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## COVER STORY

HP

A Small Garage And Big Dream



## PRODUCT SPOTLIGHT

LSTC

LS-OPT Version 3 for Windows



## SURI BALA

Deformability Switching in LS-DYNA



## FEA Information Worldwide Participants



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## FEA Information Announcements

**Welcome as a Consulting/Engineering Service Participant:  
Participation in this area is open for 2006 – trent@feainformation.com**

**Structure, Incorporated** of Neenah, WI 54956.  
www.structuretechnology.com  
Todd L. Peters – **peters@structuretechnology.com**

Structure is a company geared expressly towards Advanced Analysis, Engineering, and Design. We support the aerospace, defense, and marine industries with expert consulting and contract engineering in the fields of fluid-dynamics, structures, and advanced propulsion. Structure meets the definition of a small business as required for Federal Contracting purposes.

### Livermore Software Technology Corporation

**LS-OPT Version 3** Windows is now available

### Conference - Course

**DYNAmore - GERMANY:**

5th LS-DYNA Users Meeting - 12th-13th of Oct. 2006 in Ulm.

**KOSTECH – KOREA - January 25~27, 2006**

"ALE / Eulerian & Fluid / Structure Interface in LS-DYNA"  
M'hamed Souli, Ph.D LS-DYNA ALE Module Developer

### LSTC 9<sup>th</sup> International LS-DYNA Users Conference 2006:

Registration is now available on line  
www.ls-dynaconferences.com

**Sincerely,**

*Trent Eggleston & Marsha Victory*

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## LS-DYNA News – Part 6 Final Section Version 971 Developments

### Implicit Development

- Implicit analyses require that a stiffness matrix be assembled and factorized
- Implicit is fully integrated in the explicit solver and shares elements, contact, constraints, etc.
- Implicit must perform well in the MPP environment

### Parallel Implicit is more difficult than parallel explicit

- Explicit analysis does not require the following operations, which are very difficult to parallelize and load balance:
  - Finite element matrix assembly
  - Constraint matrix generation
  - Generation of the reduced equation set
  - Second domain decomposition for sparse solver
  - Factorization, both in and out-of-core
  - Triangular solves both in and out-of-core

### Implicit development

- LSTC's MPP linear sparse solver, DMF, is giving good scalability
- The BCSLIB-EXT eigensolver is now extended to use the DMF linear solver and is operational under MPI

- LCPACK constraint package is working in parallel
- Heat transfer is working in parallel with a parallel CG solver
- Many automotive specific options are already implemented for implicit solutions, e.g., spot welds, foam materials, etc.
- An AMG iterative solver is under development possibly for later 971 releases
- Most features used in crash analysis are implemented for static initialization and spring-back of vehicle models
- Seatbelts
- Nearly completed
- Airbags
- Fabric material forms 0 and 1 are implemented
- Inflator models 3, 5, 10, and 11 are implemented
- Airbag contact
- Soft=2 option is critical
- Additional QA problem are being developed to ensure that MPP implicit works at least as well as SMP implicit

## Version 971

- Version 971 has become a major release with many new capabilities
  - MPP implicit
  - ALE is at production level for out-of-position occupant analysis
  - EFG is implemented for scalable MPP applications
- Significant progress has been made to include most crash capabilities within the implicit solver
- LSTC main goal continues to be the development within one code all capabilities required to solve problems that involve
  - Multi-Physics  
and require:
  - Multiple-Stages  
With
  - Multi-Processing to reduce run times  
with
  - Full compatibility with linear structure models leading to a one model environment

### **30-day demo license of LS-DYNA**

log on to [www.feainformation.com](http://www.feainformation.com)

click on the link on the top menu bar DEMO

### **\$100 limited edition of LS-DYNA**

10,000 elements, full capabilities:

log on to [www.feainformation.com](http://www.feainformation.com)

click on the link on the top menu bar DEMO

On the form check Educational 10,000 elements

This is available to all engineers; educational or commercial

## Deformability Switching in LS-DYNA

© Suri Bala, Technical Writer, FEA Information Inc.

November, 2005

### Introduction:

Among several simple yet powerful techniques available in LS-DYNA, switching of bodies that affects their deformability (at run time) is certainly one of them. Switching of bodies with negligible internal strains to a rigidbody at user's specification can be useful to eliminate the calculation of element-centered variables such as stresses, which in many applications could dominate the total computation time. Additional benefits of using this feature could include the reduction of new model development time where regions of non-importance can be treated as a rigidbody for faster turn-around time. This paper presents an overview of how the switching works in theory and how they can be invoked in LS-DYNA which is supported both in SMP and MPP versions for both implicit and explicit solvers. Need for Switching

Though today's average computer's performance has improved dramatically, the use of switching presents additional benefits to reducing the total computational time, especially for new model development where the model's kinetics could be quickly evaluated before considering a detailed model. This is due to the fact that the cost of rigidbody treatment in LS-DYNA is very small when compared with the cost of a deformable-body treatment. The ability to switch a deformable component to a rigidbody with minimal changes to the original model enables the user to quickly recover his original model by simply removing a few keywords related to switching. Switching can be used on any body whose motion is purely either a rigidbody translation/rotation or both

with little sacrifice to the accuracy of the simulation model. A body in motion with negligible presence of internal strains can be expressed using rigid body mechanics where the computation of internal stresses may be ignored. A good example of bodies undergoing such a motion is a vehicle rollover event. Once the vehicle is off the ground, the total vehicle can be safely assumed to undergo a rigidbody translation/rotation prior to making contact again with the ground. During this time, calculations related to the computing of the internal stresses can be eliminated with no sacrifice to the accuracy of the model.

### Merging Rigid Bodies

Prior to understanding deformability switching, a quick review of rigid body merging is presented here. Rigidbody treatment in LS-DYNA uses either the given finite element mesh or the user-specified parameters to compute the rigidbody's initial configurations such as translational mass, center of gravity and inertia tensor. When several rigidbodies are defined in a model, LS-DYNA allows "merging" of such independent rigid bodies to form a "master" rigidbody definition. The initial configurations of the master rigidbody will then be recomputed based on all the slave rigidbodies.

This is illustrated in Figure 1.2. Merging of rigidbodies can be defined using *\*CONSTRAINED\_RIGID\_BODIES* keyword, where the user can specify any number of "slave" rigidbodies to form one "master" rigidbody. Switching capability in LS-DYNA allows merging of rigidbodies created on the fly to a "master" rigidbody which will be beneficial to

combine several newly formed rigidbodies to be treated as one master rigidbody like the entire vehicle as mentioned before.

## Invoking Deformability Switching in LS-DYNA

The keyword to use in *LS-DYNA* for deformability switching is

*\*DEFORMABLE\_TO\_RIGID*. When using the default keyword, the only required parameter is the part (*PID*) that needs to be switched to "rigid" and the switching occurs at time zero. Switching invoked using this default keyword is irreversible which means that the component will be treated as an independent rigidbody for the remainder of the simulation time. Optionally the user can specify a master rigid body (*MRB*) to which the newly created rigidbody component can be merged to. There are two optional keywords, *AUTOMATIC* and *INERTIA*, that can be added to the default keyword *\*DEFORMABLE\_TO\_RIGID*. The option *AUTOMATIC* allows greater flexibility by providing a reversible switching process where one body can be switched between "rigid"/"deformable" any number of times with the requirement that the body's initial definition is deformable. It should be noted that bodies that use *\*MAT\_RIGID* material law, are permanently rigid and cannot be converted to become deformable again. *AUTOMATIC* option allows the internal deletion/activation of the constraints that are attached to the body that is being switched. The option *INERTIA* allows the user to specify a user-defined mass/center-of-gravity/inertia-tensor when a deformable body is converted to a rigid body. Values specified using the *INERTIA* option will override all values computed using the finite element mesh. *LS-DYNA* allows any number of switch definitions (each associated with a unique id using *SWSET*) and each one

can be associated to the other so they can be triggered in a desired sequence.

## Activation of Switching

The default keyword,

*\*DEFORMABLE\_TO\_RIGID* with or without the option *INERTIA*, activates the switching at initialization and cannot be modified by the user. When the *AUTOMATIC* option is used, switch definitions can be triggered by one of five methods shown below using the parameter *CODE*.

0. Time-based. This is the default option where the switching will occur at a specified time using the parameter *TIME* (default = 0, at the start of the simulation).
1. Rigidwall force is zero. This option will associate the switching to a rigidwall definition whose resultant force will be checked every cycle and when it reaches zero, the switching will be activated.
2. Contact force is zero. This option will associate the switching to a contact definition whose resultant force will be checked every cycle and when it reaches zero, the switching will be activated.
3. Rigidwall force is non-zero a user-defined magnitude at or in-between two time states. This option will associate the switching to a rigidwall definition whose resultant force will be checked every cycle and when it reaches a non-zero value, switching will be activated.
4. Contact force is non-zero a user-defined magnitude at or in-between two time states. This option will associate the switching to a contact definition whose resultant force will be checked every cycle and when it reaches a non-zero value, switching will be activated.

## Numerical Treatment of History Variables in Switching

When a deformable body is switched to rigid or vice-versa, it is important to understand how the node-centered (displacement, velocity, acceleration...) and element-centered history variables (stresses, plastic-strain...) are treated particularly when the switched rigidbody is restored back to its deformability. When switching from a deformable to a rigidbody, the average node-centered variables of the deformable body are applied to the rigidbody. For example, if the deformable rigid body has a varying velocity field, then the average mass-weighted velocity magnitude and the vector are computed and are applied to the rigidbody. If there are non-zero element-centered history variables, they are internally recorded for every element with reference to the element's local coordinate system. When the rigidbody is switched back to its deformability, the stored element-centered variables are then re-applied to the respective elements. This way we regain back the stored internal energy and maintain energy balance. Since the element history variables are stored in the local coordinate system when deformable parts are switched to rigid, elements such as Hughes-Liu based elements (shells/beams), which store the element history variables in the global coordinate system, are not supported to regain its deformability and so only a one-way deformable to rigid can be activated for elements based on Hughes-Liu formulations. Please see Fig 1.2 for more information on the process of storing and restoring element history variables for rotational based elements.

## Numerical Treatment of Connections in Switching

When switching a deformable body to a rigidbody, the nodes on the deformable body used in a constraint definition such as

*\*CONSTRAINED\_NODAL\_RIGID\_BODY*

*\*CONSTRAINED\_SPOTWELD* etc, will

prevent the formation of the new rigidbody or cause instabilities during the simulation. This is due to the violation of the single constraint requirement on rigidbodies. To overcome this, LS-DYNA allows the user to specify deletion/activation of constraints at the time of switching thereby making it seamless. By default, LS-DYNA internally deletes all constraints that are defined using the nodes of the deformable body before switching. Deleted constraints can be reactivated when the rigidbody is switched back to its deformability. When converting a deformable body to rigid, various types of constraints on the deformable body could exist as shown in Figure 1.3. For each case, LS-DYNA's internal treatment based on the flag values of NRBF and NCSF is illustrated.

The flag NRBF is used to activate/deactivate nodal rigid bodies or spotwelds using either:

*\*CONSTRAINED\_NODAL\_RIGID\_BODY*

or

*\*CONSTRAINED\_SPOTWELD*

or

*\*CONSTRAINED\_GENERALIZED\_WELD*

whose node set may use one or more of the deformable body nodes prior to switching. The flag NCSF is used to activate/deactivate constraint node sets defined using

*\*CONSTRAINED\_NODE\_SET.*

This mechanism of internal treatment of constraints during switching helps to define the switching process with almost no change to the original model where re-



moving of the deformable to rigid keyword will result in complete recovery of the original model.

## Timestep

In certain applications, the entire model may need to be switched to one rigid body. In such instances, the global controlling timestep may lead to infinity due to non-existence of any deformable element. In such cases, the parameter DTMAX can be used to place a limit on the global timestep such that a reasonable timestep is used for the explicit solution. DTMAX has no effect when implicit solution is invoked and is not in any way associated to the DTMAX that appears in

*\*CONTROL\_IMLPICIT\_AUTO.*

## Example Applications

Some of the applications that could take advantage of the switching process are listed here. However, it is not limited to this.

- Seat cushion foam pre-stress calculation. In this model, the dummy can be prescribed to align to a design H-Point location. Since the determination of the seat cushion pre-stress is of important while the occupant's self interaction is not of much concern all the components of the occupant can be merged to form one occupant rigidbody which can be then prescribed to compress the seat cushion. It must be noted that all the individual component part ids needs to used in the contact definition as opposed to using just one master rigidbody id as the contact definitions are independent of the switching definitions.

- Wiper mechanism simulation. Simulation of the wiper sweep is dominated by rigidbody motion. The interested components such as the motor housing which undergoes straining only during the blade impact due to an obstacle on the windshield. During the rigidbody motion until impact, the motor housing can be conveniently switched to rigid until the contact force between the blade and the obstacle is zero.
  - Vehicle Rollover Event.

## General Guidelines

When using the switch functionality, it is recommended to understand the connections of the body that is being switched. A time-zero one-way deformable to rigid switch is always recommended as an initial definition. If there are any errors associated with the switching, it can be caught and diagnosed quickly. If a reversible process is of interest, then a quick review of all the shell/solid/beam formulations of the bodies being switched should ensure that the supported element formulations are used.

## References

LS-DYNA Theory Manual  
LS-DYNA Keyword Users Manual

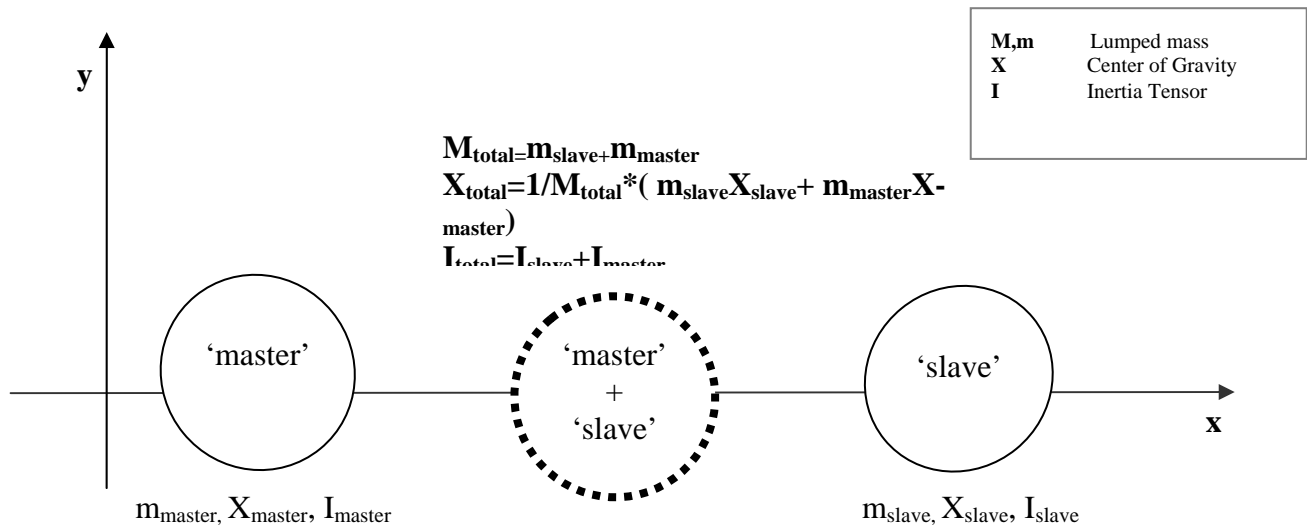


Figure 1.1: Merging of Rigidbodies

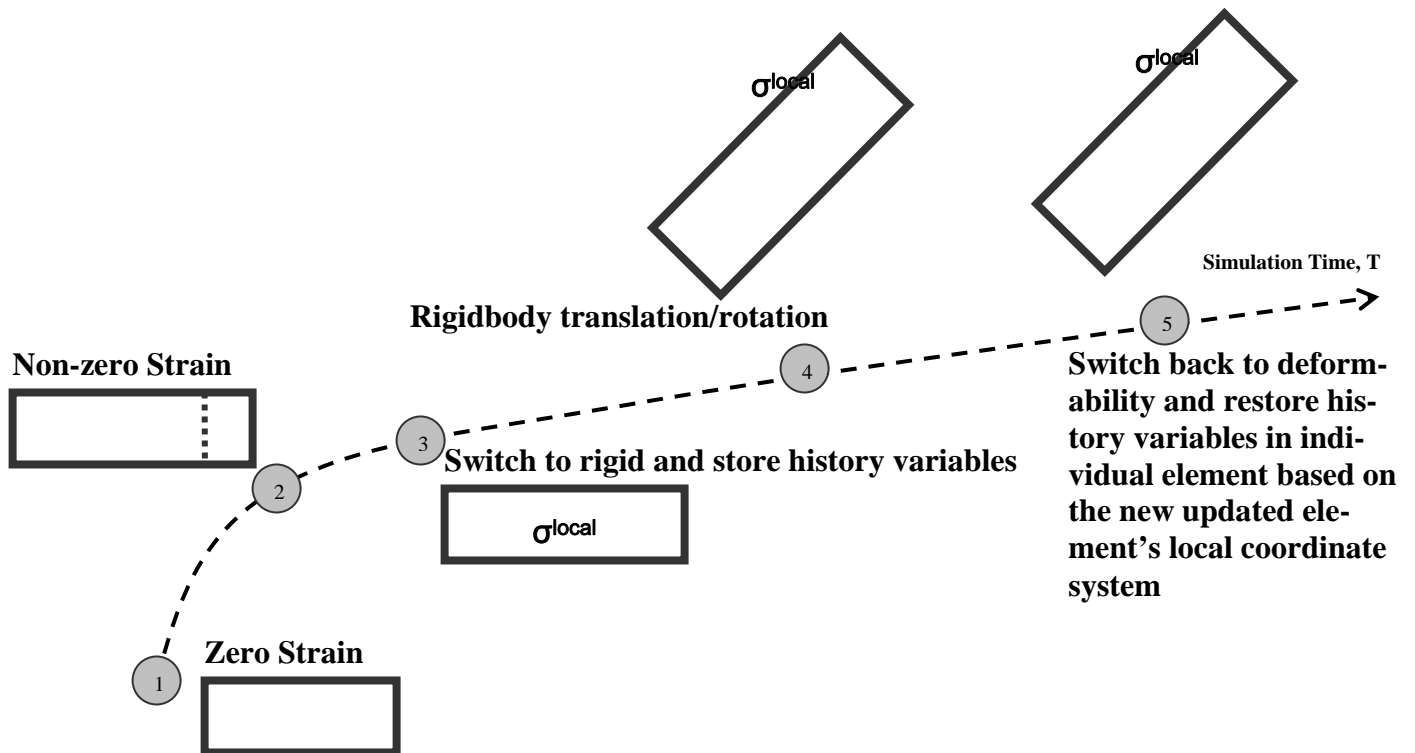
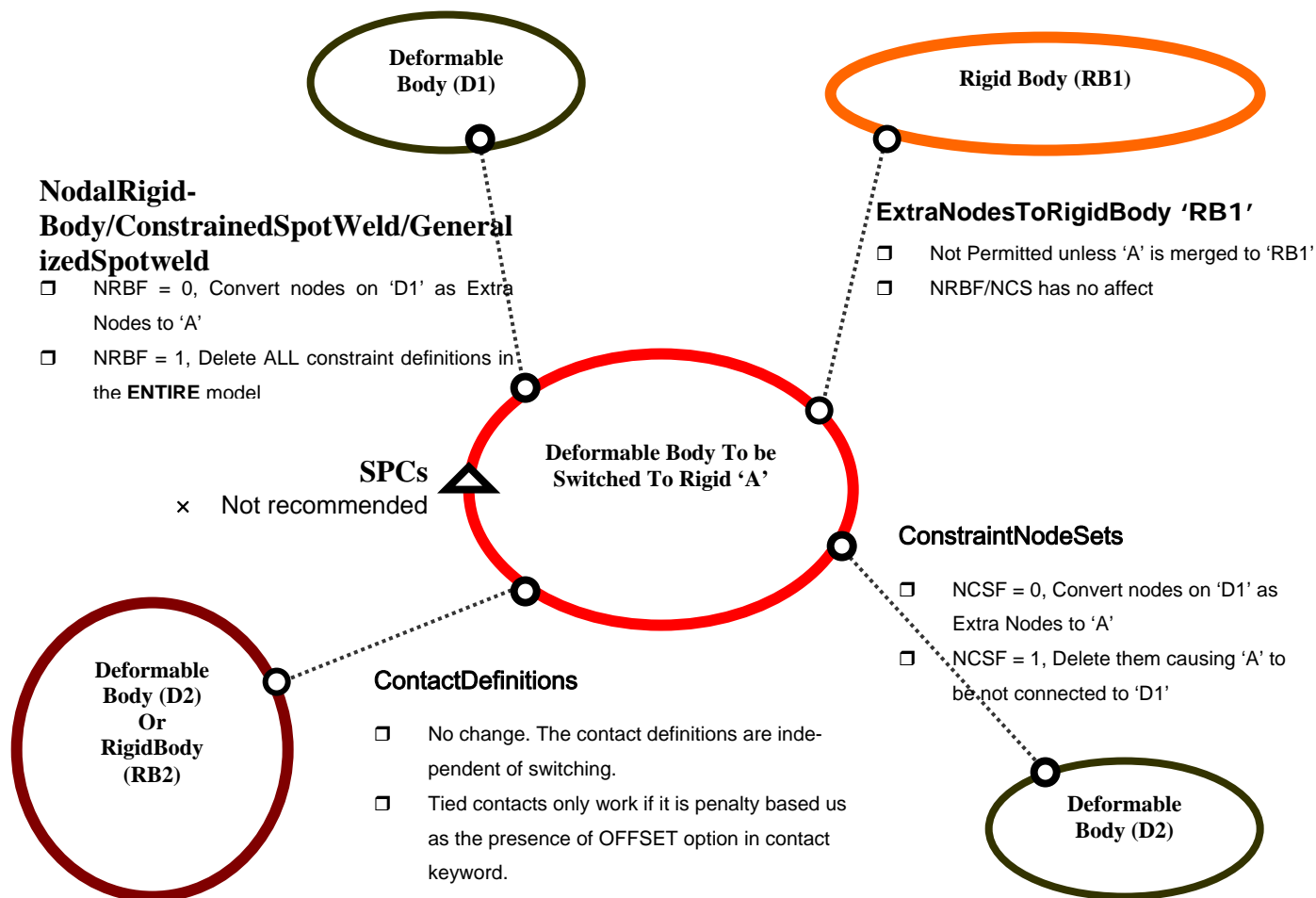


Figure 1.2: Treatment of History Variables during Switching



**Figure 1.3: Treatment of Connections in Switching**

## Engineering Interest – FEA Information Inc. Chosen Article About A Small Garage And Big Dream

**A tone heard 'round the world — HP renovates garage where company founders set the world on its ear**

The Complete article can be found on [www.hp.com](http://www.hp.com)

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1938: It was the year when ...

A nylon bristle toothbrush became the first commercial product made with nylon yarn ...

A steam locomotive set a world speed record at 126 mph ...

Howard Hughes completed his 91-hour flight around the world ...

And Bill Hewlett and Dave Packard rented a small garage where they launched a technology giant: Hewlett-Packard. The same place where HP's first patented product was created: an audio oscillator that set the tone for the company's future inventions.



**Two Stanford University graduates, David (Dave) Packard and William (Bill) R. Hewlett, founded Hewlett-Packard Company in 1939 in this Palo Alto, California, garage. The structure is a California State Historical Landmark. (1939).**

**Now, flash forward to 2005 ...**

Mark Hurd, now CEO and president of the company bearing the inventors' names, stands in that same garage for a ribbon-cutting ceremony that marks the end of a year-long restoration project. Slicing through the fabric of time, the building now reflects an era that defined a Fortune 50 company — and a company that defined an industry.



**The newly renovated garage, 2005.**

### **The Birthplace of Silicon Valley**

The Palo Alto garage at 367 Addison Avenue is generally regarded by historians, engineers and others — in and outside of the high-tech industry — as one of the most significant artifacts of the electronics industry's early days in Silicon Valley. In fact, after becoming a designated landmark by the city of Palo Alto and a California Registered Landmark by the State, the garage was dedicated as the "Birthplace of Silicon Valley" back in 1989.

Over the years, many engineers, techies, dignitaries and others visited the garage where Bill and Dave worked until they outgrew the space in 1940. Yet time began to take its toll on the structure. And

that's exactly why HP made a commitment to preserve this piece of history as a visual reminder of the industry's grass-root beginnings.

### **Déjà vu with a view**

After gaining ownership of the property in 2000, HP started working with the city of Palo Alto and preservation architects in 2004 to rehabilitate the property and grounds. This included the garage, as well as the house where Dave and Lucile Packard once lived and a shed where Bill Hewlett spent his bachelor days before he married Flora in 1939.

The restoration, which began in January of this year, focused mainly on the garage. The goal was to leave much of the structure "as is" — striking a careful balance between historical integrity and structural integrity to create a renewed structure that accurately reflected pre-WWII Palo Alto.

This included stabilizing the foundation, repairing wood damage with salvaged lumber of the same vintage, and elevating the sill to minimize future water or termite damage, all while preserving the exposed knob-and-tube wiring that characterized the period. The results are being viewed during the rededication ceremony.

### **Small Garage, Big Ideas**

To this day, HP is known for its technologists — people that find innovative technology solutions that deliver true value to customers. Consider our first invention, the HP 200A audio oscillator, an electronic instrument used to test sound equipment. Oscillators were once complex, expensive, unstable and prone to distortion. Bill Hewlett solved this by adding a light bulb to the design — creating a legacy of simplifying technology

and lowering costs for customers that still continues today.

And it all started with that light bulb — one big idea in a small garage lighting the way for the next generation of HP inventors

### **Past Perfected - Project to turn back the clock for landmark buildings - *By Deborah Hudson***

In the 1985 film, *Back to the Future*, the main character is transported by time machine decades into the past. He is stunned to note the pristine condition of a building he has only known as aging and decrepit. "Wow," he exclaims, "They really cleaned this place up. It looks brand new."

Very soon, time will roll back for HP's legendary garage, and while it won't look brand new, it will look very much as it would have when Bill and Dave burned the midnight oil in the now-famous Palo Alto landmark. A meticulous rehabilitation will return the property at 367 Addison Avenue to a state that more closely reflects the time period when the two college chums were embarking on the journey to their own futures.

"I'm really excited about this project," Anna Mancini, HP's Corporate Archivist said. "I think it demonstrates the respect and pride we feel for our community and the company's heritage."

Renovations will focus on recreating the house, garage, shed and landscaping as they would have appeared when Dave and Lucile lived in the first story apartment

Bill bunked in the 8 by 18 foot shed out back, and the two young partners designed and built the products that launched the future of Silicon Valley. If

all goes according to plan and the weather cooperates, completion should be in the fall of 2005.

The project is a cross-company collaboration working closely with the HP Corporate Archives. Following an extensive search, the Cody Anderson Wasney firm of preservation architects has been selected to execute the project

**A brief history of the property**

The two-story house on Addison Avenue was built around 1905 for Dr. John Spencer, a local physician who became the first mayor of Palo Alto. It is believed the house was divided into two flats in 1918. During the Bill-and-Dave years, the doctor's widow occupied the upstairs flat and acted as the resident landlady.

From 1938 through 1939, 367 Addison Avenue - chosen by Bill and Dave be-

cause of the garage - served as home, think-tank, lab, office and production department. There, they developed the 200A and 200B audio oscillators, HP's first products.

The garage, long a symbol of genius and entrepreneurial spirit, reached landmark status in 1987 and was dedicated as the birthplace of Silicon Valley in 1989. HP acquired the garage, along with the surrounding property, in 2000.



The future — Architectural rendering of completed house and garage at 367 Addison Avenue

**LS-DYNA Fully QA'd by Livermore Software Technology Corporation**  
**HP sales contact: Brian Lowe, [brian.lowe@hp.com](mailto:brian.lowe@hp.com).**

**SMP**

HP PA-8X00	HP-UX 11.11 and above
HP IA-64	HP-UX 11.22 and above
HP Opteron	Linux CP4000/XC
HP Alpha	True 64

**MPP and Interconnect and MPI**

HP PA-8X00	HP-UX 11.11 and above
HP IA-64	HP-UX 11.22 and above
HP Opteron	Linux CP4000/XC
HP Alpha	True 64

## **AutoSea2 real-time broadband noise and vibration prediction, analysis and design.**

© Copyright ESI-Group



[http://www.esi-group.com/SimulationSoftware/Vibro\\_acoustics/index.html](http://www.esi-group.com/SimulationSoftware/Vibro_acoustics/index.html)

**In today's competitive marketplace, noise and vibration control is of increasing importance in the design of many products, from automobiles to aircraft to consumer appliances.**

AutoSEA2, uses an analytical method called Statistical Energy Analysis (SEA) to approach noise and vibration reduction in design. Over the past 35 years, many companies have discovered that SEA is very effective for solving noise and vibration problems. Until the introduction of AutoSEA2, however, SEA modeling tools were complex and hard to use. AutoSEA2 brings to the marketplace the first easy-to-use SEA tool with a simple graphical interface. Complex models that used to take days to build can now be developed in minutes.

AutoSEA2 is redefining the way noise and vibration analysis is integrated into the design process. Before AutoSEA2, vibration problems were frequently left until physical prototypes were built and tested, late in the design process. Solving vibration problems was very expensive, causing extensive redesign.

With AutoSEA2, noise and vibration problems can be modeled earlier in the design process, eliminating costly mistakes before they go too far. AutoSEA2 is designed to work closely with existing

noise and vibration test processes, to build confidence in the SEA results.

### **Who uses AutoSEA2 and what for?**

AutoSEA2 is applied to predict interior noise levels in automobiles, trucks, trains, aircraft, ships, construction and agricultural equipment, and even the Space Station Freedom! Prediction of noise radiated by the product under design is also possible (consumer appliances, automobile pass-by noise, submarine radiated noise, etc.) as well as prediction of vibration levels (launch acoustics, microgravity, survival of sensitive electronic equipment). The excitation mechanisms may include complex acoustic fields, which is essential to treat problems such as propeller noise or aerodynamic noise. New applications

### **What kind of prediction does AutoSEA2 provide?**

Being based on Statistical Energy Analysis, AutoSEA2 provides results in a space-averaged and frequency band-integrated form. The latter means that

the results are usually in third-octave or octave bands, which makes comparison to test results easy. The former means that for a vibrating surface, the vibration level at a specific location is not predicted, but that instead an average value of the vibration level of all the points on the surface is given. This is usually a very meaningful quantity

### **What type of analyses can be done with AutoSEA2?**

Predicting noise and vibration levels is most often not enough: we need to understand how the predicted levels are generated. AutoSEA is well equipped to perform transfer path analysis (how is the energy getting from point A to point B?) and source ranking analysis (which source of excitation is dominant)?

### **How can I use AutoSEA2 as a design tool?**

In AutoSEA it is easy to study the effect of structural modifications on the noise and vibration environment of the product. For example we can modify the thickness or material of a panel, add ribs on it or replace it by a sandwich construction. Nonstructural modifications (damping treatments, acoustic materials) can also be investigated. In fact, AutoSEA offers a Trim database that allows for the design of the best possible acoustic treatment in real time

## **Features**

### **3-Dimensional Modeling**

AutoSEA2 is the only application in its class that provides fast 3D modeling for noise and vibration. All structural and

acoustic subsystems are created directly from design geometry and rendered as shaded solids.

You can import CAD and Finite Element geometry files into AutoSEA2 or interactively create your own geometry. Even the model solution results are displayed in color on the 3D geometry

- Models built faster
- Time saved and errors avoided updating models
- Avoids guessimation of radius, area, volume
- Eliminates error prone definition of junction angles & beam orientations
- Immediate model verification-visually
- Improved communication of N&V design opportunities to management

## **Computation Engine**

Unique capabilities for aero-acoustic loads, ribbed-shells and layered materials have made AutoSEA the most widely used code in its field. All formulations - based on NASA, Navy & Air Force research - are published in a formal Quality Assurance test document.

Now AutoSEA2 uses full wave transmission theory for accurate prediction of vibration and radiated sound in almost any structural configuration.

Lack of design detail at the concept design stage and uncertainty in product behavior are also managed for you.

- Reliability of the proven industry standard



- Accuracy of full wave transmission theory
- Intuitive – less dependence on user skill
- Confidence in results of Q.A.-tested code

### Open-Architecture

Designed with flexibility and expandability in mind, AutoSEA2 is built on an open-architecture platform, allowing users and third-party vendors to further expand its functionality using Extension Modules. Examples include AutoSEA-Shock (analysis of pyro-technic shock within AutoSEA2), QuickScript (Visual-Basic compatible scripting) and AutoSEA-Foam (modeling of poro-elastic, layered materials).

- Extends AutoSEA2's functionality to other applications
- Extends user's productivity range

### Auto-Connect

Point, line and area junctions between all structural and acoustic subsystems are created with the click of a single button. When subsystems share common boundary geometry, the junction is automatically detected and computed. To provide visual feedback, junctions are rendered as 3D solid objects. When selected, the junction parameters can be edited and the computed properties can be graphed.

- Saves time building & updating models
- Eliminates error-prone data entry of orientations at complex junctions

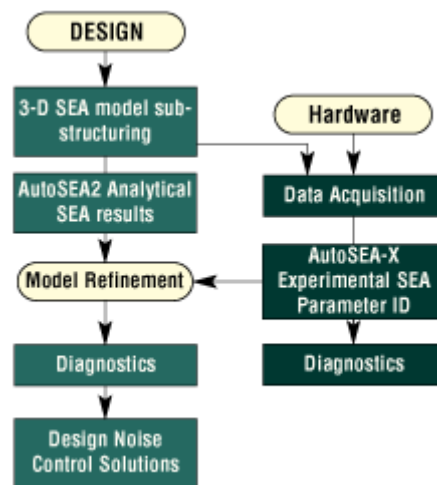
### Multi-Model Integration

AutoSEA2 allows a team of designers or group of companies to develop component parts of a large N&V design model. Each component part can be imported as an ASCII Neutral file, then automatically connected by the System Integrator in a master model. Large design projects can now be divided and subcontracted with full system-compatibility throughout the design cycle guaranteed.

- Saves time building large models
- More efficient management of large projects

### User-defined SEA

AutoSEA2's built-in modeling libraries can be infinitely expanded with user-defined functionality which allows SEA parameters to be defined by the user's own math models, finite-element models, or test results.



- Flexibility of modeling
- Improved consistency with low-frequency finite-element models

## Yahoo Groups Yammerings

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Len@Schwer.net

This installment of "Yahoo Yammerings" features two questions, with responses from the past month of postings to the LS-DYNA Yahoo Group:

1. *Material models for \*INITIAL\_STRESS\_SHELL*
2. *MAT98-Simplified Johnson-Cook Model*

### Question: Material models for \*INITIAL\_STRESS\_SHELL

I am wondering, are there a number of material models for which stress initialization *cannot* be used? If others have used shell elements with initial stress, and nonlinear materials, I would appreciate any advice.

### Response by Jim Kennedy:

A friend shared the following with me:

"Not all shell materials can use \*INITIAL\_STRESS\_SHELL; though I don't have a list. One example is Mat\_002 which employs a Total Lagrangian formulation and therefore calculates total stress based on knowledge of the unstressed geometry."

Thus for MAT\_002, \*INITIAL\_STRESS is not a valid command since there would be no record of the unstressed geometry.

In contrast, a material model which uses an incremental formulation, e.g., MAT\_ELASTIC or

MAT\_PIECEWISE\_LINEAR\_PLASTICITY, calculates incremental stresses based on incremental strains and thus no knowledge of the unstressed geometry is required. For this class of materials, \*INITIAL\_STRESS is applicable.

My memory serves me that most of the rubber models use a Total Lagrangian formulation; thus, they could not use the \*INITIAL\_STRESS\_SHELL feature.

### Question: MAT98-Simplified Johnson-Cook Model

I need clarification with respect to EPSO parameter in MAT098 (simplified Johnson-Cook ) and MAT015 (Johnson-Cook). The manual say that its a strain rate normalization factor which takes the units of time. As I am using the units of milliseconds I used the value of 0.001.

I think this value just normalizes the effective plastic strain rate and obviously takes the units of time. However, while testing this material model by unit tensile test models we find a great deviation in the results when we change this EPSO value to 1e-06 where in the response curve scaled to higher value which I feel

is some what fishy as it is tending to show some strain rate sensitivity.

However to augment my views I need some explanation for this EPSO parameter. It would be great of somebody answers this.

**Response by Jim Kennedy:**

It is my understanding that the value used for EPSO is also associated with making the units consistent. Using a smaller value of EPSO than suggested for the flow stress relationship would appear to yield a large flow stress.

You are correct in that it is a normalization factor; however, the factor appears to be unit dependent.

**Follow-up by Len Schwer:**

The various Johnson-Cook models available in LS-DYNA are popular among analysts, most likely because they typically work quite well, and are rather simple phenomenological models, as opposed to rigorous plasticity based models.

It is thus worthwhile to make clear the role of the parameter EPSO and its associated strain rate units.

The value of EPSO is the strain rate used to determine the initial yield strength parameter "A" in the Johnson-Cook model

notation. A typical quasi-static tensile test would provide a value of  $EPSO = 1E-4$  / seconds.

Thus, if the user's consistent set of units includes time units of seconds, then the appropriate input is  $EPSO = 1E-4$ . If the user's time units are milliseconds, then the conversion from seconds to milliseconds is required and the appropriate input is  $EPSO = 1E-7$  / milliseconds.

**LS-DYNA Yahoo Groups**

There are over 1500 subscribers from all over the world, and this list seems to grow by a hundred new subscribers ever few months; no small testament to the rapidly growing popularity of LS-DYNA. The group currently averages over 250 messages per month, i.e. about 10 message per work day. You can subscribe to the group by sending an email request to [LS-DYNA-subscribe@yahoogroups.com](mailto:LS-DYNA-subscribe@yahoogroups.com) or by visiting the Yahoo Groups web site <http://groups.yahoo.com>

Generally the quickest/best responses are to those questions posed with the most specifics. General questions such as "How do I use XXX feature?" either go unanswered, or are answered by Jim Kennedy with links to appropriate references in the growing LS-DYNA related literature, e.g. see the archive of LS-DYNA Conference proceedings at [www.dynalook.com](http://www.dynalook.com) .

## LS-OPT Version 3 for Windows

© Copyright Dr. Nielen Stander, LSTC

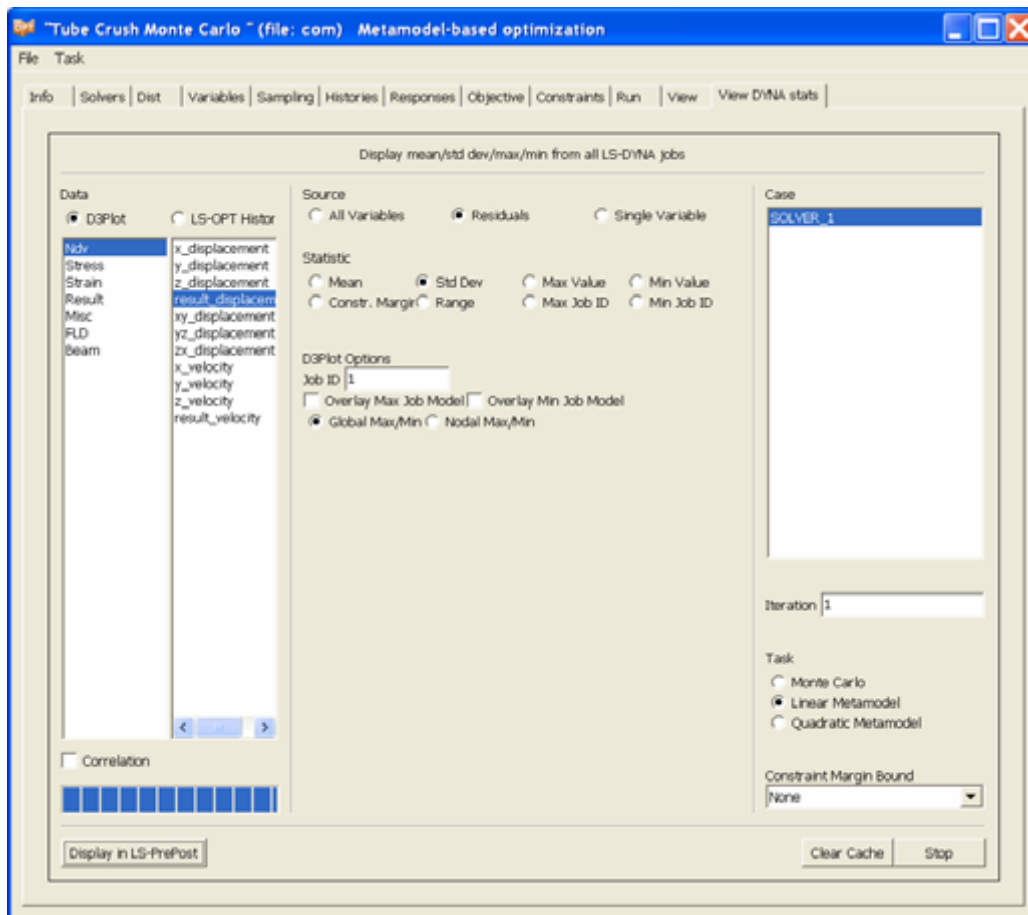
Since 1997, LS-OPT, which is bundled with LS-DYNA and LS-PrePost, has provided a means to organize multiple LS-DYNA runs for the purpose of design improvement. LS-OPT Version 3.0 was recently released to provide these capabilities also to those users of LS-DYNA who work primarily in the MS-Windows environment. Version 3.0 also has a number of new features, summarized as follows:

1. Commands have been added to simplify parameter identification using continuous curves of measured data. Optimization is a common approach used for system and material parameter identification. In the new feature, a measured response curve can be imported into LS-OPT and used to calibrate a system or material model.
2. An internal d3plot interface was developed to replace the previous LS-Taurus interface. This feature provides additional robustness to the LS-DYNA interface.
3. Reliability-based Design Optimization (RBDO) is now possible using the probability of failure in the design constraints.
4. Neural network committees were introduced as a means to improve the predictive capability of surrogate models used for optimization and trade-off studies. A committee consists of multiple fits to the same data set to center the response (e.g. by calculating the mean or median). The methodology also provides an indication of the variability of the prediction (which may occur as a result of response noise or point sparsity). The latter feature will be exploited in a future GUI enhancement.
5. Complementary to these LS-OPT features, stochastic fields have been added to LS-DYNA (Version 971) to provide the capability of modeling geometric and shell thickness variability. These fields, which are specified as perturbations of the base geometry or shell thickness, are used to introduce geometric uncertainty into the model for the purpose of generating statistical results used for reliability and robust design.

Version 3.0 is only available for Windows. Other platforms will be provided for in the Version 3.1 release (2006). LS-OPT is a standalone code and although its development is focused on the needs (e.g. result interface) of the LS-DYNA user, it can be used with any pre-processor or simulation codes.

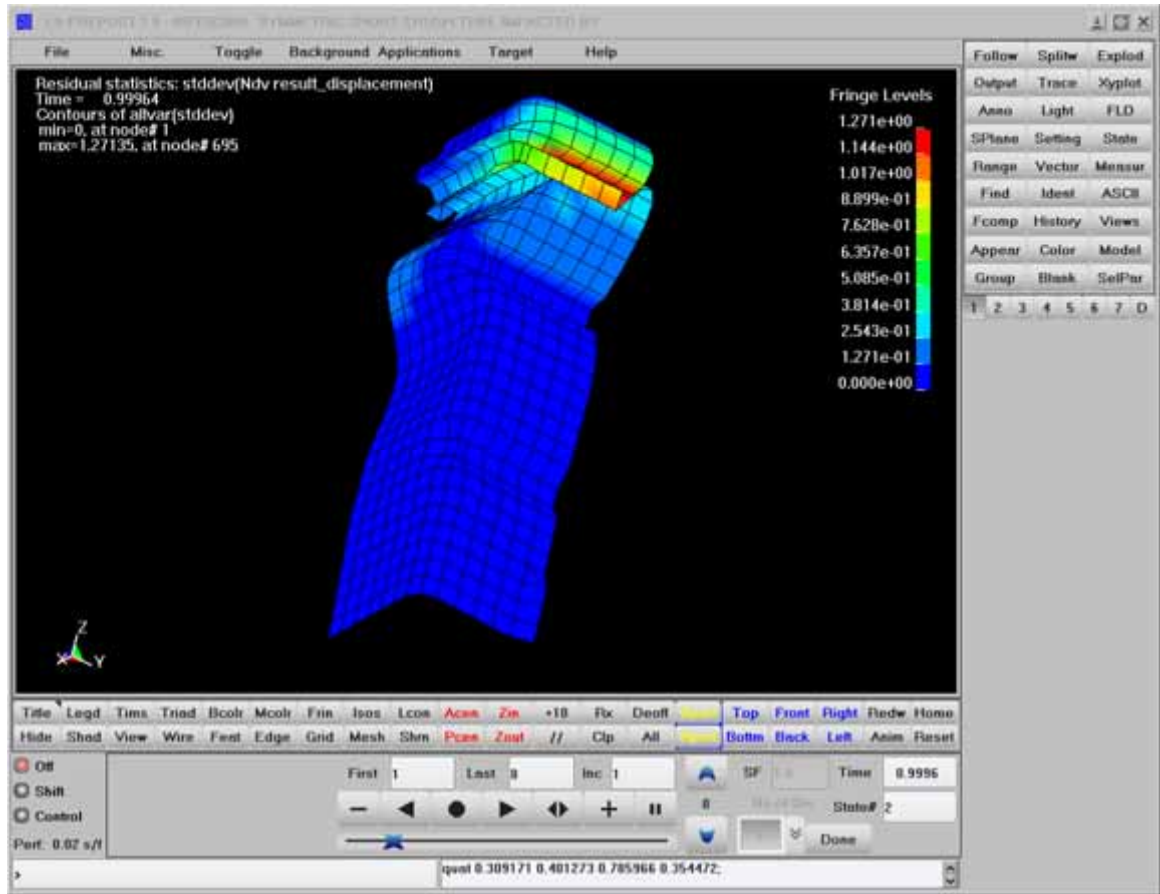
## LS-OPT Version 3 for Windows

Figure 1 Below: LS-OPT GUI for displaying Mean, StdDev, Minimum or Maximum response from multiple LS-DYNA jobs



## LS-OPT Version 3 for Windows

Figure 2 Below: A LS-PrePost display corresponding to Figure 1 in which the standard deviation of the residual displacement was selected.



## LSTC Training Classes - 2006



### LSTC Training Classes:

Jane Hallquist,  
 Training Coordinator  
 LSTC California  
 ([jane@lstc.com](mailto:jane@lstc.com))  
 Tel: 925-449-2500

### Michigan Location:

1740 W. Big Beaver Rd  
 Suite 100 , Troy , MI 48084  
 voice: 248-649-4728  
 fax: 248-649-6328  
[www.lstc.com](http://www.lstc.com)

Training Class	US \$	Livermore, CA	Detroit, MI
<b>Introduction to LS-DYNA</b>	\$750	<ul style="list-style-type: none"> <li>• Feb. 07-10</li> <li>• May 02-05</li> <li>• Aug. 01-04</li> <li>• Nov. 14-17</li> </ul>	<ul style="list-style-type: none"> <li>• Jan. 16-19</li> <li>• April 25-28</li> <li>• July 25-28</li> <li>• Dec. 11-14</li> </ul>
<b>Advanced LS-DYNA in Impact Analysis</b>	\$950	<ul style="list-style-type: none"> <li>• June 27-30</li> <li>• Sept 26-29</li> </ul>	<ul style="list-style-type: none"> <li>• Feb 21-24</li> </ul>
<b>Material Modeling Using LS-DYNA User Defined Options</b>	\$750	<ul style="list-style-type: none"> <li>• June 13-14</li> </ul>	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>
<b>LS-DYNA Implicit</b>	\$750	<ul style="list-style-type: none"> <li>• June 15-16</li> </ul>	<ul style="list-style-type: none"> <li>• Sept. 07-09</li> </ul>
<b>Introduction to LS-OPT</b>	\$750	<ul style="list-style-type: none"> <li>• May 16-19</li> <li>• Nov. 07-10</li> </ul>	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>

## LSTC Training Classes

<b>Training Class</b>	<b>US \$</b>	<b>Livermore, CA</b>	<b>Detroit, MI</b>
<b>ALE/Eulerian &amp; Fluid/Structure Interaction in LS-DYNA</b>	\$750	<ul style="list-style-type: none"> <li>• Feb. 15-17</li> </ul>	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>
<b>Geomaterial Modeling with LS-DYNA</b>	\$750	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>
<b>MESH Free Methods in LS-DYNA (SPH-EFG)</b>	\$750	<ul style="list-style-type: none"> <li>• Feb. 01-03</li> </ul>	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>
<b>LS-DYNA Composite Materials</b>	\$750	<ul style="list-style-type: none"> <li>• March 30-31</li> <li>• Sept. 14-15</li> </ul>	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>
<b>LS-DYNA for Heat Transfer &amp; Thermal-Stress Problems</b>	\$500	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>	<ul style="list-style-type: none"> <li>• Not Scheduled at this time</li> </ul>
<b>Contact in LS-DYNA</b>	750	<ul style="list-style-type: none"> <li>• March 28-29</li> <li>• Sept. 12-13</li> </ul>	<ul style="list-style-type: none"> <li>• June 22-23</li> </ul>



## LSTC Distribution & Consulting Channel – November

FEA Participants for LS-DYNA Sales – Support – Training – Benchmark – Consulting

Listing of a few of the many products they distribute

 <p><b>AUSTRALIA – LEAP</b></p> <p><a href="http://www.leapaust.com.au">www.leapaust.com.au</a></p> <ul style="list-style-type: none"> <li>• ANSYS</li> <li>• ANSYS/LS-DYNA</li> <li>• LS-DYNA</li> <li>• LS-PREPOST</li> <li>• LS-OPT</li> </ul>	 <p><b>Germany - CADFEM</b></p> <p><a href="http://www.cadfem.de">www.cadfem.de</a></p> <ul style="list-style-type: none"> <li>• LS-DYNA</li> <li>• LS-PREPOST</li> <li>• LS-OPT</li> <li>• ANSYS</li> <li>• ANSYS-LS-DYNA</li> </ul>
 <p><b>India - Altair</b></p> <p><a href="http://www.altair-india.com">www.altair-india.com</a></p> <ul style="list-style-type: none"> <li>• LS-DYNA</li> <li>• HYPERMESH</li> <li>• HYPERWORKS</li> <li>• OPTISTRUCT</li> <li>• HYPERVIEW</li> </ul>	 <p><b>Italy – Numerica</b></p> <p><a href="http://www.numerica-srl.it">www.numerica-srl.it</a></p> <ul style="list-style-type: none"> <li>• LS-DYNA</li> <li>• LS-PREPOST</li> <li>• LS-OPT</li> <li>• FEMB</li> <li>• VPG</li> </ul>
 <p><b>Japan – Fujitsu</b></p> <p><a href="http://salesgroup.fujitsu.com/plm">http://salesgroup.fujitsu.com/plm</a></p> <ul style="list-style-type: none"> <li>• LS-DYNA</li> <li>• FEMB</li> <li>• VPG</li> <li>• DYNAFORM</li> </ul>	 <p><b>Korea – THEME</b></p> <p><a href="http://www.lsdyna.co.kr">www.lsdyna.co.kr</a></p> <ul style="list-style-type: none"> <li>• LS-DYNA</li> <li>• LS-POST</li> <li>• LS-OPT</li> <li>• DYNAFORM</li> <li>• VPG</li> </ul>

## EVENTS – 2006

If you want your event listed please send the information to:  
[mv@feainformation.com](mailto:mv@feainformation.com)

<b>2006</b>	
<b>April 24-26</b>	<a href="#">MSC.Software 2006 Americas VPD Conference</a> , Detroit, MI - US
<b>May 02-04</b>	<a href="#">2006 International ANSYS Conference</a> , Pittsburgh, PA - US
<b>June 04-06</b>	<a href="#">9th International LS-DYNA Users Conference</a> - Dearborn, MI - US
<b>July 02-06</b>	<a href="#">ICSV13 Vienna</a> - Vienna, Austria
<b>July 5-7</b>	<a href="#">HEAT TRANSFER 2006</a> -Ninth International Conference on Advanced Computational Methods and Experimental Measurements in Heat and Mass Transfer - <b>The New Forest, UK</b>
<b>Oct 12-13</b>	Germany: LS-DYNA Users Meeting in Ulm. Hosted by DYNAmore
<b>Nov 14- 16</b>	<a href="#">Aerospace Design Expo 06</a> - Anaheim, CA - US

### Course Offering:

January 25~27, 2006 - Special Course being offered in Korea by KOSTECH "ALE / Eulerian & Fluid / Structure Interface in LS-DYNA".  
 Taught by M'hamed Souli, Ph.D (LS-DYNA ALE Module Developer)  
 Contact [young@kostech.co.kr](mailto:young@kostech.co.kr)

## LS-DYNA Resource Page

### Interface - Hardware - OS And General Information

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
CRAY XD1	Linux
FUJITSU Prime Power	SUN OS 5.8
FUJITSU VPP	Unix_System_V
HP PA-8X00	HP-UX 11.11 and above
HP IA-64	HP-UX 11.22 and above
HP Opteron	Linux CP4000/XC
HP Alpha	True 64
IBM Power 4/5	AIX 5.1, 5.2, 5.3
IBM Power 5	SUSE 9.0
INTEL IA32	Linux, Windows
INTEL IA64	Linux
INTEL Xeon EMT64	Linux
NEC SX6	Super-UX
SGI Mips	IRIX6.5
SGI IA64	Altix/Prism

## LS-DYNA Resource Page

MPP Interconnect and MPI

FEA Information Inc. Participant's (alpha order)

Fully QA'd by Livermore Software Technology Corporation

Vendor	O/S	HPC Intereconnect	MPI Software
AMD Opteron	Linux	InfiniBand (Silver-Storm), MyriCom	LAM/MPI, MPICH, HP MPI, SCALI
CRAY XD1	Linux		
FUJITSU Prime Power	SUN OS 5.8		
FUJITSU VPP	Unix_System_V		
HP PA8000	HPUX		
HPIA64	HPUX		
HP Alpha	True 64		
IBM Power 4/5	AIX 5.1, 5.2, 5.3		
IBM Power 5	SUSE 9.0		LAM/MPI
INTEL IA32	Linux, Windows	InfiniBand (Voltaire), MyriCom	LAM/MPI, MPICH, HP MPI, SCALI
INTEL IA64	Linux		LAM/MPI, MPICH, HP MPI
INTEL Xeon EMT64	Linux	InfiniBand (Topspin, Voltaire), MyriCom	LAM/MPI, MPICH, HP MPI, INTEL MPI, SCALI
NEC SX6	Super-UX		
SGI Mips	IRIX6.5		
SGI IA64	Altix/Prism		

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

#### ETA – VPG

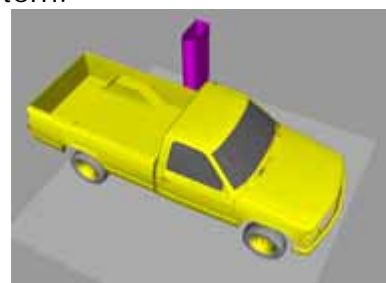
[www.eta.com](http://www.eta.com)

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.

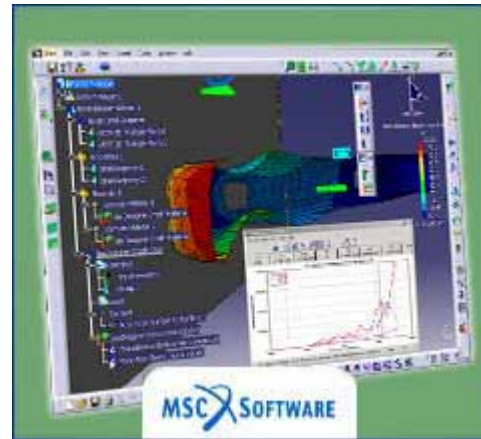
MSC.Nastran Explicit Nonlinear will allow users to work within one common modeling environment using the same Bulk Data interface. NVH, linear, and nonlinear models can be used for explicit applications such as crash, crush, and drop test simulations. This reduces the time required to build additional 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

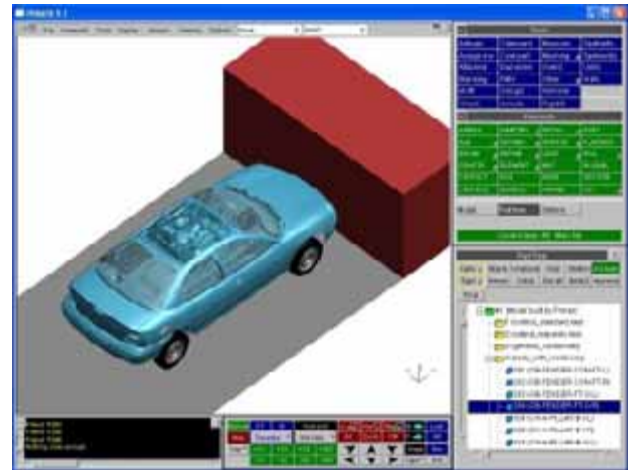
a specific Crash workbench on the GPS workspace, the application enhances CATIA V5 to allow finite element analysis models to be output to LS-DYNA and then results to be displayed back in CATIA. Gateway for LS-DYNA supports explicit nonlinear analysis such as crash, drop test, and rigid wall analysis.



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](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.



**EASI-CRASH DYNA**  
[www.esi-group.com/SimulationSoftware/EASi\\_CRASH-DYNA](http://www.esi-group.com/SimulationSoftware/EASi_CRASH-DYNA)

Interfaced to the latest version of LS-DYNA Easi-CRASH DYNA supports LS-DYNA Version 970. EASi-CRASH DYNA has powerful editing features, such as automesh and remesh.

LS-DYNA/MADYMO coupling capabilities for pre- and post processing. With direct read in of LS-DYNA® data it has highly optimized loading and animation of LS-DYNA results for design

## Hardware & Computing and Communication Products



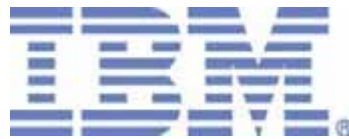
[www.amd.com](http://www.amd.com)



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

## Software Distributors (cont.)

Alphabetical order by Country

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

## 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
Canada Kingston, Ontario www.mfac.com	Metal Forming Analysis Corporation Chris Galbraith galb@mfac.com (613) 547-5395
India Bangalore www.altair-india.com	Altair Engineering India Nelson Dias info-in@altair.com 91 (0)80 2658-8540
Italy Torino www.altairtorino.it	Altair Engineering Italy sales@altairtorino.it
Italy Firenze www.numerica-srl.it	Numerica SRL info@numerica-srl.it 39 055 432010
UK Solihull, West Midlands www.arup.com	ARUP Brian Walker brian.walker@arup.com 44 (0) 121 213 3317
USA Windsor, CA www.schwer.net/SECS	SE&CS Len Schwer len@schwer.net (707) 837-0559
USA Corvallis, OR www.predictiveengineering.com	Predictive Engineering George Laird (1-800) 345-4671 george.laird@predictiveengineering.com
USA Neenah, WI www.structuretechnology.com	Structure Incorporated Todd L. Peters (920) 722 7060 info@structuretechnology.com

## Educational & Contributing Participants

Alphabetical Order By Country

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

## Informational Websites

The LSTC LS-DYNA Support site: [www.dynasupport.com](http://www.dynasupport.com)

FEA Informationwebsites	<a href="http://www.feainformation.com">www.feainformation.com</a>
TopCrunch – Benchmarks	<a href="http://www.topcrunch.org">www.topcrunch.org</a>
LS-DYNA Examples (more than 100 Examples)	<a href="http://www.dynaexamples.com">www.dynaexamples.com</a>
LS-DYNA Conference Site	<a href="http://www.ls-dynaconferences.com">www.ls-dynaconferences.com</a>
LS-DYNA Publications to Download On Line	<a href="http://www.dynalook.com">www.dynalook.com</a>
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