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A COMPUTER MODELING SUCCESS STORY

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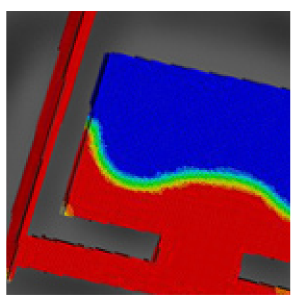

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FEA INFORMATION RESOURCE MAGAZINE

FEA Information Worldwide Participant's

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FEATURED PUBLICATION:

Editor: Trent Eggleston **Managing Editor:** Marsha Victory **Technical Editor:** Art Shapiro Graphic Designer: Wayne L. Mindle	**Technical Writers:** Dr. David Benson Uli Franz Ala Tabiei **Technical Consultants:** Steve Pilz Reza Sadeghi

FEA Information Announcements

New Participant to FEA Information China www.feainformation.cn

Altair Engineering Software (Shanghai) Co., Ltd. – China

New Participant to FEA Information Inc. www.feainformation.com

CRC Solutions Corp. –Japan
Distributors For:
LS-DYNA, LS-PrePost, LS-OPT
DYNAFORM
Msc.Nastran
Msc.Marc
iSIGHT
AdvantEdge
CRC URL: www.engineering-eye.com

Addition to LS-DYNA Resource Page:

MSC.Software's Gateway for LS-DYNA
"…..the application enhances CATIA V5 to allow finite element analysis models to be output to LS-DYNA and then results to be displayed back in CATIA…"

Cover Design:

Cameron Design
www.cameron-design.com

Sincerely,
Trent Eggleston & Marsha Victory

Cover Story

LS-DYNA: A Computer Modeling Success Story

by John D. Reid, Martin W. Hargrave, and
S. Lawrence Paulson

This sequence of photographs shows the results of a full-scale crash test in which the barrier failed because it allowed the truck to “fly” over the barrier system.

In September 1998, what had seemed like an open road to federal approval for the bullnose guardrail system suddenly developed a major barrier.

The bullnose system is one of three guardrail types that have been traditionally used to protect against median hazards such as a bridge support. The U-shaped bullnose guardrail wraps around the hazard. State highway departments like the bullnose guardrail because it is considered an effective median safety device and because compared to crash cushions (rigid barriers with cushions on each end) and open guardrail systems, it is relatively inexpensive.

However, before the bullnose system could be used on federal-aid highways, it had to meet the crash-test requirements of National Cooperative Highway Research Program (NCHRP) Report 350, also known as "Recommended Procedures for the Safety Performance Evaluation of Highway Features." The report was adopted by the Federal Highway Administration (FHWA) as a required standard for roadside safety features such as guardrails. Report 350 recognizes the growing popularity of light trucks and sport utility vehicles, which are heavier and higher off the ground than cars, and specifies that crash tests must include light trucks - up to 2,000 kilograms (4,400 pounds) - as well as passenger cars.

In 1997, the Midwest Roadside Safety Facility began a program to develop a bullnose guardrail system that would meet the requirements of Report 350. To pass the crash tests, the system had to deflect - or in the case of head-on collisions, "capture" or "trap" - vehicles hurtling into the barrier at speeds of 100 kilometers per hour (62 miles per hour).

The first two crash tests conducted by the testing facility, involving head-on collisions, had mixed results. The barrier captured a small passenger car, but a small truck plunged right through the rail. A follow-up test had the same results. (see pictures at top of story)

The project engineers decided to enlist the help of LS-DYNA, a complex computer analysis system whose predecessor, DYNA3D, was originally developed in the 1970s at the Lawrence Livermore National Laboratory to simulate underground nuclear tests and determine the vulnerability of underground bunkers to strikes by nuclear missiles. LS-DYNA, which uses nonlinear impact finite element code to simulate vehicle crashes, allowed engineers at the University of Nebraska-Lincoln (UNL) Center of Excellence, where the simulations were run, to re-create the head-on collision and analyze the elements of the crash - about 10,000 of them - in an attempt to determine what caused the failures. (See "It's a Jungle Out There: Using the Bullnose Guardrail to Protect the Elephant Traps," *Public Roads,* January/February 1999.)

LS-DYNA helped engineers find the culprit in the barrier design: longitudinal slots cut into the depressions of the three-hump beams, known as thrie beams, that constitute the guardrail. The simulations showed that the guardrails ruptured because of stresses in the top two humps of the thrie beams. The solution was to reinforce the thrie beams with two cables, a successful design change that was confirmed by a later field test that showed that the reinforced barrier withstood the collision and provided protection for the truck's occupants.

Engineers were very optimistic going into the next test - a light truck hitting the guardrail's critical impact point, which is the point where it is not known whether the barrier will trap the vehicle or redirect it. The general feeling was that the cable reinforcement of the guardrail had solved the barrier system's design problems. This was going to be a no-brainer; the system would pass.

Because the engineers were under some time constraints and they were so confident of success, they did not conduct a simulation of the critical impact-point test, known as Test 6. They ran the crash test and were surprised when the test was a failure because the truck overrode the barrier system.

The vehicle was neither redirected nor trapped. Actually, it was launched by the barrier. In the words of the official report on the test, "Vehicle trajectory behind the test article was unacceptable as the test vehicle vaulted and became airborne in the median area behind the bullnose." And when the vehicle hit the ground, it rolled over.

It was time to go back to the drawing board - or, rather, back to LS-DYNA.

LS-DYNA to the Rescue

Before running another crash test, the researchers at the UNL Center of Excellence began to do some simulations. However, simulation of the critical impact-point test turned out to be extremely difficult and time-consuming because the nature of the impact was much different than previously simulated crashes. "There were a lot of things we hadn't taken into account because it was so much different than a frontal impact," said one researcher.

Concerned about further delays, the Center of Excellence engineers decided to forgo a full simulation. They came up with a design for Test 7 that they thought would work, but because of the simulation problems that they experienced, they didn't have a detailed simulation to verify the design. To further hedge their bets, the engineers made four modifications to the guardrail design - mainly involving the posts holding up the guardrail - that they thought would strengthen the system. However, Test 7 was also a failure.

At that point, the UNL engineers knew that the only prudent course of action was to seek the approval of the project sponsors to allow more time so that the design could be studied in far more detail. The sponsors agreed.

The issue seemed relatively straightforward. As the official report on the test stated, "The lack of tension and lateral resistance allowed the pickup truck to penetrate into the guardrail with increased rail deflection and rotation and without the vehicle being captured or redirected. This combination turned the guardrail into an effective ramp for the impacting pickup truck to climb up and roll over. As a result of the failed test, design changes were necessary to allow the successful containment or redirection of the pickup truck. The thrie beam rail would need to remain upright and functional long enough to capture the front of the impacting vehicle, thus preventing vehicle climbing, vaulting, and rollover. The changes required that the rail tension and lateral stiffness be increased without adversely affecting the head-on impact performance of either the pickup truck or small car impacts."

Finding the solution, however, proved to be a complex and painstaking process that caused a delay of several months in the project. This was primarily because the frontal impact simulation that had already been developed for LS-DYNA had to be converted into a simulation of the critical impact-point collision. This required a major modeling effort.

Once the new model was completed, the center ran a simulation of the failed Test 7. The simulation showed that one tire was hitting the ground line strut and causing the vehicle to vault. Then, the center's engineers ran the simulation without a ground line strut, and it made a big difference in the design. So, they figured out how to make the bullnose without a ground line strut.

The engineers admit that it is unlikely that they would have singled out the ground line strut for attention without the computer simulation. However, they did test and verify the value of other changes.

For example, the research team thought chamfered [grooved] blockouts would help the rail go under and capture the car better. The blockouts worked in the simulation, and they were incorporated into the design. Other changes, all of which were tested in simulations, included a decrease in the distance between posts for a portion of the guardrail system to add strength and the addition of double blockouts to reduce tire snag and hold the rail higher for a longer period of time as the post rotates during impact.

The simulations weren't fully predictive. Some simulation problems remained and prohibited a complete simulation run. However, the engineers were eager to confirm the value of the changes that were substantiated by the simulations, and so, they moved ahead with Test 8 in September 1999.

The official report summarized Test 8 by noting, "The bullnose barrier successfully contained and stopped the test vehicle in a controlled manner. ... The vehicle remained upright during and after collision, and the vehicle's trajectory did not intrude into adjacent traffic lanes. Vehicle trajectory behind the test article was acceptable as the test vehicle was captured in the median area behind the bullnose." It was, in other words, an absolute success. And the bullnose guardrail system, having passed all of its Report 350 tests, is now awaiting final FHWA approval for use on federal-aid highways.

Using LS-DYNA and DYNA3D Code

As the bullnose guardrail experience makes clear, LS-DYNA simulations are not perfect; there is still a lot of trial and error involved in analyzing complex events and identifying causes and effects. However, without computer modeling, the only way to test possible modifications after a failed test is by running another actual crash test, and at between $15,000 and $25,000 per test, that's hardly cost-effective. It is apparent that performing iterative crash tests without modeling can easily become a prohibitively expensive exercise.

Another major advantage of LS-DYNA simulations is that specific factors of a crash - for example, a wheel hitting part of a highway barrier - can be isolated and examined. The computer system is perfectly suited for examining "what-if" scenarios that simply cannot be tested under real-life conditions and for identifying potential problems, such as the ground line strut, that may not be discovered without the computer.

Nevertheless, LS-DYNA is definitely not a user-friendly program. The actual physics itself is so complicated that you cannot expect the software to be any less complicated. The DYNA3D code is very powerful, but it is also very complex. An expert user of DYNA3D has spent an extraordinary amount of time just learning to use the code. It requires an expertise developed by mastering a number of courses in nonlinear computational mechanics; solid mechanics; and fluid flow, including both noncompressible and compressible liquids.

When FHWA got into DYNA3D, FHWA engineers thought that they could help develop this code and then give it to the state highway departments. However, over a period of time, they determined that this just was not possible. Understanding DYNA3D requires a level of dedicated study (and the subsequent development of expertise) that exceeds the resources and capabilities of even a very good engineer at a state highway department or at a private company that manufactures and markets roadside safety structures.

Centers of Excellence

This special expertise in DYNA3D is what makes the centers of excellence such valuable resources.

There are four centers with LS-DYNA capabilities: UNL, Texas A&M, Worcester Polytechnic Institute, and the University of Cincinnati. To date, 10 states - Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio, Pennsylvania, South Dakota, Texas, and Wisconsin - have worked with the centers on a pay-as-you-go basis on the design or redesign of roadway safety structures.

A fifth center, at the Ashburn, Va., campus of The George Washington University, houses the National Crash Analysis Center.

Besides the states, county and local departments of transportation and the manufacturers and marketers of roadside safety structures can also contract with the centers of excellence for tests and analysis.

The relationship between the centers of excellence and the universities with which they are affiliated is mutually beneficial. In addition to providing services, the centers also serve an educational function, and because they are at universities, they involve graduate students in the process. In that way, the base of LS-DYNA expertise is continually being replenished and expanded.

Dr. John D. Reid is an assistant professor of mechanical engineering at the University of Nebraska-Lincoln (UNL). He is also the director of the DYNA3D Center of Excellence at UNL. Before joining the faculty at UNL in 1993, he worked at General Motors Corp. for eight years -- the last three in safety and crashworthiness. He received his bachelor's degree, master's degree, and doctorate in mechanical engineering from Michigan State University.

Martin W. Hargrave is a research mechanical engineer on the Roadside Team in FHWA's Office of Safety Research and Development. He conducts and manages research associated with FHWA's DYNA3D finite element research program. Before joining FHWA in 1979, he worked for 17 years in various engineering assignments for private sector companies. He received a bachelor's degree in mechanical engineering from the University of Alabama, a master's degree in engineering from Pennsylvania State University, and a master's degree in civil engineering from The Catholic University of America.

S. Lawrence Paulson is a partner in Hoffman Paulson Associates, a writing/editing and public relations firm in Hyattsville, Md. He has written and edited numerous studies for the Federal Highway Administration, Federal Transit Administration, and National Highway Traffic Safety Administration. He also spent seven years covering Congress as the Washington bureau chief of a national daily newspaper, *The Oil Daily.*

For additional information about LS-DYNA and its role in supporting a new bullnose guardrail design, contact Martin Hargrave at (202) 493-3311 (martin.hargrave@fhwa.dot.gov) or John Reid at (402) 472-3084 (jreid@unl.edu).

Technical Spotlight - INTEL

The 64-bit Tipping Point

64-Bit Resource Center:
www.intel.com/business/bss/products/server/64-bit/resource_center/64-bit.htm

What is 64-bit Computing?

Most of today's high-volume server processors manipulate data and instructions in 32-bit chunks. A 64-bit processor can handle chunks that are twice as big. This doubles the potential throughput per operation and provides two key benefits:

- A 64-bit processor can directly address large amounts of physical memory, while a 32-bit application is typically limited to about 4GB. This enhanced addressing capability allows an application to store vast amounts of data in main memory, which is faster than today's fastest mass-storage subsystems.
- A 64-bit processor can manipulate high-precision data more quickly, since it can process more bits in each operation.

Technology and industry are poised for a broad transition to 64-bit computing. Planning an effective migration path will depend on your specific applications and workload requirements. Many mainstream applications will require greater memory capacity or extended 64-bit processing capabilities, while more demanding data-tier applications may require robust 64-bit capabilities to deliver the performance, scalability and reliability for transaction-heavy, business-critical environments.

For more than a decade, 64-bit architectures have played an important role at the high-end of enterprise and technical computing. Intel Itanium architecture shifted the market dynamics in that space, lowering the cost of entry and challenging high-end RISC-based systems in scalability, capacity, performance, and RAS (reliability, availability, serviceability).

Why is 64-bit Computing Important?

Many existing 32-bit applications will not directly benefit from a 64-bit migration, but a number of scientific, engineering, and design applications can take advantage of the additional memory capacity and computational accuracy. 64-bit capabilities are already critical for servers and workstations in a variety of software categories, including database, business intelligence, enterprise resource planning (ERP), digital content creation, engineering design.

64-bit platforms are also valuable for an increasing percentage of enterprise business solutions, such as security applications and real-time transactional systems that rely on large data sets. In the next few years, 64-bit migration will most likely be fueled by explosive growth in data transaction

Advantages of 64-bit Solutions

There are two key advantages to platforms with 64-bit capabilities. First, a 64-bit processor transcends the 4GB memory limit encountered with 32-bit processors, and can directly access virtually unlimited physical memory.1 This allows an application to store vast amounts of data in main memory, which is several orders of magnitude faster than today's fastest mass-storage subsystems. Large, memory intensive applications that can take advantage of this extra capacity can see dramatic performance increases. Secondly, a 64-bit processor can manipulate data and execute instructions in chunks that are twice as large (64-bits versus 32 bits). This can be a key advantage for complex calculations that require a high-level of precision.

Although most existing 32-bit applications have no immediate need for additional memory, many scientific, engineering, and design applications will benefit. So will an increasing percentage of enterprise business solutions, such as security applications and real-time transactional systems that rely on large data sets. The availability of highly affordable 64-bit platforms will simplify migration for many of these applications, and fuel the development of additional 64-bit software solutions.

Over the next few years, a variety of additional factors will accelerate the move toward 64-bit computing. The most important is the ongoing explosion in data storage and access requirements, along with the growing need for near real-time processes to improve customer service, productivity, regulatory compliance, and business transparency. The rise of Web Services and Service Oriented Architecture (SOA) is accelerating these developments, by simplifying integration across businesses and supply chains. High volume business transactions are increasingly taking place interactively and in real-time, requiring both high security and fast server response times.

The impact of these trends is magnified by the ongoing proliferation of high-performance client devices, including smart phones, wireless-enabled notebooks, and PDAs. Non-user end-points, such as radio frequency identification (RFID) tags and point of sale devices, are causing a quantum leap in processing, capacity, and data requirements that may ultimately dwarf the end-user-related workloads we know today.2 As these trends converge, 64-bit computing capabilities will become increasingly important for a growing number of mainstream enterprise applications.

The Value of Choice for 64-bit Migration

All 64-bit applications and workloads are not the same. Data, processing, and RAS requirements can vary dramatically. For example, a complex engineering application may access terabytes of data and consume vast processing resources. Yet response times are typically not critical and an isolated system failure may not be catastrophic. An enterprise resource planning (ERP) application, on the other hand, may require less total compute and data resources, yet failure or slow response times may impact thousands of users and cost millions of dollars per minute. In any implementation, it is therefore vital to clearly determine workload and business needs, and to craft a best-fit solution that balances reliability, cost, and performance.

Intel offers two complementary architectural choices that cover the full range of 64-bit requirements. One is Intel Itanium architecture, which is designed for the most demanding and business-critical enterprise and technical applications. The other is the family of Intel Xeon processor based systems with Intel EM64T. Though not equivalent to Itanium architecture in terms of capacity, performance, and RAS, these platforms enable a more gradual migration to 64-bit solutions, since they provide native support for existing, legacy 32 bit applications.3 In most enterprise computing environments, both platforms will be needed.

The new Intel Xeon processor with Intel Extended Memory Technology (Intel EM64T) will trigger a broader shift toward 64-bit solutions. Servers and workstations based on this new processor offer reliable and exceptionally cost effective 64-bit support, while simultaneously providing leading performance for existing 32-bit applications. They deliver a valuable addition to the high-end capabilities of Itanium architecture, and will help reduce 64-bit migration costs for a wide variety of general-purpose enterprise and technical applications.

The move toward 64-bit computing for mainstream applications, will initially focus on applications that are already constrained by 32-bit memory limitations. The challenge for IT organizations is to determine the best architecture for specific solutions, while taking into account total cost and value within the broader IT and business environments. Itanium architecture remains the platform of choice for the most demanding, business-critical data tier applications, such as high-end database and business intelligence solutions. Platforms based on the Intel Xeon processor with Intel EM64T are preferable for general purpose applications, such as Web and mail infrastructure, digital content creation, mechanical computer aided design, and electronic design automation; and for mixed environments in which optimized 32-bit performance remains critical. For some mid-tier enterprise applications, the best choice may not be obvious, and will require a close look at software availability, business drivers, and workloads.

INTEL & LS-DYNA
QA'd by LSTC for LS-DYNA

INTEL IA 32
Linux, Windows

INTEL IA64
Linux

INTEL Xeon EMT64
Linux

Optimizing Performance, Flexibility, and Value with Intel® Itanium® Architecture and Intel® Extended Memory 64 Technology (Intel® EM64T)

Visit the 64-bit Resource Center:

http://www.intel.com/business/bss/products/server/64-bit/resource_center/64-bit.htm

To read the 64-bit Tipping Point article by INTEL, please visit the Intel website:
http://www.intel.com/business/bss/products/server/64-bit_tipping_point.pdf

Product Spotlight - SGI

SGI class performance in a cost-effective Intel® Itanium® 2 cluster

The SGI® Altix® 1350 cluster delivers SGI's award-winning Altix® architecture in a fully-integrated cluster solution. SGI Altix 1350 provides customers with the quality and performance that they've come to expect from SGI —in a cost-effective Intel Itanium 2 processor-based cluster platform. Altix 1350 leverages SGI's NUMAflex™ architecture to uniquely provide a cluster solution that can support the most demanding application mix in a multi-user environment, with unsurpassed scalability in all dimensions.

Achieve world-class performance at a cost-effective price

- Modular architecture that can independently scale processors, memory, and I/O resources on the node for ultimate in system right-sizing and resource efficiency.
- Highly scalable nodes that can handle more real work with fewer systems, dramatically reduces the overall cost of solution by decreasing requirements for interconnect fabric, software licenses, and administration.
- Industry-standard architecture, built on Linux® operating systems and Intel Itanium 2 processors, for the best performance and enhanced investment protection.

Discover Breakthrough Productivity

- Advanced system design leverages the best of large node capability PLUS cluster capacity—with nodes that can scale to 32 processors and 384GB of memory.

- High-performance, shared-memory SGI® NUMAlink™ interconnect technology for unparalleled I/O at 6.4GB/second on each Altix 1350 node virtually eliminates I/O bottlenecks.
- Efficiently supports complex, mixed workloads and dynamic resource requirements—eliminating the need to expend precious resource in decomposing or parallelizing code.

Designed with ease of administration in mind

- Fully integrated cluster solution that includes the industry's leading cluster, interconnect and system management tools from SGI, Voltaire and Scali.
- Large node Altix 1350 clusters result in fewer systems to deploy, manage and provision.
- Comprehensive support for Altix 1350 hardware and system software provided by SGI.

CERTIFIED APPLICATIONS

FEA Information Inc. Participants listed below (complete list can be located at ww.sgi.com)

Applications Certified for SGI® Altix® as of February 7, 2005

The following applications have been certified by the ISV for use with Altix® as of the date shown above.

SGI is working in a high-touch manner with many more ISVs who are developing and often enhancing their applications for the Altix® platform.

Manufacturing

ANSYS Inc.
- ANSYS®
- TASCflow

LSTC
- LS-DYNA®

MSC Software Corp
- Mentat
- MSC Dytran™
- MSC.Marc™
- MSC.Nastran™
- MSC.SuperForm™

Horizontal Software and Hardware

IBM®
- DB2® Universal Database
- Informix® Dynamic Server (IDS)

Intel®
- Intel® C++ Compiler for Linux
- Intel® Fortran Compiler for Linux
- Intel® Integrated Performance Primatives
- Intel® Math Kernel Library
- Intel™ Trace Analyzer
- Intel™ Trace Collector
- Intel® VTune™ Performance Analyzer

FEATURES AND BENEFITS

SGI® Altix® 1350 Cluster delivers SGI class performance and quality in a cost-effective Intel® Itanium® 2 cluster.

Feature	Benefit
Scalable Nodes	Reduce the overall cost of solution, with Altix 1350 nodes that scale to 32 processors and 384GB memory—dramatically decreasing the cost of compute nodes, software license, interconnect fabric, and administration.
Complete Cluster Solution	Achieve immediate productivity, with a fully integrated cluster solution that includes Altix 1350 cluster nodes, Scali Manage™, SGIconsole™ remote multiserver management system and choice of InfiniBand (with VoltaireVision™ Interconnect Manager), Gigabit Ethernet or Quadrics® high-speed interconnect.
Expand on Demand	Seamlessly and independently scale system resources (CPU, I/O, memory) on each node to efficiently meet current and changing compute needs for optimal resource usage.
Large node capability PLUS cluster capacity	Dramatically shorten time to solution by processing large data sets and analytic models using up to 384GB shared memory on each Altix 1350 node—scaling out across Altix 1350 nodes to take full advantage of distributed memory configurations.
High Performance Scale-up/Scale-out	Achieve maximum performance with SGI world-leading 6.4GB/second NUMAflex interconnect technology on each Altix 1350 node. In scale-out configurations, Altix 1350 supports up to eight InfiniBand Host channel Adapters (HCA) on each compute node for unparalleled performance and deployment flexibility.
Advanced Linux Cluster Platform	Leverage the best of open systems, with a choice of Red Hat® EL 4 or SUSE® Linux Enterprise Server 9, and the option of turbo-charging HPC applications with SGI ProPack™ on SUSE Linux Enterprise Server.
Industry-leading HPC Platform	Built on the industry's leading high-performance, 64-bit platform: Intel Itanium 2.
Seamless Growth Path	Easily scale Altix 1350 nodes from 1P to 32P without incurring any additional expense to switch systems or chassis.
Single Source Support	Resolve all hardware and system issues with a single vendor: SGI.
Altix Hybrid Cluster	Maximize productivity and current investment with a solution that combines the power of Altix with 32-bit platforms to effectively meet today's capability and capacity needs while preparing for the 64-bit future of HPC.

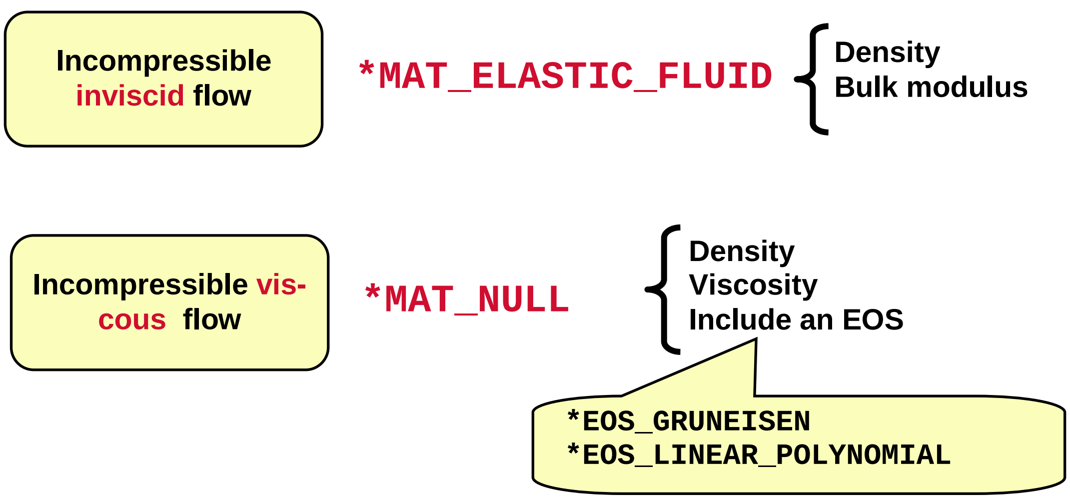
CASTING ANALYSIS

Dr. Arthur B. Shapiro

Casting Modeling

The LS-DYNA ALE formulation allows LS-DYNA to model the fluid filling of a casting. The benchmark problem selected comes from the 7th Conference on Modeling of Casting, Welding, and Advanced Solidification Process, London, England, 10-15 September, 1995. The conference proceedings define a benchmark test for analysis codes. The benchmark test fully defines the problem and presents experimental results including X-ray video of the mold filling. Eight different analysis codes were compared in their prediction of the process.

The first step in using LS-DYNA is to select a material model for incompressible liquid metal flow. There are 2 choices:



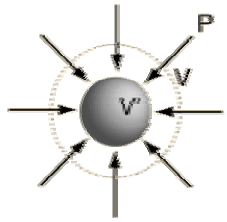
MAT_ELASTIC_FLUID and MAT_NULL only consider the normal (pressure) stresses and neglect the deviatoric (shear) stresses

$$\sigma_{ij} = \overbrace{\underbrace{\sigma^e_{ii}}_{\text{Dilatation (normal)}} + \sigma^e_{ij}}^{\text{Elastic}} + \overbrace{\sigma^p_{ij}}^{\text{Plastic}}$$

Deviatoric (shear): $\sigma^e_{ij} + \sigma^p_{ij}$

The bulk elastic properties of a material determine how much it will compress under a given amount of external pressure. The ratio of the pressure to the fractional change in volume is called the Bulk Modulus (B) of the material.

Bulk Modulus	
Steel	160.e+09 N/m^2
Aluminum	71.3e+09 N/m^2
Water	2.20e+09 N/m^2



$$B = \frac{P}{-\frac{dV}{V}} = \frac{P}{\mu}$$

The material bulk modulus and density are all that is required to use material model *MAT_ELASTIC_FLUID. An equation of state (EOS) is needed for *MAT_NULL. The EOS requires the speed of sound in the material. The propagation speed of traveling waves is characteristic of the media in which they travel. The speed of sound in liquids and solids is predictable from their density and bulk modulus.

Elastic wave speed	
Steel	4512 m/s
Aluminum	5149 m/s
Water	1483 m/s

$$c = \sqrt{\frac{B}{\rho}}$$

Either *EOS_LINEAR_POLYNOMIAL or *EOS_GRUNEISEN can be used to model an incompressible liquid.

EOS_LINEAR_POLYNOMIAL

$$P = C_0 + C_1\mu + C_2\mu^2 + C_3\mu^3 + \left(C_4 + C_5\mu + C_6\mu^2\right)E$$

E = internal energy

For a liquid, set C_1 = B (bulk modulus), and $C_0 = C_2 = C_3 = C_4 = C_5 = C_6 = 0$.

Then, $P = B\mu = \rho c^2 \mu$

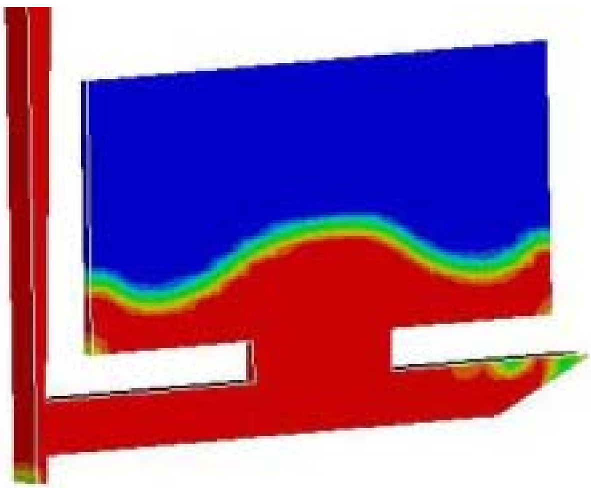
EOS_GRUNEISEN

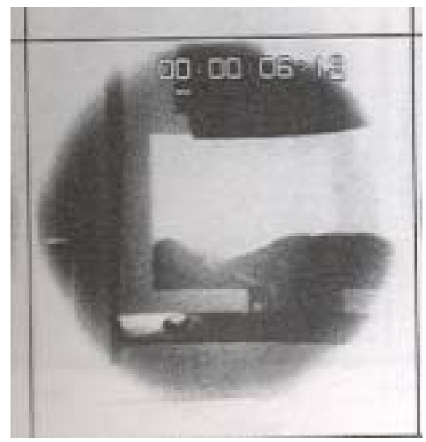
$$P = \frac{\rho_0 c^2 \mu \left[1 + \left(1 - \frac{\gamma_0}{2}\right)\mu - \frac{a}{2}\mu^2\right]}{\left[1 - (S_1 - 1)\mu - S_2\frac{\mu^2}{\mu + 1} - S_3\frac{\mu^3}{(\mu + 1)^2}\right]^2} + (\gamma_0 + a\mu)E$$

For an incompressible liquid, set $S_1 = S_2 = S_3 = a = \gamma_0 = 0$.

Then, $P = \rho c^2 \mu$

The benchmark casting problem was modeled using 8-node solid elements. The elements were defined as ALE with a single material (the flowing aluminum) and void (initial element fill is vacuum) formulation. The inlet mass flow rate is defined in the problem specification. The fill time is 2 seconds. Shown below is the calculated fill pattern at 1 second. Also shown is an X-ray of the experiment from (M. Cross & J. Campbell, Modeling of Casting, Welding, and Advanced Soldification Processes VII, p929, 1995).





AVI Library

AVI #74 of the AVI Library
www.feainformation.com - link on menu bar: AVI Lib

Article is archived in pdf format on:

www.heattransferanalysis.com - Page 3

Website Review

M. Victory

We've chosen this month to highlight one of the many websites dedicated to FEA. Many websites – many types – many applications – many - many. Of the sites that I've visited I found a site called Varmint Al's. Now, this may seem like a hunting website, but far beneath that html exterior I've found Varmint Al is an engineer like many of you.

Direct From the Website of:

Varmint Al's

The Engineer's Golden Rule:

Never use a 1/4 inch bolt where a 1/2 inch bolt will do!

Notice in the music, it's almost as if the tune were divided into a mesh.

Before retiring in 1990, I worked at the Lawrence Livermore National Lab for 30 years. The last few years I was the Advanced Engineering Analysis Group Leader in Weapons Engineering Division. We analyzed very complex structures. Physics developed the concepts and engineering made them deliverable. It was a great job and it was rewarding to help win the Cold War. Before becoming group leader, the last weapon system I worked on was the B-83.

See a web page on the B-83
(http://nuclearweaponarchive.org/Usa/Weapons/B83.html)
and here: (www.atomicmuseum.com/tour/es3.cfm)

This is a page on Deployment
(http://nuclearweaponarchive.org/Usa/Weapons/B83deploy.html)

The critical thinking required for engineering analysis is hard work and is like weight lifting for the brain.

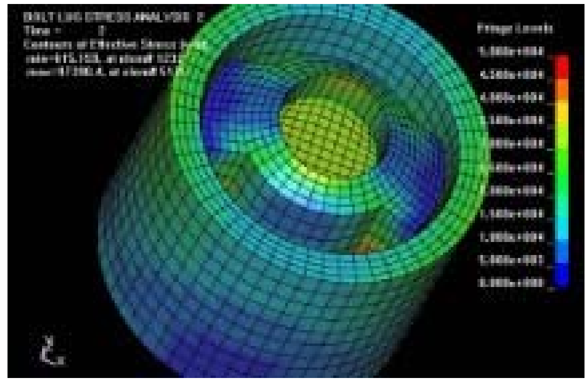
Stolle Panda Bolt Stress and Deflection Analysis

(Full resolution graphics are located at:
http://www.varmintal.com/abolt.htm

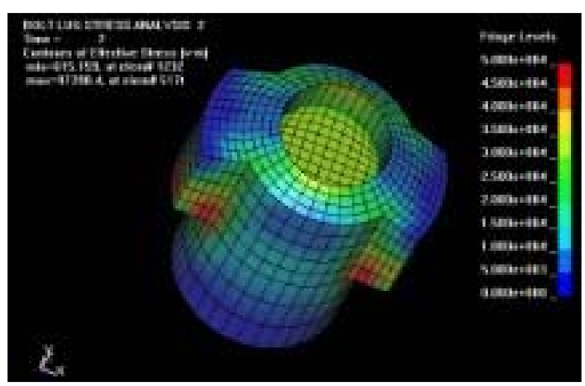
This analysis was done with the LS-DYNA Finite Element Code. This code is a very powerful tool for analyzing the dynamic and static loading of structures.

The loading condition is 50,000 psi on the face of the bolt. This it the equivalent force that would be applied to the bolt face from a 223 Rem caliber with a case head separation. The components in the calculation remain in the elastic state. There is no yielding of the 4041 steel, so the stress levels may be linearly scaled as long as the maximum effective stress level remains below the 120,000 psi yield stress. The dimensions of the model were taken from my Stolle Panda rifle in 23/40 caliber. This caliber is essentially a long neck 223 Ackley Improved with the neck to shoulder junction set back about 0.1". In the model, the Z-axis is inline with the bullet's path, see the triad in the lower left corner of each view. There is info on how could actually measure a representative chamber pressure here: Recreational Software, Inc. Software & Instrumentation Technology for the Shooting Sports (www.shootingsoftware.com).

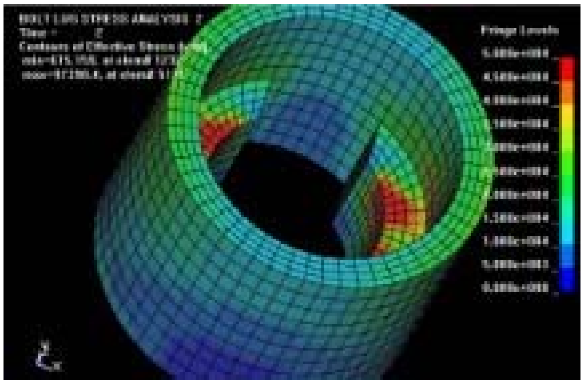
The material properties for the 4140 steel were implemented with a power law hardening model that allows for plastic flow if the effective stress (Huber-Hencky-von-Mises stress) exceeds the 120 ksi yield stress.



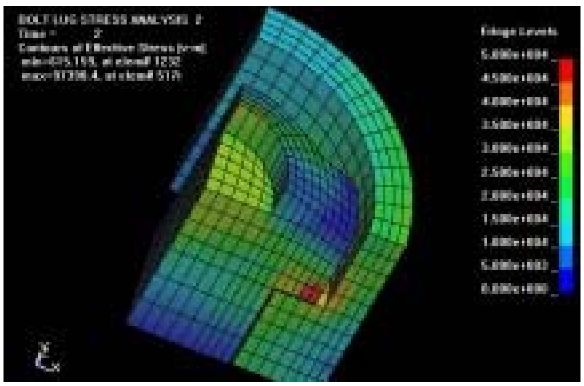
The maximum effective stress level of 97,390 psi is located at the surface of the bolt lugs where they contact the receiver. For 50,000 psi in an intact 223 Rem case, the maximum effective stress level would be about 63,500 psi and well below the yield stress. This view of the bolt, lugs, and receiver does not clearly show the location of the high stresses. In the analysis, the top plane of the receiver, shown in the view, is fixed in the Z-direction and the pressure is applied to the bolt face. For simplicity, the firing pin and hole was not included in the mesh. The contact surface between the bolt lugs and the receiver was modeled with a sliding surface including a 0.3 friction coefficient.



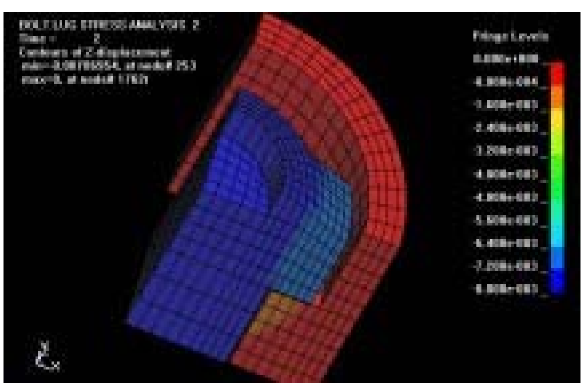
This view of the bolt and lugs, shows more clearly that the high stress levels are located at the lug contact surfaces.



This view of the receiver shelf shows the high contact stress levels where the bolt lugs rest.



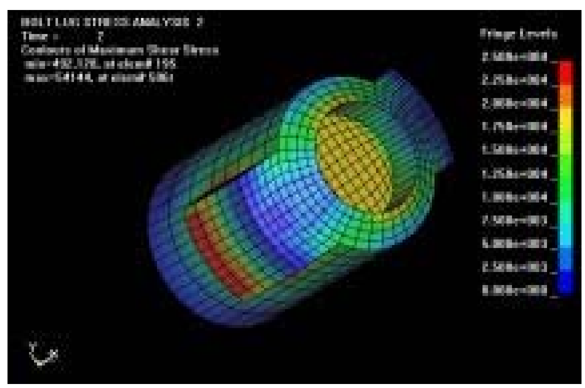
This it the actual mesh used in the calculation. An X-Z plane of symmetry and Y-Z plane of symmetry were used in the model. Using these two planes of symmetry requires a much smaller mesh and gives results identical to what a full 3-D mesh would give.



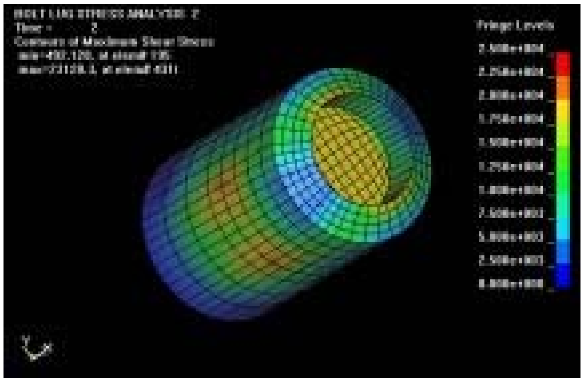
Here are the fringes of axial displacement in the Z direction. The bolt face moves rearward about 0.0077". There is about 0.0002" of slop in the model before the contact surfaces from the bolt lugs to the receiver shelf start to load each other. This was intentional so that when the mesh was being made, certain nodes wouldn't be removed. This displacement with a 50,000 psi pressure on the bolt face would be equivalent to a non ruptured 223 Rem brass case with about 76,600 psi internal pressure. For an intact 223 brass case head with 50,000 psi internal pressure, the bolts rearward deflection would be about 0.005". This amount of bolt deflection is twice that calculated by Dan Lilja of Lilja Precision Barrels,

(http://www.riflebarrels.com/articles/custom_actions/bolt_lug_strength.htm

but his calculation was only for the bolt lugs and did not include the deflections of the lug contact points and a slight amount of stretch in the receiver from the barrel threads rearward. The magnitude of the action's axial deflections is one more reason that the chamber should be low friction and allow the brass case head to contact the bolt face early in the firing sequence.



Finally, this plot shows the fringes of maximum shear in the bolt. However, in this view, one can not view the shear stresses at the junction of the bolt body to bolt lug.



Here the bolt lug has been removed so the shear stresses can be viewed at the base of the bolt lugs. Dan Lilja assumes, in his analysis, that the shear stresses are uniform over the area of the bolt body to lug. Assuming a uniform shear is necessary for a simple stress calculation and gives reasonable results. However with the more detailed calculation, the shear stress are shown to have a maximum near the base of the lugs and decreases to as little as fifth of maximum near the forward end of the bolt. The use of the LS-DYNA code allows one to view and understand more clearly the complicated stress and deflection conditions that structures undergo when resisting service loading.

WHAT IS EFFECTIVE STRESS?.... In structures under load, the stress state is not a simple uniaxial state of stress but a more complex triaxial state of stress. Plastic deformations (also called plastic flow) will occur in a material when the effective stress, σ_{eff} exceeds the uniaxial yield stress. Here is the equation for the effective stress when a triaxial state of stress exists and σ_1, σ_2, and σ_3 are the principal stresses in the three orthogonal directions. The effective strain is ε_{eff}.

$$\sigma_{eff} = (\sqrt{2}/2)\,[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]^{1/2}$$

$$\varepsilon_{eff} = (\sqrt{2}/3)\,[(\varepsilon_1 - \varepsilon_2)^2 + (\varepsilon_2 - \varepsilon_3)^2 + (\varepsilon_3 - \varepsilon_1)^2]^{1/2}$$

1. When all three orthogonal stresses are equal (hydrostatic stress state), the effective stress is zero. There is no yielding.
2. When σ_2 and σ_3 are zero, then the effective stress is the uniaxial stress. This is the stress condition of an axial pull test specimen.

Looking at the equation, one can see some interesting concepts. If there is no tension, but sufficient biaxial compression in the other two directions, then there could be axial yielding in extension in the third direction. (This is like squeezing a cylinder of putty in your hand and having it squirt out each end).

WHEN YIELDING OCCURS.... One can visualize yielding as a cylinder in 3-D space. The axis of the cylinder is the line of the hydrostat. It is a line where $\sigma_1 = \sigma_2 = \sigma_3$. When the triaxial stress state deviates from the hydrostat line but stays within the cylinder, there is no yielding. When the triaxial stress state deviates from the hydrostat outside of the cylinder then yielding occurs.

NO YIELDING IN HYDROSTATIC COMPRESSION.... When a metal is in hydrostatic compression (immersed in a fluid and the pressure increased), there is no yielding, no matter how high the pressure. With a real material, micro voids would be closed and at extremely high pressures, the crystal structure could be changed, such as converting carbon to a diamond. These pressures are beyond those normally considered in engineering analysis of the strength of structures.

NO YIELDING IN HYDROSTATIC TENSION.... When a metal is in hydrostatic tension, in theory, there is no yielding. I can't think of any realistic way to apply extremely high hydrostatic tensions. The limiting point would be the bond strength of the atoms in the crystals.

Finally... The rifle bolt and lugs are in a complicated triaxial stress state at each location and the FEA codes determine this for each tiny element. The back-of-the-envelope p/a type calculations are of little value in accurately predicting and understanding what is happening during loading such structures where a triaxial state of stress exists.

Good Hunting... from Varmint Al

www.varmintal.com

ASIA Pacific News

This Month's News features: FEA Information – SGI - INTEL

FEA Information China - www.feainformation.cn

We would like to welcome, as a China Participant, Altair China

FEA Information China Participants Software/Services/Hardware/Universities

Altair Engineering Software (Shanghai) Co., Ltd.	**Richard Yen** **Tel: +86 (0)21 5383 0011** **Website: www.altair.com.cn** **Contact: support@altair.com.cn** **Contact: sales@altair.com.cn)**
Ansys-China, Inc.	**Tel: 86-10-84085558** **Website: www.ansys.com.cn** **Contact: China@ansys.com.cn**
Beijing Yuntong Forever CPC. Co. Ltd.	**Tel: +86-10-82561200/01/03** **Website: http://cpc.ytforever.com** **Sole Distributor of LINUX NETWORX, INC. (USA) in China|** **Contact: service@ytforever.com**
Engineering Technology Associates (China) Inc.	**Martin Ma** **Tel: + 86-21-64385725** **Contact: support@eta.com.cn**
Hewlett-Packard Asia Pacific Ltd.	**Jerry Huang** **Tel: +86-10-65645261** **Contact: J.Huang@hp.com**
IBM China	**Ms. Ling WANG -** **Tel: +86-10-6539-1188 x4463 (T/L:901-4463)** **Website: http://www.ibm.com/cn/** **Contact: wangling@cn.ibm.com**
MSC. Software Corp.	**Tel: +86-10-6849-2777** **Website: www.mscsoftware.com.cn** **Contact: msc.contact@mscsoftware.com.cn**
SGI China	**Carl Zhang** Tel: **+86 -10 - 65228868 Ext. 3362** **Contact:** carl@sgi.com
Tsinghua University	**Qing Zhou, PhD. - Professor** **Department of Automotive Engineering** **Beijing, 100084, China**

SGI - KOREA

Hyundai Motor Company Selects SGI Altix Servers to Improve New Car Design and Analysis

Hyundai Motor Company Deploys SGI Altix Supercomputers Powered by 148 Intel Itanium 2 Processors—The Largest CAE Supercomputer Purchase This Year In Korea

SEOUL, Korea and MOUNTAIN VIEW, Calif., (January 27, 2005)—In recent years, the model size of automobile design and analysis has become larger and more complex than ever before - from thousands of model elements in a single automobile design to millions of detailed elements. These influences have driven the need for high performance computing power with faster I/O, faster bandwidth and higher scalability in the automobile industry. To address these industry challenges, Hyundai Motor Company, the number one motor company in Korea, has purchased computing and storage solutions from Silicon Graphics Korea...(The complete article is available at www.sgi.com)

INTEL - CHINA

Intel has an active presence throughout China where its employees are involved in research and development, customer support and marketing, product assembly and testing, and corporate programs. They also support community projects and volunteer their time for community activities.

Shanghai

Intel's largest site in China is Shanghai, where the company currently operates two campuses and is planning a third.

Intel’s assembly and testing facility in Shanghai is located at the Waigaoqiao Free Trade Zone in Pudong District. Assembly and testing services take place in three factories operated by the Assembly and Test Division of Intel's Technology and Manufacturing Group.

In addition to assembly and test services, employees at the Shanghai Pudong campus also develop new production process technologies and new platform configurations and applications. They also perform customer services. This work involves employees of Assembly Technology Development, Flash Products Group, Enterprise Platforms Group, Platform Architecture and Solutions Division, Mobile Platforms Group, and others.

At Shanghai Mart in Changning District, Intel employees are engaged in hardware and software research, marketing, and administration. Among the Intel organizations represented are Software and Solutions Group, Sales and Marketing Group, Enterprise Platform Group, Desktop Products Group, Intel Communications Group, Consumer Electronics Group, Mobile Platforms Group, Corporate Services, and Information Technology.

In 2005, employees involved in research and development will move to a new Intel campus at Shanghai Zizhu Science-Based Industrial Park in Minhang District.

Chengdu

In 2004, Intel began to construct an assembly and test factory in Chengdu in western China's Sichuan Province. The factory is scheduled to begin operations in 2005. Intel CEO Craig Barrett and local community leaders took part in the ceremonial groundbreaking ceremony April 7, 2004.

Beijing, Shenzhen and Beyond

In mainland China, Intel also has research and development, marketing and administrative offices in Beijing, customer support facilities in Shenzhen, and offices in other cities, including Chongqing, Fuzhou, Guangzhou, Harbin, Jinan, Nanjing, Shenyang, Wuhan, and Xi’an. Among the organizations represented are Intel's Sales and Marketing Group, Corporate Technology Group, Human Resources, Finance, and others.

Corporate Programs

Based in Beijing, Intel China's corporate programs in the country include Government Affairs, Press Relations, Intel Education and Intel Capital. Based in Shanghai, Intel's Public Affairs programs in China include local government affairs, Intel Involved volunteer programs, community programs and donations.

Industry News

MSC.Software Corporation

(excerpt: full article can be read on www.mscsoftware.com)

William J. Weyand to Succeed Frank Perna as Chairman and CEO of

MSC.Software Corporation

SANTA ANA, Calif., - February 11 - MSC.Software Corp. (NYSE: MNS),..., today announced that its Board of Directors has appointed William J. Weyand, an experienced software industry executive, as its new Chief Executive Officer and Chairman of the Board of Directors. He succeeds Frank Perna who will be retiring as CEO and Chairman....

Hewlett-Packard Company

(excerpt: full article can be read on www.hp.com)

Carly Fiorina Resigns

Former Chairman and Chief Executive Officer

In July 1999, Carly Fiorina joined HP as chief executive officer, and was named chairman a year later. She resigned from her position on February 8, 2005.

ANSYS 9.0 Now Available

Integrated Product Development Environment

...Workbench 9.0 is the first ANSYS software release featuring electromagnetics capability, CFD and mesh creation technologies of CFX and ICEM CFD with the structural analysis capability. Additionally, Workbench 9.0 offers enhanced mechanics and materials data.

... ANSYS 9.0 offers significant new advances in integrating core technology within its ANSYS Workbench environment. Developments within the Workbench environment, offers users enhanced productivity and integrated solutions within its related products suites. Enhancements in parametric modeling, CAD data manipulation, engineering data handling and design for six sigma offers users advanced tools in areas of low frequency electromagnetics, nonlinear analysis and robust design...(For Complete Information visit: www.ansys.com)

EVENTS

Feb 14-17, 2005
LinuxWorld

March 16, 2005
MSC.Software Motorsports Seminar - Mooresville, North Carolina, USA

March 18, 2005
LS-DYNA and Optimization Korean Conference (KOSTECH)

April 5-7, 2005
Westec 2005 Technical Conference - Los Angeles, California, USA

April 11-14, 2005
SAE Global Congress - Detroit, Michigan, USA

May 10, 2005
16th Annual HP Technology Trend in Automotive Engineering Symposium
Plymouth, MI

May 31 – June 03, 2005
Dresden, Germany
Third Joint ANSYS CFX & FZR Workshop on Multiphase Flows

May 17-20, 2005
LeMeridien, St. Julians, Malta
NAFEMS World Congress

May 25-26, 2005
5th European LS-DYNA Conference
The ICC, Birmingham UK (ARUP)

June 06-09, 2005
Westin Harbour Castle, Toronto, Ontario, Canada
AIAA Fluid Dynamics Conference & Exhibit

June 6-10, 2005
HP Software Forum, Denver, CO

June 13-17, 2005
Group (SGIUG) – Munich Germany

June 25-27, 2005
8th U.S. National Congress on Com;utational Mechanics, Austin, TX

November 25
Korean Users Conferece –
LS-DYNA (THEME)

November 29-30, 2005
Japanese Users Conference (Nagoya) LS-DYNA (JRI)

June 2006
LS-DYNA
9th International LS-DYNA Users Conference – Deerborn, MI (LSTC)

LS-DYNA Resource Page

Interface - Hardware - OS And General Information

LS-DYNA General Information- www.lstc.com sales@lstc.com

Version: 970

Classes:
www.lstc.com classes

30-day demonstration licenses available – no fee

Sales
sales@lstc.com

Participant Hardware and OS that run LS-DYNA (alpha order)

All Hardware and OS listed have been fully QA'd by Livermore Software Technology Corporation

AMD Opteron Linux	HP PA8000 HPUX	INTEL IA32 Linux, Windows	SGI Mips IRIX6.5
CRAY XD1 Linux	HPIA64 HPUX or Linux	INTEL IA64 Linux	SGI IA64 Altix
FUJITSU Prime Power SUN OS 5.8	HP Alpha True 64	INTEL Xeon EMT64 Linux	
FUJITSU VPP Unix_System_V	IBM Power 4/5 AIX 5.1	NEC SX6 Super-UX	

LS-DYNA Resource Page

Participant Software Interfacing or embedding LS-DYNA

Each software program can interface to all, or a very specific and limited segment of the other software program. The following list are software programs interfacing to or having the LS-DYNA solver embedded within their product. For complete information on the software products visit the corporate website.

ANSYS - ANSYS/LS-DYNA
www.ansys.com/products/environment.asp

ANSYS/LS-DYNA - Built upon the successful ANSYS interface, ANSYS/LS-DYNA is an integrated pre and postprocessor for the worlds most respected explicit dynamics solver, LS-DYNA. The combination makes it possible to solve combined explicit/implicit simulations in a very efficient manner, as well as perform extensive coupled simulations in Robust Design by using mature structural, thermal, electromagnetic and CFD technologies.

AI*Environment: A high end pre and post processor for LS-DYNA, AI*Environment is a powerful tool for advanced modeling of complex structures found in automotive, aerospace, electronic and medical fields. Solid, Shell, Beam, Fluid and Electromagnetic meshing and mesh editing tools are included under a single interface, making AI*Environement highly capable, yet easy to use for advanced modeling needs.

ETA – DYNAFORM
www.eta.com

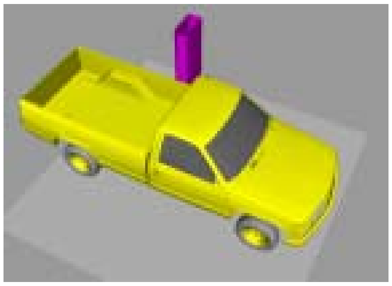
Includes a complete CAD interface capable of importing, modeling and analyzing, any die design. Available for PC, LINUX and UNIX, DYNAFORM couples affordable software with today's high-end, low-cost hardware for a complete and affordable metal forming solution.

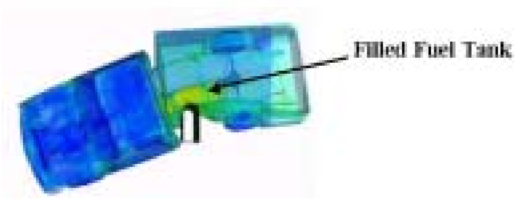
ETA – VPG
www.eta.com

Streamlined CAE software package provides an event-based simulation solution of nonlinear, dynamic problems. eta/VPG's single software package overcomes the limitations of existing CAE analysis methods. It is designed to analyze the behavior of mechanical and structural systems as simple as linkages, and as complex as full vehicles

MSC.Software
"MSC.Dytran LS-DYNA"
www.msc.software.com

Tightly-integrated solution that combines MSC.Dytran's advanced fluid-structure interaction capabilities with LS-DYNA's high-performance structural DMP within a common simulation environment. Innovative explicit nonlinear technology enables extreme, short-duration dynamic events to be simulated for a variety of industrial and commercial applications on UNIX, Linux, and Windows platforms. Joint solution can also be used in conjunction with a full suite of Virtual Product Development tools via a flexible, cost-effective MSC.MasterKey License System.





Side Impact With Fuel Oil Inside

MSC.Software - MSC.Nastran / SOL 700

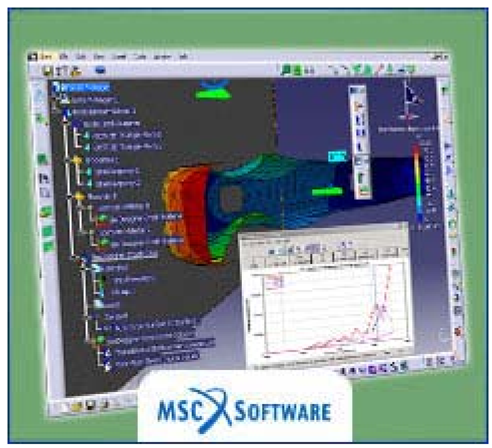
The MSC.Nastran™ Explicit Nonlinear product module (SOL 700) provides MSC.Nastran users the ability access the explicit nonlinear structural simulation capabilities of the MSC.Dytran LS-DYNA solver using the MSC.Nastran Bulk Data input format. This product module offers unprecedented capabilities to analyze a variety of problems involving short duration, highly dynamic events with severe geometric and material nonlinearities.

MSC.Nastran Explicit Nonlinear will allow users to work within one common modeling environment using the same Bulk Data interface. NVH, linear, and nonlinear models can be used for explicit applications such as crash, crush, and drop test simulations. This reduces the time required to build additional models for another analysis programs, lowers risk due to information transfer or translation issues, and eliminates the need for additional software training.

The MSC.Nastran Sol 700 will be released in November 2005. Beta release is available now !

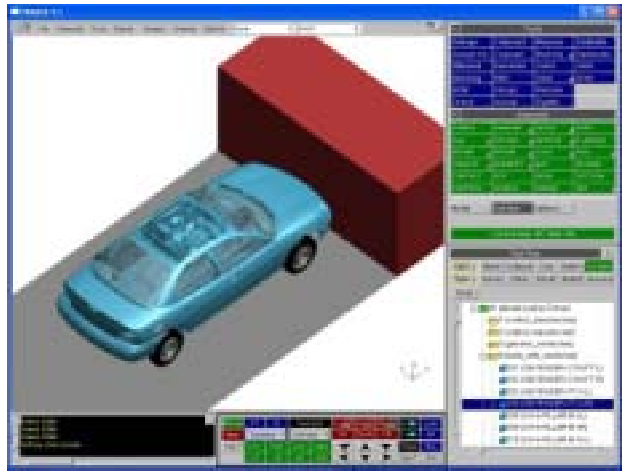
MSC.Software – Gateway for LS-DYNA

Gateway for LS-DYNA provides you with the ability to access basic LS-DYNA simulation capabilities in a fully integrated and generative way. Accessed via a specific Crash workbench on the GPS workspace, the application enhances CATIA V5 to allow finite element analysis models to be output to LS-DYNA and then results to be displayed back in CATIA. Gateway for LS-DYNA supports explicit nonlinear analysis such as crash, drop test, and rigid wall analysis.



Gateway products provide CATIA V5 users with the ability to directly interface with their existing corporate simulation resources, and exchange and archive associated simulation data.

Oasys software for LS-DYNA
www.arup.com/dyna



Oasys software is custom-written for 100% compatibility with LS-DYNA. Oasys PRIMER offers model creation, editing and error removal, together with many specialist functions for rapid generation of error-free models. Oasys also offer post-processing software for in-depth analysis of results and automatic report generation.

LS-DYNA Metal Forming Technologies

Publications 2004 & 2003 LS-DYNA Conferences:

2004 8th International LS-DYNA Users Conference

Review of Sheet Metal Forming Simulation – Progress to Date, Future Developments
Trevor Dutton, Dutton Simulation Ltd.

An Eulerian Finite Element Model of the Metal Cutting Process
Raczy, Dept. of Mechanical, Automtoive and Materials Engineering,
(University of Windsor)

Determination of Optimal Cutting Conditions in Orthogonal Metal Cutting Using LS-DYNA with Design of Experiments Approach
David P. Masillamani, Dept. of Mechanical and Industrial Engineering
(University of Texas at El Paso)

Simulation and Analysis of the Beverage Can Necking Process Using LS-DYNA
Jordan-Cordera, Mechanical Engineering Dept.
(ITESM, Campus Toluca)

Learning Module for Using DYNAFORM ® to Study The Effects of Die-Entry and Punch-Nose Radii on Drawing Cups
W.K. Waldron, Mechanical Engineering Department,
(Kettering University)

Computer Simulated and Experimental Verification of Tooling For Progressive Deep Drawing
Peter Kostka,
(Slovak Univ. of Tech. In Braitislava, Fadulty of Mechanical Engineering, Dept. of Materials & Technologies

Numerical Simulation of Aluminum Alloy forming Using Underwater Shock Wave
Hirofumi Iyama
(Dept. of Mech. And Elec. Engineering, Yatsushiro National College of Techonology)

Through Process Modelling of Self-Piercing Riveting
R. Porcaro,
(Structural Engineering, Norwegian Univ. of Science and Technolog)

Application of FEA in Stamping Auto Underbody Parts
Yuyuan Wang,
(Canadian Engineering & Tool)

The Dynamic Problems in High Speed Transfer Stamping Systems
Ming-Chang Yang,
(Metal Industries Research and Development Center, Taiwain)

A New Concept on Stamping Die Surface Compensation
Li Zhang
(Theme Development Dept., Advance Stamping Manufacturing Engineering, DaimlerChrysler Corporation)

2003 4th European LS-DYNA Users Conference

Stress Analysis of Connector PIN Produces by Reverse Stamping Process with LS-DYNA Numerical Simulation and Comparison to Experiments
Won Y.-H
(LG-Cable Ltd)

Finite Element Analysis of Stresses Due to Normal and Sliding Contact Conditions on an Elastic Surface
RamA., Prof. Dr. Danckert J., Faurholdt T.G.
(University of Aalborg)

Sheet Metal Forming: Spring-back of hydro mechanical deep drawn parts
Buchert J., Prof. Dr. Harrison D.K., Dr. DeSilva A.K.M., Prof Dr. Bauer H.
(Aalen University of Applied Science)

Simulation of the Forming Process of Metal-Plastics-Metal Sheets
Dr. Borg R.
(Engineering Research Nordic AB)

Newly Developed Capabilities of DYNAFORM Version 5.0
Tang A.
(ETA)

Finite Element Analysis of Superplastic Forming Process Using LS-DYNA
Samekto H. (Univ. of Stuttgart); Prof. Dr. Roll K. (Daimler Chrysler AG)

Forming to Crash Simulation in full Vehicle Models
Dr. Cafolla J., Hall R.W., Norman D.P., McGregor I.J.
(CorusAutomotive Engineering)

Influence of The Effect of Strain Rates on Springback in Aluminum 2024 (ISO AICu4Mg1)
Kulkarni P., Prabhakar S.
(Cessna Aircraft Company)

Process Optimised FEA-Calculations for Hydroforming Components
Keigler M., Prof. Dr. Hall R., Prof Dr. Mihsein M., Prof Dr. Bauer H.
(Aalen University of Applied Science)

More Realistic Virtual Prototypes by Means of Process Chain Optimization
Gantner P., Prof. Dr. Harrison D.K., Dr. DeSilva A.K.M., Prof. Dr. Bauer H.
(Aalen University of Applied Science)

Virtual Die Tryout of Miniature Stamping Parts
Yang M.-C., Tasi T.-C.
(Metal Industries R&D Center)

Sheet Metal Forming in a Virtual Reality Environment using LS-DYNA and Neural Networks
Gokhale A.
(University of Wichita)

Manufacturing Simulation of an Automotive Hood Assembly
Dr. Galbraith C.
(Metal Forming Analysis Corp/Medusa Comp. Corp);
Thomas D.
(Metal Forming Analysis Corp.)

A Method for Modifying the Forming Tool Geometry in Order to Compensate for Springback Effects
Jemberg A. (Engineering Research Nordic AB)

LS-DYNA Conference Publication Information

FEA Publications: **www.feapublications.com**

DYNALOOK: **www.dynalook.com /**

Hardware & Computing and Communication Products

www.amd.com

www.fujitsu.com

www.hp.com

www-1.ibm.com/servers/deepcomputing

www.intel.com

www.nec.com

www.sgi.com

www.cray.com

Software Distributors

Alphabetical order by Country

Australia	**Leading Engineering Analysis Providers** www.leapaust.au
Canada	**Metal Forming Analysis Corporation** www.mfac.com
China	**ANSYS China** www.ansys.cn
China	**MSC. Software – China** www.mscsoftware.com.cn
Germany	**CAD-FEM** www.cadfem.de
Germany	**Dyna*More*** www.dynamore.de
India	**GissETA** www.gisseta.com
India	**Altair Engineering India** www.altair.com
Italy	**Altair Engineering Italy** www.altairtorino.it
Italy	**Numerica SRL** www.numerica-srl.it
Japan	**Fujitsu Limited** www.fujitsu.com
Japan	**The Japan Research Institute** www.jri.co.jp
Japan	**CRC Solutions Corp.** http://www.engineering-eye.com
Korea	**Korean Simulation Technologies** www.kostech.co.kr
Korea	**Theme Engineering** www.lsdyna.co.kr

Software Distributors (cont.)

Alphabetical order by Country

Russia	**Strela, LLC** www.ls-dynarussia.com
Sweden	**Engineering Research AB** www.erab.se
Taiwan	**Flotrend** www.flotrend.com.tw
Turkey	**FIGES** www.figes.com.tr
USA	**Altair Western Region** www.altair.com
USA	**Engineering Technology Associates** www.eta.com
USA	**Dynamax** www.dynamax-inc.com
USA	**Livermore Software Technology Corp.** www.lstc.com
USA	**ANSYS Inc.** www.ansys.com
UK	**Oasys, LTC** www.arup.com/dyna/

Consulting And Engineering Services

Alphabetical Order By Country

Australia Manly, NSW www.leapaust.com.au	**Leading Engineering Analysis Providers** Greg Horner info@leapaust.com.au 02 8966 7888
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Informational Websites

FEA Informationwebsites	www.feainformation.com
TopCrunch – Benchmarks	www.topcrunch.org
LS-DYNA Examples (more than 100 Examples)	www.dynaexamples.com
LS-DYNA Conference Site	www.ls-dynaconferences.com
LS-DYNA Publications to Download On Line	www.dynalook.com
LS-DYNA Publications	www.feapublications.com
LS-DYNA Forum	http://portal.ecadfem.com/Forum.1372.0.html
LS-DYNA CADFEM Portal	http://www.lsdyna-portal.com

Archived News Page

January 3rd

- **ETA**: CAE Software Products
- **Oasys**: Primer
- **Flotrend**: Taiwan, sales, consulting, training

January 10

- **HP**: Remote Workstations Solutions - 2D and 3D Graphics, anywhere, anytime
- **INTEL**: The Intel® Pentium® 4 Processor provides the performance, quality, and reliability demanded by consumer and business customers.
- **KOSTECH**: Korea – sales, consulting, training

January 17

- **FUJITSU**: Time to stop monkeying around with your information management
- **AMD**: The AMD Athlon™ MP processor for workstations provides exceptional performance on demanding applications
- **DYNAmore**: Germany – sales, consulting, training

January 24

- **NEC**: NEC Corporation today announced the worldwide launch and availability of the SX series model "SX-8,"
- **ANSYS**: ANSYS Workbench is a desktop simulation tool that enables you to perform more product development tasks faster.
- **Altair** Italy: Italy- sales, consulting, training

January 31

- **IBM**: All of IBM Deep Computing solutions leverage IBM's long-standing leadership in supercomputing.
- **Numerica** SRL: Italy, sales, consulting, training