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FEA Information Participants

Getting Ready for The Big One
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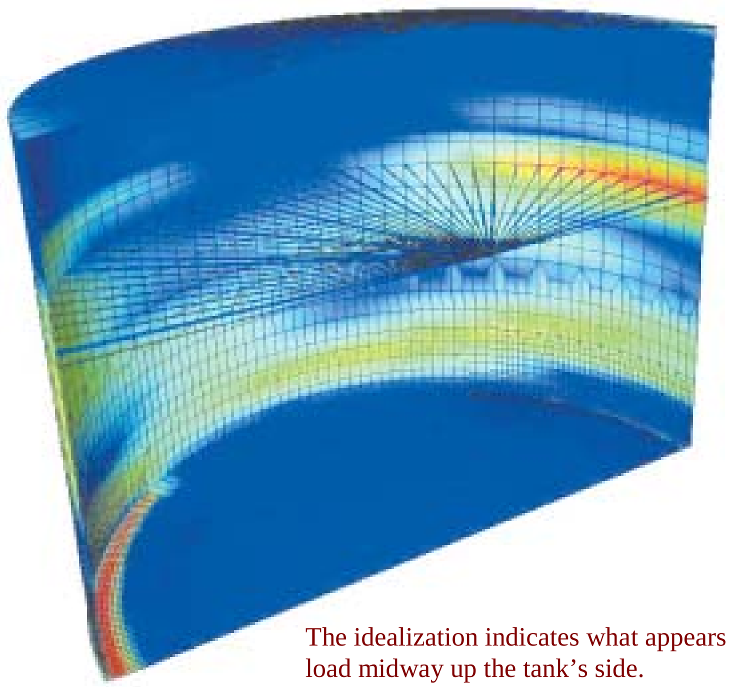

The idealization indicates what appears to be a load midway up the tank's side.

Million-gallon water tank on the San Andreas Fault undergoes earthquake analysis

In the hills just south of San Francisco sits a million-gallon steel water storage tank that provides the local domestic water supply. Buried deep within the hills beneath it lies the infamous San Andreas Fault, almost imperceptibly building up stress for a major seismic event.

In the valley below lies a stress of a different kind – lack of housing. Some of the Bay Area's most desirable remaining land is located downhill from the tank, and to a subdivision developer, the real estate is very valuable.

The potential for tank failure during some foreseeable earthquake – what Californians call "The Big One" – is a considerable risk to the development, and to estimate the degree of risk and the potential consequence of tank failure was not an easy task. With public opinion against the development, one of the leading structural engineering and earthquake specialist firms, URS/Dames & Moore Group of Huston, Texas, was called in to analyze the water tank using ANSYS/LS-DYNA.

"Our main focus was to demonstrate to the public that the tank will not fail and send a wall of water down the hill in some kind of an Armageddon scenario," said Ahmed Nisar, leader of the engineering team. "Seismic response of steel water tanks is very complex, and since this tank is not anchored to the foundation, it can shift or lift off the slab, move about, and come down with considerable impact.

"With the public and the city's review committee breathing hard on our necks, we turned to ANSYS/LS-DYNA, and what a good decision it was," Nisar said. Paul Summers and Paul Jacob, the URS/Dames &

Moore analysis team, chose LS-DYNA over other analysis codes for its ability to model the nonlinearities and rapid changes in applied forces to the tank. “The big benefit was that LS-DYNA (and not ANSYS per se) was able to do the task at all. We chose DYNA because it was readily available and had all the functionality to hand. Therefore, we did not need to spend time verifying code options such as rigid wall contact,” Jacob said.

The problem presented to URS/Dames & Moore was what could happen if 7,100 tons of water, contained in 20 tons of 30-year-old steel, is violently shaken in an earthquake. “In an earthquake, the unanchored tank could lift off the slab, move, and come down with considerable impact, generating considerable contact forces as well as material nonlinearity.” Since the explicit solution does not need to search for equilibrium at each time step, it could reasonably be expected to easily cope with this type of problem. “LS-DYNA would need to use small time steps, to ensure solution stability, but this was not expected to be a difficulty. We required proper modeling of the earthquake’s energy input to the structure anyway,” Nisar said. “This meant that a small time step, on the order of at most 0.01 second, would be needed to define loading conditions.”

The biggest modeling challenge was how to represent the water. “Backed by studies from the American Water Works Association, we decided to ‘idealize’ the water rather than actually model it,” Jacob said. “Modeling the water would have added at least an order of magnitude to the solution time. Further, solution time was saved by modeling one-half the steel tank. The resulting model had 4,218 nodes, 4,255 elements, and 25,308 degrees of freedom.”

The key loads on the structure are hydrostatic pressure, gravity’s pull on the water, and the earthquake loads applied as acceleration time histories. The solution database was 500 megabytes. Each analysis took about 15 hours on the only available workstation, a 6-year-old Silicon Graphics, Inc., PowerIndigo. The machine is powered by SGI’s R8000 CPU with a clock speed of only 75 MHz. By today’s standards, this is not a powerful machine, but it was up to the job,” Jacob said.

“In our experience, the most common failure mode of the tank is the buckling of the bottom tank shell in the shape of an elephant’s foot,” Summers said. “The LS-DYNA model clearly showed that bulge as the simulated tank bounced up and crashed down again.”

The final results showed that the tank – 75 feet in diameter and 53 feet high – could even be expected to withstand the anticipated level earthquake shaking used in studying a number of similar events.

“We concluded that the model gave us a very good approximation of the real world,” Jacob said.

A Tale of Two Workstations…And Five Graphics Boards
Article by Mark Devlin
Adapted with permission of Desktop Engineering Magazine,
a Helmers Publishing Inc. publication, www.deskeng.com

The Silicon Graphics Zx10 Workstation (Courtesy SGI)

The SGI Model 330 Workstation (Courtesy SGI)

Several months ago, Desktop Engineering's Tony Lockwood said, "We have a chance to review a Silicon Graphics Zx10 VE. Interested?….

Basics

While most any workstation provider can design, outsource, and provide a high-end graphics powerhouse, it's a considerably greater challenge to do so with industry-standard components. SGI has clearly met that challenge, masterfully packaging top-of-the-line components in cases that are about as highly designed and anti-beige as anything you're likely to encounter…

Drive bays are plentiful in the Zx10 VE, power supplies are more than ample for anything this side of Three Mile Island (450W), and the many rows of expansion slots bring tears of joy. Formidably sized standard and optional hard disks are driven by on-board SCSIs, while on-board Ethernet makes network integration as easy as plugging in a 10/100 cable and tweaking through the Control Panel. ATA66, also on-board, controls the standard ATAPI CD-ROMs and floppy drives. CD burners and ZIP drives are optional. Both of these powerhouses include the standard battery of serial, parallel, USB, and PS/2 ports, as well as an external Ultra-SCSI connector.

Both the Zx10 VE and the Model 330 systems include the Windows NT 4.0 platform, also available standard are Red Hat Linux 3.2 (330) and Windows 2000 Professional….

Case design and construction are to be highly commended. Nary a buzz or creak emitted from either of the cases before, during, or after testing, which of course required case disassembly and card swapping. Pop off a couple of thumbscrews to access the Model 330 workstation's innards. The Zx10 VE has regular screws retaining its covers, but they need only be removed once—SGI has also provided slide-locking case clips if you need regular access.

Their cooling systems move air much in the manner of Blue Thunder in whisper mode. These SGI-designed boxes will outlast most bipeds and still make purchasing managers and other specifiers look like heroes years down the road.

Available processors for the Model 330 include single or dual implementations of Intel Pentium III 800, 866, or 933MHz or 1GHz variants. The Zx10 VE reduces that to the three most useful choices in its range, eliminating the 800MHz option. (According to SGI, Pentium 4s are not supported in dual-processor Wintel configurations. With performance like this, who needs a P4?) Memory for the Model 330 ranges from 256K to 1.5GB of PC133 SDRAM, while the Zx10 VE boasts a 2.1GB/second bandwidth with up to 6GB of RAM (three banks, two DIMMs per bank). Distancing the Zx10 VE from the Model 330 is a 266MHz high-speed interconnect between chip set and PCI bus; and two peer PCI buses with aggregate I/O bandwidth of 800MB/sec.

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APPLICATIONS & BENCHMARKS – Gravity Loading with Implicit Dynamics

In many sheet stamping models, the binder surface is not flat. When the operator places a flat sheet metal blank into the press, the blank sags down into the die cavity under gravity loading. In some cases this deformed shape has a pronounced effect on the formability (and springback) of the final part, so simulation of this gravity loading process becomes important.

Several procedures are available for gravity loading simulation, including explicit dynamic relaxation, and either implicit static or dynamic analysis. If the blank deformation due to gravity loading is very large (it can exceed 400 mm in rear deck lids, for example), then the explicit dynamic relaxation method can require excessive CPU times. If the blank is not precisely in contact with the binder at time zero, or if the blank is cantilevered freely over one end of the die cavity, then the static implicit method will identify several zero eigenvalues due to the presence of rigid body modes, and will fail to converge. In these cases, the dynamic implicit method is a good alternative technique since the rigid body modes are then eliminated.

Below are the four keywords to activate the dynamic implicit method.

1. Activate the implicit method and select the time step size (try 0.010 seconds):

```
*CONTROL_IMPLICIT_GENERAL
$   imflag       dt0
         1     0.010
```

2. Activate dynamics:

```
*CONTROL_IMPLICIT_DYNAMICS
$    imass
         1
```

3. Choose a termination time (try 0.50 seconds):

```
*CONTROL_TERMINATION
$   endtim
      0.50
```

4. Request a “dynain” file for the next stage of the forming simulation:

```
*INTERFACE_SPRINGBACK_DYNA3D
$     psid  (input the part ID, x, in the first field below)
         X
```

Run the simulation, and monitor the resultant velocity of several nodes in the blank. The velocity of all nodes should be near zero by the termination time. It may be necessary to extend the termination time slightly to allow some models more time to equilibrate.

In most cases the sheet blank can be meshed with very large (~40mm) elements. This means that the binder tool will probably be the more finely meshed surface. For this situation, the node-to-surface type contact works well, where the slave nodes are defined as the binder tool. Another important contact option is to prevent sticking of the sheet to the binder by activating the implicit gap flag: IGAPF=2 on optional contact card "C". The contact keyword looks like this:

```
*CONTACT_NODES_TO_SURFACE
$     ssid      msid     sstyp     mstyp    sboxid    mboxid       spr       mpr
         0         0         0         0         0         0         0         0
$       fs        fd        dc        vc       vdc    penchk        bt        dt
         0         0         0         0         0         0         0         0
$      sfs       sfm       sst       mst      sfst      sfmt       fsf       vsf
         0         0         0         0         0         0         0         0
$ optional card "A"
$     soft    sofscl    lcidab    maxpar      edge     depth     bsort    frcfrq
         0         0         0         0         0         0         0         0
$ optional card "B"
$   penmax    thkopt    shlthk     snlog      isym     i2d3d
         0         0         0         0         0         0
$ optional card "C"
$    igapf
         2
```

In some models the dynamic implicit method can exhibit high frequency oscillations. Damping can be added using the Newmark parameters which is particularly effective at high frequencies. In order to maintain unconditional stability of the time integration scheme, the Newmark parameters must obey the following relation:

$$\textbf{gamma} \geq \textbf{0.5} \quad , \quad \textbf{beta} \geq \textbf{0.25(gamma+0.5)}^2$$

A good starting point for introducing a small amount of damping is gamma=0.6, beta=0.38. These values are entered using:

```
*CONTROL_IMPLICIT_DYNAMICS
$    imass     gamma      beta
         1      0.60      0.38
```

Multimaterial Eulerian Hydrodynamics
Part 1: Overview and the Lagrangian Step

David J. Benson, FEA Information

The traditional Lagrangian finite element formulation uses a computational mesh that follows the material boundaries and moves with the material deformation. This approach is computationally efficient and accurate for problems involving moderate deformations. Distorted elements have low accuracy and their stable time step size is small.

A different approach is often appropriate for problems with large deformations, evolving topology (e.g., penetration and perforation), and chemical reactions. The multi-material Eulerian finite element method fixes the mesh in space, and the materials flow through the mesh. Since the mesh is fixed in space, the numerical difficulties associated with the distortion of the elements are eliminated. Individual elements may contain several materials, and numerical interface reconstruction methods calculate the location and orientation of the material interfaces within the elements. Phase changes, chemical reactions, and material failure are relatively easy to include in the Eulerian formulation by simply changing the composition of the elements.

Since the material boundaries don't follow the mesh lines in an Eulerian calculation, the mesh generation is completely independent of the structure, which greatly simplifies both the mesh generation and the definition of the structure. Structures are typically defined by adding and subtracting geometric primitives in a manner similar to geometric modeling in CAD programs. The material boundaries are defined when two or more materials, assigned different ''colors" or numbers, occupy a single element. Material numbers therefore serve a function beyond distinguishing materials with different properties.

An introduction to the Eulerian finite element formulation is presented here, the first part of a series on Eulerian hydrocodes. A review [1] of the methods currently in general use provides additional information on multi-material Eulerian formulations.

Most multimaterial Eulerian formulations are based on operator splitting, which permits the sequential solution in two steps of the Eulerian conservation equations,

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho u) = 0$$
$$\frac{\partial \rho u}{\partial t} + \nabla \cdot (\rho u \otimes u) = \nabla \cdot \sigma + \rho b$$
$$\frac{\partial \rho e}{\partial t} + \nabla \cdot (\rho e u) = \sigma : \dot{\varepsilon}$$

where ρ is the density, u is the velocity, σ is the Cauchy stress tensor, $\dot{\varepsilon}$ is the strain rate tensor, b is the body force, and e is the internal energy. The Lagrangian step, performed first, advances the solution in time, while the Eulerian step accounts for the transport between the elements, see Figure 1.

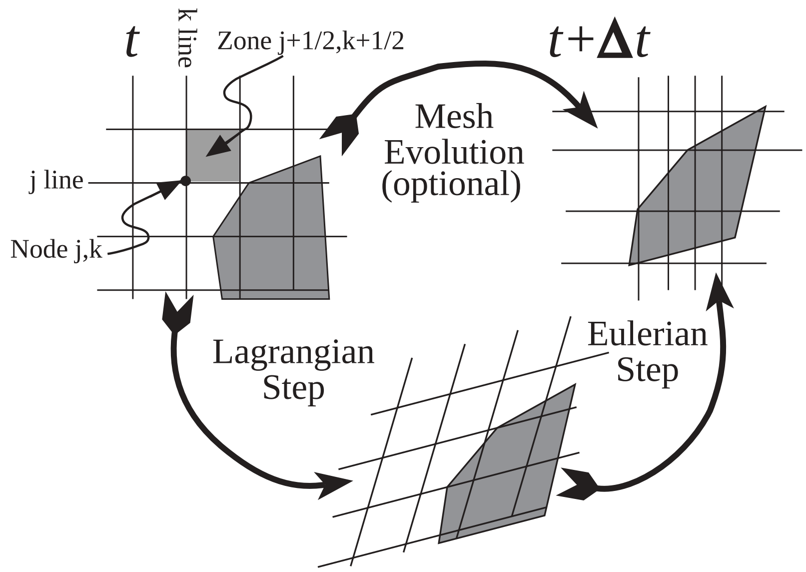


Figure 1. The evolution of the computational mesh and the material evolution in a multimaterial Eulerian, or arbitrary Lagrangian Eulerian (ALE), calculation.

The Lagrangian step in the Eulerian formulation is very similar to the explicit step in Lagrangian finite element programs. The solution of the momentum equation,

$$\rho \frac{\partial u}{\partial t} = \nabla \cdot \sigma + \rho b$$

is advanced in time using the central difference method,

$$\ddot{u}^n = M^{-1}\left\{F_{ext}^n - \int B^T \sigma^n d\Omega\right\}$$

$$\dot{u}^{n+1/2} = \dot{u}^{n-1/2} + \Delta t \cdot \ddot{u}^n$$

$$x^{n+1} = x^n + \Delta t \cdot \dot{u}^{n+1/2}$$

where Δt is the time step size, F_{ext}^n is the vector of external forces, B is the discrete gradient operator, and the superscript n is the number of the time step. The stable time step size in an Eulerian formulation is limited by the minimum of the stable Lagrangian time step size and the condition

$$\frac{\dot{u} \cdot \Delta t}{L} \leq 1$$

where L is the element length.

There are two primary algorithmic differences between the Lagrangian step in an Eulerian calculation and the time step in a Lagrangian calculation. The first difference is the absence of contact algorithms in the Eulerian calculation. The interactions between adjacent materials is handled by the mixture theory, which is the second major difference between the two formulations. The mixture theory 1) distributes the strain increment of an element among the materials in an element, and 2) calculates the element stress from the stresses in the materials.

The sum of the strain increments in the materials over a time step must add up to the overall strain increment in the element, $\Delta\varepsilon = \dot{\varepsilon}\Delta t$. More formally,

$$\sum_{m=1}^{M} \Delta\varepsilon_m V_m = \Delta\varepsilon V \text{ .}$$

The constraint says that the volume-weighted strain increment equals the element strain increment.

A common, and very simple, algorithm for partitioning the strain increment is to set each $\Delta\varepsilon_m$ to $\Delta\varepsilon$. This algorithm works surprisingly well, but it has some obvious shortcomings. Among them is the problem that in an element containing a solid material and void (or vacuum), the void will never be completely compressed out because its strain is limited to the strain in the solid. Most implementations of this simple algorithm are modified to preferentially squeeze out the void before compressing any of the other materials.

Another common algorithm distributes the strain increments so that the stresses or pressures in the materials are equal. For nonlinear material models, the equilibration problem requires an iterative strategy, which drives up the cost of the algorithm and reduces its robustness. Many implementations are based on a relaxation strategy. Rather than solving the equilibrium problem exactly, a single iteration is performed so that equilibrium is approached over several time steps. Since equilibrium isn't instantaneous in the real world, many view the relaxation strategy as being more realistic than enforcing equilibrium within the element every time step. While the first mixture theory is too stiff, the equilibrium algorithm is too soft. Taking the previous example of an element containing a mixture of void and a solid material, the equilibrium algorithm forces the solid to have zero stress since the void is unable to support any stress.

FEA Information Web Site Summary

Each week on the news page we showcase:
Software – Participant's Headquarters and/or a software distributor

June news pages and previous News Letters are archived on the New Page on FEA Information:

June 4th:

- **Software: JVISION** from Japanese Research Institute (JRI), a general purpose pre- and post-processor for FEM software such as LS-DYNA, Nastran, JMAG-Words, etc. and others.
- **Distributor: DYNAMAX** located in Troy Michigan.
- Updates: We added the information request form and the first technical description on our site Auto Meshing www.automeshing.com

June 11th

- **Software: MSC.PATRAN** from MSC, enables a user to conceptualize, develop and test prior to manufacturing and material commitments. Interfaces to LS-DYNA from LSTC.
- **Distributor: Metal Forming Analysis Corporation** (MFAC) located in Ontario, Canada
- Added: New area on the site Metal Forming Simulation – The Presentation Library. This site is directed by Xinhai Zhu. www.metalformingsimulation.com
- Added: University Employment Opportunities in our Educational Forum

June 18th

- **Hardware: SGI Origin** 3000 Series of Servers
- **Distributor: Japanese Research Institute** (JRI) located in Tokyo, Japan
- **Announcement: Trent Eggleston as Editor** of the monthly FEA International News Letter. Trent has ten years of experience in software development specializing in mesh generation.

June 25th

- **Software: eta/VPG** available for Linux from Engineering Technology Associates, eta/VPG is a streamlined CAE software package that provides an event-based simulation solution of nonlinear, dynamic problems.
- **Distributor: THEME** Engineering located in Seoul, Korea.

Announcements:

- On the news page I have started a link called Quick Index. This will give a quick description of what products can be found and applications.
- On the news page is a link called Participant Showcase that showcases our participant's products.

Marsha Victory
President, FEA Information

Courses and Events will be limited to 1 page
For further information visit the events page on FEA Information

Events

USA	Aug 1-4	Sixth US National Congress on Computational Mechanics, Dearborn, MI, USA.
France	Sept 24-26	Worldwide Aerospace Conference & Technology Showcase, Toulouse Congress Center, Toulouse, France
USA	Sept 25-26	LMS 2001 Conference for Physical and Virtual Prototyping, Michigan State Management Education Center, Troy, MI.
Germany	Oct 17-19	19th CAD-FEM Users' Meeting - International Congress on FEM Technology will be held October 17-19, 2001 at the DORINT SANS SOUCI Hotel in Potsdam, near Berlin.
Japan	Oct. 30-31	LS-DYNA Users Conference, sponsored by Japanese Research Institute (JRI) - to be held at the Sheraton Grande Tokyo Bay Hotel.
France	Nov 13-14	LMS 2001 Conference for Physical and Virtual Prototyping, Hotel New York, Disneyland Paris, Paris France
USA	May 19-21 2002	7th International LS-DYNA User's Conference, Hyatt Regency Hotel & Conference Center, Dearborn, MI

August Classes – Seminars

AUG	Country	For Information	Class Title
7	USA	LMS Int'l	Digital Signal Processing Technical Seminar
13-15	USA	ANSYS Headquarters	CFD Analysis
13-17	USA	MSC - Lowell MA	Computer Based Modeling for Design and Analysis With MSC.Patran
14	USA	LMS Int'l	Time Data Processing and Sound Quality Monitor Product Training
16-17	USA	ANSYS Headquarters	Advanced CFD
20-22	USA	ANSYS Headquarters	Intro to ANSYS, I
20-24	USA	MSC - Southfield, MI	Computer-Based Modeling for Design and Analysis With MSC.Patran
21	USA	LMS Int'l	Transfer Path Analysis and FRF Based Substructuring Product Training
22-24	Korea	Theme	LS-DYNA Introductory Training
23-24	USA	ANSYS Headquarters	Intro to ANSYS, II
30-31	Korea	Theme	eta/FEMB Introductory Training

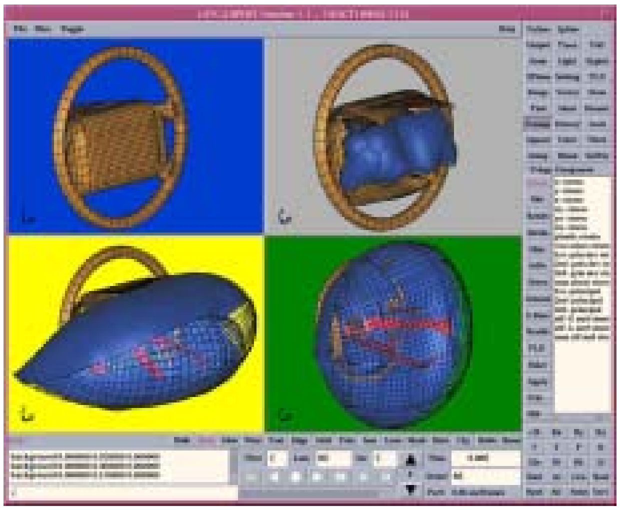
Product Showcase

Livermore Software Technology Corporation

[www.lstc.com]

LS-POST

Post Processor



Hewlett-Packard Company

[www.hewlettpackard.com]

Vectra v8100

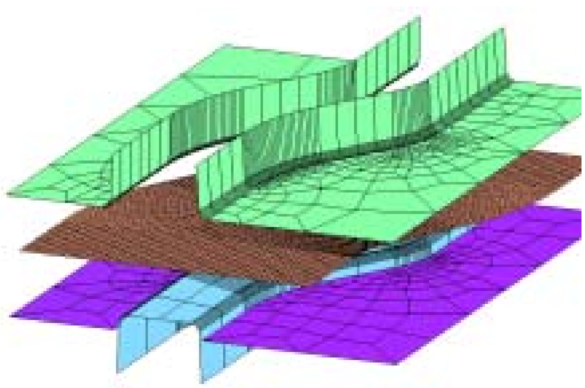
HP Vectra vl800 with Pentium 4 processor and powerful multimedia capabilities.

The Japan Research Institute Limited

[www.jri.co.jp]

J-STAMP

A Sheet Metal Forming Simulation System

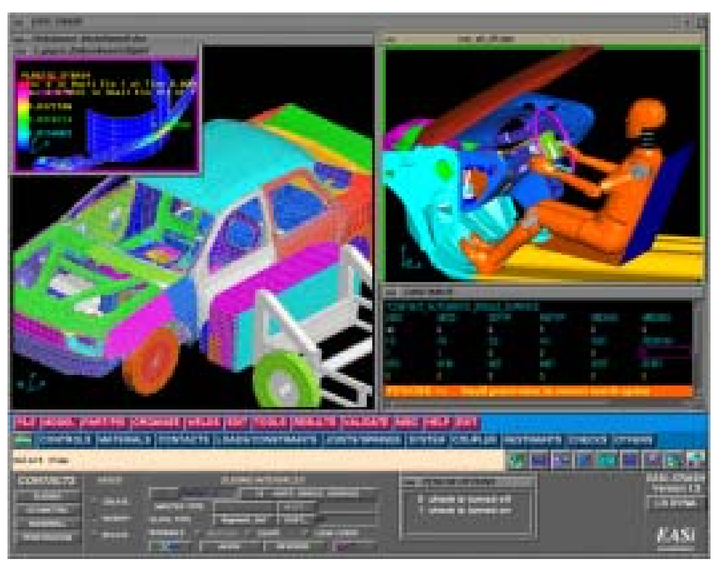


EASi Engineering

[www.easi.com]

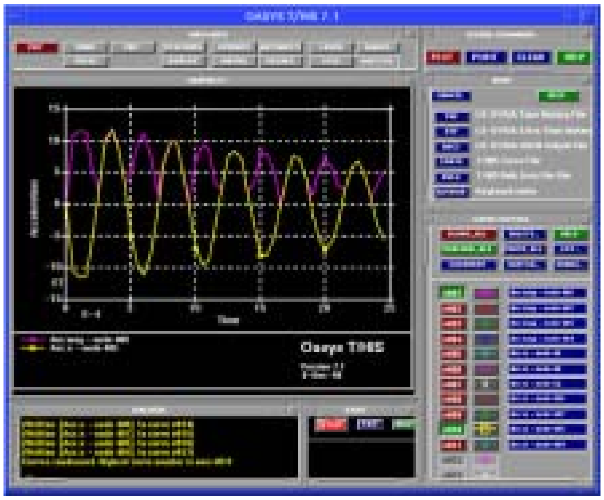
EASi-CRASH

A Productivity Tool for Crash Engineering



Oasys Ltd.
[www.arup.com/dyna]

T/HIS
An XY data plotting package designed primarily for use with LS-DYNA



Silicon Graphics, Inc.
[www.sgi.com]

SGI™ Origin™ 3800 System
Up to a single 512-processor shared memory system, or use partitioning to divide it into as many as 32 partitions and run them as a tightly coupled cluster.

LMS International
[www.lmsintl.com]

LMS Pimento
A noise & vibration analyzer.

MSC Software
[www.mscsoftware.com]

MSC.LINUX OS
Delivers all the required pieces to support extreme performance computing.

Fujitsu Ltd

[www.fujitsu.com]

PRIMEPOWER 2000

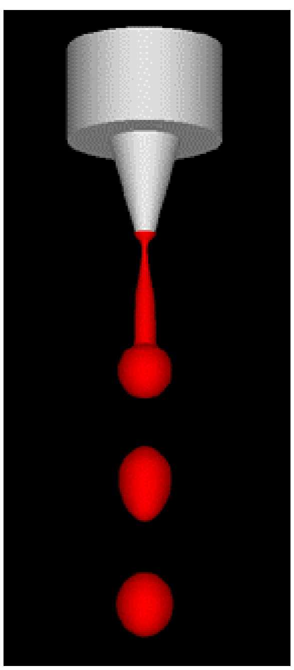
PRIMEPOWER 2000 provides linear scalability. With up to 128 new high-performance Fujitsu SPARC64-GP processors, it delivers flexible system configuration.

ANSYS Inc.

[www.ansys.com]

ANSYS/FLOTRAN CFD

Computational Fluid Dynamics Simulation



Livermore Software Technology Corporation

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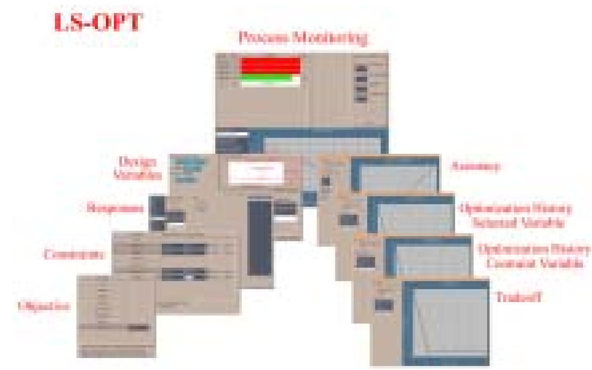
LS-OPT

Optimization



Engineering Technology Associates Inc.

[www.eta.com]

Eta/VPG

Virtual Proving Ground, CAE Tools For full-vehicle Systems Simulations