December 2003

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December 2003 LS-DYNA Status Version 970 – 971 – 980
Reprinted from Current and Future Developments of LS-DYNA
Livermore Software Technology

- Advantages over version 960:
  - The implicit capabilities are greatly expanded
  - The ALE airbag deployment for out-of-position occupants is nearing production level
  - The MPP version is more scalable and, therefore, faster
  - Many new features
- 970 our current production code
- An updated theory manual is ready for release on CD.
- Improvements to increase the accuracy in single precision are continuously added to the source code as problems arise
  - On some machines single precision is much faster
- ALE in version 970 is being updated continuously between major releases.
  - Goal: out-of-position occupant models must run coupled ALE in the production 970 release under MPI.
  - Non-critical developments are not added to version 970-only to versions 971 and 980.

Version 971 Status

Version 971 is a major, but limited, update to 970 for release in 2004.

- Many new user requested features are added
- Distributed memory implicit
  - To support of auto-switching between explicit/implicit solvers under MPI
  - Requires a second domain decomposition for the solver.
    - Since the explicit domain decomposition is not suitable for efficient sparse equation solving.

Version 980 Status

- Version 980 introduces significant developments in CFD for solving fluid-structure interaction problem.
  - A greatly enhanced incompressible flow solver
    - Radiative heat transport through participating media, as well as using exchange factors
    - Solid-fluid heat flow coupling
  - An explicit compressible flow solver based upon the Conservation Element/Solution Element (CE/SE) Method
  - A new highly flexible output database, called LSPLOT, that allows almost unlimited flexibility
- An updated code architecture, including new meshes, has been created for these CFD solvers in order to handle the fluid-structure interaction problems.

Recent developments in Version 970 added in 2003

Constitutive Models

*Mat_modified_honeycomb

- Used to model aluminum honeycomb barriers
  - Frontal
  - Side
- Off-axis loading response is nonphysical
  - Excessive deformation of vehicle is predicted in oblique side impacts
  - Related to this same problem, the transversely_anisotropic_ crushable_foam was developed first. This model was found by Toyota not to work well for aluminum honeycomb.
  - Ove Arup Ltd has developed widely used barrier models that tie solid elements together with discrete beam elements that fail
    - Greatly improves off-axis loading behavior
- A new yield surface that corrects problems with off-axis loading has been developed as a result of tests on aluminum honeycombs at Toyota Motor Corporation

- A modification to the modified honeycomb material has added a transversely anisotropic yield surface that can match the experimental data

$$\sigma^y\left(\varphi,\varepsilon^{vol}\right)=\sigma^b\left(\varphi\right)+\left(\cos\varphi\right)^2\sigma^s\left(\varepsilon^{vol}\right)+\left(\sin\varphi\right)^2\sigma^w\left(\varepsilon^{vol}\right)$$

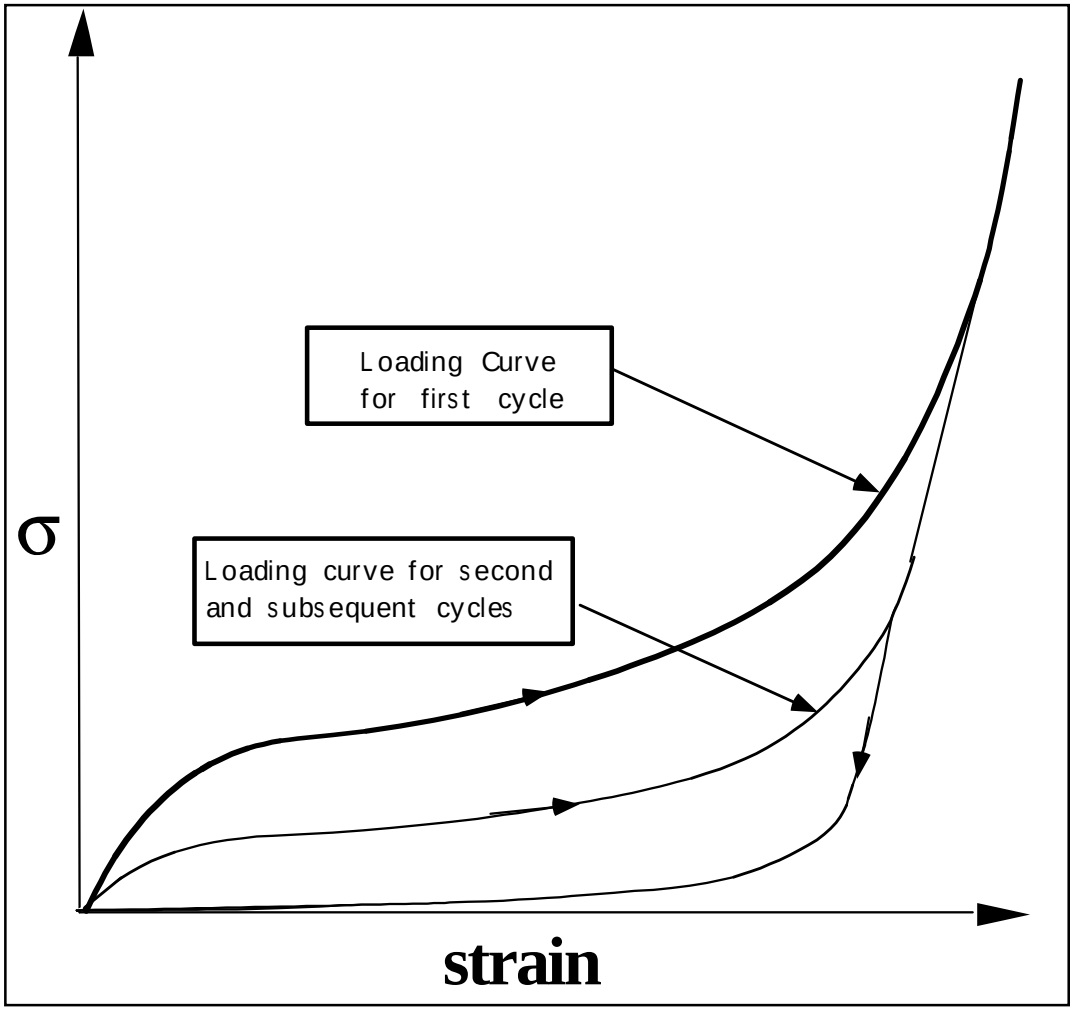
φ = *angle with the strong axis*

$\sigma^b\left(\varphi\right)$ = *yield stress as a tabulated function of* φ

$\sigma^{s/w}\left(\varepsilon^{vol}\right)$ = *stiffening as a tabulated function of* ε^{vol}

***Mat_low_density_synthetic_foam**

- For modeling rate independent low density foams, which have the property that the hysteresis in the loading-unloading curve is considerably reduced after the first loading cycle.
- After the first loading cycle the loading-unloading curve is identical
- If orthotropic behavior develops after the first loading cycle where the material behavior in the orthogonal directions are unaffected then the _ORTHO option should be used
- Implicit implementation in version 971



***Mat_Simplified_rubber**

- Uses uniaxial data given by a load curve which is defined for the entire range of expected behavior
  - Force versus change in gauge length, i.e., nominal stress versus engineering strain can be used
- Table may be used to include strain rate effects
  - Models hysterisis
  - Engineering strain rates are optional
- No fitting of material parameters means that nearly all rubber like behavior can be approximately simulated
- Implicit implementation completed in version 971.

***Mat_piecewise_linear_plasticity**

- Viscoplastic option with table lookup has been reformulated.
  - The secant iterations for the viscoplastic strain rate may not converge in current release of ls-dyna
    - A new iteration scheme (Ritter's method) now replaces the secant iterations
      - Runs all test problems that previously failed.
      - More validation work is underway
  - Modifications have been added to version 970 for the next release
    - Constitutive models for solid and shell elements are updated

***Element_direct_matrix_input**

- Option for reading and using superelements in explicit computations is now extended to implicit applications
- Required input is a file in Real*8 NASTRAN format containing:
  - Mass Matrix (must be positive definite)
  - Stiffness Matrix
  - Damping Matrix (optional)
- The matrices share degrees of freedom with model boundaries and also introduce additional degrees of freedom with nodes and generalized coordinates.

Penalty rigidwalls

- The penalty method has now been implemented for all rigid walls options to support the implicit solver. The penalty method can optionally be used for explicit calculations either for rigid nodes or as the default method
  - RIGIDWALL_GEOMETRIC_FLAT
  - RIGIDWALL_GEOMETRIC_PRISM
  - RIGIDWALL_GEOMETRIC_CYLINDER
  - RIGIDWALL_GEOMETRIC_SPHERE
  - RIGIDWALL_PLANAR
  - RIGIDWALL_PLANAR _ORTHO
  - RIGIDWALL_PLANAR _FINITE
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  - RIGIDWALL_PLANAR _FORCES

Article January 2004 – Developments in Version 971

JMAG Studio © Copyright The Japan Research Institute, Ltd.
For Complete Information visit: http://www.jri.co.jp/pro-eng/jmag/e/jmg/index.html

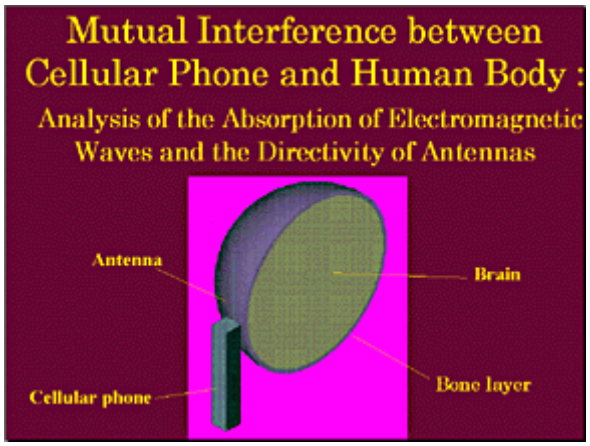
JMAG-Studio is a magnetic field analysis program that supports the development and design of electrical and electronic devices such as motors, actuators, circuit components, and antennas. It incorporates the latest analysis techniques with know-how cultivated by The Japan Research Institute, Ltd. over eighteen years, and breaks through previous conventions that state that simulations require costly computer systems and special knowledge to use.

Extensive Applications: Motors, Generators, Magnetization, Solenoids, Actuators, Transformers, Induction Heating, Magnetic Recording, Non-Destructive Testing, Superconductors, Antennas, Printed Circuit Boards, Electronic Devices, Electromagnetic Shields, Magneto-Optical Recording, Resonators, Displays,Printers, and many more.

Analysis Functions: Magnetic Field Analysis, Electromagnetic Wave Analysis, Thermal Analysis, Electric Field Analysis, Structural Analysis.

Analysis Example: Mutual Interference between a Cellular Phone and the Human Body (TD)

Analysis of Absorption of Electromagnetic Waves and Directivity of Antennas:



This example shows a simulation of the correlation between the human head and a cellular phone. In this simulation, you can see how the radiation pattern of the cellular phone changes with regard to the human head and determine the amount of radiated electromagnetic energy that is absorbed by the head. The human head is modeled as a sphere of 200 mm in diameter covered with a 5-mm thick bone layer, and a cellular phone with a mono pole antenna is positioned next to it. The frequency is 900 MHz (See Figure 1).

Figure 1: Modeled head and cellular phone Proceedings of the COST 244 meeting on Reference Models for Bioelectromagnetic Test of Mobile Communication Systems, Roma, 17-19, November 1994, Edited by Dina Sumunic.

The analysis method is to apply a voltage pulse to the gap between the antenna and the enclosure of the cellular phone and determine the radiation pattern and absorption distribution at 900 MHz. Frequency response analysis is also possible since the frequency is given. The JMAG TD module has an automatic grid generator, and users have only to define the shape and specify the width of grids **(Figure 2).** Unequal division is also supported in order to represent the shape accurately. For boundary conditions, PML absorbing boundary conditions are used

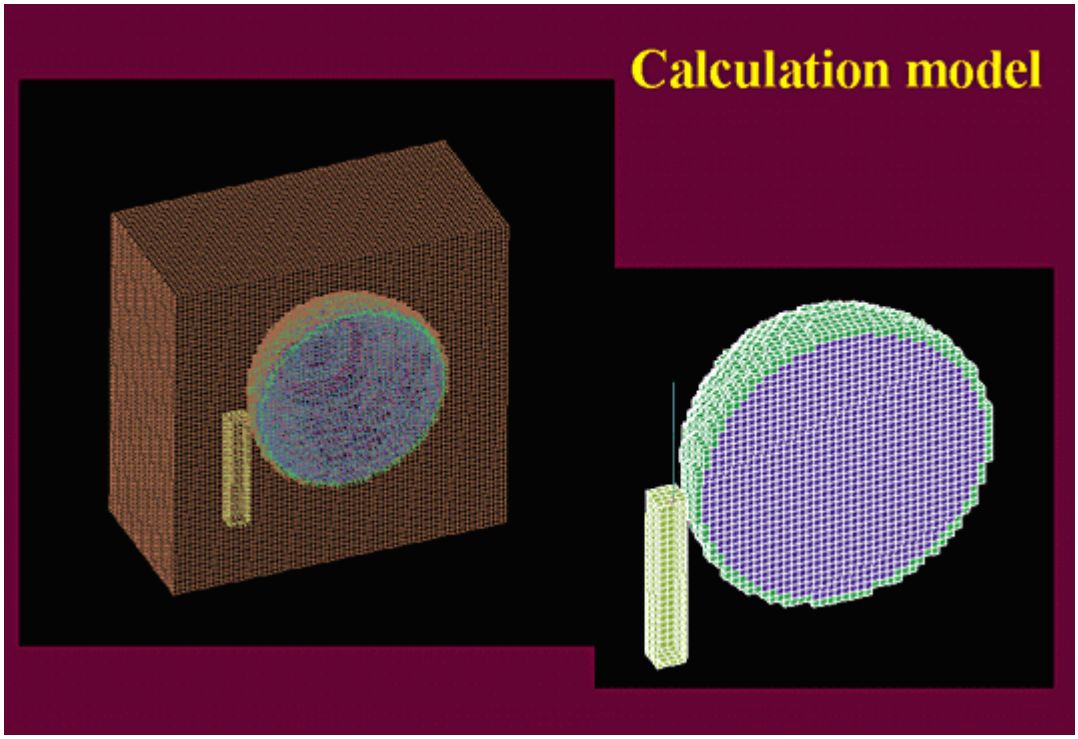


Figure 2: Automatic generation of calculation grids

Figures 3-5 can be viewed at: http://www.jri.co.jp/pro-eng/jmag/e/analysis/cellular/analysis.html

Figure 3: Figure 3 shows the distribution of power density and electromagnetic field that was obtained from calculations.

Figure 4: Figure 4 shows the radiation pattern at a distance

Figure 5: Figure 5 shows the radiation pattern in the vertical plane. These patterns are calculated using the JMAG far field calculation feature.

Excerpt from ANSYS ParaMesh 2.2
Standing the Typical Design Process on its EAR!
Steve Pilz – Ansys Inc.
Jean-Daniel Belay – CADOE S.A.
For complete details visit: http://www.ansys.com/ansys/paramesh.htm
For complete article in pdf format contact: steve.pilz@ansys.com

ParaMesh is a Parametric Mesh modification tool that directly works on an existing FE mesh to perform shape modifications. It is discipline neutral (Structural, CFD, electromagnetic, multiphysics...) and also mesh-type neutral so it can handle solid meshes (tetra, hex as well as pyramids and wedges), shell meshes (quad or triangles) and mix of solid and shells.

With ParaMesh, you read in a meshed model, and you shrink, stretch, move, indent, bulge, thicken, thin and generally do what you want to the mesh, as many times as you want, and all without that painful CAD model updating/import step.

How Does ParaMesh Work: Input to ParaMesh is simply a node and an element file. Format allowed include structural analysis solver input files such as ANSYS, NASTRANs, PATRAN, CFD solvers input files such as StarCD, Fluent, CGNS, and general text files.

ParaMesh uses the data from these files as a starting point. Features, such as holes, ribs, protrusions etc. are identified and made able to move, or morph to a different shape. Surface offset, translations, and rotations, or more complex features, such as emboss shape creation are associated with a ParaMesh parameter, giving you parametric control over the mesh changes requested.

ParaMesh modifies the nodal locations to stretch and shrink the mesh, without changing anything else. This means that the rest of the analysis input isn't harmed in any way, that is, no boundary conditions need to be updated, deleted, reapplied etc.

Mesh Morphing Algorithm Details: The node moving, or mesh morphing process is optimization based. ParaMesh technology is based on a global smoothing technique, which allows large transformations of the mesh while still maintaining solution accuracy.

The smoothing algorithm seeks to find new node locations maximizing mesh quality, such that : $\underset{elements}{Max}\left(\underset{integpoints}{Max}\left(\underset{qualitycriteria}{Max}\left(\frac{C}{C_0}\right)\right)\right)$, where C is one of the quality measure on one integration point of the current element, and C_0 is the quality measure on the initial mesh.

This optimization technique works to maximize individual and global element shape metrics subject to millions of quality measures, with hundreds of thousand parameters that are geometrically tied.

This problem is complex and computationally intensive to resolve, which is why most previous mesh local optimization algorithms have attempted this optimization on an element basis, rather than process the entire mesh at one time, tuning global element quality as a whole.
.
For large modifications of the mesh, local algorithms have had a lot of trouble getting a useful result, producing some elements that were very distorted, and others, such as those close the modified boundaries, were often inverted.

ParaMesh's global optimization algorithm processes all the elements simultaneously, allowing larger modifications of the mesh by taking advantage of the computational processing power available today.

Exporting the New Mesh: Finally, the mesh can be re-exported back, generating an input file that is similar to the initial input file, but with new coordinates, for any value of the parameters. If the initial input file is ready to solve, the updated input file will also be ready to solve.

Legacy Models: Many companies maintain a library of previously created, or legacy, finite element models. Collectively, these models at once represent a huge financial investment as well as a treasure trove of digital information.

Previously, these legacy models were mostly worthless. Because they were not parametric or geometrically modifiable, most companies, using the traditional process, started any geometric changes or iterations at the CAD model level, despite the large costs.

ParaMesh is adept at reading these legacy models, extracting the pertinent mesh information, modifying the mesh parametrically to take the shape desired, an exporting the new mesh back to the surgically modified input file of the legacy model. ParaMesh, in many ways, gives life to previously dead legacy models.

Summary of Benefits:

- ParaMesh modifies only nodal coordinates, and nothing else. After the modification of the node coordinates, the input file is ready to solve: material properties, physical properties, solution controls remain unchanged. Running design of experiment (DOE) or optimization studies after parameterizing the mesh with ParaMesh is straightforward, and very cost effective.
- ParaMesh does not require geometry. No CAD license and/or experts are needed.
- Every modification will be done on the original mesh, without a new CAD model, without healing, without remeshing, without reapplying boundary conditions. Most of the shape modifications can be done in a few minutes with ParaMesh's intuitive interface, and its powerful mesh manipulation tools. ParaMesh can also easily change the model in ways that a CAD model couldn't be.

Stiffing bracket without adding mass

For complete graphics and streaming video visit: Phttp://www.ansys.com/ansys/paramesh.htmP

IBM Success Story: © Copyright IBM
Amadeus flies high with IBM Total Storage
Excerpt from IBM website
The complete Story can be found at:
http://www.ibm.com/software/success/cssdb.nsf/cs/slow-5f5ul2

The Challenge	Mission-critical flight reservations system required very high availability storage solution capable of handling very large interactive database.Requirements include better than 99.996 percent uptime, throughput of more than 5,500 transactions/second
The Solution	IBM Enterprise Server Storage (Shark) attached to IBM @serverzSeries
The Benefit	Scalable system capable of handling more than 20 percent growth.High performance delivering very fast responses to customer inquiries.Always-up system offers enhanced customer service

The European airlines reservation system, Amadeus, has selected IBM TotalStorage Enterprise Storage Server (ESS)to meet its demanding uptime criteria. With IBM @serverzSeries running IBM's Transaction Processing Facility (TPF), Amadeus reports that it is 'impressed in the extreme' by the system performance.

Through the Amadeus System some 57,200 travel agency locations and more than 10,400 airline sales offices around the world are able to make bookings with around 470 airlines, representing more than 95 percent of the world's scheduled airline seats, more than 58,500 hotel properties, some 50 car rental companies, serving some 24,900 locations and many other travel provider groups such as ferries, rail, cruise, insurance companies and tour operators.

Amadeus is one of the four global airline reservations systems, handling passenger bookings made by travel agents, via the Web and directly by airlines. Amadeus provides the capacity for common shared access to flight reservations and frequent flyer information to almost 109 airlines as Amadeus System Users. Enabling secure information sharing between carriers, Amadeus is a key support to the global trend towards carrier alliances. Current Amadeus System Users include four of the eight oneworld airlines, eight of the 14 Star Alliance airlines, and two of the six SkyTeam airlines.

The Amadeus system handles almost 400 million reservations a year–for air tickets and associated travel needs such as transfers, menu requests, car hire, hotel bookings and more. With revenues of 1,785 million euro and almost 20 percent growth, Amadeus is a major business on which airlines absolutely depend.

These business pressures led Amadeus to review the storage systems attached to its central zSeries systems, which handle the reservations database. After a lengthy review process, Amadeus selected IBM ESS,with 40TB of storage. Hamilton Baird comments: "The entire system relies on the availability and performance of the database. At peak, Amadeus is processing 150,000 I/Os per second. If there had been any question about the availability or performance, then we would have looked elsewhere. As it is, not only does the ESS deliver on our demanding availability targets, the performance has impressed us in the extreme!"

Confirming your reservation

Amadeus runs its reservations system on the zSeries server using TPF version 4.1.TPF is used throughout the worldwide travel and finance industries to provide ultra-high online transaction processing capability for business-critical systems.

Essentially, the Amadeus system consists of a massive interactive database of around 40TB that handles and updates requests for travel between travel agencies and airlines. Some 57,200 travel agents use Amadeus,and an additional 2,100 travel agency Web sites, 173 corporate sites, 18 hotel sites, and 129 Web sites serving 39 airlines, use Amadeus as the engine providing reservations data.

Every flight reservation request makes a direct impact on the Amadeus database, from checking current availability of flights through reserving seats, confirming bookings and distributing confirmations. This interactive system requires very high transaction performance from both the zSeries server and its associated storage system.

Initial requirements included 99.996 percent availability capable of handling better than 5,500 transactions per second. Hamilton Baird comments: "Our choice depended on more than price-points; it was about total performance levels, about availability, and about the service we need. The IBM approach was a winner in terms of providing exactly what was necessary to meet our needs."

Flying high

The IBM ESS is the high-performance disk storage solution from IBM. Designed to provide very high availability and data integrity, the ESS works with a variety of hardware and software technologies, such as Windows NT**, UNIX**, Novell NetWare, the entire IBM @server family, and supports all the major interfaces such as Fibre Channel, Ultra SCSI, FICON* and ESCON*.

On implementation, the quality of service and total commitment from IBM impressed the Amadeus team. During the testing phase, some issues were identified during warm starts of the system, as Hamilton Baird reports: "Initially, to address the issue, IBM provided additional Enterprise Storage Servers at very short notice until a permanent solution could be found. They were very positive, and found immediate answers, as well as committing engineers and significant resources to overcome the challenge.

"Not only did we solve the immediate concern, but IBM provided new microcode for the ESS as a permanent solution, which is currently undergoing acceptance testing. Amadeus has subsequently purchased the additional ESS systems, since we are growing so quickly it makes sense to have a scalable,

proven solution in place."

The new zSeries server and ESS implementation is now serving Amadeus and its thousands of customers with high-performance storage, ensuring near-permanent availability of flight reservation services. Hamilton Baird concludes: "We know there are other storage solutions; who but IBM can demonstrate the same level of service that simply makes it happen?"

For Deep Computing Information Visit: http://www-1.ibm.com/servers/deepcomputing/

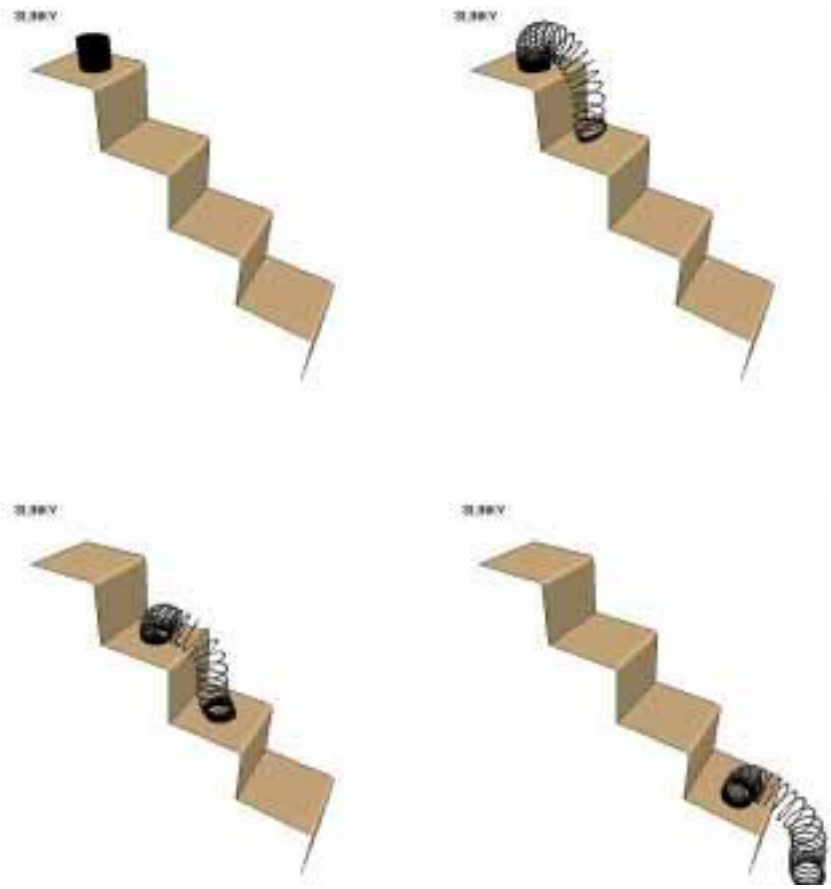
* * * * * * * * * *Complete credits can be viewed on the IBM website story:

SDCEE01016-2 (5/03) AD

Showcased AVI File

The following AVI file is a Christmas Gift to FEA Information
From ERAB - Engineering Research AB
A Slinky Toy AVI
AVI can be found in the AVI Library #69a on www.feainformation.com

A coil "walking" down a staircase. This type of spring was a popular toy some years ago and also in mechanics courses illustrating wave propagation. The analysis has been done with LS-DYNA 970 (explicit integration) and the spring is modeled using shell elements.



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The following AVI file is courtesy Gennaro Monacelli

Product Development Methods Manager of Elasis, a FIAT research company in the South of Italy - Pomigliano d'Arco (Napoli). General Director of **PRODE**, a research consortium made by Elasis and univ. of Napoli, Federico II, for industrial Design

Pole Test: Numerical Simulation of EuroNCAP pole test at 29 km/h with LS-DYNA software of a FIAT car – C segment. AVI can be found in the AVI Library # 22b on www.feainformation.com

Top Crunch - A Web Site for Benchmarking LS-DYNA

David Benson
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University of California, San Diego

A new web site, **www.topcrunch.org** , is dedicated to benchmarking high performance computer systems with commercial engineering software. The site is funded by DARPA through a subcontract from USC's Information Sciences Institute. The motivation behind the site is to obtain performance data that reflects the actual performance that scientists and engineers experience with their analysis codes. Most current benchmarks are based on synthetic problems that don't accurately reflect the algorithms where most of the time is spent in production analysis codes.

The current leader in benchmarking supercomputers is www.top500.org. Its benchmark uses the LAPACK dense matrix equation solver. While engineering codes do solve large systems of simultaneous equations, the equations are usually sparse instead of dense, with only a few percent of the entries in the matrix being nonzero. In terms of millions of floating point operations per second (MFLOPS), a dense matrix solver will always outperform a sparse matrix solver, but the sparse solver will solve a sparse system many times faster in terms of actual CPU time. LAPACK therefore reports much higher MFLOPS than a sparse solver even on a single processor.

For parallel computer systems, the dense solver also has significant advantages in terms of peak performance. The work associated with a particular section of a dense matrix on a processor can be calculated very accurately, as can the information the processor must share with other processors. This means that the workloads can be balanced across the processors, and the messages can be scheduled, with a high degree of precision. These issues are much more complicated for a sparse equation solver -- actually, they are still research issues -- and therefore they don't scale as well as the dense solvers.

Furthermore, the dominant commercial use of massively parallel systems in engineering is explicit finite element analysis, and frequently the application is automobile crashworthiness. Direct sparse equations solvers aren't yet widely available in the commercial codes, and the iterative ones don't work well on structural problems. It is hard to predict when distributed direct sparse solvers will be available in commercial finite element programs. When they are, implicit benchmark problems will be added to the site.

Assuming that the domain decomposition algorithm does a good job, an explicit finite element calculation without contact scales very well on parallel systems. The scaling degrades with contact because the regions in contact evolve with time, making load balancing a dynamic problem instead of a simple static one that can be solved during initialization. With applications such as automobile crashworthiness, elements updated on two different processors may come into contact, which requires additional communication between processors.

Recognizing the limitations of synthetic benchmarks, Top Crunch uses real-world production codes to measure real world performance of high performance computer systems. Three different engineering codes, each with its own difficult load balancing issues are currently being used. Benchmark problem files can be downloaded from the site for each code, and anyone can submit their results to the site. LS-DYNA is the first code, and two automobile crashworthiness data sets are available for download. The smaller of the two is a single vehicle, a Plymouth Neon, crashing into a rigid barrier. The second involves three vehicles, and is intended for benchmarking systems with sixteen or more processors.

The second code is CTH, an explicit Eulerian hydrocode from Sandia National Laboratories. Two data sets will soon be posted for CTH. Both are shaped charges, one in two dimensions, and the second, in three. If you are interested in performing benchmarks on CTH, please e-mail me and I will send the files to you.

Domain decomposition and load balancing with CTH is a challenge because material models range from the simple (e.g., void or no material) to the complicated and expensive. While the mesh is fixed, material flows through the mesh, and therefore between processors. A processor that starts out with a large number of empty elements can be filled later with a material that is expensive to evaluate.

Additionally, elements that contain more than one material are more expensive to update than ones with a single material because of the mixture theory. The mean strain rate is calculated for each element, and the mixture theory is responsible for partitioning the strain rate between the materials, and calculating the mean stress in the element after the material models have updated the stresses for the individual materials in the element. The cost of an element with multiple materials is therefore much more than the sum of the individual stress updates. Depending on the chosen mixture theory, the material models may be evaluated multiple times during an iterative solution for the strain rates, making the multi-material elements very expensive.

The third code is SPaSM, is a molecular dynamics code from Los Alamos National Laboratory. Benchmark files for it are not yet available. Molecular dynamics, as the name implies, simulates materials down at the molecular and atomic level. The short-range forces acting between it and its nearest neighbors govern the motion of an individual atom. SPaSM exhibits excellent scaling on large numbers of processors.

As mentioned earlier, the data files for LS-DYNA can be downloaded from www.topcrunch.org, and anyone may submit their benchmark results. We encourage people in industry and academia to run the benchmarks. To date, most of the results we have posted come from the computer vendors. The benchmarks are therefore run under the optimal circumstances, i.e., the machine is dedicated to the benchmark, and the engineers know the optimal settings for the environment variables.

Our experience to date has shown that environment variables can have a profound effect on the benchmark timings. While the user might expect the default settings supplied by the vendor to be nearly optimal, we have seen changes to the environment variables reduce the wall clock time by nearly a factor of two. Finding the optimal settings is not a trivial task; there are a large number of environment variables and how they interact is generally not clear from the documentation. We would like the user community to contribute their findings on the optimal settings.

The site is an evolving project. In addition to the results of the benchmarks, your comments about the site would be valued. Feel free to contact me with your comments and questions at dbenson@ucsd.edu. Results should be submitted directly through the web site.

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Personal Websites of Interest

Marsha Victory FEA Information Inc.	**horse rescue**	**www.livermorehorses.com**
Len Schwer SE&CS	**travel diaries -photos**	**www.schwer.net/LenSchwer/**
Ray Jurevicius Jurevicius Engineering, Inc	**Miscellaneous details about binoculars made from two 8" f/6.3 Newtonian telescopes.**	**www.j-engineering.com/ATM**

Posted on FEA Information and archived one month on the News Page

Nov 3rd	**INTEL**	**Intel® server** and workstation components
	Fujitsu	**Fujitsu High-End PRIMEPOWER**
	Dynamax	**Distributor - Michigan**
Nov 10th	**AMD**	**Information**
	NEC	**The SX-6 NEC supercomputers**
	ERAB	**Distibutor - Sweden**
Nov 17th	**ANSYS**	**ParaMesh**
	LSTC	**Conference Information**
	THEME	**Distributor - Korea**

2004	**If you have a conference to list e-mail details to mv@feainformation.com**
May 2-4	8th International LS-DYNA Users conference will again be held at the Hyatt Regency Dearborn, Fairlane Town Center, Dearborn, MI hosted by LSTC and ETA
May 10-12	OPTECH04, Optimization Technology Meeting 2004
May 24-26	2004 ANSYS Users Conference and Exhibition to be held in Pittsburgh, Pennsylvania, U.S.A.