MODELING & SIMULATION WITH LS-DYNA®: INSIGHTS INTO MODELING WITH A GOAL OF PROVIDING CREDIBLE PREDICTIVE SIMULATIONS

An LS-DYNA Training Class
Presented by

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Abstract

Most applications of LS-DYNA are for complex, and often combined, physics where nonlinearities due to large deformations and material response, including failure, are the norm. Often the goal of such simulations are to provide predictions which will ultimately be used to guide product development and safety assessments. In very few cases, some limited experimental data is available to help guide the model development, and assess the accuracy of the results. When no experimental data are available, or the LS-DYNA predictions are intended to guide development of limited experiments, in addition to the predicted result, the analyst needs to provide, and convey to the customer, the degree of confidence in the results.

This two day class focuses on two critical aspects in the application of LS-DYNA: modeling and simulation. Here modeling is taken to mean the large number of decisions the analyst makes in constructing an LS-DYNA input file, which is intended to mimic the response of some physical event. Simulation refers to the results produced by LS-DYNA to a given analyst's input. The emphasis for simulation is how to assess the credibility, i.e. correctness and accuracy, of predictive simulation results. Hopefully, long gone are the days when the quip "It came from the computer, so it must be right." may have been taken as a serious statement.

Insights into modeling and simulation are illustrated through case studies. An emphasis is placed on modeling techniques, guidelines for which technique(s) to select, which techniques work well and when, and possible pitfalls in modeling choice selections. Simulation credibility is demonstrated through solution of multiple models, with associated multiple solvers, required checks of global and local energies, and mesh refinement strategies. In addition, strategies for recovering from obvious errors conditions are discussed.

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. The training class will attempt to provide the analyst with the additional tools and knowledge required to make appropriate modeling decisions and convey the level of confidence in predictive results. The typical attendee is likely to have one or more years experience in modeling and simulation, and has become aware there is more to providing predictive simulation result than just running LS-DYNA. Because the class uses example problems to illustrate concepts and techniques, numerous modeling 'tricks' and options are discussed, and this knowledge would benefit any LS-DYNA user.

Instructors

The motivation to create this Modeling & Simulation class came from the numerous attendee interactions during the instructors' popular Blast and Penetration classes. Some of the most interesting discussions were not about the details needed to create an LS-DYNA input file, but why certain selections and options were chosen. Both instructors always place a strong emphasis on assessing the credibility of results: from simple hand calculations to confirm 'ballpark' values, to more rigorous estimates of discretization error.

Over 50 years of LS-DYNA experience in a wide range of commercial and defense applications allows the instructors to provide insights into many aspects of modeling and simulation. In addition, their presentation style has often been complemented for being clear, concise, useful, and interesting, and at times hopefully also entertaining.

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 for crashworthiness and impact problems. Amongst Paul's customers are most of the world's automotive assemblers such as Daimler, GM, Ford, Opel, Fiat, Porsche, Volvo, PSA, Renault, Toyota, Nissan, Honda, Hyundai and many others including automotive suppliers and design and engineering companies. Paul's more recent projects include a Daimler sponsored development of a generalized plasticity law for the simulation of plastics and the formulation of a tabulated hyper-elastic material law with damage for the simulation of rubber and foam. He was involved with the joint research organization of the German automotive industry, FAT, in the working groups: 'side impact dummies' from 1992 through 1997 and 'Foam materials' from 1996 until 2009. In 2003 Paul was asked by LSTC to perform a training mission at the Russian national laboratory in Snezinskh. Since 2004 he has also been a consultant to NASA and has worked on the space shuttle's 'return-to-flight' program. In the field of defense 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 "Advanced Impact Analysis.," and co-teaches, with Len Schwer, the LS-DYNA Blast & Penetration classes. The corresponding course notes were first edited as a book by LSTC in 2004 and the first revised edition will appear in 2009. 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 30 years; he had 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. He is currently working with the US Navy to develop an analysis capability for predicting the penetration & perforation of metallic, concrete, and soil targets associated with improvised explosive devices (IED's). He is currently consulting with NASA LARC on crew vehicle recover simulations. He has a strong interest in verification and validation in computational solid mechanics, and is the past 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," and co-teaches, with Paul Du Bois, the LS-DYNA Blast & Penetration classes. 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 **(Len/Paul)**

Introduction to Modeling & Simulation (**Len**)

Constitutive Models – Metals

Selecting an appropriate model. (**Paul**)

Failure and Damage Modeling. (**Paul**)
Stress-strain data to LS-DYNA input parameters. (**Len**)

Element Formulations- What is the 'Right' Element for an Analysis
Discrete Elements & Beams – Numerical Cross Integration. (**Len**)
Shells & Solids – Hourglass Control. (**Paul**)
Fasteners: spot welds, line welds, glue, bolts, etc. (**Paul**)

Time Integration – Explicit & Implicit
How to choose and appropriate time integrator.
Effects of element size and mesh quality.

Open Discussion **(Paul/Len)**

Day 2

Contact – Which Type to Use, When, and Why. (**Paul**)

Stress Initialization –
Static, Dynamic Relaxation, Thermal, Hydrostatic, Rotational, *Stress_Initialization

Introduction to Multi-Material ALE (MM-ALE) (**Paul**)
Advantages and Disadvantages.
*Keyword details and examples.

Introduction to Meshfree Methods (**Len**)
Advantages and Disadvantages.
*Keyword details and examples.

Introduction to Coupled Thermal-Mechanics Analysis (**Drop?)**

Post-Processing – (**Paul/Len**)
"Abnormal Termination" investigation and determination of problems.
What are 'NaN's" and how to get rid of them.
Negative volumes: causes and remedies.
When implicit integration fails to converge.
The advantages and dangers of Mass Scaling.
Systematic Assessment of Results – "How do I know my results are correct?"
Mesh Refinement

Open Discussion **(PD/LS)**