MARCH
2007

fea INFORMATION

WWW.FEAINFORMATION.COM

LSTC

Presentation

at

18th HP CAE Symposium

IBM

IBM SYSTEM X

BLADECENTER SOLUTIONS

Henry H. Fong

FROM FEA TO MCAE TODAY

A 40-YEAR PERSONAL ODYSSEY

Part 1

FEA INFORMATION RESOURCE MAGAZINE

New Participant Introduction:

Full Company Information will appear in the April Issue

CARHS – "Since 1994 we have been working with the leading automobile manufacturers worldwide. We know the engineering processes and tools in the industry in great detail. Our core business is offering state-of-the-art products and services in the field of Vehicle Safety: Simulation services for the internal and external safety of vehicles. Innovative engineering methods and tools. Extensive seminar programme and SafetyKnowledge." For Complete Information visit: **CARHS**.

Linux Networx – "Linux Supercomputing is our only business. That means we focus exclusively on solving our customers' toughest supercomputing challenges. For nearly a decade Linux Networx has delivered supercomputing excellence. We blend the price performance advantage of Linux clusters with real-world supercomputing expertise and innovation." For Complete Information visit **LNXI**

ARUP – INDIA - nHance Engineering Solutions Pvt Ltd was established in 2004 to provide software development resources to Oasys and to Arup divisions. Distributors of the Oasys pre-and post-processing software, they will additionally distribute LS-DYNA, LS-OPT and LS-PrePost

Series:

From FEA To MCAE Today – A 40-Year Personal Odyssey – Part 1 of 3
by Henry H. Fong, San Francisco, Caifornia.

Sincerely,

Art Shapiro
art@feainformation.com

Marsha J. Victory
mv@feainformation.com

Table Of Contents

FEA Information Inc. & News:
Editor
Art Shapiro
Graphic Designer
Wayne L. Mindle
Business Manager
Trent Eggleston
President
Marsha J. Victory

FEA Information News:

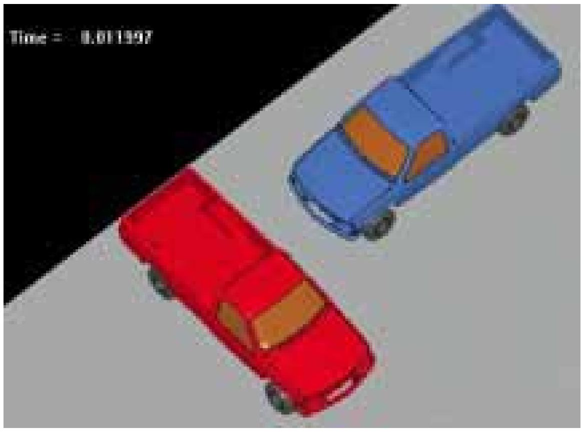
Technical Writers:
Dr. David Benson
Dr. Ala Tabiei
Uli Franz
Suri Bala

Writing Consultants:
Steve Pilz – Reza Sadeghi

LS-DYNA Featured AVI

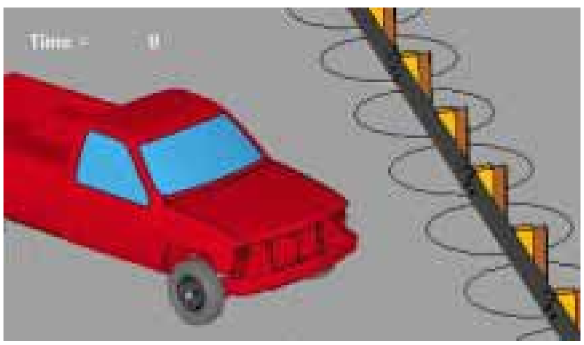
Complete AVI's can be viewed at:

www.feainformation.com – top bar link "AVI Lib"



AVI 204 Side collision - light weight truck

Courtesy Gaurav Nilakantan - Univ. Delaware



AVI 204a Oblique crash - light weight truck – guardrail

Courtesy Gaurav Nilakantan - Univ. Delaware

LS-DYNA Publication Abstract / Introduction

Updated information may be available. Contact the paper author.
Chosen from the 9th International LS-DYNA Users Conference 2006

The Complete Paper: on FEA Publications Side Bar Link: "Featured"

A High Strain Rate Model with Failure for Ice In LS-DYNA

Kelly S. Carney – NASA Glenn Research Center – USA
David J. Benson – Univ. of California, Sand Diego – USA
Paul Du Bois – Germany
Ryan Lee – The Boeing Company – USA

Abstract

Modeling the high velocity impact of ice was a requirement in the safety calculations for the return-to-flight of the Space Shuttle on July 26, 2005. Ice, however, is not a common structural material and commercial finite element programs didn't have any appropriate models. A phenomenological model with failure was developed to match experimental ballistic tests. The model has a relatively small number of material constants, most of which have been measured experimentally. A description of the model and comparisons of calculations to experiments are presented.

Introduction

The destructive effects of the impact of ice at high speeds is well known. For man-rated vehicles, experiments are usually required to certify the safety of the design. Jet engines, for example, are required to pass ice ingestion tests by the FAA. Concern about the impact of ice on the Space Shuttle dates back to at least to the 1983 test program described by DeWolfe [1].

Analyses were rarely carried out previously for many reasons, including the absence of sufficient computer power, software that could handle both the extreme deformations of the ice and accurately model the structural response of the vehicle, and an accurate model for ice. Low cost PC clusters have provided the required computer power. Finite element methods have advanced dramatically since DeWolfe's investigation. There has been, however, little effort previously in the development of a constitutive model for ice that can be used in finite element calculations.

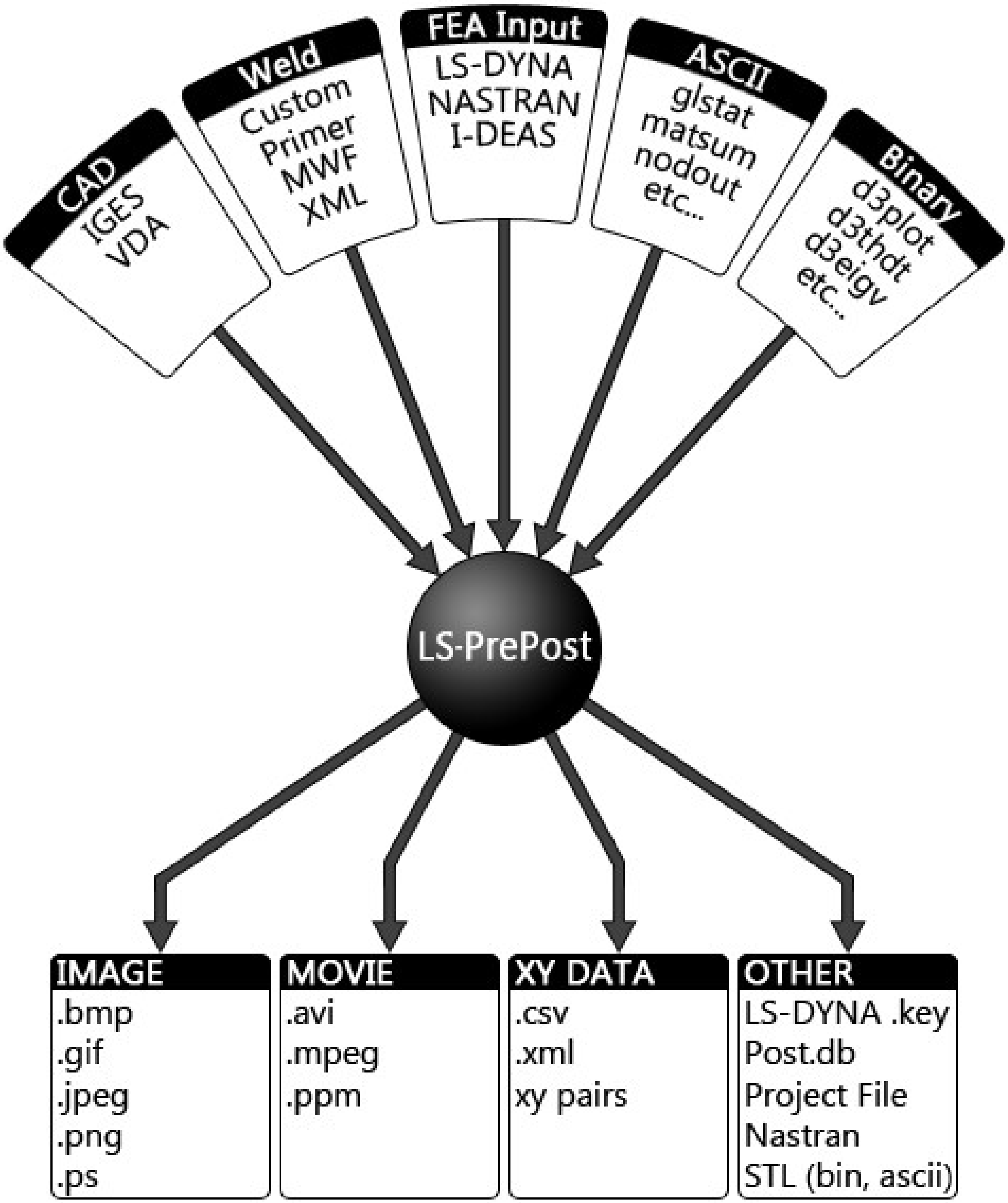
The Columbia Space Shuttle tragedy motivated a large scale safety review of the Space Shuttle, and included in that review was a requirement for certifying the ability of the leading edge of the wing to safely sustain impacts of various types of debris [2]. The leading edge is made of carbon-carbon composites, with each section costing over one million dollars. Given the wide range of debris, impact locations, and velocities, and the many months it takes to produce a single panel, a complete experimental test program would be prohibitively expensive and could not be accomplished in a timely manner. Finite element analysis, carefully validated by a series of experiments, was therefore required to certify the Space Shuttle for flight.

After calculating the relative velocity of the leading edge and debris, analyses were limited to low density materials that would rapidly decelerate in the atmosphere. Dense objects, such as bolts, are not believed to endanger the leading edge since the relative impact velocity would be low. Low density materials, such as the foam that brought down Columbia, rapidly decelerate to the point that the Shuttle flies into the debris at a velocity up to 3000 ft./s. Ice decelerates rapidly enough to be considered a potential problem, with a maximum expected impact velocity of up to 1000 ft./s.

Constitutive models for reinforced carbon-carbon composites and the low density foams covering the external fuel tank are reasonably mature, and validation experiments using the shuttle materials demonstrated their accuracy. Ice, however, is not a commercial structural material, and aside from high velocity impact situations of interest to the aerospace industry, is rarely subject to high strain rate impact conditions. Although ice has been studied extensively, e.g., [3], only a very few efforts have been made to model it numerically at high strain rates [4,5]. Attempts to use existing models, including some intended for brittle engineering materials, demonstrated the need for an improved model.

The ice model presented here was developed under the deadlines required to return the Space Shuttle to flight. It is phenomenological in nature, and its value was judged based on how well it modeled the ballistic experiments. As far as possible, the material parameters have been measured by experiments that are independent of the experiments used to validate the accuracy of the ice model.

LS-PrePost® Online Documentation Update



LS-PrePost® Continued

10-Mar - Added *Record Orient* option to Toggle Menu to suppress writing of orientation commands to Command File

28-Feb - Tutorial 16 added to online documentation (Intro to Block Mesher)

24-Feb - Update of SphGen Interface

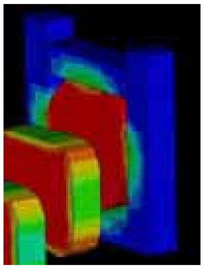
LS-PrePost® was designed to provide the following core functionalities:

- Full LS-DYNA® keyword support
- LS-DYNA model visualization
- LS-DYNA model creation and editing
- Advanced post-processing

LS-PrePost's main post-processing capabilities include states result animation, fringe component plotting, and XY history plotting.

LS-PrePost is also capable of importing and exporting data in a number of common formats. The figure on the right illustrates a sampling of those that a typical user might find most useful.

LSTC California & Michigan Training Classes
April – May – June



A complete list of dates can be found on the LSTC website

April

10-13	CA	LS-OPT

May

01-04	CA	Introduction to LS-DYNA

June

05-08	MI	Introduction to LS-DYNA
12-13	CA	Contact
14-15	CA	Composite Materials
18-19	CA	Material Modeling Using User Defined Options
26-29	CA	Advanced – Impact Analysis

For Class Details:
www.lstc.com

Participant Benchmarks On TopCrunch.

TopCrunch.org For Complete Vendor Submitted Benchmarks

Vendor Submitted – QLogic
Feb. 15 – March 09, 2007

Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	32 x 2 x 2 = **128**	208	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	32 x 2 x 1 = **64**	223	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	16 x 2 x 2 = **64**	293	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	16 x 2 x 1 = **32**	388	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	8 x 2 x 2 = **32**	482	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	8 x 2 x 1 = **16**	700	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	4 x 2 x 2 = **16**	879	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	4 x 2 x 1 = **8**	1290	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	2 x 2 x 2 = **8**	1714	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	64 x 2 x 1 = **128**	1886	3 Vehicle Collision
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	48 x 2 x 1 = **96**	1937	3 Vehicle Collision
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	32 x 2 x 2 = **128**	2398	3 Vehicle Collision
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	24 x 2 x 2 = **96**	2651	3 Vehicle Collision
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	1 x 2 x 2 = **4**	3242	neon_refined_revised
Cambridge Cluster/ QLogic InfiniPath IB	Intel Dualcore Xeon 5160 3.0 GHz	1 x 2 x 1 = **2**	4863	neon_refined_revised

LSTC Presenting at 18th HP CAE Symposium

Tuesday April 3rd, 2007

18th Annual HP CAE Symposium on Technology Trends in Computational Engineering – 8:30 – 4:00 pm – St. John's Inn and Conference Center, Plymouth, MI

LSTC will be offering the following presentations:

Pre & Post-Processing Track

Capabilities of LS-Prepost 2.1 2.

Philip Ho, Manager, Visualization software. Philip Ho is in charge of the development effort of LS-PrePost at LSTC. He holds a Bachelor degree in Civil Engineering, and a Master degree in Aerospace Engineering, both from Texas A&M University. He has been doing software development in Finite Element Analysis and the related fields for more than 25 years.

Abstract: LS-PrePost is an advanced pre and post-processor that is delivered free with LS-DYNA. The user interface is designed to be both efficient and intuitive. Key features and capabilities of LS-PrePost will be introduced in this presentation which includes 2D, 3D mesh generation, LS-DYNA entities creation, model manipulation, special applications, and post-processing.

Safety/Impact Track

Recent Developments in LS-DYNA

Dilip Bhalsod, Technical Manager of the LSTC Michigan office in Troy Michigan. His current responsibilities include LS-DYNA technical support, overseeing LS-PrePost user interface development, and customer training. Dilip worked at General Motors for 20 years on various aspects of automotive crash analysis. During the last 10 years at GM, Dilip provided LS-DYNA technical support. He started his career in the automotive industry at British Leyland, UK in 1978. Dilip Bhalsod holds a Bachelor of Science in Automotive Engineering from Hertfordshire University in UK.

HP Keynote Presentations:

Suzy Tichenor, VP & Director of High Performance Computing Initiative, Council on Competitiveness "Out-Compute to Out-Complete: Driving Competitiveness with HPC"

Lee Fisher, WW CAE Business Manager, Hewlett-Packard Company "Ever Evolving HPC Solutions for CAE"

For complete Information:
www.hp.con/go/caesymposium

Experience LS-DYNA® by the hour… FREE!!

www.hp.com/services/flexiblecomputing

A 5,000+ hour HP Flexible Computing Services utility computing trial to qualified LS-DYNA commercial customers

Flexible IT for your most demanding jobs

A $4,500 value, this offer includes:

- **16 Xeon 64-bit CPU's for 2 weeks (5,376 CPU-hours**
- **LS-DYNA MPP version 971**
- **Redhat Enterprise Linux**
- **HP MPI**
- **SSH connectivity**

Take advantage of this offer NOW to ensure your access to capacity!

About the LS-DYNA HP Flexible Computing Services Solution

Hewlett-Packard delivers a new, complete LS-DYNA Utility Computing Service under the HP Flexible Computing Services portfolio. This unique utility computing service offers LS-DYNA customers servers, networking, storage and LS-DYNA licensing, all hosted at a highly secure, HP-owned data center.

Pay As You Go Computing

The LS-DYNA HP Flexible Computing Service is a pay-as-you-go service. There is no long-term financial commitment necessary. You can use it once and pay only for the hours of service you reserved. It is designed to extend and complement your in-house LS-DYNA resources.

Terms of offer:

Offer is valid for North America-based LS-DYNA commercial customers and is subject to qualification. Agreement with HP Flexible Computing Services and LS-DYNA terms of use is required. Introductory session

www.hp.com/services/flexiblecomputing

Yahoo Group Yammerings

Note: LS-DYNA Yahoo Group is neither owned nor operated by LSTC, and LSTC has no control over the content.

Jim Kennedy
KBS2 Inc.
jmk@kbs2.com

Len Schwer
Schwer Engineering & Consulting Services
Len@Schwer.net

The LS-DYNA Yahoo Group archives contains a wealth of information that can be helpful to any LS-DYNA user. We suggest you review the archives when you are seeking help on any topic related to LS-DYNA. *NOTE: Questions and responses may have been edited for clarity & brevity.*

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

1. *Recommendation for DT2MS value?*
2. *Penalty factor help?*
3. *Volumetric Strain for MAT_63?*
4. *BOUNDARY_NON_REFLECTING?*

Question: Recommendation for DT2MS value?

I am trying to simulate a tube flaring process and I am using mass scaling to reduce the computation time.

I used DT2MS = 0.005 as a starting value (baseline) and then compared the results with DT2MS = 0.0005. The results were not that identical, but the computation time difference was huge (4 mins. vs 31 mins.).

I have read the how-to on mass scaling from the LS-DYNA support website. I would like to know if anyone with mass scaling experience in metal forming simulations has a recommendation for the DT2MS value.

Reply by Jim Kennedy:

Please use good engineering judgment when using mass scaling. Adding mass can change the physics of the problem. You need to evaluate how much increase you can allow and not alter the intent of your simulation. Remember that increasing the mass will add kinetic energy to the simulation; usually, you would like to keep that small.

To monitor the changes in mass, LS-DYNA prints out the added mass and the percentage increase, as shown here:

```
problem cycle = 49960
time = 2.9999E-02
added mass = 8.1457E-03
percentage increase = 2.6333E-01
```

The percentage increase provides an excellent evaluator for assessing the quality of your simulation. The allowable increase is a decision you must make, based on good engineering judgment, that will not alter the solution results significantly.

In addition, you can use the change in kinetic energy from GLSTAT or MATSUM output files for guideline support.

Question: Volumetric Strain for MAT_63?

I have two questions concerning the definition of the volumetric strain for *Mat_Crushable_Foam (MAT_063). The Keyword User's Manual defines the volumetric strain as:

1-V

where V = relative volume. The Theory Manual defines the volumetric strain as :

-ln V (the negative natural log of the relative volume)

At this point my first question is which is correct?

Obviously, when deflections (and subsequent strains) are small, these two definitions produce values that have no appreciable difference. However, at large strains (like those seen in foams subjected to impact loading) these values can differ by more than 50%.

My second question is, how does the natural log come into play when defining the volumetric strain? Restated, what is the mechanical derivation behind this relationship?

Reply by Philipp Roemelt

Regarding your second question, volumetric strain = integral (1/V dV) with the integration limits of V0 (initial volume) to V (current volume). So if you integrate that you get volumetric strain = ln(V/V0) or = ln(1+delta V/V0).

Reply by Len Schwer

Phillipp’s answer is essentially correct. This is a case of engineering versus natural strain. In the laboratory, volume strain is measured as

v = (V0-V)/V0 = 1-V/V0 (engineering volume strain)

LS-DYNA always uses the natural (logarithmic strain)

V = Int[dv/V0] from V0 to V = ln(V/V0)

Thus the two are related by

V = ln(1-v)

So the Keyword Manual is referring to laboratory (engineering) volume change and the Theoretical Manual is taking about logarithmic volume strain.

You should always convert your laboratory data to logarithmic strain for LS-DYNA input, as that is what LS-DYNA uses internally.

LS-DYNA Yahoo Groups: There are over 2195 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 about 200 message per month, i.e. about 7 message per day. You can subscribe to the group by sending an email request to 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

FROM FEA TO MCAE TODAY – A 40-YEAR PERSONAL ODYSSEY

Henry H. Fong
San Francisco, California
henryhfong@yahoo.com

Part 1. Beginnings (1950s-1960s)

1.1 Introduction

I'm a lucky fellow. Lucky in the sense that at the beginning of my 40-year career, I witnessed the golden age of finite element method (FEM) research, and the subsequent development of commercial finite element analysis (FEA) codes in the 1970s and 1980s. In my career, I have applied FEA codes in the structural integrity assessment of many interesting aerospace structures and components – launch vehicles and missiles, spacecraft, solar energy heliostats, rocket nozzles, and traveling wave tubes. The finite element method is an approximate numerical analysis technique to solve a wide variety of engineering problems.

The immense technical advances and increasingly widespread use of FEA coincided with the exponential increase in computer power in the past 40 years. We have moved in this period from multi-million dollar mainframes and supercomputers (usually placed in restricted-access, air-conditioned, machine rooms with raised floors – guarded zealously by IT geeks whose first priority was to run business applications) to the affordable desktop PCs/workstations and laptops available today.

I came to the U.S. in 1956 as a teenager, and graduated from Lowell High School in San Francisco. I then enrolled at the University of California at Berkeley, majoring in civil engineering. In my freshman year, I took an "engineering measurements" course, where my teaching assistant was a friendly graduate student named Bob Taylor. Then, in my junior year, Bob had just received his Ph.D degree, and was my instructor in strength of materials. After obtaining my B.S., I proceeded onto graduate school at Berkeley, took a solid mechanics course from Bob, and then did my M.S. research project with him. Bob told me that in the mid-1960s, things were getting "pretty exciting" in a new field called finite elements, and that there were many challenging research opportunities in this field. He had a twinkle in his eyes, like a kid who was going on his first roller coaster ride with a carton of cotton candy.

This article is a 3-part survey paper on my 40-year career in FEA/MCAE (mechanical computer-aided engineering). It reflects my own FEA user experiences (working at four Southern California aerospace companies for 14 years), and then, doing customer support, training, documentation, and technical marketing for another 14 years at two MCAE software developers (PDA Engineering, MARC Analysis). Finally, for the past 12 years, I was involved in Manufacturing Industries business development and worldwide sales support, for high performance computing (HPC) hardware platforms that run MCAE applications. As such, this article neither pretends to be authoritative nor complete, and I hereby apologize for any unintentional omissions of someone's name or FEM/FEA contribution. The interested reader who may be unfamiliar with FEA is referred to the Bibliography, which contains a selected list of FEM textbooks and technical articles.

Part 1 of the article gives a brief historical sketch (1950s-1960s) of the finite element method, and the contributions of some early researchers – most of whom were engineers. In the late 1960s to early 1970s, applied mathematicians finally validated the FEM approach, put the method on firm mathematical foundations, and proved its convergence and accuracy.

Part 2 – Development of Commercial FEA Codes (1970s-1980s) describes the first generation of commercial FEA codes (e.g., STARDYNE, NASTRAN, ANSYS, MARC, ASKA, etc.) and pre- and post-processors (SDRC/SUPERTAB and PDA/PATRAN). The MacNeal-Schwendler Corporation, developer of the MSC/NASTRAN FEA code for structural and dynamic analyses, was the first FEA software vendor to go public. All of a sudden, Wall Street heard the terms FEA and MCAE for the first time, and FEA/MCAE was no longer a “cottage industry.”

The development of the DEC VAX 11/780 minicomputer in 1977 made it feasible to develop interactive graphics used in the pre- and postprocessors. Instead of doing a “batch submit” of the FEA job in a box of punch cards (. . a major disaster if the box was dropped), the user could now do an “interactive submit,” construct and see and modify the model in real time, for instance, on a Tektronix graphics terminal. The user could also visualize the results after the finite element analysis, and interactively make improvements to the model if needed.

Researchers also started to realize, beginning in the 1960s, that FEM could be extended from its structural analysis roots to solve other problems in heat transfer, fluid mechanics, electromagnetism, geomechanics, acoustics, and biomechanics.

Also mentioned in Part 2 are some FEA/MCAE conferences which were organized for code developers, researchers, and end users to learn about the latest FEM developments. These included: the three Wright-Patterson Air Force Base Matrix Methods in Structural Mechanics conferences held in 1965, 1968, and 1971; the Chautauqua’s organized by Dr. Harry G. Schaeffer; AIAA/ASME/ASCE/AHS Structures, Structural Dynamics, and Materials conferences; Dr. John Robinson’s World Congresses of Finite Element Methods; and worldwide conferences organized by the UK-based National Agency for Finite Elements Method and Standards (NAFEMS). Each FEA code developer, of course, also held its own user conferences, usually once a year.

Part 3 – Maturing of FEA/MCAE (1990s to Today) discusses the maturing of the FEA/MCAE industry in the past two decades. The PC made FEA computing affordable and personal; the FEA engineer was finally liberated, and no longer had to fear the IT geek. A brief overview is given of the MCAD industry. Current MCAD market leaders (Dassault Systemes/CATIA, Unigraphics) have been recently gobbling up FEA/MCAE vendors, in order to offer their customers “one stop shopping.” Some recent mergers and acquisitions are mentioned, confirming the shakeout and consolidation going on in MCAD/MCAE. New and powerful graphics chips (e.g., Nvidia and ATI), driven by the game industry, have also made an impact on the FEA/MCAE workplace.

Linux, the open-source operating system created by Linus Torvalds, has become a significant trend on computing worldwide, including MCAE and other HPC markets (e.g., life sciences – genomics, proteomics, and big pharma, energy, and Wall Street). It has become the OS of choice for many HPC/MCAE customers, who purchase clusters primarily for price/performance reasons. This led to the emergence of two new Linux OS vendors – Red Hat and SuSE.

Recent hardware innovations are surveyed: the current battle between Intel vs. AMD Opteron; product transitions from single-core processors to dual-core, and soon, quad-core; and, clusters – commonly using Linux or Unix OS's with medium- and high-speed interconnects offered by vendors such as: Myricom/Myrinet, Scali, and Infinband vendors Cisco/Topspin, Voltaire, and QLogic/Silverstorm. Recent 2006 Q4 HPC server market share and revenue growth (according to IDC and Gartner estimates) are reviewed, comparing IBM, HP, and Sun. The scalability (with increasing processor count) of various MCAE explicit transient codes (e.g., LS-DYNA for crash) and CFD codes (e.g., FLUENT, STAR-CD) is discussed.

Finally, some challenges and trends in MCAE today and in the future are discussed – e.g., training and technical support issues in a 24x7 world; software distribution using the Internet (vis-a-vis Google) instead of shipping CD's by FedEx or UPS; the mentoring of new engineers when the older, experienced FEA analysts retire and pass on; Grid Computing – a useful concept, but still struggling to become mainstream; the emergence of China and India in this decade as worldwide manufacturing and outsourcing powerhouses; continued absence of standards for nonlinear FEA; and over-reliance of U.S. manufacturing and hi-tech industries on foreign-born, U.S.-trained engineers – what if they decide to go home to China or India to seek better job opportunities?

Professor Bob Taylor retired in 1994 after a distinguished teaching and FEM research career at UC Berkeley, and since then, he is a Professor in the Graduate School. In 1991, he was elected to the National Academy of Engineering, a peer-elected academy (2,405 members) of engineers who have made outstanding contributions to the engineering profession. Bob and I had kept in touch and remained friends over the past 47 years; he was always curious in how I was doing, and what interesting projects I was working on. Through Bob, I was introduced to four distinguished FEM researchers: Professors Olek Zienkiewicz, Tinsley Oden, Tom Hughes, and Juan Simo. I fondly remember Olek, Bob, my wife Evelyn and I enjoying a great seafood lunch by the beautiful Barcelona harbor, on one lazy, sunny afternoon in 2002. After lunch, Olek kindly offered to drive us back to our hotel. Bob acted as the backseat driver, shouting directions to Olek – who had impaired vision and hearing, in addition to being a rather poor driver and terribly confused by Barcelona's meandering streets. (Evelyn and I were glad to get out of Olek's car!) I dedicate this article to Bob Taylor – my teacher, mentor, and life-long friend.

1.2 Beginnings of FEM / FEA

In the beginning, there was the triangle. The first "commercial" finite element was a triangular element used for analyzing plane stress problems in Boeing airplanes (see the seminal 1956 paper by Turner, Clough, Martin, and Topp in the Bibliography). This paper described the development of a (linear) triangular element, based on virtual work principles. Such an approach became the basis of what was later named the "Matrix Displacement Method" or "Direct Stiffness Method," since the nodal unknowns are displacements or deflections, and the solution of the numerical problem involves an inversion of the stiffness matrix. It was also known that in 1943, the eminent mathematician Richard Courant had used an assembly of triangular elements, and the principle of minimum potential energy, to solve the St. Venant torsion problem. Professor Ray Clough at UC Berkeley was the first to coin the term "finite element method," in his classical 1960 ASCE paper on solving plane-stress civil engineering problems (Clough, 1960).

Around the same time, in England, Professor John H. Argyris published in Aircraft Engineering a famous series of articles on numerical analysis of structural mechanics (Argyris, 1954-55), which were later collected and re-published, with S. Kelsey as co-author, a monograph entitled Energy Theorems and Structural Mechanics (Argyris and Kelsey, 1960).

These two trail-blazing articles in the mid-1950s by Argyris (1954-55) and Turner, Clough, Martin and Topp (1956) are considered to be the "foundation papers" for the Finite Element Method (specifically, the Displacement Method). Starting in the 1960s, Professor O.C. Zienkiewicz and his colleagues at University of Swansea in Wales initiated a series of FEM research projects, primarily aimed at extending FEM from structural analysis to solve other field problems (see the texts by Zienkiewicz and Taylor, 1989, 1991, 2005). Professor Robert L. Taylor from UC Berkeley spent three sabbatical leaves at Swansea, and this rich collaboration between Taylor and Zienkiewicz's group led to many outstanding FEM papers and Ph.D theses at Swansea. Professor Argyris then moved from UK to head the Institut fur Statik und Dynamik (ISD) in Stuttgart, Germany, and assembled an impressive German FEM research group there. Amongst their many notable FEM achievements, the ISD research team developed the theoretical bases for the linear/nonlinear FEA code ASKA – which I used at Rockwell International in 1977 to perform nonlinear FEA of the carbon-carbon tiles (which undergo extremely high temperatures during reentry), that made up the Space Shuttle thermal protection system.

Someone once estimated that these three preeminent FEM research centers – UC Berkeley (Ray Clough, Bob Taylor, Ed Wilson, et al), University of Swansea (Olek Zienkiewicz, et al), and ISD Stuttgart (John Argyris, et al) – accounted in the 1960s-1980s for something like half of all the most outstanding FEM research achievements (and FEM Ph.D degrees awarded) in the entire world!

Meanwhile, at Douglas Aircraft Co. in Long Beach, California, Paul Denke and his Stress Group colleagues had developed during the 1960s-1970s a different Matrix Force Method computer program, to analyze Douglas jets such as the DC-8, DC-9, DC-10, C-130, and MD-11 (Denke, 1968). Instead of using nodal displacements as the unknowns, the Force Method uses nodal forces. An innovative scheme is used to automatically "cut" the structure into substructures. The "flexibility matrix" is solved, instead of the stiffness matrix used in the Displacement Method.

Denke and his colleagues validated the method by successfully correlating their results with many test results. Although Argyris had also established the validity of the Force Method in his 1954-55 papers, the Displacement (Stiffness) Method gradually won out over time, and became the de facto standard Finite Element Method. This happened for a variety of reasons: real-world complex structures and components were easier to model; and computer programming was easier. And politically, the NASA-sponsored NASTRAN program (Jones and Fong, 1981, 1982) became the aerospace industry-standard FEA code starting in the early 1970s. NASTRAN also rapidly became the dominant NVH (noise, vibration, and harshness) code used in the worldwide automotive industry. Douglas Aircraft Co. (later McDonnell Douglas, now part of Boeing) was, as far as I know, the only major manufacturer using a Force Method finite element code.

The Finite Difference Method (FDM) gives a pointwise approximation to the governing equations — as opposed to FEM's idealizing a region as many small, interconnected subregions or elements and giving a piecewise approximation. FDM was popular in the 1940s and 1950s – especially in CFD codes used to simulate laminar and turbulent flows around aircraft fuselage, tails, and wings. In FDM, the model is formed by writing difference equations for an array of grid points. Engineers, however, found the FEM codes easier to use than FDM codes, especially to model complex, irregular boundaries in the structure, and also when they encountered an unusual specification of boundary conditions.

Another numerical analysis scheme developed was the Boundary Element Method (C.A. Brebbia, F. J. Rizzo, et al). This method utilizes Green's theorem to reduce the dimensionality of the problem – a volume problem is reduced to a surface problem, a surface problem is reduced to a line problem. The method is computationally less efficient than FEM, and is therefore not widely used in industry. However, it is popular for acoustics, and is also used in analyzing electromagnetics and geomechanics problems.

In the past 40 years, FEA has become ubiquitous, worldwide, and mind-boggling as to its vast array of innovative applications. Using FEA codes has enabled manufacturers to develop safer and better products faster, optimize use of materials, minimize weight – and thus gain a competitive edge. You can bet that virtually any product you see, touch, or use today most likely have been designed using FEA – an airplane, car, truck, windshield, locomotive engine, satellite, or a Herman Miller ergonomically-designed chair, jet engine, dam, car fender, electric shaver, or a light bulb, golf club, golf ball, violin, tooth implant, a stent for a cardiovascular surgeon to pry open a artery clogged with plaque, or a Zimmer artificial "Gender Knee" specifically customized for women (using ABAQUS and ANSYS for FEA, and currently advertised on TV). FEA usage started in the aircraft/aerospace industries, moved quickly to the automotive and nuclear industries, and has now spread to virtually all industries – such as consumer goods, electronics, heavy equipment, machinery, chemical, and big pharma.

A Google search today on the two keywords "finite element" yielded 36.0 million hits! For keywords "finite element method": 19.3 million hits; for "finite element analysis": 20.9 million hits. A Google book search today using the keywords "finite element method" showed a total of 2,575 books – a tremendous increase over one FEM textbook in 1967 (O.C. Zienkiewicz and Y.K. Cheung's The Finite Element Method in Engineering Science), 10 books in 1974, 40 in 1982, and 400 in 1991 (Noor, 1991).

1.3 Validation of FEM

But wait a minute, the finite element method was developed by engineers! In their 1956 paper, Turner and Topp were research engineers from Boeing, Harold Martin was an aerospace engineering professor at University of Washington, and Ray Clough was a civil engineering professor at UC Berkeley. How do we know the method they developed and their FEA results were correct? Was it safe to fly a 707, 727, 737, or a 747?

It remained for two MIT applied mathematicians, Professors Gilbert Strang and George Fix, to validate the finite element method, give the method a firmer mathematical foundation, and prove mathematically and rigorously that with increased mesh density, the predicted FEA results indeed converged (Strang and Fix, 1973). They also examined and estimated discretization error, rates of convergence, and stability for different types of finite element approximations.

A third individual should be mentioned: Bruce Irons. Irons was an outstanding UK FEM researcher who made key contributions to the development of isoparametric elements (see any FEM text on isoparametric elements and on the patch test). He attributed the widely used 2D, 5-quad element, "picture window" patch test (which tests convergence for a plane problem) to John Robinson. They stipulated that any 2D finite element, for example a plane-stress quadrilateral element, must pass the patch test in order to converge. With a point load at a corner node, the patch test states that the stresses in all five quadrilateral elements in the "picture window" patch test model must be the same. The patch test also comes in 3D – a 7- brick element model with a small cube inside a larger cube. The patch test was controversial, stirring up heated debate amongst finite element researchers and mathematicians in the 1970s. Eventually, the furor wound down, and the FEM community accepted it as a valid test for convergence.

Chapter 2 will appear in the April Issue

ACKNOWLEDGMENTS For All Chapters

In my career, I had the great fortune to study under, befriend, and work with hundreds of outstanding FEA pioneers, professors, researchers, FEA/MCAE software developers, finite element analysts, engineers/designers, and sales/marketing professionals. I have learned from each of them.

In particular, I wish to express my gratitude to (* members of the National Academy of Engineering) Professors Ray W. Clough*, Bob L. Taylor*, Ed L. Wilson*, Olek C. Zienkiewicz*, Tom J.R. Hughes*, Ted B. Belytschko*, J. Tinsley Oden*, Juan C. Simo, Carlos A. Brebbia, Y.C. Fung*, T.Y. Paul Chang, Y.K. Cheung, Ron L. Sakaguchi, Walt D. Pilkey, Harry G. Schaeffer, Hiroshi Takeda, Tadahiko Kawai, Karl Schweizerhof, and Ted H.H. Pian*. Among FEA/MCAE code developers: Dick H. MacNeal*, John A. Swanson, John O. Hallquist*, Pedro V. Marcal, H. David Hibbitt, Bengt Karlsson, E. Paul Sorensen, Joop C. Nagtegaal, Ed L. Stanton, Lou M. Crain, Michael S. Engelman, Farzin Shakib, Siu S. Tong, Gary Vanderplaats, and Armin Wulf. And, in industry: J. Greg Crose, Rick E. Caselli, Ken A. McClymonds, Kevin J. Forsberg, Aldo Cella, Mike A. Burke, Svenn E. Borgersen, M. Jeff Morgan, Tom C. Curry, Gunter Muller, Larsgunnar Nilsson, Mike Sheh, Arthur Tang, Mike J. Wheeler, Nobuki Yamagata, Greg Clifford, Fritz Hatt, Reza Sadeghi, Nick Perrone, Bob E. Nickell*, James W. (Bill) Jones, Mark A. Skidmore, Michael A. Schulman, and Stephen C. Perrenod.

GLOSSARY

CAE computer-aided engineering (usually refers to a design/analysis process that includes preprocessing, FEA, postprocessing – with the analysis step typically involving the specification of material properties, boundary conditions, and loads)

CFD computational fluid dynamics (e.g. CFD codes such as: ANSYS/FLUENT, STAR-CD, ANSYS/CFX, Acusim, Exa/PowerFLOW, etc.)

Computational mechanics a term favored by academic FEM researchers, with an emphasis on the numerical analysis, convergence, and accuracy aspects of solid and fluid mechanics

EDA electronic design automation, also known as ECAD (leading vendors being Cadence, Synopsys, and Mentor Graphics)

FEA finite element analysis

FEM finite element method; finite element model

HPC high performance computing, also used: HPTC (high performance technical computing). Typical HPC markets include, for example: MCAE, life sciences (genomics), oil and gas, risk management, etc.

IGES Initial Graphics Exchange Specification (sponsored in 1979 by the National Institute of Science and Technology [NIST])

MCAD mechanical computer-aided design, also used: CAD. The term refers to software (e.g., CATIA, UGS, PTC, SolidWorks, AutoCAD, etc.) that is used to generate a geometric representation of an object. [The term MCAD usually does not include analysis capabilities.]

MCAE mechanical computer-aided engineering – a term which includes pre- and post-processing and FEA (but not MCAD geometry)

MDO multidisciplinary optimization (e.g., VR&D/Genesis and VisualDOC, Engineous Software/iSIGHT and FIPER, LSTC/LS-OPT, HEEDS, etc.)

NAFEMS National Agency for Finite Element Methods and Standards, a Scotland-based (but international in coverage) agency that publishes FEM and FEA-related documentation, standards, benchmark problems, and training/certification. See www.nafems.org for a description of the agency, their publications, and steering committees in various FEA technical disciplines.

NVH noise, vibration, and harshness – used in the automotive industry as a measure of ride comfort in a vehicle. PDES Product Data Exchange Specification (sponsored by NIST, succeeded IGES in 1984)

PDM product data management
PLM product lifecycle management (e.g., DS/Enovia, UGS/Metaphase, etc.)

American professional societies in engineering:
AHS American Helicopter Society
AIAA American Institute of Aeronautics and Astronautics
ASCE American Society of Civil Engineers
ASME American Society of Mechanical Engineers
USACM United States Association for Computational Mechanics

BIBLIOGRAPHY

Argyris, J.H., “Energy Theorems and Structural Analysis,” Aircraft Engineering, vol. 26, Oct-Nov. 1954, pp.347-356, 383-387, 394; vol. 27, Feb-May 1955, pp. 42-58, 80-94, 125-134, 145-158.

Argyris, J.H., and S. Kelsey, Energy Theorems and Structural Analysis, Butterworth, London, UK, 1960.

Bathe, K.J. and E.L. Wilson, Numerical Methods in Finite Element Analysis, Prentice-Hall, Englewood Cliffs, N.J., 1976.

Bathe, K.J., Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, N.J., 1982.

Brebbia, C.A. (ed.), Finite Element Systems, Springer-Verlag, 1982.

2007 Worldwide Events

LS-DYNA Events

DATE	Country	Conference	Hosted By:
April 26-27	Korea	2007 Korea LS-DYNA Conference,	KOSTECH
May 29-30	Sweden	6th European LS-DYNA Conference	ERAB
Oct 11-12	Germany	LS-DYNA Users Meeting, hosted	DYNA*more*
Oct 30-31	Japan	Japan LS-DYNA Users Conference	JRI

The 8th International Users Conference 2008
will again be held in Dearborn, MI, USA – Conference Website

Events

DATE	Country	Conference
June 01-08	UK	Int'l Conferenc on Computational Ballistics
June 12-13	German	VAUC 2007 – Vibro-Acoustic User Conference
July 02-04	Russia	Computational Methods and Experimental Measurements
July 23-26	USA	Ninth US National Congress on Computational Mechanics
Sept 17-19		Annual Technical Conferencs of the American Society for Composites

Distributor of the LS-DYNA Suite of Products in India

As of February 2007 FEA Information Inc. is pleased to announce a new participant located in India. Additionally ARUP UK, has been appointed by LSTC as a distributor in India. ARUP will be distributing LS-DYNA, LS-OPT and LS-PrePost through nHance Engineering Solutions Pvt. Ltd., a local distributor of the Oasys software and FE model products in India.

nHance Engineering Solutions Pvt Ltd was established in 2004 to provide software development resources to Oasys and to Arup divisions. Over the last two and half years, nHance's team involvement has spread to all aspects of software development and to all Oasys structural, geotechnical and document management products. Now, as well as distributing the Oasys pre-and post-processing software, they will additionally distribute LS-DYNA, LS-OPT and LS-PrePost.

For a free demo license and price list of LS-DYNA, LS-OPT and LS-PrePost contact:

Lavendra Singh
nhance Engineering Solutions Pvt. Ltd
101, Cyber Heights

Plot 13, Road No. 2
Banjara Hills
Hyderabad - 500033
India
lavendra.singh@arup.com
+91 (0) 40 23544420/28

2nd ANSA & μETA International Congress organized by BETA CAE Systems S.A.

It is our pleasure to invite you to participate in the “2nd ANSA & μETA International Congress” to be held in June 14-15, 2007, in Halkidiki, Greece.

Following the success of last year's event, the biannual ANSA & mETA International Congress becomes a tradition.

This anticipated event provides a global forum for the exchange of state-of-the-art knowledge and ideas in the CAE simulation field.

Our goal is to give to the CAE community an opportunity to personally interact with the executive, development and services engineers of BETA CAE Systems S.A., to be informed about the latest software trends and to present new requirements for future developments.

To ensure the success of the event, we address this invitation to strategic decision makers, simulation experts and application users from all sectors, including the automotive, motorsports, aerospace, chemical and academic.
This invitation appeals to anyone who is interested in the FEA development trends, wants to add proposals and suggestions for CAE-process advancements and wants to have an international experiences exchange in the CAE field.

Following is the link to the event brochure:

http://www.beta-cae.gr/congress_2007.pdf

DYNAmore GmbH Training and Event Announcement

Headquartered in Germany

Seminars

Material models (New date! April 19)

Crash by Paul du Bois (April 24)

Optimization week

Stuttgart, Mai 7-11
Four events in one week focusing on optimization and related topics.

LS-OPT Update (Mai 7, free of charge)

Structural optimization (Mai 8)

Optimization with LS-OPT (Mai 9-10)

Robustness with LS-OPT (Mai 11)

German LS-DYNA Forum

Frankenthal, 11th-12th October 2007

All users are kindly encouraged to contribute with a presentation.

Call for papers (pdf, English)

Call for papers (pdf, German)

DYNA*more* is dedicated to support engineers to solve non-linear mechanical problems numerically. Our tools to model and solve the problems are the finite element software LS-DYNA as solver and LS-OPT for optimization. Both software packages are developed by LSTC in California. We may assist you by licensing LS-DYNA on your site and supporting or benchmarking the software. Alternatively, we may be part of your development team and contribute as a consultant. We may work on-site or in one of our offices with full or part time contracts.

As German based company we mainly work in Germany, Austria, Switzerland and the neighboring countries.

IBM – HPC Solutions for CAE
IBM System X BladeCenter solutions that deliver value

(adapted – The complete article can be found at:
http://www-03.ibm.com/systems/x/solutions/industry/auto/hpcsolutions)

Collaboration brings innovative Solutions to market

The complexity of your simulation, design and analytical tasks requires extreme computing power, but your bottom line demands flexibility, the power to choose what's best for your business, with great price-performance. Combining IBM System x™ and BladeCenter® pre-tested and configured Linux® or Microsoft® — based clusters with IBM System Storage™ and innovative offerings from IBM Business Partners, you can help simplify management, enhance cluster availability and reduce time and resources necessary to deploy HPC clusters while keeping fixed costs to a minimum.
Enable an affordable, scalable, high-availability computing solution designed to support compute-intensive applications.

Accelerate time to market with high productivity across engineering organizations through ease of use and information sharing.

Help reduce implementation and development costs with innovative technology designed to maximize productivity with a collaborative environment.
Innovative Technology

Hardware

Clustered System x and BladeCenter servers provide a single point-of-control to help simplify management, enhance cluster availability and reduce time and resources necessary to deploy HPC clusters. Available for Linux® and Windows Compute Cluster Server 2003, our cluster nodes can include:

IBM BladeCenter HS21 extended memory (XM) blade server offers higher processing performance at lower power levels, and is packed with up to 32GB of internal memory, all in a 30mm blade.

The IBM System x3455 provides outstanding performance in a 1U package for compute-intensive environments at an affordable price.
The x3550 delivers application density for power-managed data centers.

Storage

System Storage DS3200 and DS3400 are designed to help you meet the demands of your business today while offering room to grow.
The DS3200 system can help improve storage availability at an affordable price by accessing your data across System x servers.

The DS3400 system offers access to your data across System x, as well as BladeCenter servers in either direct-attach or SAN configurations.

Deep Computing Capacity on Demand

IBM also offers customers the ability to run their compute intensive HPC workloads in the IBM Deep Computing Capacity on Demand (DCCoD) centers. With access to over 20,000 processors ranging from Intel, AMD, POWER5+ to Blue Gene, customers large and small can tap into IBM HPC Systems to help accelerate time to market and improve quality while keeping fixed costs to a minimum.

Ansys Inc.
ANSYS is leading the evolution of CAE tools and technologies, delivering customer value by enabling companies to improve product development and processes. ANSYS is committed to developing simulation solutions — from mechanical to computational fluid dynamics (CFD) — that illustrate realistic and accurate modeling and simulation of components, subsystems, and systems. Replacing hardware prototyping and testing, ANSYS solutions drive product designs from concept to reality.

ESI Group
ESI Group has developed a suite of coherent industry-oriented applications to realistically simulate a product's behavior during certification testing, to fine tune the manufacturing processes in synergy with the desired product performance, and to evaluate the operational or accidental environment's impact on product usage. ESI Group's product portfolio, represents a unique collaborative, virtual engineering solution, known as the Virtual Try-Out Space (VTOS), enabling a continuous improvement on the virtual prototype.

MSC.Software
Delivered over the fully integrated and extendable SimEnterprise platform, MSC Software's integrated virtual product development tools use detailed digital product models to simulate and verify every aspect of product performance. This empowers manufacturers to make and track critical design decisions and communicate and coordinate product development with all points of the enterprise.

Livermore Software Technology Corporation (LSTC)
A team of engineers, mathematicians, and computer scientists are engaged in the development of LS-DYNA, LS-PrePost, and LS-OPT for use in various industries, including Automobile Design, Aerospace, Manufacturing, and Bioengineering. LS-DYNA development is focused on one code methodology that includes Implicit, Explicit, SMP and MPP solvers and is optimized for clusters running Unix, Linux, and Windows operating systems.

MSC.Software March Product Showcase Part 1

(To be continued)

SOFY

Sofy is a finite-element (FE) modeler that allows you to capture, create and deploy robust, standardized finite-element processes throughout your organization.

A variety of modules in Sofy allow you to capture standard finite-element processes or to program your own custom processes. The ability to pre- and post-process finite-element models automatically increases overall productivity and eliminates the need to constantly check and recheck the modeling methods.

An intuitive set of tools and technology in Sofy enable you to quickly and effectively generate, manipulate and manage complex finite element models. Sofy supports linear, non-linear, and transient post-processing for finite element analysis.

Easy5

In the aerospace and automotive industries, engineers often assemble products schematically using special iconic blocks that represent systems and subsystems, such as valves, actuators, heat exchangers, and so on. Easy5 is a schematic-based simulation software that allows you to model and simulate dynamic systems containing hydraulic, pneumatic, mechanical, thermal, electrical, and digital subsystems.

Work with libraries of ready-made parts

So that you can model and simulate a variety of dynamic systems quickly and easily, Easy5 comes with an extensive library of pre-built components sorted by industry. In Easy5, you model systems using functional blocks (summers, dividers, wave generators, and so on) and pre-defined components that represent physical elements (pumps, gears, engines, and so on). You can also link to entire system designs in computer-aided engineer software.

Access powerful analysis tools

Another powerful aspect of Easy5 are its analysis tools, which allow you to do nonlinear simulation, steady-state analysis, control system design, data analysis and plotting. Easy5 generates the source code automatically to support real-time requirements. An open architecture provides links to a broad set of popular computer-aided engineering software and hardware tools.

DYTRAN

A ship runs aground, a cell phone drops off a table, gasoline sloshes in a gas tank and explodes. These are events that happen very quickly and involve permanent structural damage or the interaction of fluid and structure. You need to design products to hold up, but real world testing may be expensive or impossible. You can't build a oil tanker and then run it aground to check for oil spills, for example. But you can use Dytran to simulate the behavior of small to extremely large assemblies in disastrous events, such as a drop, an impact, a shake, or a blast, to examine what might cause a product to fail.

Dytran is an explicit finite element analysis (FEA) solution for analyzing complex nonlinear behavior involving permanent deformation of material properties or the interaction of fluids and structures. Dytran enables you to study the structural integrity of designs to ensure that final products stand a better chance of meeting customer safety, reliability, and regulatory requirements.

MARC

Finite element analysis (FEA) is a critical part of the virtual design process. But because most FEA programs are linear, they can only study parts that deform a small amount, certainly not enough to deformation to exceed the linear elastic range of the materials.

But Marc has no such limitations. A nonlinear FEA program, Marc enables you to assess the structural integrity and performance of parts undergoing large permanent deformations as a result of thermal or structural load. The types of deformations the program can study include geometric nonlinearities .

(metals bending) and material nonlinearities (elastomers and metals that yield under structural or thermal loading). You can also use Marc to simulate deformable, part-to-part or part-to-self contact under varying conditions that include the effects of friction—critical for analyzing nonlinear behavior in tool-and-die set-up, spring coil clash, or a windshield wiper system.

And whether you are designing with glass, rubber, steel, or concrete, Marc offers an extensive library of metallic and non-metallic material models, along with a library of 175 elements for structural, thermal, and fluid analysis.

Combine with pre- and post-processors

You can drive all Marc products through the common GUI offered by Patran or Marc Mentat, two pre- and post processors that work with Marc. Mentat also provides the unique ability to process large problems in parallel using the domain decomposition technique. Loading conditions can originate from physical tests or virtual tests using Adams. MSC Software AFEA is a bundled version of Patran and Marc

ANSYS News Release

Latest Version of ANSYS Icemax Offers System-in-Package Support

SOUTHPOINTE, Pa., March 6 /PRNewswire-FirstCall/ -- ANSYS, Inc. (Nasdaq: ANSS), a global innovator of simulation software and technologies designed to optimize product development processes, today announced the release of version 3.0 of its ANSYS(R) Icemax(R) software for circuit extraction of advanced integrated circuit (IC) package designs. This new release provides IC package designers with a flexible modeling environment, to set up and analyze a wide range of system-in-package designs, including package-on-package, package-in-package and package-on-PCB structures. ANSYS Icemax technologies are now part of the ANSYS suite, from the company's 2006 acquisition of Fluent Inc. The release aligns with the ANSYS focus on powerful industry solutions, based on the Company's commitment to Simulation Driven Product Development.

The ANSYS Icemax user interface allows users to import multiple designs within the same model, use automatic alignment tools and analyze the assembled design as a unified structure. "Stacked packages are becoming increasingly common, especially in the handheld and wireless space. Existing design flows in most semiconductor companies are set up to analyze individual layouts separately and then connect them up in the system-level electrical model. For 3-D stacked packages, and in general system-in-package designs, this approach has obvious limitations," says Chetan Desai, ANSYS Icemax product manager. "The electrical model has to be extracted by accounting for all possible interactions within the 3-D package assembly at the field solver level. Appropriate return paths across package interfaces have to be accurately detected for generating the final equivalent circuit. ANSYS Icemax 3.0 technology helps engineers realize this objective."

The software enhancements are complemented by additional optimizations of core meshing and field solver technologies that have been integral to earlier product releases. Improvements have been made to simplify the specification and detection of return paths in the package and PCB.

Batch processing is a major new addition to the solver, providing further automation in the design flow. ANSYS Icemax 3.0 software will continue to operate on multi-CPU machines as well as 64-bit Windows(R) and Linux(R) platforms, helping customers easily analyze high pin-count packages with complex power and ground structures.

New visualization capabilities include custom widgets for layer-by-layer model display and finite volume mesh display. Other key enhancements include analysis of lossy dielectrics and specification of user-defined terminals in the ANSYS Icemax model. In addition to RLCG data, results can now be exported in the form of S/Y/Z parameters in industry standard touchstone format.

About ANSYS, Inc.
ANSYS, Inc., founded in 1970, develops and globally markets engineering simulation software and technologies widely used by engineers and designers across a broad spectrum of industries. The Company focuses on the development of open and flexible solutions that enable users to analyze designs directly on the desktop, providing a common platform for fast, efficient and cost- conscious product development, from design concept to final-stage testing and validation. The Company and its global network of channel partners provide sales, support and training for customers. Headquartered in Canonsburg, Pennsylvania, U.S.A., with more than 40 strategic sales locations throughout the world, ANSYS, Inc. and its subsidiaries employ approximately 1,400 people and distribute ANSYS products through a network of channel partners in over 40 countries. Visit www.ansys.com for more information.

About Fluent Inc.

Fluent Inc. is a wholly owned subsidiary of ANSYS, Inc. (Nasdaq: ANSS), one of the world's largest providers of computational fluid dynamics (CFD) software and consulting services. Fluent's software is used for simulation, visualization and prediction of fluid flow, heat and mass transfer and chemical reactions. It is a vital part of the computer-aided engineering (CAE) process for companies around the world and is deployed in nearly every manufacturing industry. Using Fluent's software, product development, design and research engineers build virtual prototypes and simulate the performance of proposed and existing designs, allowing them to improve design quality while reducing cost and speeding time to market.

SOURCE ANSYS, Inc.

Industry News

AMD Delivers Program Offerings for Freedom of Choice for System Builders with Four New Platforms Based on the AMD 690G Chipset

— Stunning graphics, stability, longevity enabled by leading-edge commercial desktop platforms under AMD Validated Solutions banner —

SUNNYVALE, Calif. -- March 12, 2007 --AMD (NYSE: AMD) today announced the expansion of AMD Validated Solutions (AVS) to include four new platforms based on the new AMD 690G chipset. This expansion brings the total number of platforms available through AVS to eight. Incorporating 3D graphics and optimized for the full-featured versions of the Windows Vista™ operating system including the Aero interface (1), the new motherboards can help AMD channel partners to quickly and affordably create differentiated, industry-leading commercial desktop solutions with the confidence of longevity, validation and support.

As part of the evolution of AVS, the four new AVS-validated and supported motherboards join four existing platforms that combine to offer unprecedented choice in building commercial desktop systems. The new motherboards are based on the recently-introduced AMD 690G chipset—AMD's first chipset with the industry-leading features of ATI Radeon™ X1250 graphics. The motherboards, which adhere to the AVS 15-month stability requirement, are designed to provide the ultimate Windows Vista Premium/Business experience….. Complete Information can be found at www.amd.com

NEC's iStorage S Series Receives Oracle's Hardware Assisted Resilient Data

Validation for Oracle Database 10g

*****For immediate use March 22, 2007

Tokyo, March 22, 2007 -- NEC and Oracle have jointly verified NEC's implementation of Oracle's Hardware Assisted Resilient Data (H.A.R.D.) technology in NEC's iStorage S Series. As a result, NEC's iStorage Series of SAN disk array(S4900) is the first to achieve H.A.R.D. certification for Oracle Database 10g.

A SAN environment consists of various types of hardware and software. Before the data in a database is written to a disk, it passes through numerous components, including the OS (Operating System), drivers, HBAs (Host Bus Adapters), switches, and storage controllers. Although the hardware and software components are typically reliable, data error may still occur by human-cause and data can be written to the disk without being corrected…. Complete inforamtion can be found at www.nec.com

Engineer's Market Place

FUJITSU

The comfort and ease of a traditional notebook combined with the versatility of a Tablet PC. Built-in wireless access and the latest Intel® Centrino™ mobile technology means you can instantly input and access information whenever, wherever needed.

LifeBook E Series notebook	LifeBook T3000 Notebook
Fujitsu LifeBook T4215 Notebook	New Fujitsu LifeBook® Q Series Notebook PC
New Fujitsu LifeBook® T4210 Tablet PC	New Fujitsu LifeBook® S7110 Notebook
New Fujitsu LifeBook® E8210 Notebook	New Fujitsu LifeBook® N3530 Notebook

---

iomega

Love your Zip Drive? Try a new high capacity Iomega REV 35GB Drive.
Need to keep a secret? Get password protected, portable drives from Iomega.
Ready to add storage to your network? Buy an Iomega NAS server and get free shipping!
Iomega Micro Mini 512MB Drive - Only $49.95.
The Iomega Super DVD Burner Dual-Format USB 2.0 external drive. Buy now and SAVE!
Iomega HotBurn - the quickest and easiest way to create custom music and data CDs on your PC or Mac.

gdex.jp

is your one stop source to find any Japanese products! We currently offer a wide selection of Japanese games, CD / DVDs, Electronics, and more! gdex.jp was founded in May 2006,

GDEX Inc.

APPLE STORE

Apple Store for Education. College Students save on MacBooks and more.

The perfect fit. Find accessories designed for your iPod at the Apple Store.

Apple products on clearance with a One Year Warranty!

DELL

$312 off Select Inspiron™ E1405 Notebooks!

Save up to 20% on Select Electronics & Accessories!

COMPUTERS4SURE

Products that Protect your Technology - Computers4SURE

LS-DYNA Resource Page

MPP Interconnect and MPI

FEA Information Inc. Participant's (alphabetical order)

Fully QA'd by Livermore Software Technology Corporation

TABLE 1: SMP - Fully QA'd by LSTC	
AMD Opteron	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	IRIX 6.5 X
SGI IA64	SUSE 9 with ProPack 4 Red Hat 3 with ProPack 3

TABLE 2: MPP Interconnect and MPI

Vendor	O/S	HPC Intereconnect	MPI Software
AMD Opteron	Linux	InfiniBand (SilverStorm), MyriCom, QLogic InfiniPath	LAM/MPI, MPICH, HP MPI, SCALI
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, QLogic InfiniPath	LAM/MPI, MPICH, HP MPI, INTEL MPI, SCALI
NEC SX6	Super-UX		
SGI Mips	IRIX 6.5	NUMAlink	MPT
SGI IA64	SUSE 9 w/ProPack 4 RedHat 3 w/ProPack 3	NUMAlink, InfiniBand, (Voltaire)	MPT, Intel MPI, MPICH

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

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

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

ETA – DYNAFORM

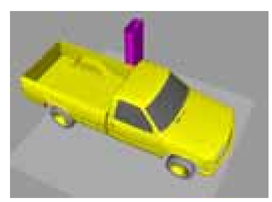
Includes a complete CAD interface capable of importing, modeling and analyzing, any die design. Available for PC, LINUX and UNIX, DYNAFORM couples affordable software with today's high-end, low-cost hardware for a complete and affordable metal forming solution.

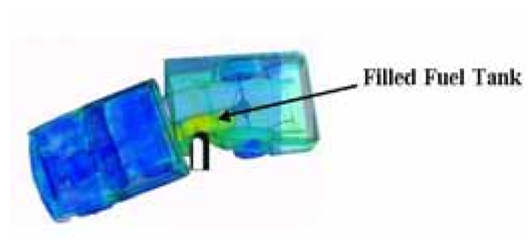
ETA – VPG

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

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

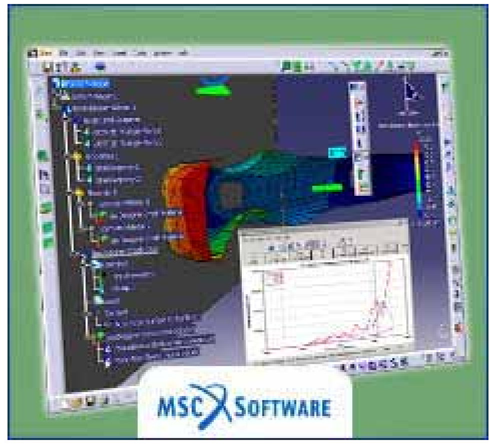
MSC.Software - MSC.Nastran/SOL 700

The MSC.NastranTM 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.

MSC.Software – Gateway for LS-DYNA

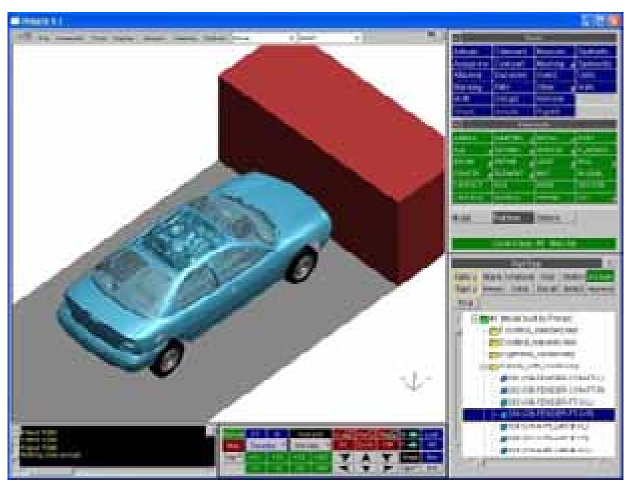
Gateway for LS-DYNA provides you with the ability to access basic LS-DYNA simulation capabilities in a fully integrated and generative way. Accessed via a specific Crash workbench on the GPS workspace, the application enhances CATIA V5 to allow finite element analysis models to be output to LS-DYNA and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

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 offers post-processing software for in-depth analysis of results and automatic report generation.



EASi-CRASH DYNA

EASi-CRASH DYNA is the first fully integrated environment for crashworthiness and occupant safety simulations with LS-DYNA, and covers the complete CAE-process from model building and dataset preparation to result evaluation and design comparisons.

EASi-CRASH DYNA can be used for concept crash, FE crash and coupled rigid body/FE crash simulations in conjunction with MADYMO.

EASi-CRASH DYNA's main features include:

Support of all keywords of LS-DYNA 970/971

Powerful mesh editing features, such as automesh and remesh

LS-DYNA/MADYMO coupling capabilities for pre- and post processing

Model Assembler for organizing the model through sub assembly/sub models and included files

Enhanced Weld tools for manipulation of connections and Weld comparison

Simple dummy positing and seat belt routing

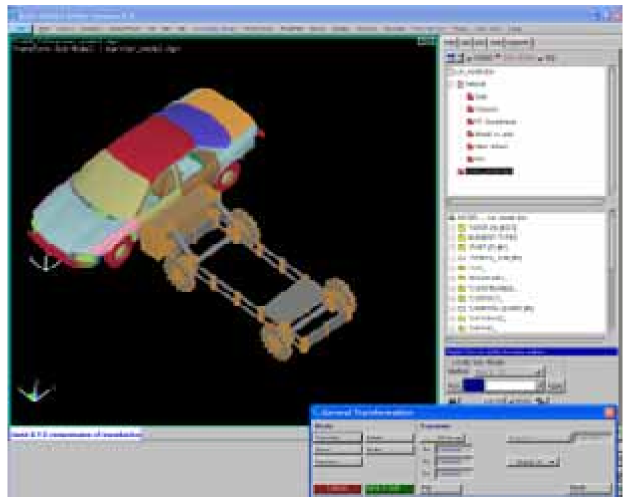
Pre and Post processing in same environment

Superpose and merge multiple models

Animation and plotting

Process compatible

Full capability to handle IGES, CATIA V4, CATIA V5, UG and NASTRAN files



Hardware - Computing - Communication Products

Logo's hyperlink to company's website

Software Distributors

Alphabetical order by Country

Australia	Leading Engineering Analysis Providers
Canada	Metal Forming Analysis Corporation
China	Arup
China	MSC. Software – China
Germany	CAD-FEM
Germany	DynaMore
India	Altair Engineering India
India	ARUP
Italy	EnginSoft Spa
Japan	Fujitsu Limited
Japan	JRI Solutions, Limited
Japan	ITOCHU Techno-Solutions Corporation
Korea	Korean Simulation Technologies
Korea	Theme Engineering

Software Distributors (cont.)

Alphabetical order by Country

Netherlands	Infinite Simulations Systems B.V.
Russia	State Unitary Enterprise - STRELA
Sweden	Engineering Research AB
Taiwan	Flotrend Corporation
USA	Engineering Technology Associates, Inc.
USA	Dynamax
USA	Livermore Software Technology Corp.
UK	ARUP

Consulting and Engineering Services

(continued on next page)

Alphabetical Order By Country

Australia Manly, NSW	Leading Engineering Analysis Providers (LEAP) Greg Horner info@leapaust.com.au 02 8966 7888
Canada Kingston, Ontario	Metal Forming Analysis Corp. Chris Galbraith galb@mfac.com (613) 547-5395
Germany Alzenau	CARHS. 49 6023 96 40 60 info@carhs.de
India Bangalore	Altair Engineering India Nelson Dias info-in@altair.com 91 (0)80 2658-8540
Italy Firenze	EnginSoft Spa info@enginsoft.it 39 055 432010
UK Solihull, West Midlands	ARUP Brian Walker brian.walker@arup.com 44 (0) 121 213 3317
USA Austin, TX	KBEC L.C Khanh Bui kdbui@sbcglobal.net (512) 363-2739
USA Windsor, CA	SE&CS Len Schwer len@schwer.net (707) 837-0559

Consulting and Engineering Services

(continued)

USA Corvallis, OR	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
ETA	Engineering Technology Associates, Inc. (248) 729-3010 sales@eta.com

Educational & Contributing Participants

Alphabetical Order By Country

China	Dr. Qing Zhou	Tsinghua University
India	Dr. Anindya Deb	Indian Institute of Science
Italy	Professor Gennaro Monacelli	Prode – Elasis & Univ. of Napoli, Frederico 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

FEA Information China Participants

Arup China: LS-DYNA sales, support, training	Name: Li YuQiang Email: Yu-qiang.li@arup.com Tel 021 5396 6633 extn 151
Tsinghua University	Qing Zhou, PhD. – Professor Department of Automotive Engineering Beijing, 100084, China
Engineering Technology Associates (China) Inc.	Martin Ma Tel: + 86-21-64385725 Contact: support@eta.com.cn

China Company Listings

Ansys-China, Inc.	Tel: 86-10-84085558 Website: www.ansys.com.cn Contact: China@ansys.com.cn
Hewlett-Packard Asia Pacific Ltd.	Jerry Huang Tel: +86-10-65645261 Contact: J.Huang@hp.com
IBM China	Ms. Ling WANG - Tel: +86-10-6539-1188 x4463 (T/L:901-4463) Website: http://www.ibm.com/cn/ Contact: wangling@cn.ibm.com
MSC. Software Corp.	Tel: +86-10-6849-2777 Website: www.mscsoftware.com.cn Contact: mscprc.contact@mscsoftware.com
SGI China	Carl Zhang Tel: +86 -10 - 65228868 Ext. 3362 Contact: carl@sgi.com
Zhong Guo ESI Co., Ltd	Yang Xiaojum Phone: +86 (020) 8235 6272 Contact : Yang Xiaojun

Informational Websites

The LSTC LS-DYNA Support site: www.dynasupport.com

LSTC LS-DYNA Support Site	www.dynasupport.com
FEA Informationwebsites	www.feainformation.com
TopCrunch – Benchmarks	www.topcrunch.org
LS-DYNA Examples (more than 100 Examples)	www.dynaexamples.com
LS-DYNA Conference Site	www.ls-dynaconferences.com
LS-DYNA Publications to Download On Line	www.dynalook.com
LS-DYNA Publications	www.feapublications.com