are becoming popular with engineers and designers are adaptive refinement and geometry based analysis. Both of these are made possible by systems that have a common database for design, engineering and manufacturing. By using this same database, the finite element analysis does not have to redefine the model. This reduces the chance for errors and helps bring a product to market faster. These features are bringing the use of finite element analysis into mainstream mechanical conceptual design.

Intergraph Corporation has recently developed a suite of tools for mechanical computer aided engineering (MCAE). These tools break from the traditional design - analysis relationship in that both design and engineering data are retained in a single database. This concept, which is termed "geometry-based analysis," makes the analytical FEA model an extension of the design geometry. To the COSMIC NASTRAN user, this means all model attributes such as loads, boundary conditions, materials and properties are assigned to the CAD design geometry before finite element analysis begins.

These features are made possible by a system that differs structurally from Computer Design and Analysis systems of the past. The basis for the design - analysis relationships described above is a unique design tool named The Intergraph Engineering Modeling System (I/EMS). Built onto I/EMS are application specific tools for finite element analysis, mechanism analysis and other engineering-specific requirements. In the area of finite element analysis, I/FEM is built directly onto I/EMS. I/FEM is a complete system for model generation, analysis and post processing as well as a full support system for **COSMIC NASTRAN.** Some of the features of I/FEM include automatic mesh generation and geometry-based analysis methods as mentioned above. Mesh generation within the I/FEM environment includes traditional single and semi-automatic, meshing as well as fully automatic meshing. With automatic mesh generation, the user can mesh an entire surface model with a single command, without extensive setup work. The mesher recognizes boundaries of different material, load, or property and places nodes and elements at the proper locations. In addition the system performs smoothing operations that result in correctly shaped elements. At all times, the user has control over element shape criteria and is warned when rules are violated. I/FEM is the only finite element system system available with all of the following features:

* Object oriented programming concepts.
* A common mathematical description for **all** geometric entities, the Non-Uniform Rational B-Spline (NURB).
* The ability to generate surface, solid and wireframe entities within a single model.
* A Relational Data Base.

These four features provide the basis for design - analysis relationships within the Intergraph environment. Object oriented programming allows a graphic entity such as a surface or solid to know its material composition. An "object" can be defined as entities that contain within themselves both the information that defines how they behave (action) and information that defines their existence (state). Within an object-oriented software system, this means that an object is a package (in memory) of data and procedures that go together. In an object-oriented software environment, a subclass inherits all of the instance variables, methods, and message protocols of its superclass. To specialize from a class, one merely creates a subclass, adding additional instance variables, methods and messages only as needed to define what is different between the new subclass and its superclass. A subclass may also choose to override a method which it inherits, if the overridden method performs differently that the superclass method, based on some difference between the two classes. This powerful concept has far reaching potential. The finite element engineer can now receive an intelligent design geometry that includes many modeling attributes. When combined with automatic meshing capabilities, the result is reduced model generation time. In addition, these features add a new dimension to adaptive refinement and optimization.

Beyond the benefits in the traditional engineering areas, I/FEM offers its greatest potential in the conceptual design phase. The use of engineering tools in this phase of design is considered by many to be one of the ways American manufacturing will again become competitive in the world market. To bring tools like finite element analysis into mainstream mechanical design the designer must be be given user friendly software tools. In many cases designers can perform preliminary analysis that can be very beneficial. The detailed analysis must of course be left to the finite element specialist. Intergraph has designed a user interface into I/FEM that greatly simplifies model generation. Other features such as adaptive refinement and element shape optimization give the designer more confidence in finite element analysis.

Another major factor that will determine to what extent finite element analysis will be used by design groups is hardware availability. Traditionally engineers have run finite element analysis on large computers. Recently engineering workstations have proven to be a viable platform for numerical analysis. All major finite element systems now run on engineering workstations. By migrating to such platforms the user has more control over the total process and in almost all cases has faster turnaround. **COSMIC NASTRAN runs on Intergraph's workstations.**

The geometry based application capability also applies to other areas of MCAE including mechanism and computational fluid dynamics. These concepts result in integration between different areas of engineering as well as between design and engineering. For example mass properties from a finite element model can be used directly by the mechanism model. The result is a system that brings the engineer closer to the design and manufacturing process which in turn reduces the overall cost associated with product development.

In summary, changes in both software and hardware are rapidly bringing conceptual engineering tools like finite element analysis into mainstream mechanical design. Systems that integrate all phases of the manufacturing process provide the most cost benefits. The application of programming concepts like object oriented programming allow for the "encapsulation" of intelligent data within the design geometry. This combined with declining cost in per seat hardware bring new alternatives to the user. Such systems are being offered by Intergraph today.