



# **8<sup>th</sup> International LS-DYNA Users Conference**

Co-sponsored by

Livermore Software Technology Corporation (LSTC)

and

Engineering Technology Associates, Inc. (ETA)

May 2-4, 2004  
Dearborn, Michigan

Mailing Address:

Livermore Software Technology Corporation  
2876 Waverley Way  
Livermore, California 94551-1740

Support Address:

Livermore Software Technology Corporation  
7374 Las Positas Road  
Livermore, California 94551

TEL: 925-449-2500  
FAX: 925-449-2507  
EMAIL: sales@lstc.com

Copyright © 2004 by Livermore Software Technology Corporation.  
Permission to reproduce any papers contained herein is granted provided that credit is given to LSTC, the author and his/her company. Authors retain their respective copyrights.

## Table of Contents

Welcome Remarks	<b>Arthur Tang (ETA)</b>
Introduction of Keynote Speakers	<b>John O. Hallquist (LSTC)</b>

### Keynote Presentations

#### “Future Challenges in Vehicle Safety”

**Dr. Priya Prasad**

*Ford Technical Fellow*

*Safety Research & Advanced Engineering*

*Ford Motor Company*

#### “Developments and Challenges in Computational Mechanics”

**Dr. Ted Belytschko**

*Walter P. Murphy Professor*

*Northwestern University*

#### “Powering the Record Chrysler Group Product Onslaught”

**Mr. Lawrence J. Achram**

*Vice President*

*Virtual Engineering and Crossfire*

*DaimlerChrysler Corporation*

### Common Session

**Development of Shipping Package Drop Analysis Capability at Westinghouse .....C-1**

*J. F. Staples, Westinghouse Electric Company*

**A Summary of the Space Shuttle Columbia Tragedy and the Use of LS-DYNA  
in the Accident Investigation and Return to Flight Efforts .....C-17**

*Matthew E. Melis, NASA Glenn Research Center*

### Session 1 - Crash/Safety (1)

**Prediction of Seat Deformation in Rear Crash Using LS-DYNA .....1-1**

*Biswanath Nandi, Lear Corporation*

**Strain Rates in Crashworthiness .....1-9**

*Moisey B. Shkolnikov*

**An Evaluation of Active Knee Bolsters .....1-21**

*Zane Z. Yang, Delphi Corporation*

**Development of a Hybrid Energy Absorbing Reusable Terminal (HEART) Using  
Finite Element Modeling in LS-DYNA for Roadside Safety Applications .....1-33**

*Nauman M. Sheikh, Texas Transportation Institute, The Texas A&M University System*

**Curved Barrier Impact of a NASCAR Series Stock Car .....1-47**

*Eric A. Nelson Altair Engineering*

### Session 2 - Methods Development

**A Process of Decoupling and Developing Optimized Body Structure for Safety  
Performance .....2-1**

*John M. Madakacherry, Technical Specialist, General Motors*

<b>Virtual Try Out and Process Optimization for an Innovative Conic Poles Production Concept</b> .....	2-3
<i>A. Anglani Department of Innovation Engineering, University of Lecce, Lecce, Italy</i>	
<b>FEA - Calculation of the Hydroforming Process with LS-DYNA</b> .....	2-15
<i>Michael Keigler, Aalen University, Aalen, Germany</i>	
<b>Implicit and Explicit Finite Element Simulation of Soft-Pad Grinding of Silicon Wafers</b> .....	2-23
<i>A.H. Zhao, Department of Industrial and Manufacturing Systems Engineering, Kansas State University</i>	
<b>FEA - Simulation of Bending Processes with LS-DYNA</b> .....	2-33
<i>Peter Gantner, Herbert Bauer, Aalen University, Aalen, Germany</i>	
<b>Session 3 - Simulation Technology (1)</b>	
<b>The Use of LS-DYNA in the Columbia Accident Investigation and Return to Flight Activities</b> .....	3-1
<i>Jonathan Gabrys, The Boeing Company Philadelphia</i>	
<b>Test and Analysis Correlation of Foam Impact onto Space Shuttle Wing Leading Edge RCC Panel 8</b> .....	3-11
<i>Edwin L. Fasanella, US Army Research Laboratory, Vehicle Technology Directorate, Hampton, VA</i>	
<b>Application of Non-Deterministic Methods to Assess Modeling Uncertainties for Reinforced Carbon-Carbon Debris Impacts</b> .....	3-23
<i>K. Lyle, NASA Langley Research Center, Hampton VA</i>	
<b>Material Modeling of Space Shuttle Leading Edge and External Tank Materials for Use in the Columbia Accident Investigation</b> .....	3-35
<i>Kelly Carney, NASA Glenn Research Center Cleveland, OH</i>	
<b>Modeling the Nonlinear, Strain Rate Dependent Deformation of Shuttle Leading Edge Materials with Hydrostatic Stress Effects Included</b> .....	3-45
<i>Robert K. Goldberg, NASA Glenn Research Center Cleveland, OH</i>	
<b>Session 4 - Fluid/Structure</b>	
<b>The Use of LS-DYNA to Simulate the Water Landing Characteristics of Space Vehicles</b> .....	4-1
<i>Benjamin A. Tutt, Irvin Aerospace Inc, Santa Ana CA</i>	
<b>Modeling of Fuel Sloshing Phenomena Considering Solid-Fluid Interaction</b> .....	4-15
<i>Jean Ma, Plastics Products and Processing CAE, Visteon Corporation</i>	
<b>Investigation of the Arbitrary Lagrangian Eulerian Formulation to Simulate Shock Tube Problems</b> .....	4-21
<i>C.P. Salisbury, University of Waterloo</i>	
<b>The Effects of Numerical Result and Computing Time Due to Mass Scaling in Rolling Analysis</b> .....	4-33
<i>J.Y. Chin, Theme Engineering Inc</i>	
<b>ALE and Fluid Structure Interaction in LS-DYNA</b> .....	4-39
<i>M. Souli, Laboratoire de Mécanique de Lille</i>	

**Session 5 - Crash/Safety (2)**

- Study of a Driver Airbag Out-Of-Position Using ALE Coupling** .....5-1  
*Wenyu Lian, General Motors*
- A Benchmark Study of CAE Sensor Modeling Using LS-DYNA** .....5-3  
*C. C. Chou, Passive Safety R&A, Ford Motor Company*
- A FE Modeling and Validation of Vehicle Rubber Mount Preloading and Impact Response** .....5-23  
*Sae U. Park, DaimlerChrysler Corporation*
- Influence of Pre-stressed Parts in Dummy Modeling - Simple Considerations -** .....5-33  
*Ulrich Franz, DYNAmore*
- IIHS Side Impact Analysis Using LS-DYNA/Madymo Coupling** .....5-47  
*Jiri Kral, TNO Madymo North America*
- Implementation of Modal Representation for Full Vehicle VPG Simulations** .....5-55  
*Xianggang Zhang, Engineering Technology Associates, Inc.*
- FEM for Impact Energy Absorption with Safety Plastic**.....5-57  
*Iulian Lupea, The Oakwood Group*
- A Numerical Investigation into HIC and  $N_{ij}$  of Children for Forward and Rearward Facing Configurations in a Child Restraint System** .....5-69  
*William Altenhof, Department of Mechanical, Automotive and Materials Engineering, University of Windsor*

**Session 6 - Material Technology**

- Modeling Crushable Foam for the SAFER Racetrack Barrier** .....6-1  
*Robert W. Bielenberg, Midwest Roadside Safety Facility, University of Nebraska-Lincoln*
- Implementation of a Constitutive Model for Aluminum Foam Including Fracture and Statistical Variation of Density** .....6-11  
*A. Reyes, Structural Impact Laboratory (SIMLab), Department of Structural Engineering, Norwegian University of Science and Technology*
- Theory and Evaluation of Concrete Material Model 159** .....6-25  
*Yvonne D. Murray, APTEK, Inc.*
- A Model for Process-Based Crash Simulation** .....6-37  
*O.-G. Lademo, SINTEF Materials and Chemistry, Structural Impact Laboratory (SIMLab) Department of Structural Engineering, Norwegian University of Science and Technology*
- Application of LS-DYNA in Identifying Critical Stresses Around Dowel Bars** .....6-45  
*Samir N. Shoukry, West Virginia University*
- Formability Modeling with LS-DYNA** .....6-53  
*Torodd Berstad, SINTEF Materials and Chemistry, NO-7465 Trondheim, Norway*

**Session 7 - Simulation Technology (2)**

- Finite Element Analysis of Unanchored Structures Subjected to Seismic Excitation** .....7-1  
*Sreten Mastilovic, Bechtel SAIC Company, LLC*

<b>Validation of LS-DYNA Computer Code for Seismic Qualification of Reactivity Control Mechanisms</b> .....	7-3
<i>A.S. Banwatt, Atomic Energy of Canada Ltd., 2251 Speakman Drive, Mississauga, Ontario, Canada</i>	
<b>A Study on Shock Wave Propagation Process in the Smooth Blasting Technique</b> .....	7-5
<i>Masahiko Otsuka, Graduate School of Science and Technology, Kumamoto University</i>	
<b>Vulnerability of Bridge Piers to Impact by Heavy Vehicles</b> .....	7-13
<i>Sherif El-Tawil, Dept. of Civil and Env. Eng., U. of Michigan, Ann Arbor, MI</i>	
<b>Modeling of Welded Structures Residual Strains</b> .....	7-21
<i>Sergey Medvedev, United Institute of Informatics Problems, National Academia of Sciences of Belarus, Minsk, Republic of Belarus</i>	
<b>Nonlinear Finite Element Analysis of Airport Approach Lighting Structures Under Impact Loading</b> .....	7-31
<i>M. Nejad Ensan, Institute for Aerospace Research, National Research Council Canada</i>	
<b>Finite Element Modeling of Material Damage in Axially-Loaded Aluminum Tubes with Circular Hole Discontinuities</b> .....	7-39
<i>Bryan Arnold, Department of Mechanical, Automotive, and Materials Engineering, University of Windsor</i>	
<b>Session 8 - Penetration/Explosive Modeling</b>	
<b>Preliminary Assessment of Non-Lagrangian Methods for Penetration Simulation</b> .....	8-1
<i>Leonard E. Schwer, Schwer Engineering &amp; Consulting Services</i>	
<b>Energy Absorbing Sandwich Structures Under Blast Loading</b> .....	8-13
<i>Dong Kwan (David) Lee, Department of Mechanical Engineering, University of Nevada, Las Vegas</i>	
<b>Transient Response of a Projectile in Gun Launch Simulation Using Lagrangian and ALE Methods</b> .....	8-25
<i>Ala Tabiei, Department of Aerospace Engineering &amp; Engineering Mechanics, University of Cincinnati</i>	
<b>Effects of Pre-Pressurization on Plastic Deformation of Blast-Loaded Square Aluminum Plates</b> .....	8-45
<i>R.L. Veldman, Hope College, Department of Physics and Engineering</i>	
<b>Explosive Welding of Light Weight Metal Sheets</b> .....	8-59
<i>Yamato Matsui, Graduate School of Science and Technology, Kumamoto University</i>	
<b>Simulation of Energy Absorbing Materials in Blast Loaded Structures</b> .....	8-67
<i>Michael J. Mullin, Department of Mechanical Engineering, University Nevada Las Vegas</i>	
<b>Moving Beyond the Finite Elements, a Comparison Between the Finite Element Methods and Meshless Methods for a Ballistic Impact Simulation</b> .....	8-81
<i>Murat Buyuk, FHWA/NHTSA-NCAC, National Crash Analysis Center, The George Washington University</i>	
<b>Session 9 - Metal Forming Technology (1)</b>	
<b>Review of Sheet Metal Forming Simulation – Progress to Date, Future Developments</b> .....	9-1
<i>Trevor Dutton, Dutton Simulation Ltd</i>	

<b>An Eulerian Finite Element Model of the Metal Cutting Process</b> .....	9-11
<i>A. Raczy, Department of Mechanical, Automotive, and Materials Engineering, University of Windsor</i>	
<b>Determination of Optimal Cutting Conditions in Orthogonal Metal Cutting Using LS-DYNA with Design of Experiments Approach</b> .....	9-27
<i>David P. Masillamani, Department of Mechanical and Industrial Engineering University of Texas at El Paso</i>	
<b>Simulation and Analysis of the Beverage Can Necking Process Using LS-DYNA</b> .....	9-37
<i>Jordan-Cordera, Mechanical Engineering Department, ITESM Campus Toluca</i>	
<b>Learning Module for Using Dynaform<sup>®</sup> to Study the Effects of Die-Entry and Punch-Nose Radii on Drawing Cups</b> .....	9-47
<i>W.K. Waldron, Mechanical Engineering Department, Kettering University</i>	
<b>Computer Simulated and Experimental Verification of Tooling for Progressive Deep Drawing</b> .....	9-59
<i>Peter Kostka, Slovak University of Technology in Bratislava, Faculty of Mechanical Engineering, Department of Materials &amp; Technologies.</i>	
<b>Session 10 - Optimization</b>	
<b>LS-OPT Capabilities for Robust Design</b> .....	10-1
<i>Nielen Stander, Livermore Software Technology Corporation</i>	
<b>Crashworthiness Design of Vehicle Structures via Equivalent Mechanism Approximations</b> .....	10-3
<i>Karim Hamza, Department of Mechanical Engineering, University of Michigan</i>	
<b>Horizontal Tailplane Subjected to Impact Loading</b> .....	10-11
<i>M. Hörmann, CAD-FEM GmbH, Grafing/Munich, Germany</i>	
<b>Robustness Study of an LS-DYNA Occupant Simulation Model at DaimlerChrysler Commercial Vehicles using LS-OPT</b> .....	10-31
<i>Frank C. Günther, DaimlerChrysler, Commercial Vehicles Analysis</i>	
<b>An Investigation of Structural Optimization in Crashworthiness Design Using a Stochastic Approach</b> .....	10-43
<i>Larsgunnar Nilsson, Engineering Research Nordic AB</i>	
<b>Session 11 - Simulation Technology (3)</b>	
<b>Development of an LS-DYNA Model of an ATR42-300 Aircraft for Crash Simulation</b> .....	11-1
<i>Karen E. Jackson, U.S. Army Research Laboratory, Vehicle Technology Directorate, Hampton VA</i>	
<b>Simulation of Cure Volume Shrinkage Stresses on Carbon/Vinyl Ester Composites in Microindentation Testing</b> .....	11-15
<i>Tom Mase, Composite Materials and Structures Center, Michigan State University</i>	
<b>Effect of Triggering Mechanism on the Load-Displacement Response and Folding Pattern of Square Aluminum Tubes</b> .....	11-23
<i>H. El-Hage, University of Windsor, Windsor, Ontario, Canada</i>	

<b>Numerical Modeling of Woven Carbon Composite Failure</b> .....	11-33
<i>Paul F. Deslauriers, University of Waterloo and Alex Duquette, Multimatic Technical Centre</i>	
<b>LS-DYNA Implicit for Dent Performance Evaluation</b> .....	11-43
<i>Gagan Tandon, Altair Engineering Inc.</i>	
<b>Dynamic FE Analysis of the High-Speed Planetary-Motion Mixer UM-500</b> .....	11-49
<i>Alexey I. Borovkov, Computational Mechanics Laboratory of St.Petersburg State Polytechnical University, ANSYS/LS-DYNA Center of Excellence</i>	
<b>Investigation of dsDNA Stretching Meso-Mechanics Using LS-DYNA</b> .....	11-61
<i>C. A. Yuan, Department of Power Mechanical Engineering, National Tsing Hua University,</i>	
<b>Session 12 - Computing / Code Technology (2)</b>	
<b>LS-DYNA Communication Performance Studies</b> .....	12-1
<i>Ananthanarayanan Sugavanam, High Performance Computing, IBM</i>	
<b>Improving Crash Analysis by Increasing Throughput of Large-Scale Simulations</b> .....	12-11
<i>Dale I. Dunlap, Platform Computing</i>	
<b>Determining the MPP LS-DYNA Communication and Computation Costs with the 3-Vehicle Collision Model and the Infiniband Interconnect</b> .....	12-27
<i>Yih-Yih Lin, Hewlett-Packard Company</i>	
<b>SPH Performance Enhancement in LS-DYNA</b> .....	12-33
<i>Gregg Skinner, Advanced Technical Computing Center NEC Solutions (America), Inc.</i>	
<b>Experiences with LS-DYNA Implicit MPP</b> .....	12-37
<i>Cleve Ashcraft, Livermore Software Technology Corporation</i>	
<b>Session 13 - Metal Forming Technology (2)</b>	
<b>Numerical Simulation of Aluminum Alloy Forming Using Underwater Shock Wave</b> .....	13-1
<i>Hirofumi Iyama, Dept. of Mechanical and Electrical Engineering, Yatsushiro National College of Technology</i>	
<b>Through Process Modelling of Self-Piercing Riveting</b> .....	13-7
<i>R. Porcaro, Structural Impact Laboratory (SIMLab), Department of Structural Engineering, Norwegian University of Science and Technology, N-7491 Trondheim, Norway</i>	
<b>Application of FEA in Stamping Auto Underbody Parts</b> .....	13-17
<i>Yuyuan Wang, Canadian Engineering &amp; Tool</i>	
<b>The Dynamic Problems in High Speed Transfer Stamping System</b> .....	13-21
<i>Ming-Chang Yang, Metal Industries Research and Development Centre, Taiwan</i>	
<b>A New Concept on Stamping Die Surface Compensation</b> .....	13-33
<i>Li Zhang, Theme Development Department, Advance Stamping Manufacturing Engineering, DaimlerChrysler Corporation</i>	

**Session 14 - Drop / Impact Simulations**

<b>Drop Simulation for Portable Electronic Products</b> .....	14-1
<i>Raymon Ju, Flotrend Co., Taipei, Taiwan</i>	
<b>Simulation and Verification of the Drop Test of 3C Products</b> .....	14-7
<i>Hsing-Ling Wang, Aviation Management Department, Chinese Air Force Academy</i>	
<b>Predictive Numerical Modeling of Foreign Object Damage</b> .....	14-19
<i>Pierangelo Duó, University of Oxford, Department of Engineering Science,</i>	
<b>Blast Impact on Aluminum Foam Composite Sandwich Panels</b> .....	14-29
<i>Rajan Sriram, The University of Alabama at Birmingham, Department of Materials Science &amp; Engineering</i>	
<b>Numerical Modeling of Ballistic Penetration of Long Rods into Ceramic/Metal Armors</b> .....	14-39
<i>Khodadad Vahedi, Department of Mechanical Engineering, Louisiana Tech University</i>	
<b>FE Analysis of Contact Interaction Between Rigid Ball and Woven Structure in Impact Process</b> .....	14-51
<i>Alexey I. Borovkov, Computational Mechanics Laboratory of St.Petersburg State Polytechnical University, ANSYS/LS-DYNA Center of Excellence</i>	

**Session 15 - Visualization**

<b>Immersive Visualization and Collaboration with LS-PrePost-VR and LS-PrePost-Remote</b> .....	15-1
<i>Todd J. Furlong, Inv3rsion, LLC</i>	
<b>VPG Solutions Using MotionView®</b> .....	15-9
<i>Michael White, Altair Engineering</i>	
<b>Rapid Development of Multiple Fold Patterns for Airbag Simulation in LS-DYNA Using Oasys Primer</b> .....	15-15
<i>Miles Thornton, Arup</i>	
<b>Fast New Methodology for Regulatory Test Simulation</b> .....	15-29
<i>Velayudham Ganesan, ESI Group</i>	

**Session 16 - Computing / Code Technology (2)**

<b>Improved LS-DYNA Performance on Sun Servers</b> .....	16-1
<i>Youn-Seo Roh, Sun Microsystems, Inc.</i>	
<b>Benefits of Scalable Server with Global Addressable Memory for Crash Simulation</b> .....	16-7
<i>Christian Tanasescu, SGI Inc.</i>	
<b>Improved LS-DYNA Parallel Scaling From Fast Collective Communication Operations on High-Performance Compute Clusters</b> .....	16-9
<i>Lars Jonsson, Intel Corporation</i>	
<b>A Mesh-free Analysis of Shell Structures</b> .....	16-11
<i>C. T. Wu, Livermore Software Technology Corporation</i>	

**Common Session**    *“Computing Infrastructure”*

Cray  
HP  
Intel  
IBM  
Linux Networx  
Microsoft  
NEC  
RackSaver  
SGI

**Final Session**    *“LS-DYNA Development”*

Dr. John O. Hallquist, LSTC