

LS-DYNA MODELING OF BLAST & PENETRATION: APPLICATIONS TO PROTECTIVE STRUCTURES, VEHICLES AND HOMELAND SECURITY THREATS

*An LS-DYNA Training Class
Presented by*

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Abstract

Blast and penetration events form a class of simulation environments well suited to the solution capabilities of LS-DYNA. LS-DYNA is unique in offering the analyst the choice of Lagrange, Eulerian (ALE) and Meshfree Methods, and combinations of these methods, for simulating high energy events such as blast loading, penetration and perforation. In addition to high energy, these events are typically associated with large deformations, damage, and failure both on the material and structural level. During the past decade successful modeling of such damage and failure has moved steadily from a 'Black Art' to a widely accepted engineering analysis.

This class focuses on the application of LS-DYNA for the simulation of high energy events. The analysis methods, and modeling, are illustrated through case studies. An emphasis is placed on modeling techniques: guidelines for which technique(s) to select, insights into which techniques work well and when, and possible pitfalls in modeling choice selections. Sufficient mathematical theory is presented for each technique, especially Eulerian and Meshfree Methods, to provide the typical user with sufficient knowledge to confidently apply the appropriate analysis technique. However, this training class is not a substitute for the in-depth treatments presented in the associated LS-DYNA training classes, i.e. "ALE/Eulerian & Fluid Structure Interaction" and "Mesh-Free Methods (SPH-EFG)," respectively.

Intended Audience

This training class is intended for the LS-DYNA analysts possessing a comfortable command of the LS-DYNA keywords and options associated with typical Lagrangian analyses. This training class will attempt to provide the analyst with the additional tools and knowledge required to model the above described class of high energy events. The typical attendee is likely to have a

background in defense applications, to include protective structures and vehicles, Homeland Defense topics, and terrorist threat mitigation techniques.

Instructors

Paul Du Bois has worked as an independent consultant in the field of industrial application of large scale numerical simulations since September 1987. He has specialized in the application of explicit integration techniques to crashworthiness and impact problems. Amongst Paul's customers we find most of the worlds automotive assemblers such as DaimlerChrysler, GM, Ford, Opel, Fiat, Porsche, Volvo, PSA, Renault, Toyota, Nissan, Honda, Hyundai and many others including automotive suppliers and design and engineering companies. Amongst Paul's more recent projects for DaimlerChrysler are the development of a generalized plasticity law for the simulation of plastics and the formulation of a tabulated hyperelastic material law with damage for the simulation of rubber and foam. He was involved with the joint research organism of the German automotive industry, FAT, in the working groups 'side impact dummies' from 1992 till 1997 and 'Foam materials' from 1996 till today. In 2003 Paul was asked by LLNL to perform a training mission at the Russian national laboratory in Snezhinsk. Since 2004 he is also a consultant to NASA and has worked on the space shuttle's 'return-to-flight' program. In the field of defence applications, he is a consultant to Rafael in Haifa, Israel where he was involved with the simulation of mine blast problems and helicopter crash landings.

Paul Du Bois also teaches the LS-DYNA training class "Crashworthiness engineering with LS-DYNA." . The corresponding course notes were first edited as a book by LSTC in 2004 and the first revised edition will appear in 2006. The training class takes place about 7 to 8 times per year in the United States, Japan, Germany, France and Scandinavia..

Len Schwer has worked in the area of defense applications where failure prediction is of primary interest, for the past 25 years; he has been a DYNA3D user since 1983 and an LS-DYNA user since 1998. His early work at SRI International included modeling the collapse of deeply buried tunnels under very high pressure loadings. While at Lockheed Missile and Space Company he worked on high speed earth penetrators designed to penetrate reinforced concrete structures buried in soil. From 1997 - 2001 he worked with Professors Belytschko and Liu of Northwestern University on applying their meshfree methods to reinforced concrete problems of interest to the Defense Threat Reduction Agency. During 1999 - 2000 he contributed to a test and simulation program focused on non-standard loading of buried pipelines. He is currently working with the US Navy to develop an analysis capability for predicting the penetration & perforation of metallic structures associated with improvised explosive devices (IED's). He has a strong interest in verification and validation in computational solid mechanics, and is the Chair of the ASME Standards Committee on Verification and Validation in Computational Solid Mechanics. Dr. Schwer is a Fellow of the American Society of Mechanical Engineers (ASME) and the United States Association of Computational Mechanics (USACM).

Len Schwer also teaches the LS-DYNA training class “Geomaterial Modeling with LS-DYNA.” He is the Director of Geomaterial Modeling for FEA Information (www.feainformation.com) and contributes to the associated web site: www.geomaterialmodeling.com

Daily Class Schedule

Day 1

Opening Remarks (PDB/LS)

Equations-of-State (EOS), Shocks, and Explosives (PD)

Introduction to Engineering Models for Air Blast (LS)

Introduction to Arbitrary Eulerian Lagrangian (ALE) Techniques (PD)

Applications: Vehicles, Underwater Structures, & Buildings with Windows (PDB/LS)

Open Discussion (PDB/LS)

Day 2

Constitutive Modeling:

Metals – Johnson-Cook Model and Damage Modeling (PDB)

Johnson-Cook Model – Strain Rate effects (LS)

Concrete & Geomaterials – Simplified Input Concrete Models (LS)

Introduction to Meshfree Methods (LS)

Element Free Galerkin (EFG)

Smooth Particle Hydrodynamics (SPH)

Penetration & Perforation Examples (PD/LS)

Applications: thin metal plates, multiple plates, pipes, concrete slabs, complex geometry (fuzing)

Explosively Formed Projectiles (EFP) and Shaped Charges (PD)

Open Discussion (PDB/LS)