Integrated Design Systems - Capturing, Reusing And Optimizing Design Methods In New Millennium

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1.0 ABSTRACT

An important goal of New Millennium is to research new methods of performing " '" spacecraft and mission design. We have completed the first phase of our effort on how to make design tools such as analysis programs more available. We are now embarking with Stanford University on discovering methods to allow more project history and knowledge to be automatically captured and reused and with Ames Research Center on how to use virtual reality to enhance the visualization of new missions before any hardware exists. We are also trying to capture the design process in an electronic form so that computer aided optimization may lead to a vastly greater search of the possible designs which meet the design requirements.

2.0 BACKGROUND

An important function of the NASA New Millennium program is to put together a Set of design tools which are integrated, span life cycle, enhance productivity, capture knowledge, and allow virtual prototyping and systematic treatment of performance, cost and risk. This umbrella effort is called "*Integrated Design System*" and covers several individual products to aid designers in producing better spacecraft at lower cost while taking loss time.

in 1993, we began a collaboration with Lockheed Martin Corp. to produce a design environment where it was easy to integrate new design tools (for example, analysis programs) and to describe the data flow through collections of these tools so as to produce results to aid in the decision making. This environment, called the Multidisciplinary Integrated Design Assistant For Systems (MIDAS) has been in use now for several years at JPL with notable success.

Building on this base we are now working on two separate areas of Integrated Design Systems. One is a collaboration with Stanford University to allow the automatic capture of design history as it occurs and allow for the recovery of the history when requested by later designers. The other is to add a virtual reality system (Interpretive Product Design Environment, IPDE) which will allow designers to examine and test their designs before any hardware exists. A key part of the IPDE is to connect it directly to the MIDAS system so that the full tool set is available from within the IPDE. Recently we have teamed with Ames Research Center to take advantage of their knowledge of virtual reality.

3.0 TOOL BASE

Integrated Design Systems requires the best design tools for spacecraft and missions, Whenever possible wc use starl-of-the-al-t tools but sometimes can only find best-practice tools. Certain of these technologies are available commercially, and the spacecraft industry is using them to some degree. Other tools arc "home-grown" and still others arc in development, such as probabilistic analysis methods.

The early New Millennium missions are benchmarking existing tools, customizing them for the new process as it emerges and clearly defining to the commercial suppliers what must be added and enhanced for the complete seamless development of next millennium spacecraft.

4.0 MIDAS

MIDAS is a design infrastructure developed at JPL to integrate these tools and present the user with a "plug and play" interface which allows many of the goals of *Integrated Design Systems* to be met, MIDAS provides a database of components, analysis tools, visualization tools, drawings, and documents. A designer is able to access these items and seamlessly use them to come up with an optimized design methodology. The methodology is generated graphically ("methogram") and describes the process that the designer is accustomed to following when making decisions about the form and attributes of each component. The methogram can be saved in the database and reused either in another part of the design or in a later design. There arc many processes in spacecraft design which arc quite straightforward and repeated each time a ncw design comes along.

Such processes arc candidates to be transferred into methograms. For example, a certain shape may be chosen with beginning dimensions, a thermal analysis run, a new dimension based on the results of the analysis chosen, and the process repeated until satisfactory anal ysis results found. All of these steps make up a methogram which can be executed on a supercomputer or a network of workstations automatically.

After designing, the methogram, the operator needs to debug it using MIDAS facilities until the operator feels that the methogram is as general and detailed as possible.

A designer, who may or may not be the originator of the methogram, can then provide the input, in the form of design requirements, and execute the methodology to arrive at the point design. If the requirements change (as they nearl y always do) the designer can repeat the process in a matter of minutes instead of having to manually go through all the design steps necessary.

5.0 Capturing Design History

The Stanford University Center For Design Research (CDR) has been working for several years on the general subject area of capturing design decision making in electronic form, One of the biggest problem areas is in terms of interpretation, Design decisions arc not always based on technical concerns. Sometimes a component is chosen because it is available from a supplier or enables spacecraft assembly to be facilitated. Decisions must then be interpreted by people from different organizations - procurement, manufacturing and finance for example. The CDR product, the each user 10 customize the captured knowledge so that it is couched In terms that they understand. Stanford is presently working to add new features to ICM to automatically import knowledge from design meetings and written communications without the designers having to manually type it in.

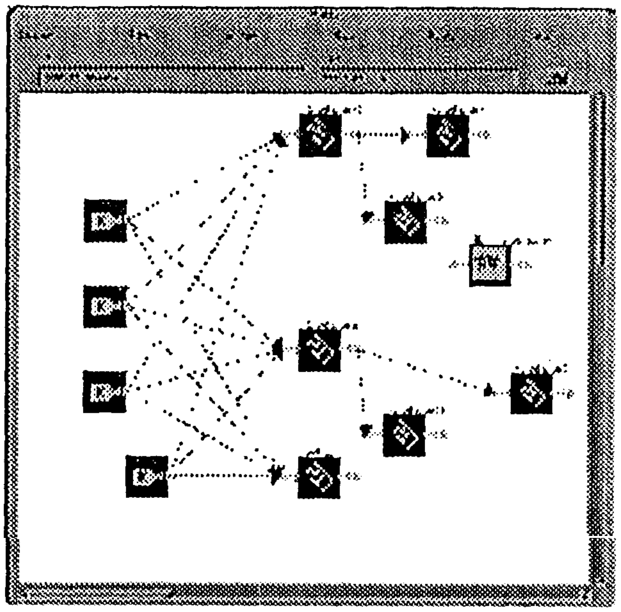

Fig. 1 An Example Of A Methogram

6.0 Interpretive Product Design Environment

MIDAS was successful in linking the components and the analysis tools to be able to tell how good the present design was, but the IPDE will add the capabilities to make the design as good as it can be. We arc using a commercial virtual reality system from MuSE Technology to visualize the spacecraft and the target body. The Muse systcm is connected to MIDAS running on a separate platform by means of a Common Object Request Broker Architecture (CORBA) compliant interface, The Muse system acts as a client to a ncw product derived from MIDAS called the "Millennia Engine". The Millennia Engine is essentially MIDAS without its user interface. The Muse system now provides the user interface by allowing the designer to explore the design in virtual reality. At voice command, the user can request that a certain analysis tool or methogram be connected to a component of the design. The tool or methogram arc then executed and the results presented to the designer using advanced visualization techniques. This presentation may be through colors applied to the surface of the component, by posting graphs of various kinds in the virtual world, by producing various sounds.

To assist the human designer working from within the IPDE, wc plan to offer a "virtual human" assistant, Designers arc often senior employees who arc put off by high tech equipment. We hope that the virtual human will be lifelike enough that he will case some of their concerns. We arc using the "Jack" product from the University of Pennsylvania for our virtual human. Jack will offer advice about how to usc the equipment when requested by the user. He will also bc able to under-take such as search for a particular methogram or standard component which might bc useful to the designer.

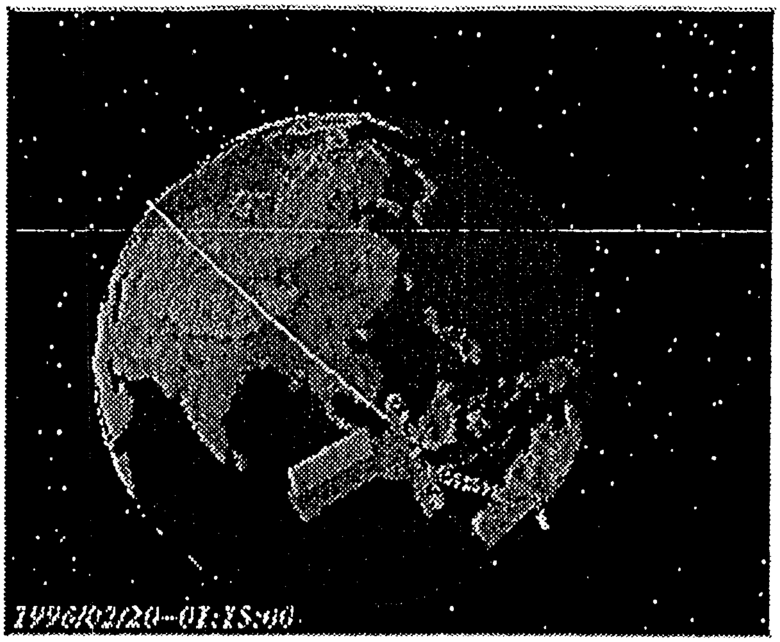

Fig. 2 An Example Of A Scene In Virtual Reality

A design scenario for the year 2000 might consist of a spacecraft designer sitting at a control boom and looking at the scene shown in Fig. 2 which consists of a S1 M spacecraft in orbit around the Earth. With a voice command, the designer can stop time and point the spacecraft to the star that it is observing. The designer can then request that a calculation of the light path through the optical system bc performed using the JPL I-MOS software. The results would return in the form of twin light paths becoming visible on the spacecraft image, The designer could then say "Remove panel A" and this would bc done showing the light path interior to the spacecraft. They could then make some modification to a mirror position and redo the calculation all with voice command. Then it would bc possible to ask Jack why the mirror poisiton was so close to the telemetry and Jack will search the data base and reply verbally by repeating the conversions that were exchanged on the subject in 1998.

7.0 CONCLUS1ONS

The virtual reality design center is coming soon. All the pieces arc now available and graphics technology is fast enough to support them. Voice recognition is also developed to the point where annoying delays arc minimized though parsing and data retrieval arc still marginal on this point. Strategies to divert the user during these delays arc being actively investigated and some preliminary results point the way to overcoming this technological weakness.

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