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Advanced Concurrent-Engineering Environment Final Report

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Advanced Concurrent Engineering Environment

Final Report

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ABSTRACT

Sandia demonstrated large-scale visualization in a conference room environment. Project focused on the installation of hardware for visualization and display, and the integration of software tools for design and animation of 3-dimensional parts. Using a high-end visualization server, 3-dimensional modeling and animation software, and leading edge World Wide Web technology, an advanced concurrent engineering environment was simulated where a design team was able to work collectively, rather than as solely disjoint individual efforts. Finally, a successful animation of a Sandia part was demonstrated, and a computer video generated. This video is now accessible on a Sandia internal web server.

1.0 Introduction

Sandia has invested in a number of technologies to support concurrent engineering and integrated manufacturing. Effective integration of those technologies is essential to realize their full potential. The Advanced Concurrent Engineering (ACE) Environment is a demonstration of how large-scale visualization environments can be used to effectively immerse a collaborative team within a real-time 3-D rendering of an interactive scene to work together in a completely new way. With utilization of this system, we are trading increased costs at the modeling and design stage for decreased problems in the manufacture and stockpile of parts.

A visualization environment provides an engineer the capability to design, assemble, and test a simulated component, subsystem, or system before actual production. Revolutionary new technology for scientific visualization is just now becoming available with the latest generation of ultra-high performance real-time 3-D rendering computers. Those systems are used to immerse a collaborative team totally within a 3-D rendering of an interactive scene. In an immersive collaborative environment, a design team will be able to work together, rather than in disjoint individual efforts. The ACE environment greatly enhances the effectiveness of design efforts by allowing: (1) designers and analysts to consider simulation results with real-time (up to 60-frame/sec) rendering that demonstrates dynamic processes far more explicitly than possible with other techniques; (2) complete immersion of an entire work group into the 3-D scene for a greater sense of reality, while permitting close interaction and communication between team members as they navigate interactively through the simulated component, subsystem, or system; and (3) dynamic image resolution resulting in an extraordinary range of spatial resolution from one large enough to display a complete system assembly down to molecular separation distances. Furthermore, the same environment can be used to train manufacturing engineers for fabrication and assembly (or dis-assembly), as well as technicians who service and handle fielded systems.

In the prototype ACE environment built in this project, a design team is able to view and manipulate assemblies of parts using Pro-Engineer, as well as generate VRML versions of the assemblies for inspecting and analyzing the part via 3-D interactive navigation with a World-Wide Web browser. In a production version, designers will have the added capabilities of analyzing assembly and service issues, component and system functioning, and potential failure modes.

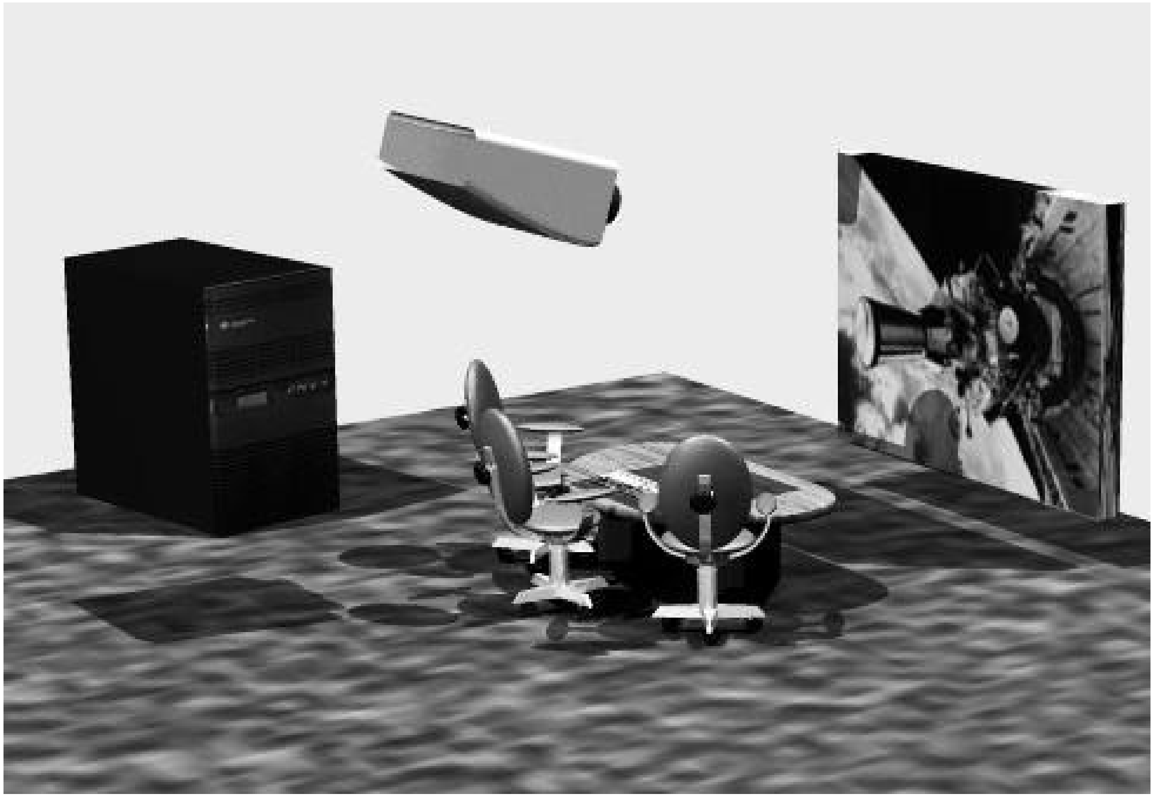

Figure 1. Prototype Visionarium Environment

2.0 ACE Environment Hardware Configuration

The ACE Environment provides a visualization environment in which design teams working on large scale projects can meet and collectively view and interact with their designs thus facilitating collaboration among the teams members. In a conference room setting, team members can comfortably view real-time computer generated visualizations and simulations on a 10 foot diagonal screen. Content generated for display is created using a high-speed graphics supercomputer. The output from the supercomputer is converted to analog video and delivered to a high-resolution graphics projection system.

The graphics supercomputer chosen for this project is produced by Silicon Graphics, Inc. It is a Power Onyx with the following features:

- (2) 200 MHz R10000 CPUs
- 512 MBytes memory
- 20 GBytes Disk Array
- Sirius Video
- Infinite Reality Graphics
- Audio/Serial Option

The Sirius Video option provides full performance video capture and manipulation, digital image manipulation, data capture and record, and sequence playback. It also provides color space conversion and live video texturing at real-time rates. The Infinite Reality Graphics exploits parallelism in all areas to provide bicubic, trilinear, and bilinear image filtering, 3D, geospecific and dynamic texture support, texture/image download rates up to 220 Mbytes per second, and dedicated image processing support. The Audio/Serial Option provides audio processing capabilities for visual simulation applications and for film and video editing.

The projection system chosen for this project consists of a projector, screen, and RGB interface converter:

- Barco Graphics 1209 Data/Video Projector with 9” CRT lenses
- Stewart 120” Diagonal Wall Mounted Snapper Screen
- Extron Analog RGB Interface

The projector was chosen based upon it capabilities for brightness, graphics resolution, and horizontal scan frequency range. It handles all the major video formats including S-VHS, composite, and high-resolution component RGB. The wall screen is rigidly mounted for better resolution and pixel accuracy. The screen dimensions are 8 feet wide by 6 feet tall, and is positioned 30 inches above the floor.

3.0 ACE Environment Software Configuration

The standard 3D solid modeling software used at Sandia for design work is Parametric Technologies Corporation’s Pro/Engineer. This is the basis for all other software decisions made for the ACE environment. Although Pro/Engineer is very good at modeling individual parts and small assemblies, large assemblies become very cumbersome to both manipulate and view. For collaborative purposes, it is necessary to dynamically manipulate large assemblies in real time. To look into the details of the assembly, the capability of changing the visual properties of parts (i.e. color, transparency, texture, geometric representation) is critical. Also, for assemblies with moving parts, it is very important to be able to visually simulate part motion. Finally, it is crucial to deliver analysis and simulation results to colleagues at distant locations.

Based on the above needs, a thorough search of existing animation/visualization software resulted in our selection of the VisLab and VisFly products from Engineering Animation, Inc. Commercial software was desired for ease of installation, ease of use, and maintainability. The EAI products were chosen based on the following properties:

- Direct interface with Pro/Engineer
- Maintains Pro/Engineer assembly structures
- Accepts data from a host of standard and industry-accepted analysis programs including SDRC I-DEAS, ANSYS, RASNA as well as Sandia’s in-house programs
- Interactive, dynamic inspection of large assemblies
- Ability to animate deflection and stress data
- High-speed rendering optimized for accelerated hardware graphics
- Designed for use by both engineers and visual animators.
- Process only the components that have been altered since the last database update, providing the most current design iteration.
- Products are easy to learn and use and have high performance and capacity.

VisLab is used to generate realistic and accurate animations which demonstrate and/or simulate motion, finite element analysis, and particle flow. Engineers can use VisLab to create simulations which demonstrate operations and procedures to technicians, support personnel, etc. They can also create training videos to show step-by-step assembly instructions to manufacturing personnel, by graphically exploding or imploding any sub-assembly into it's associated parts, at any speed and any angle, then re-assemble them.

Using the VisFly software, engineers can check for part conflicts and interferences, by conducting an interactive fly through of the assembled model looking for errors. They can also use interactive functionality to manually zoom into and inspect any part of the design during a live review process. Animations created in VisLab can be imported into VisFly, thus allowing engineers to fly-through a dynamic assembly with moving parts.

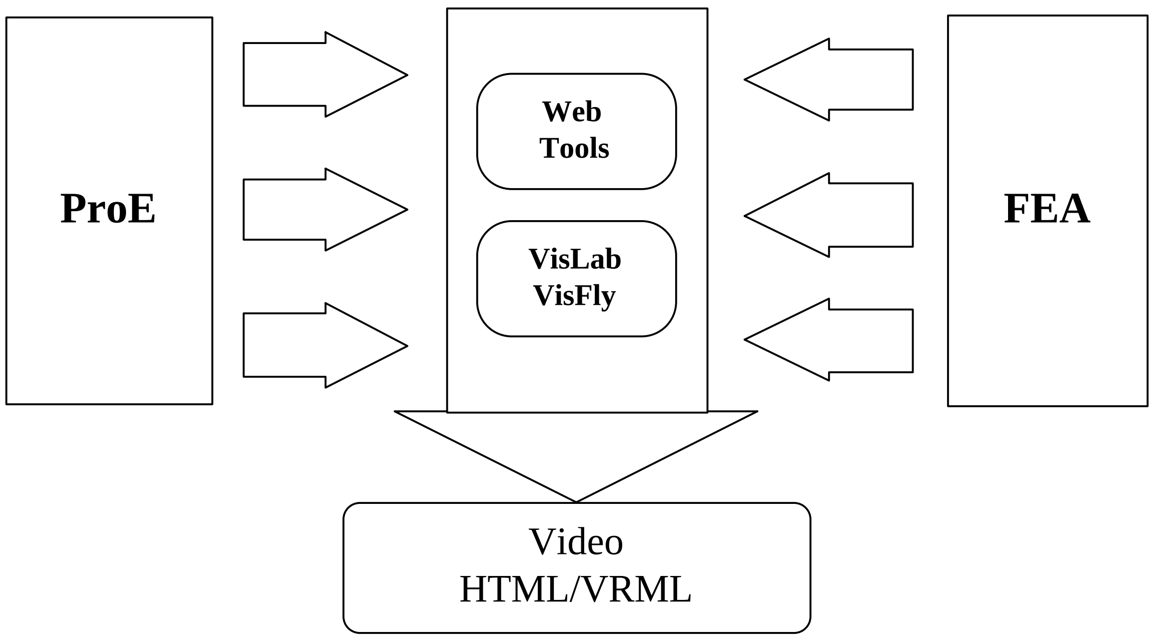

Figure 3. Software Environment

We chose to use Web-based technology to distribute results to a large audience for the following reasons:

- Sandia has adopted the use of Web technology as part of Sandia's information infrastructure
- Sandia's adoption of Netscape as a standard browser provides for the dissemination of information using HTML and VRML with no additional software requirements.
- Animations can be made available to colleagues instantaneously after production without having to generate video tapes.
- VRML models will allow the combination of simulation data and model geometry while providing an easy-to-use interface that can respond to user interactions.

4.0 Demonstration of Concept

The Sandia part chosen for demonstration of the Advanced Concurrent Engineering (ACE) environment was the MC4438 single stronglink assembly (SSA). This mechanism is one of two independent stronglinks used in the Pit Reuse for Enhanced Safety and Security, Cruise Missile applications (PRESS/CM). The stronglink is a rugged, mechanical device used to ensure the safety of nuclear weapons in both normal and abnormal environments. In the prototype ACE that was built for this project, the simulated design team was able to view and manipulate the stronglink assembly by using both a solid modeling application (ProEngineer) and an interactive engineering visualization/animation tool (Visfly/Vislab). Additionally, a static VRML model of the assembly and an kinematic animation were generated for viewing with a World-Wide Web browser.

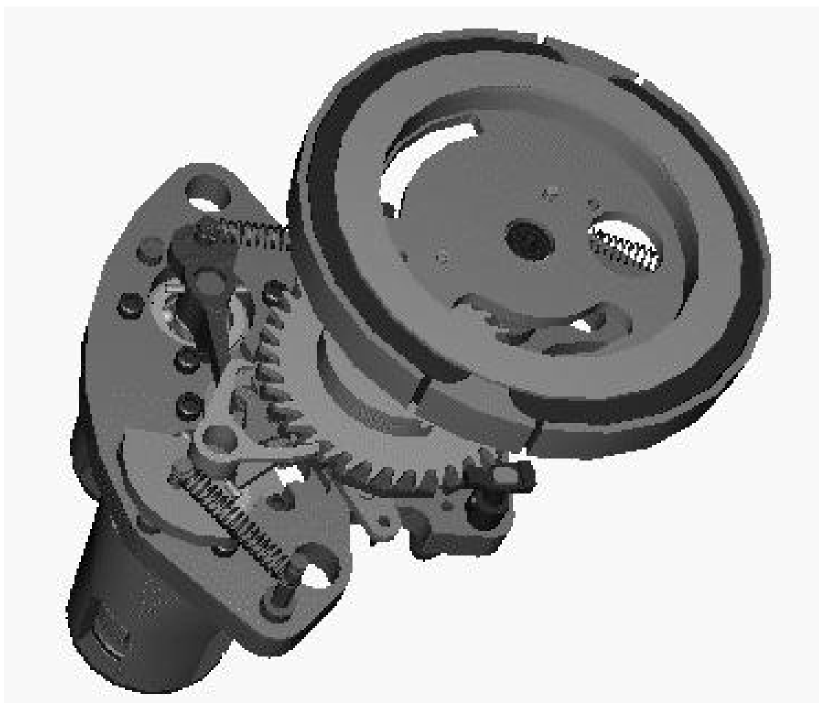

Figure 4. MC4438 Single Stronglink Assembly

5.0 Conclusion

The Advanced Concurrent Engineering Environment provides an engineer the capability to design, assemble, and test a simulated component, subsystem, or system before actual production. In the immersive collaborative environment, a design team will be able to work together, rather than in disjoint individual efforts. This environment will be used to facilitate interactions between design, manufacturing, and stockpile support personnel while still in the design stage.

The results of this project demonstrate the following capabilities:

- Immersion of an entire work group into a 3-D scene for a greater sense of reality, while permitting close interaction and communication between team members as they navigate interactively through the simulated component, subsystem, or system.

- Quickly generate real-time motion simulations of mechanical assemblies imported as ProEngineer models.

- Distribute results to remote locations using web technology.

The ACE Environment integrates leading-edge technologies for real-time rendering of 3-D objects into a collaborative environment that will facilitate more effective product design and process analysis. Performing critical functions such as design, manufacturing, assembly, limited lifetime component exchange (LLCE), dismantlement, and training for those functions will benefit greatly from these new capabilities for reducing cost and cycle time. As systems like ACE become more widespread, Sandia will have access to an important tool for engineering collaboration with industry.

We have performed demonstrations for several groups at Sandia, all of which are very interested in applying this testbed to their projects. For example, the animation of the stronglink assembly was the first time the designers of the assembly were able to demonstrate the motion of the mechanism without having to use a physical model. Based on the feedback from Sandia project managers and engineers, we recommend the following: (1) expand to include links to engineering analysis (kinematics, finite element, test data); (2) continued development of the environment into a larger system; (3) apply system to other projects which can reap immediate benefits.

This type of project is important for Sandia. Sandia has made substantial investments in a number of technologies to support concurrent engineering and integrated manufacturing. Blending those technologies in novel ways that fully exploit modern computing and visualization technology is crucial for maximizing the return on Sandia’s investments in this area.

APPENDIX A

Related URL Links

http://ghidrah.ran.sandia.gov
http://ghidrah.ran.sandia.gov/~jafries/cdsl.html
http://ghidrah.ran.sandia.gov/~jill/vrml/stronglink.wrl

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