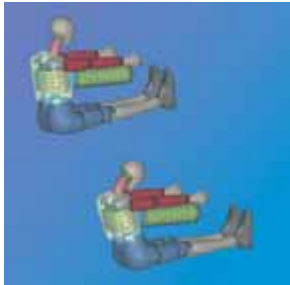


MAY  
2005

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## COVER STORY

ANSYS

ANSYS ICEM CFD ON SUPERCOMPUTER

HELPS DESIGNERS 'CUT CORNERS'

IN RACE CAR DESIGN



## TECHNICAL SPOTLIGHT

AMD

MULTI-CORE PROCESSORS

REPRESENT A MAJOR EVOLUTION

IN COMPUTING TECHNOLOGY

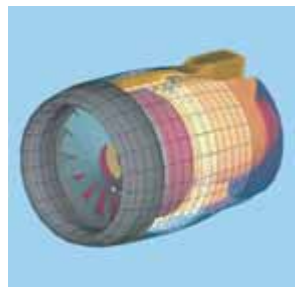


## ANALYSIS SPOTLIGHT

BIRD STRIKE ON A

COMPOSITE JET

ENGINE INLET



## FEA Information Worldwide Participant's



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## FEA Information Announcements

**Conference CD:** You can sign up now for the 5<sup>th</sup> European LS-DYNA Conference CD. There is no fee and shipping is free. Anticipated shipping is late June.

[www.ls-dynaconferences.com](http://www.ls-dynaconferences.com)

The link for the sign up form is on the side menu

Information for the 2006 Conference will be posted in August

### Travel:

Our news is being published a week early due to travel by Marsha Victory and Dr. Arthur Shapiro to attend the 5th European LS-DYNA Conference UK 05/25-26/05 (Arup). Please feel free to locate them and discuss articles or ideas for FEA Informational websites.

### Training:

LSTC Michigan is pleased to announce the first two training courses available at their Michigan location:

Implicit LS-DYNA, May 25-27

Introduction to LS-DYNA, June 8-10

For information:

Training Class Coordinator Jane Hallquist [classes@lstc.com](mailto:classes@lstc.com)

**Sincerely,**  
*Trent Eggleston & Marsha Victory*

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## ANSYS ICEM CFD on Supercomputer Helps Designers 'Cut Corners' in Race Car Design

© Copyright ANSYS Inc.



**Photo showing key areas of the Pratt & Miller - General Motors C5R Corvette from the 2002 racing season that impact fluid flows.**

### Challenge:

Designing and engineering racecars requires, like anything else, prototyping and testing. Problem is, building prototypes and putting them through the necessary aerodynamic tests in wind tunnels can easily top \$1 million. Aletheon Technologies LLC eliminated these costs and developed far more detailed data for future racecar designs.

### Solution:

Move the aerodynamic design analyses and testing away from prototypes and wind tunnels to ANSYS® ICEM CFD as a pre- and post-processor for computational fluid dynamics problems that take a supercomputer to solve.

### Benefits:

By using CFD to optimize and balance the two key aerodynamics forces in race-downforce and drag-cars built by Aletheon's parent company, Pratt &

Miller Engineering, hug the track more tightly and corner faster. And it's in the corners that races are won and lost.

### Introduction

It's not just how fast a racecar goes that makes a design a winner, it's also how fast it goes around the curves. In large part, speed in the curves is a function of how much "downforce" is created by air flowing over the car's surfaces.

Thus much of the computational fluid dynamics (CFD) analysis of race cars has to do with making sure the airflow pushes down on the car as it does with how smoothly the car slips through the air. The major benefit of CFD in auto racing: Cutting down the high costs of building prototype cars and physically testing in them in wind tunnels and on race tracks.

Aletheon Technologies LLC, Mooresville, North Carolina, has long been a leader in applying CFD to racecars. Since early

2002 it has been part of Pratt & Miller Engineering, New Hudson, Michigan. Pratt & Miller designs, develops, builds, racecars "from a blank sheet of paper to the victory circle" for General Motors, Ford and DaimlerChrysler, among others.

CFD models the layer of surface flow that is as thin as 0.0001 inch. But with all the vortexes and friction, this flow is so complex that over 30 million points- corresponding to degrees of freedom in conventional finite element modeling-to model an entire racecar is modeled. CFD solutions for a racecar model require the equivalent of computing's racetrack, a supercomputer.

"At the current state of development for CFD, the more points the better," explained Dr. David F. Robinson. "Computationally speaking, what happens with each element effects all of its neighbors and, in fact, everything else in the model." An alumnus of the Department of Defense CFD programs, Dr. Robinson has built his own supercomputer, nicknamed Hannibal, with 210 Intel Corp. Xeon CPUs.

Dr. Robinson also built his own solver, called Raven, which is marketed by Aletheon in conjunction with ANSYS CFX based in Waterloo, Ontario, Canada.

## **Challenge**

Aletheon models the entire car body-tires, wheel tubs, cockpit, underbody, shock absorbers, exhaust manifold, radiator-any surface that air passes over, under or through.

CFD's tedious and time-consuming gridding, or meshing, and its pre-processing is handled by ANSYS ICEM CFD from ANSYS, Inc.

"The main reason we model the entire car all at once instead of a single com-

ponent at a time, is due to the fully coupled nature of the solution," Dr. Robinson explained. "Since the air flow of a racecar is subsonic, information can propagate in all directions. This means changes in the rear-wing can, and often do, have strong influence on the aerodynamics of the front of the vehicle. Therefore, you cannot do an analysis of the wing independent of the other components."

The enormous files are generated because every racecar surface over which air flows has to be modeled. A rule of thumb in solving models of this complexity is that every million data points requires a gigabit of RAM, hence the supercomputer. Most other Aletheon models are in the range of 250,000 to 300,000 points. If yawing is not a factor in a given analysis, the model for an entire car can be sliced lengthwise, halving the model to 15 million points.

## **Solution**

"We put most of our CFD emphasis on improving downforce and making sure this downforce is balanced around the vehicle's center of gravity" or CG. He emphasized, "the distribution of both drag and downforce around the CG is as important as the actual drag and downforce numbers."

The sanctioning body of a given racing series, and its insurers often limits top-end speed. "The overall aerodynamic performance envelope-drag-is strictly controlled by the sanctioning body," he added. "We use ICEM to expand this envelope."

An important ICEM CFD capability for Aletheon is geometry tolerance, the ability to computationally ignore gaps and overlaps when gridding. This great simplifies and speeds up that up.

Also important to Dr. Robinson is the fact that ICEM is a top-down modeler, whereas the vast majority of the others are bottom-up. "ICEM starts by putting a tetrahedral volume around the object you are modeling and then subdivides and re-subdivides the grid until you are done," Dr. Robinson noted.

"Bottom-up models require trimming all surfaces together and then laying hundreds of thousands of tiny triangles over these surfaces and marching them outward. If there is a hole or an overlap in the geometry, it cannot be ignored as with ICEM. You have to back to the CAD or solid modeler [Unigraphics, CATIA, SolidWorks or Rhino 3D], repair the geometry, then re-import the new geometry [with IGES, STEP, or the SolidWorks direct translator] and then and restart the gridding.

### **Benefits**

The speed and power of ICEM lets Aletheon build better models. "ICEM lets us model directly on the CAD data rather than rebuilding the geometry model in the pre-processor," Dr. Robinson said. "You get an accurate representation rather than an approximation. Human error is eliminated along with inaccurate interpolations for lofted curves. And ICEM helps use make sure we have all the right elements in all the right places."

Aletheon's analyses are used mainly to cut down on wind tunnel tests and building and testing prototypes. "Just to build a one-half scale model and all of the test parts needed for a year of wind tunnel tests might cost upwards of \$500,000," said Dr. Robinson. "Rent for a wind tunnel for one day can be north of \$20,000. On top of that you still need to bring in half a dozen test engineers" to set up, monitor and interpret the results.

"Wind tunnel tests give you the total drag, the drag of the airflow over the entire vehicle and the total downforce," he noted. "This does not accurately simulate a race car's operating environment unless you also model the physics of the road rolling under the car. To do this, a 'rolling-road' wind tunnel must be used." In addition, to the global vehicle data provided by a wind-tunnel, CFD also provides the drag and downforce of every single component, even the left rear tail-light, if you need that information.

"Each CFD run may take several days, but you get significantly more data from each run," Dr. Robinson pointed out. "The entire flowfield is captured and can be viewed using a post-processing tool. With wind tunnel testing's global data results, this can't be done very effectively.

Starting the design process using CFD lets Aletheon learn enough about the problem to put bounds around the amount of additional testing that will be required. "We use CFD to narrow our choices to only those that have the highest likelihood of improving the performance of the vehicle," he continued.

"Building a prototype car costs \$400,000 to \$600,000," Dr. Robinson noted. "Testing it means a lot of other costs" such as renting a track, expert personnel, travel, insurance, etc. Moreover, CFD analyses can be carried on while the car is being designed, long before any metal is cut or components assembled.





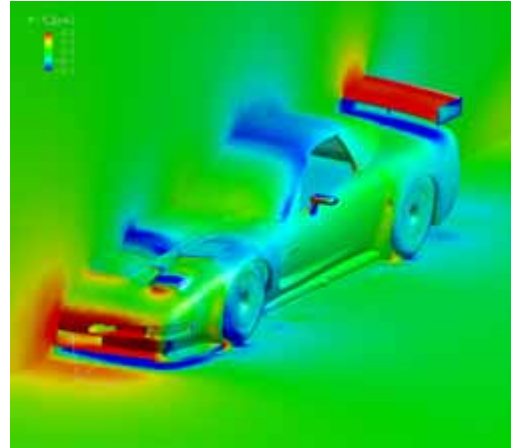
Photo showing key areas of the Pratt & Miller - General Motors C5R Corvette from the 2002 racing season that impact fluid flows.

**Image courtesy of Mindfeed® Marcomm, Santa Fe, N.M.**



Detail of the ICEM CFD - RAVEN computation. All the relevant features have been adequately resolved.

**Image courtesy of Aletheon Div., Pratt & Miller, Mooresville, N.C.**



The surface mesh from ANSYS ICEM CFD used for the RAVEN solver calculations. There is a very high level of fidelity in this grid.

**Image courtesy of Aletheon Div., Pratt & Miller, Mooresville, N.C.**

## Multi-core Processors Represent a Major Evolution in Computing Technology. [www.amd.com](http://www.amd.com)



**Placing two or more powerful computing cores on a single processor opens up a world of important new possibilities. Learn about the evolution of multi-core technology and its advantages.**

### **The Evolution of Multi-Core Technology**

With the introduction of the first computer came market demands for more computing capacity. Symmetrical multiprocessing (SMP) has long been a technology used to increase computing performance and efficiency by spreading computing loads across multiple processors. SMP is especially effective in multi-threaded environments where many tasks (threads) need to be handled simultaneously.

As application performance demands grow, processor designers are facing the issue that it takes more power to drive more computing capability. More power means that dissipation levels also need to be managed. Add to this the demands of the industry for computers to become smaller more servers in a rack, thin and lighter laptops, and smaller footprint for a desktop system. Multi-core processing will help address these computing challenges. This evolution in technology will allow for increased performance and higher productivity in smaller computers that can simultaneously run multiple

complex applications and successfully complete more tasks in a shorter amount of time.

### **The Multi-Core Advantage**

In today's digital world the demands of complex 3D simulations, streaming media files, added levels of security, more sophisticated user interfaces, larger databases, and more on-line users are beginning to exceed single-core processor capabilities.

Multi-core processors enable true multi-tasking. On single-core systems, multi-tasking can max out CPU utilization, resulting in decreased performance as operations have to wait to be processed. On multi-core systems, since each core has its own cache, the operating system has sufficient resources to handle most compute intensive tasks in parallel.

Multi-core technology can improve system efficiency and application performance for computers running multiple applications at the same time.



## Benefits of Multi-Core Technology

- Improved system efficiency and application performance for computers running multiple applications
- Enhanced performance for multi-threaded applications
- Support for more users or tasks for transaction-intensive applications
- Superior performance for compute-intensive applications
- Simplified overall computing infrastructure requirements helping to save you money
- Helps to eliminate thermal and environmental issues

## AMD Multi-Core Product Benefits

The introduction of x86 multi-core technology will change commercial and consumer computing while offering new opportunities for software developers.

AMD believes the evolution to multi-core processors is an exciting technological advancement that will play a central role in driving relevant advancements, providing greater security, resource utilization, and value for businesses and consumers. The client and consumer markets will have access to superior performance and efficiency compared to single-core processors, as the next generation of software applications are developed to take advantage of multi-core processor technology. Consumers will now be able to experience true multitasking and increased performance on optimized digital media and content creation applications.

The widespread availability of hardware using multi-core processor technology

will forever change the computing universe.

## Commercial Benefits

Corporate IT systems currently optimized for SMP multi-threaded applications should see significant performance increases by using AMD multi-core processors.

This logical performance boost will take place within current, available hardware and socket designs, enabling corporate IT managers to add more sophisticated system layers, like virtualization and security, without significant disruption to legacy systems.

Another key benefit: Simplified manageability, lower TCO, and maximum processor performance. The AMD Opteron™ processor with Direct Connect Architecture enables one platform to meet the needs of multi-tasking environments, providing platform longevity.

## Consumer Benefits

AMD multi-core processors can immediately benefit businesses and general consumers by providing the capability to run multimedia and security applications with increased performance.

With multi-core processors, a new era of true multitasking emerges. AMD Athlon™ 64 X2 Dual-Core processors will take computing to a new level by enabling people to simultaneously burn a CD, check e-mail, edit digital photos, and run virus protection software - all with increased performance. Multi-core processors also will enable the growth of the digital home - now a centralized PC will

be able to serve multiple rooms and people in the home.

Imagine Dad working on his finances in his office, while his son watches a movie on the living room TV that he recorded the day before to the PC, while his daughter listens to MP3s from the same PC while in her room. This will be possible with the phenomenal multi-tasking capabilities that multi-core processors enable. In the commercial market, businesses will realize enhanced security, improved resource utilization, and greater return on their investments in PCs.

### **Developer Benefits**

Software professionals regularly push the limits of current processor capacity. Multi-core processors will solve many of the challenges currently facing software designers by delivering significant performance increases at a time when they need it most.

Multi-core processors, in combination with new compiler optimizers, will reduce compiling times by as much as 50 percent, giving developers a critical advantage in meeting time-to-market demands. Software vendors also can use more multi-threaded design methods for delivering enhanced features.

With the advent of multi-core processors and adoption of multi-core computer platforms by businesses and consumers, software vendors will have a much larger marketplace to distribute new and improved applications.

## **The AMD64 Multi-Core Advantage**

### **Ease of Migration to Multi-Core Processors**

- OEMs and system builders can easily incorporate multi-core products into their existing AMD Opteron™ processor-based and AMD Athlon™ 64 processor-based designs
- Socket infrastructure compatible with existing 90nm single-core processor architectures (Contact your solution provider to guarantee system readiness.)

### **Higher Performance Per Watt**

- Customers can experience the performance advantages of multi-core processors by getting the best performance per watt available in the market

### **Direct Connect Architecture**

- For servers and workstations, the best 2-way and 4-way architecture for x86 computing
- Addresses and helps reduce the real challenges and bottlenecks of system architecture because everything is directly connected to the CPU
- Directly connects the processor cores to a single die to even further reduce latencies between processors

### **Dual-Core Processor Overview**

- AMD64 processors were designed from the start to add a second core
- Port already existed on crossbar/SRI
- One die with 2 CPU cores, each core has its own 1MB L2 cache

- Drops into existing AMD Opteron processor 940-pin sockets and AMD Athlon 64 processor 939-pin sockets that are compatible with 90nm single-core processor architectures
- A BIOS update is all that is necessary to get a compatible system up and running with dual-core processors
- The 2 CPU cores leverage the same memory and HyperTransport™ technology resources available in single-core processors

## A Mini-Symposium On Sheet Stamping Simulation



On April 25 and 26, 2005, Die Face Engineering Project (DFEP) held its Annual Offsite Meeting at the headquarters of Livermore Software Technology Corporation (LSTC), in Livermore, California.

Dr. John O. Hallquist, president of LSTC, started the meeting with a welcome message and a thorough overview of LS-DYNA for stamping applications. DFEP team members and several LSTC engineers gave presentations regarding the status of stamping simulation and springback prediction and the methodology for improvements. The team members were very satisfied by LSTC's efforts in making LS-DYNA more accurate and efficient. At the same time, they also proposed that LSTC conduct studies in several areas such as contact, element formulations, etc.

The DFEP is funded by DOE through USCAR. The main objective of the DFEP is to improve springback prediction for difficult metal parts by developing new simulation technology. Project activities are aimed at providing feedback and guidance to LSTC on enhancing existing or developing new functions to be incorporated into LS-DYNA. Members of the

DFEP project include DaimlerChrysler (Mercedes-Benz and Chrysler), Ford, GM, Volvo Car Corporation, Alcoa, US Steel, and ThyssenKrupp Budd Company (TK-Budd). Dr. Chung-Yeh Sa of GM is the project leader and Dr. Edmund Chu of Alcoa is the technical leader of the project. Project administration is handled by TCR/NCMS.

LSTC participates as a supplier by providing benchmarking, consulting, training, and other technical support services to the DFEP members. With the new features and enhancements to be developed, LS-DYNA will maintain its position as the industry leader in predicting springback encountered in sheet forming operations.

In his one-hour presentation titled "Metal Forming in LS-DYNA", Dr. Hallquist gave a general introduction of LS-DYNA in metal forming simulations, with an emphasis on element technique, contact, and recent developments. He pointed out that one of the goals for LSTC was to "combine multi-physics capabilities in a scalable code for solving highly nonlinear transient problems", since one code can offer "huge cost savings relative to de-

veloping an array of software applications." He also presented several new features which could fulfill the requirements of some team members.

- the new keyword "*\*CASE*" allows users to run multiple load cases sequentially in a single run;
- several new features in using local coordinate systems;
- new material models;
- improvements in MPP

Dr. Hallquist provided his vision for LS-DYNA and said "LSTC is committed to providing the 'best' technology for sheet metal forming." During the follow-up discussion, the team members showed appreciation toward the efforts John and other LSTC's engineers had spent in improving LS-DYNA; the participants also raised several challenging issues.

Tim Lemke from Mercedes-Benz gave a live demo on setting up a job by using LS-PrePost (LSPP) from scratch. He started the demo with an IGES file representing tool geometry. At the end, he could define everything and build an input deck ready for job submission completely within the GUI environment. Tim has spent tremendous time in designing and testing LSPP in the last couple of years to get this capability developed. While most of the participants thought that there was still a large room for improvement, they were surprised to see its current capability.

Brian Wainscott of LSTC reported that several bugs related to MPP had been fixed, for example, the detection and deletion of poor elements, node release conditions, and drawbead positioning. The code also went through rigorous QA to ensure stability. He then talked about some recent improvement in mesh adaptivity, and new features in contact.

LS-DYNA/MPP has long been used with its explicit solvers and has become the

dominant code worldwide for crash & safety simulations. Implicit solvers are also available now for the MPP versions as presented by Dr. Roger Grimes. The most important improvement in implicit/MPP include: a distributed memory matrix assembly and constraint application package; a distributed memory parallel linear equation solver based on multifrontal; a parallel eigensolver based on Boeing's Lanczos software and our linear equation solver. Dr. Grimes also showed desired scalability with MPP/implicit code in springback analysis. To increase convergence performance in gravity loading and binder wrapping simulation, a new constraint algorithm was also implemented.

Dr. Yong Guo gave a detailed review of shell element formulations, and discussed the advantages and disadvantages of each element type. Later on, he showed two new shell element formulations under development, which might have great potentials in improving forming simulation and springback prediction, especially in regions with small radius, such as in hemming, flanging simulations.

To seamlessly analyze a multi-stage process by using LS-DYNA, Dr. Nielen Stander presented a proposed process manager. He raised several important technical issues in designing such an interface, for example, file handling logistics, restart, recovery features, etc. He also mentioned that it is critical to integrate the manager with LSPP. The proposed manager should handle all the stamping related stages, such as gravity loading, binder wrapping, forming, trimming, springback, and it can run the job on different machines/platforms.

A robustness study of using LS-DYNA in stamping simulation was presented by Dr. Willem Roux of LSTC. In his study, Dr. Roux proposed a method to estimate



random uncertainty required for an accurate margin of safety and estimate systematic uncertainty, such as thickness, friction, and material anisotropy.

“Looking-ahead” adaptivity algorithm was improved to better handle sliding nodes, as reported by Dr. Xinhai Zhu. At the same time, he also discussed some issues related to materials models.

Due to the partnership of this DFEP project, LSTC has been able to work with some of the best engineers and scientists in the metal forming industry. It is not surprising that LS-DYNA has made significant improvements in stamping and springback prediction. Using the Numisheet'93 U-Channel as an example, Dr. Chung-Yeh Sa showed that the prediction from LS-DYNA had become more accurate and less sensitive to modeling practice and numerical parameters.

One of the most interesting presentations in springback compensation study was presented by Li Zhang of DaimlerChrysler – Chrysler Group. They relied on numerical predictions solely from LS-DYNA to re-machine a real die of an automotive underbody cross member. After making the parts from the new die in which springback compensation was

incorporated, they scanned the laser-trimmed part. It was found that they were able to reduce the maximum deviation to less than 1mm from a maximum of 9mm before, all within one iteration of die re-cut. More significantly, the side wall curl in the original part was greatly reduced to almost negligible amounts.

After the forming meeting, informal and open discussions followed. Each participant discussed their specific concerns with the LSTC engineer in that field. For example, Laurent B. Chappuis raised some issues regarding LS-PrePost with Philip Ho; Chung-Yeh Sa discussed implicit problems with Roger Grimes; and Cedric Xia from Ford discussed contact and frictional force impact on stamping dies with Xinhai Zhu and Jason Wang.

As expected, this meeting turned out to be very successful. The team members were able to talk to John and other LSTC engineers about their concerns and ideas. At the same time, LSTC was able to get direct feedback from industrial experts. The mutual communications will give LSTC more motivation and insight to improve LS-DYNA in sheet stamping simulations.

**The participants from the DFEP team include:**

Chung-Yeh Sa, Technical Manager, GM, DFEP Project Leader;  
Edmund Chu, Senior Manager, Alcoa, DFE Project Technical Leader;  
Laurent B. Chappuis, Section Supervisor, Stamping CAE & Aluminum Technology, Ford;  
Cedric Xia, Technical Leader of Advanced Forming Technologies at Ford Research;  
Li Zhang, Theme Department Manager, DaimlerChrysler, Auburn Hill, USA  
Tim Lemke, DaimlerChrysler, Stuttgart, Germany  
Ming F. Shi, Manager, Advanced Applications Technology, US Steel  
Ming Chen, Technical specialist, US Steel  
Manish Mehta, Executive Director, Technologies Research Corporation (TRCNCMS)

**Teleconference from remote sites:**

Alf Anderson & Mats Sigvant, Volvo Car Corporation, Sweden;  
Yu Xu, Alcoa;  
Lyle Levine, Mark Stoudt and Steve, NIST



## LS-DYNA SUPPORT/CUSTOMER SITES ONLINE

### LS-DYNA SUPPORT

#### LSTC DYNAmore

[www.dynasupport.com](http://www.dynasupport.com)

A first release of the web based support database for LS-DYNA is now available online. The site gathers the knowledge of various support engineers by providing answers to frequently asked questions, howto's, tutorials and news related to LS-DYNA. The site will be extended and updated continuously. All information is provided by experienced support engineers and double-checked by an internal review process before it is published on the web. The database can be accessed via:

<http://www.dynasupport.com>

The full range of information is available free of charge. No sign-up process or password is required to access the support database.

It is not the aim of the site to substitute the local hotline. The goal is rather to give detailed explanations to the customers in addition to the local distributor contacts. As a result it might help to obtain better understanding of the features in LS-DYNA, and to facilitate a more

precise and effective exchange with the hotline.

The site runs under the direction of LSTC and DYNAmore. In the near future the support site will also cover the LSTC products LS-OPT and LS-PREPOST.

We would like to encourage the feedback from all LS-DYNA users. So please feel free to visit our site, and let us know your opinion.

Please e-mail to: [vic@lstc.com](mailto:vic@lstc.com) or [uli.franz@dynamore.de](mailto:uli.franz@dynamore.de)

### LS-DYNA Service & Support Network

#### CAD-FEM GmbH

[www.lsdyna-portal.com](http://www.lsdyna-portal.com).

The LS-DYNA Service and Support Network is a close collaboration of LS-DYNA distributors all over Europe and the world. The Network partners work together and exchange their knowledge, such that every partner can profit from the expertise of the others. The LS-DYNA Service and Support Network has currently about 40 experienced LS-DYNA engineers.

The intention of the Network is to provide our LS-DYNA customers one contact facility. Hereby the Network virtually acts as one com-

pany, such that the customer has always access to the same know-how and the same people, no matter where the development center is actually located.

On this site we provide information on the LS-DYNA Service and Support Network and general information on [»LS-DYNA](#). In the [»LS-DYNA support](#) area you may find information on technical questions, LS-DYNA manuals as well as contact persons. Additionally the [»LS-DYNA forum](#) acts as the platform for LS-DYNA users to post questions and answers, to exchange comments, news, tips and tricks as well as getting latest information on LS-DYNA. Soon we will present on this page a category concerning [seminars](#), which are offered by the Network partners in the different countries all over the world.

Especially we would like to encourage students from abroad to apply for a [thesis](#) in cooperation with Network partner. So even if there is currently no specific thesis posted, we are always open for your good ideas.

## INDUSTRY NEWS Press Releases – SGI – AMD – NEC

The full Press Releases can be viewed on their websites.

### **SGI: Fraunhofer-Institut IAO Accelerates Vehicle Design at Lower Cost with Silicon Graphics Prism System**

Shared Memory Visualization System Delivers Greater Visual Realism and Enables Functional Evaluation of Virtual Vehicle Prototypes

MUNICH and MOUNTAIN VIEW, Calif., (May 12, 2005)—To increase the level of realism when evaluating virtual vehicles and to accelerate its adoption by industry, scientists at Fraunhofer Institute for Industrial Engineering (IAO) have selected the Silicon Graphics Prism™ platform from SGI (NYSE: SGI) to solve a new class of data and rendering intensive problems never before possible in virtual environments. Using Virtual Drive, physical prototypes become unnecessary and test drives of many different variants can be performed in the very early stages of vehicle design - reducing costs, accelerating work flows and resulting in more mature products.

The most important criteria for the choice of the Silicon Graphics Prism system was its industry-leading shared memory architecture which gives scientists easy-to-use, flexible high-performance deployment options. The Silicon Graphics Prism system at IAO is equipped with four graphics pipes, eight Intel® Itanium® 2 CPUs and 16GB of main memory. This system will be used to drive a 4-plane CAVE immersive environment that integrates the simulation of vehicle interiors with a classical driving

simulator. It will also be used with a Scalable Graphics Compositor to combine the rendering power of all four graphics pipes to deliver a whole new level of scene complexity and realism. The powerful and flexible design of Silicon Graphics Prism platform enables IAO to efficiently press ahead with its industrially oriented research activities in the area of innovative production method development...”

### **AMD: AMD 64 Processors Deliver World-Class 64-Bit Performance On Microsoft® Windows® x64 Platform**

*—AMD 64 Innovative Single- and Dual-Core Processors Enable Customers to Experience Full Benefit of x86 64-bit Computing—*

SUNNYVALE, CALIF. -- April 25, 2005 -- AMD (NYSE: AMD) today announced all existing and upcoming single- and dual-core AMD Athlon™ 64, AMD Opteron™ and AMD Turion™ 64 processors are designed to be fully compatible with and deliver world-class performance on Microsoft® Windows® Server 2003 x64 Editions and Windows XP Professional x64 Edition.

“AMD is setting the 64-bit standard that the industry is embracing today and our innovative AMD64 technology, together with Microsoft’s new x64 operating systems, will give millions of businesses, PC and mobile users a chance to see the power of 64-bit computing come to life,” said Marty Seyer, corporate vice president and general manager, Microproces-

sor Solutions Sector, AMD. "AMD's industry leadership is enabling a new set of applications and making pervasive 64-bit computing a reality. As the industry's only x86 processor designed from the ground up for 64-bit computing and multi-core technology, AMD64 technology-powered notebooks, desktops and servers are the best choice for leveraging these two evolutionary computing advances."

"While some suggested it would be impossible to create an x86-compatible processor with competitive 64-bit and 32-bit performance, AMD plowed ahead and demonstrated it could be done," said Nathan Brookwood, principal analyst at Insight 64. "AMD64 technology has altered the industry's direction and provides users with a non-disruptive path to 64-bit computing. Microsoft's release of these x64 Windows editions provides another critical element needed for that 64-bit migration."

### **NEC Receives Orders for Vector Supercomputers SX-8 and SX-6 from Suzuki Motor Corporation**

Tokyo, April 1, 2005-- NEC Corporation ("NEC") today announced that it has received orders for two of its vector supercomputers, the "SX-8/8A" (128GFLOPS peak vector performance) and "SX-6/8A" (64 GFLOPS peak vector performance), from Suzuki Motor Corporation. (GFLOPS: one billion floating-point operations per second)

Suzuki Motor Corporation has been utilizing supercomputers for development of automobile performance and simulation analysis through computer aided engineering ("CAE") since 1987. The company is conducting more and more analyses that require large-scale simulation models for performance improvement, weight reduction, safety improvement, and reduction of the development period.

## LS-DYNA and Cray XD1 System Bundle

\* Available in North America through Cray, including paid up LS-DYNA license, LS-DYNA support through LSTC, California or Michigan



\*Starting price for 12 AMD Opteron™ processor single chassis system - Price includes shipping. Tax not included.

### System Includes:

- 12 - 2.6 GHz AMD Opteron™ Processors Series 200
- LS-DYNA Paid Up License
- Cray HPC Enhanced Linux
- 24 GB Memory
- 6 - 74 GB SATA Disk Drives, 10K rpm
- RapidArray Interconnect with 1.7 microsec Latency and 96 GB/sec Bandwidth



**www.lstc.com**  
**sales@lstc.com**  
**925-449-2500**



**THE SUPERCOMPUTER COMPANY**  
**For Sales Contact:**

**1-877-CRAY-INC.**  
**www.cray.com**  
**sales@cray.com**

Cray is a registered trademark, and the Cray logo, Cray XD1 are trademarks of Cray Inc. AMD, the AMD Arrow logo, AMD Opteron, and combinations thereof, are trademarks of Advanced Micro Devices, Inc. Car models developed by FHWA/NHTSA National Crash Analysis Center of the George Washington University.

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## LS-DYNA Sales – Support – Training – Benchmarks

**figes | cad-cae**

[www.figes.com](http://www.figes.com)

Located in Bursa, Turkey – Branch offices are located in Istanbul and Ankara

FIGES provides ANSYS/Multiphysics software - LSTC's LS-DYNA, LS-PrePost, LS-OPT – ETA's Dynaform, and other software products.

**Tarik Ogut - [tarik.ogut@figes.com.tr](mailto:tarik.ogut@figes.com.tr)**

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[www.flotrend.com.tw](http://www.flotrend.com.tw)

Located in Taipei, Taiwan

Flotrend provides LSTC's LS-DYNA, LS-OPT, LS-PrePost – ETA's ETA/VPG, ETA's Dynaform and other software products.

**Gary Chen [gary@flotrend.com.tw](mailto:gary@flotrend.com.tw)**

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[www.infinite.nl](http://www.infinite.nl)

Located in The Netherlands

Infinite provides ANSYS, LS-DYNA, LMS Virtual Lab

**Jurgen Mathijssen [j.mathijssen@infinite.nl](mailto:j.mathijssen@infinite.nl)**



## EVENTS

- May 31 – June 03, 2005  
Dresden, Germany  
Third Joint ANSYS CFX & FZR  
Workshop on Multiphase Flows
- May 25-26, 2005  
5<sup>th</sup> 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  
SGI User's Group – Munich Ger-  
many
- June 25-27, 2005  
8<sup>th</sup> U.S. National Congress on  
Computational Mechanics, Austin,  
TX
- October 05-08, 2005  
TCN CAE 2005 International Con-  
ference on CAE and Computational  
Technologies for Industry  
Italy – (Numerica)
- August 12, 2005  
Altair India – 3<sup>rd</sup> South Asia LS-  
DYNA User Conference, Bangalore,  
India
- October 20-21, 2005  
German-LS-DYNA Forum  
(DYNAmore)  
Bamberg, Germany
- November 09-11, 2005  
23<sup>rd</sup> CADFEM Users' Meeting – Int'l  
Congress on FEM Tech. W/ANSYS  
CFX & ICEM CFD Conference,  
Bonn, Germany
- November 25, 2005  
Korean Users Conferece –  
LS-DYNA (THEME)
- November 29-30, 2005  
Japanese Users Conference  
(Nagoya) LS-DYNA (JRI)
- June 2006  
LS-DYNA  
9<sup>th</sup> 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](http://www.lstc.com)    [sales@lstc.com](mailto:sales@lstc.com)  
**Now available – Training at LSTC Michigan Office****

Version: 970	Classes: <a href="http://www.lstc.com">www.lstc.com</a> classes	30-day demonstration licenses available – no fee
		Sales <a href="mailto:sales@lstc.com">sales@lstc.com</a>

### 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	HP IA64 HPUX or Linux	INTEL IA64 Linux	SGI IA64/Linux Altix/Prism
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](http://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\*Environment highly capable, yet easy to use for advanced modeling needs.

#### **ETA – DYNAFORM**

**[www.eta.com](http://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 af-

fordable software with today's high-end, low-cost hardware for a complete and affordable metal forming solution.

#### **ETA – VPG**

**[www.eta.com](http://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

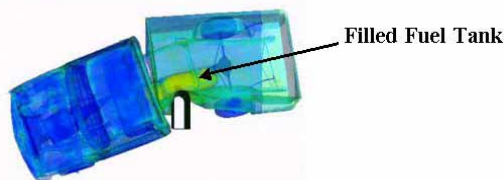
#### **MSC.Software**

**“MSC.Dytran LS-DYNA”**

**[www.msc.software.com](http://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.

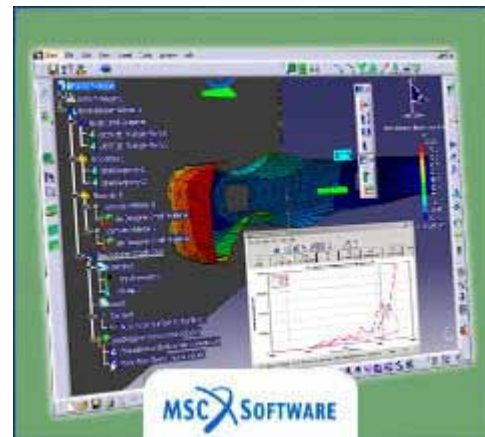
cMSC.Nastran Explicit Nonlinear will allow users to work within one common modeling environment using the same Bulk Data interface. NVH, linear, and nonlinear models can be used for explicit applications such as crash, crush, and drop test simulations. This reduces the time required to build additional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

lation 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

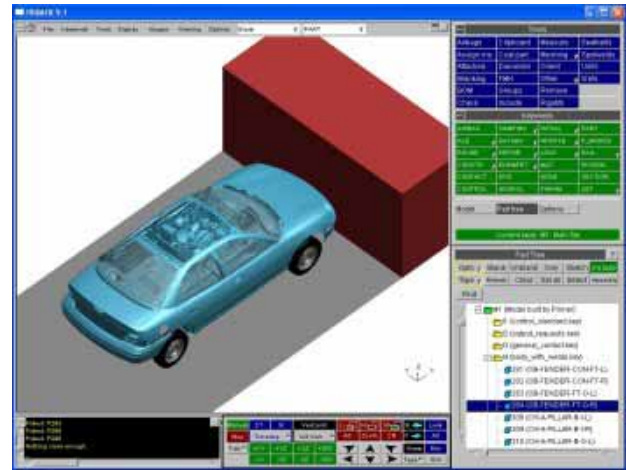
Gateway for LS-DYNA provides you with the ability to access basic LS-DYNA simulation capabilities in a fully integrated and generative way. Accessed via a specific Crash workbench on the GPS workspace, the application enhances CATIA V5 to allow finite element analysis models to be output to LS-DYNA and 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](http://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.



<p><b>LS-DYNA Events</b></p>
<p><b>UK 05/25-26/05 (Arup)</b>  <b>5th European LS-DYNA Conference</b></p>
<p><b>INDIA 08/12 (Altair India)</b>  <b>3rd South Asia LS-DYNA User Conference,</b></p>
<p><b>Italy 10/05-10/06 (Numerica)</b>  <b>(Numerica)</b>  <b>TCN CAE 2005 International Conference on CAE and Computational Technologies for Industry - workshops focusing on LS-DYNA</b></p>
<p><b>Germany - 10/20-10/21 (DYNAmore)</b>  <b>German LS-DYNA Forum</b></p>
<p><b>Germany - 11/09-11/11 (CADFEM)</b>  <b>Int'l Congress on FEM Tech.. workshops focusing on LS-DYNA</b></p>
<p><b>Korea 11/25/05 (THEME)</b>  <b>Korean LS-DYNA Users Conference</b></p>
<p><b>Japan 11/29-30/05 (JRI)</b>  <b>Japanese LS-DYNA Users Conference (Nagoya)</b></p>
<p><b>US 06/06 (LSTC)</b>  <b>9th International LS-DYNA Users Conference</b></p>

## Hardware & Computing and Communication Products



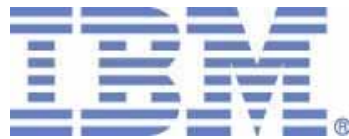
[www.amd.com](http://www.amd.com)



[www.fujitsu.com](http://www.fujitsu.com)



[www.hp.com](http://www.hp.com)



[www-1.ibm.com/servers/deepcomputing](http://www-1.ibm.com/servers/deepcomputing)



[www.intel.com](http://www.intel.com)



[www.nec.com](http://www.nec.com)



[www.sgi.com](http://www.sgi.com)



[www.cray.com](http://www.cray.com)



## Software Distributors

Alphabetical order by Country

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

## Software Distributors (cont.)

Alphabetical order by Country

<b>Netherlands</b>	<b>Infinite Simulation Systems B.V</b> www.infinite.nl
<b>Russia</b>	<b>Strela, LLC</b> www.ls-dynarussia.com
<b>Sweden</b>	<b>Engineering Research AB</b> www.erab.se
<b>Taiwan</b>	<b>Flotrend</b> www.flotrend.com.tw
<b>Turkey</b>	<b>FIGES</b> www.figes.com.tr
<b>USA</b>	<b>Altair Western Region</b> www.altair.com
<b>USA</b>	<b>Engineering Technology Associates</b> www.eta.com
<b>USA</b>	<b>Dynamax</b> www.dynamax-inc.com
<b>USA</b>	<b>Livermore Software Technology Corp.</b> www.lstc.com
<b>USA</b>	<b>ANSYS Inc.</b> www.ansys.com
<b>UK</b>	<b>Oasys, LTD</b> www.arup.com/dyna/

## Consulting and Engineering Services

Alphabetical Order By Country

<p><b>Australia</b>                  Manly, NSW                  www.leapaust.com.au</p>	<p><b>Leading Engineering Analysis Providers</b>                  Greg Horner info@leapaust.com.au                  02 8966 7888</p>
<p><b>Canada</b>                  Kingston, Ontario                  www.mfac.com</p>	<p><b>Metal Forming Analysis Corporation</b>                  Chris Galbraith galb@mfac.com                  (613) 547-5395</p>
<p><b>India</b>                  Bangalore                  www.altair.com</p>	<p><b>Altair Engineering India</b>                  Nelson Dias info-in@altair.com                  91 (0)80 2658-8540</p>
<p><b>Italy</b>                  Torino                  www.altairtorino.it</p>	<p><b>Altair Engineering Italy</b>                  sales@altairtorino.it</p>
<p><b>Italy</b>                  Firenze                  www.numerica-srl.it</p>	<p><b>Numerica SRL</b>                  info@numerica-srl.it                  39 055 432010</p>
<p><b>UK</b>                  Solihull, West Midlands                  www.arup.com</p>	<p><b>ARUP</b>                  Brian Walker brian.walker@arup.com                  44 (0) 121 213 3317</p>
<p><b>USA</b>                  Irvine, CA                  www.altair.com</p>	<p><b>Altair Engineering Inc. Western Region</b>                  Harold Thomas info-ca@altair.com</p>
<p><b>USA</b>                  Windsor, CA                  www.schwer.net/SECS</p>	<p><b>SE&amp;CS</b>                  Len Schwer len@schwer.net                  (707) 837-0559</p>

## Educational & Contributing Participants

### Alphabetical Order By Country

<b>China</b>	Dr. Quing Zhou	Tsinghua University
<b>India</b>	Dr. Anindya Deb	Indian Institute of Science
<b>Italy</b>	Professor Gennaro Monacelli	Prode – Elasis & Univ. of Napoli, Federico II
<b>Russia</b>	Dr. Alexey I. Borovkov	St. Petersburg State Tech. University
<b>USA</b>	Dr. Ted Belytschko	Northwestern University
<b>USA</b>	Dr. David Benson	University of California – San Diego
<b>USA</b>	Dr. Bhavin V. Mehta	Ohio University
<b>USA</b>	Dr. Taylan Altan	The Ohio State U – ERC/NSM
<b>USA</b>	Dr. Ala Tabiei	University of Cincinnati
<b>USA</b>	Tony Taylor	Irvin Aerospace Inc.

**Informational Websites**

<b>FEA Informationwebsites</b>	<a href="http://www.feainformation.com">www.feainformation.com</a>
<b>TopCrunch – Benchmarks</b>	<a href="http://www.topcrunch.org">www.topcrunch.org</a>
<b>LS-DYNA Support Site LSTC &amp; DYNAmore</b>	<a href="http://www.dynasupport.com">www.dynasupport.com</a>
<b>LS-DYNA Examples (more than 100 Examples)</b>	<a href="http://www.dynaexamples.com">www.dynaexamples.com</a>
<b>LS-DYNA Conference Site</b>	<a href="http://www.ls-dynaconferences.com">www.ls-dynaconferences.com</a>
<b>LS-DYNA Publications to Download On Line</b>	<a href="http://www.dynalook.com">www.dynalook.com</a>
<b>LS-DYNA Publications</b>	<a href="http://www.feapublications.com">www.feapublications.com</a>
<b>LS-DYNA CADFEM Portal</b>	<a href="http://www.lsdyna-portal.com">www.lsdyna-portal.com.</a>

## Archived News Page

April 2005

### April 4<sup>th</sup>

MSC.Dytran: Execute LS-DYNA from inside MSC. Dytran.

GISSETA – Distributor in India

### April 11<sup>th</sup>

JRI: The Japan Research Institute, Limited (JRI) offers the following services as a distributor of LS-DYNA in Japan and a developer of CAE package software:

Flotrend - Distributor in Taiwan

### April 18<sup>th</sup>

ETA: eta/VPG (Virtual Proving Ground) is a revolutionary new systems analysis software package.

KOSTECH - Distributor in KOREA

### April 25<sup>th</sup>

The HP 9000 server family

Intel® Extended Memory 64 Technology

DYNAmore - Distributor in Germany



## Bird Strike on a Composite Jet Engine Inlet

Work conducted by:

Sergey Kukanov and Dimitry Roschikhmarov  
*SAROV LABS*

Report written by:

Fabio Mantovani  
*Livermore Software Technology Corporation*  
*fabio@lstc.com*

### Goals of the project

The interest of the Aerospace Working Group is to have a representative simulation for a bird strike on a composite jet engine inlet as a starting point for further work. This simulation also serves as an Aerospace Quality Assurance Benchmark that LSTC is putting in place in order to provide consistency in results among computer platforms and versions of LS-DYNA. Both a Lagrangian and an ALE (Arbitrary Lagrangian Eulerian) simulation were performed.

### Units

Units are (mass, length, time, force, stress, energy) lbf-s<sup>2</sup>/in, in, s, lbf, psi, lbf-in unless otherwise specified.

### Composite Inlet Section:

The inlet section was modeled using \*MAT\_LAMINATED\_COMPOSITE\_FABRIC. The material data does not directly represent any actual material in use in the aerospace industry, but are "good enough" for the purpose of this work. The material erodes at 0.5 effective strain. Twelve equally-spaced integration points through the thickness were used.

```
*MAT_LAMINATED_COMPOSITE_FABRIC
$#   mid      ro      ea      eb      (ec)      prba      taul      gamma1
      1 1.4400E-4 6.5300E+6 6.6100E+6 6.5300E+6 0.290000      0.0      0.0
$#   gab      gbc      gca      slimt1     slimc1     slimt2     slimc2     slims
2.5800E+6 2.5600E+6 7.0000E+5 1.000000 1.000000 1.000000 1.000000 1.000000
$#   aopt      tsize     erods      soft      fs
      0.0      0.0      0.500000      0.3      1.000000
$#   xp      yp      zp      a1      a2      a3
      0.0      0.0      0.0      0.0      0.0      0.0
$#   v1      v2      v3      d1      d2      d3      beta
      0.0      0.0      0.0      0.0      0.0      0.0      0.0
$#   ellc      ellt      e22c      e22t      gms
0.026000 0.034000 0.019800 0.024000 0.024000
$#   xc      xt      yc      yt      sc
147000.000 2.3340E+5 122400.00 132200.00 30000.000
```



Figure: A close up of the inlet section. The inlet section was modeled with 2 alternating parts. This was done so that the different parts would refer to alternate integration rules that represent the weave of the composite

### Bird Material Properties

The bird was modeled with an ellipsoidal shape (10in x 5 in by 5 in), a weight of 9 pounds, and material properties similar to water. The \*MAT\_NULL and \*EOS\_GRUNEISEN were used for the material constitutive model.

```
*MAT_NULL
$#   mid      ro      pc      mu      terod      cerod      ym      pr
    910000 1.8100E-4 -0.001000 2.0000E-7      0.000      0.000      0.000      0.000

*EOS_GRUNEISEN
$#   eosid      c      s1      s2      s3      gamao      a      e0
    910000 58267.000  2.560000 -1.986000  0.226800  0.500000  0.000  0.000
$#   v0
    0.000
```

### Lagrangian Bird Model

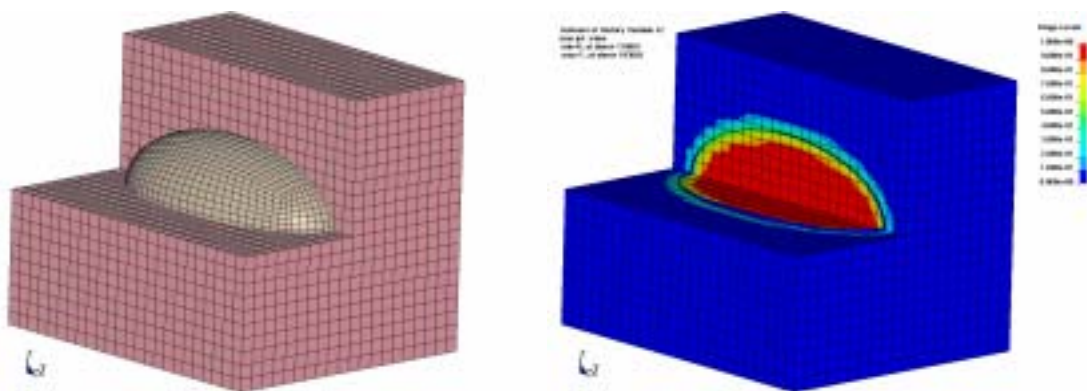
The Lagrangian bird was translated to contact the engine inlet. The contact was defined using the \*CONTACT\_ERODING\_SURFACE\_TO\_SURFACE keyword. Once contact takes place most of the bird elements get highly distorted and the following keyword permits the erosion of these elements. A criterion based on the equivalent effective strain was used.

```
*MAT_ADD_EROSION
$#   mid      excl
    910000 1234.0000
$#   pfail      sigpl      sigvm      epspl      epssh      sigth      impulse      failtm
    1234.0000 1234.0000 1234.0000  0.550000 1234.0000 1234.0000 1234.0000 1234.0000
```

The hourglass coefficient QM was lowered to 1.0E-04 in order to reduce the amount of hourglass energy that is produced.

### ALE Bird Model

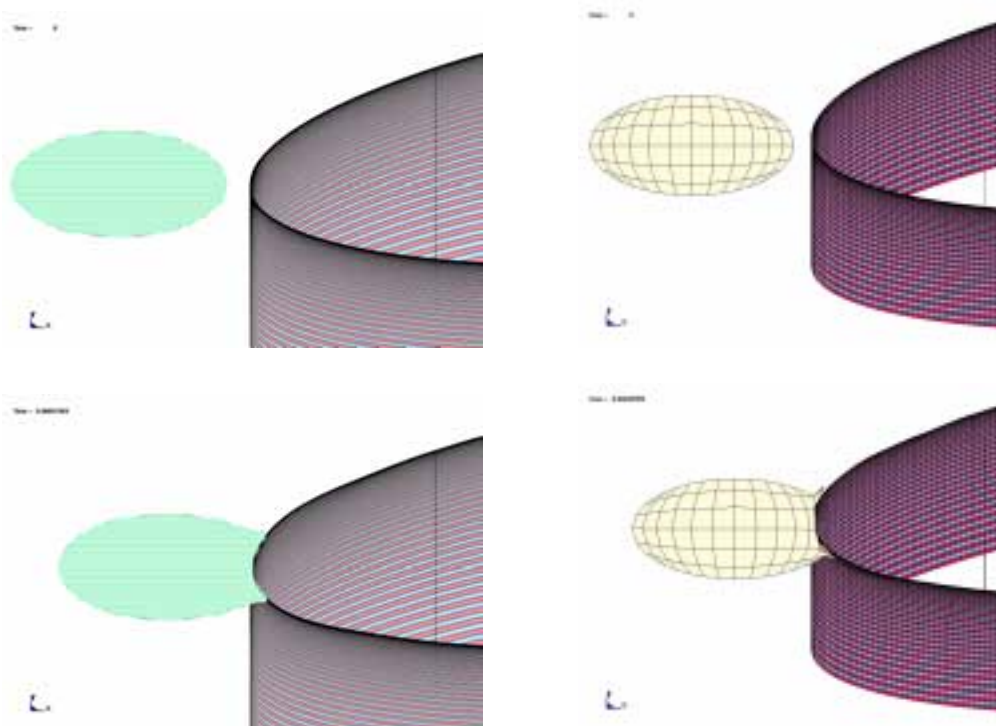
The ALE bird was defined within the Eulerian mesh by means of a geometric surface as shown in the following figure.

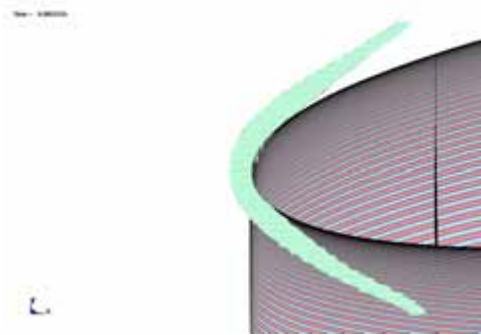
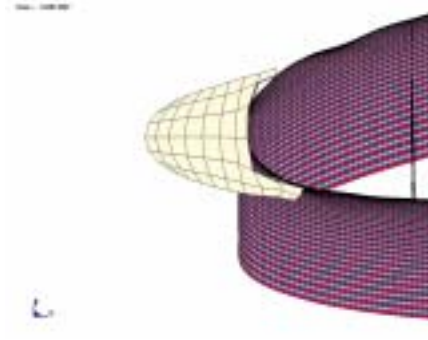
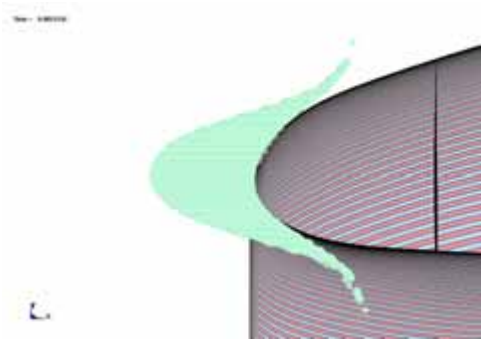


The ALE mesh was translated to contact the Lagrangian engine inlet using the `*ALE_REFERENCE_SYSTEM_GROUP` keyword. The contact between bird and the composite inlet is enforced using the `*CONSTRAINED_LAGRANGE_IN_SOLID` keyword. We changed the default coupling type to penalty with erosion (`CTYPE=4`), since it showed better energy conservation. The hourglass coefficient `QM` was lowered to  $1.0E-06$  to reduce the amount of hourglass energy that is produced.

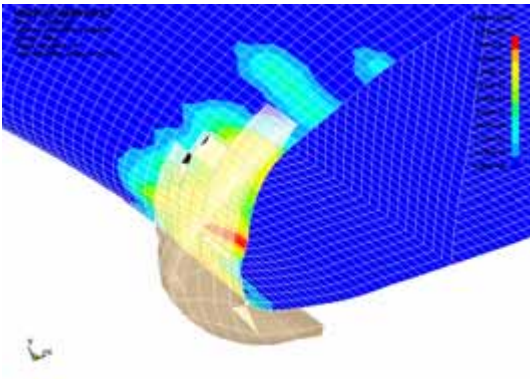
### Lagrangian and ALE Simulation Results

The following sequence of snapshots show the deformed geometry for the ALE simulation (left) and the Lagrangian simulation (right)





The following figure shows the deformation of the composite inlet section. Shown are fringes of the damage parameter  $\omega_1$  for \*MAT\_LAMINATED\_COMPOSITE\_FABRIC.



## TOP CRUNCH NEWS

Dr. David Benson  
[www.topcrunch.org](http://www.topcrunch.org)

Ting-Ting Zhu at CRAY Inc., has provided Top Crunch with benchmark performances on the 3 Vehicle Collision for the CRAY XD1

The LS-DYNA MPP970, Version 970/Rev 5434a

Processor: AMD Opteron 2.4 GHZ

The input file along with the instructions on running it, are available on the download page of Top Crunch.

Visitors to the site can plot the performance of any of the machines that have been benchmarked on the site.

