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LSTC Livermore Software Technology Corp.

Volume 8, Issue 8, August 2019

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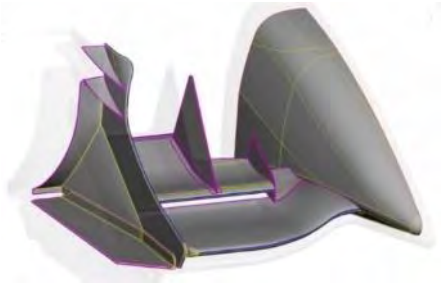
BETA CAE



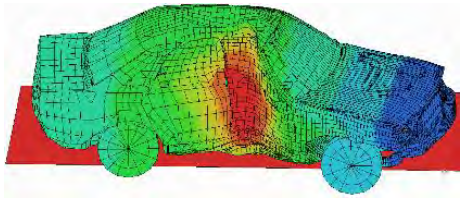
DYNAmore

French LS-DYNA User Forum

Hengstar

LSTC

LS-OPT® 6.0



2019 4th China LS-DYNA® Users' Conference

FEA Information Engineering Solutions

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The focus is engineering technical solutions/information.

FEA Information China Engineering Solutions

www.feainformation.com.cn

Simplified and Traditional Chinese

The focus is engineering technical solutions/information.

LSTC - Livermore Software Technology Corp.

Development of LS-DYNA, LS-PrePost, LS-OPT,
LS-TaSC (Topology), and LSTC's Dummy &
Barrier models for use in various industries.

www.lstc.com

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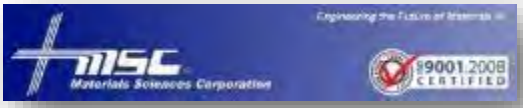
If you have any questions, suggestions or recommended changes, please contact us.

Editor and Contact: Marsha Victory - mv@feainfomation.com
Yanhua Zhao - yanhua@feainformation.com
Noi Sims – noi@feainformation.com

Platinum Particpants



Platinum Particpants

Table of contents

Announcements

LSTC.MPDB.190730_V2.2 **Livermore Software Technology Corp.**

LSTC has a updated version of the Mobile Progressive Deformable Barrier (MPDB) available for download through our website. You can access the models through our website: http://www.lstc.com/download/dummy_and_barrier_models

Engineering Technology Associates, Inc. Announces the Release of All New Die System Simulation Solution (DYNAFORM® 6.0)

More information, as well as an opportunity to sign up to be among the first to try DYNAFORM 6.0, can be found by visiting **dynaform.com**

BETA CAE Systems announces the release of the v20.0.0 of its software suite

Always aiming to take the CAE experience further, BETA CAE Systems proudly presents the release of v20.0.0 of its software suite. **Website:**

https://www.beta-cae.com/news/20190722_announcement_suite_v20.0.0.htm

LSTC announces the release of LS-OPT 6.0

LS-OPT 6.0 is now available on LSTC ftp. Along with other new features, it introduces major developments such as classification-based constraint handling and digital image correlation.
New version download: **http://ftp.lstc.com/user/ls-opt/6.0.0**

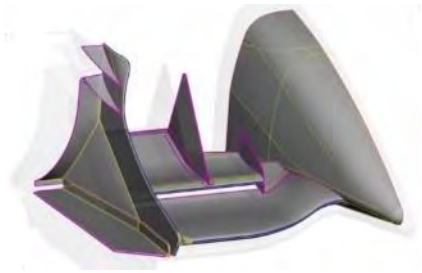
2019 China LS-DYNA Conference **October 21-23, Shanghai, China**

The 4th China LS-DYNA Users' Conference will be held on October 21st - 23rd, 2019 in Shanghai by LSTC and Shanghai Fangkun. LSTC will share the latest product function and development strategy during the conference. We wholeheartedly welcome your paper submission and attendance.

Conference Website: conference.lsdyna-china.com/

Developing CAE software systems for all simulation disciplines. Products: ANSA pre-processor/ EPILYSIS solver and META post-processor suite, and SPDRM, the simulation-process-data-and-resources manager, for a range of industries, incl. the automotive, railway vehicles, aerospace, motorsports, chemical processes engineering, energy, electronics…

BETA CAE Systems announces the release of the v20.0.0 of its software suite



BETA CAE Systems International AG; Platz 4, 6039 Root D4, Switzerland

About this release:

Always aiming to take the CAE experience further, BETA CAE Systems proudly presents the release of v20.0.0 of its software suite.
There are many new tools and improvements to look forward to in this release.
BETA CAE Systems product line, with a plethora of revolutionary tools and groundbreaking solutions, unquestionably addresses all challenges involved in the contemporary engineering simulation industry.
It successfully combats all bottlenecks introduced by modeling complexity in any application area, and offers a significant boost to the operations of the CAE modeling process as a whole.

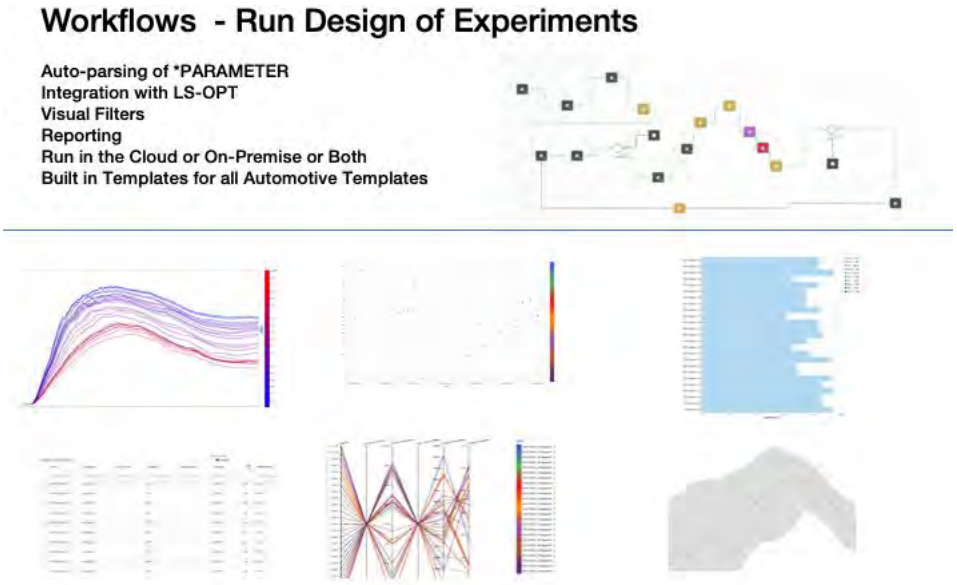
Do not miss:

- The new potential that arises with our Modular Run Management solutions.
- The abundant developments that took place for mid-surface extraction and meshing in ANSA, with special concern on CFD processing demands. An indicative example of the latter is the Conv2Poly function that can now be applied on Light Volume Representation meshes, thereby completing the full process in light mode with significant memory and time reduction.
- The long-awaited parallel volume meshing of multiple independent volumes via the functions that produce unstructured volume mesh.
- The extended capabilities of ANSA via the implementation of Virtual Reality in pre-processing, captivating the perception and cognition of any given FEA workflow from a closer and more realistic perspective.
- Our dedicated solutions on User Toolbar development in META for post-processing applications, augmenting development acceleration and robustness.
- The innovative introduction and implementation of Machine Learning in BETA products, starting with RETOMO.

Website: https://www.beta-cae.com/news/20190722_announcement_suite_v20.0.0.htm

d3VIEW is a data to decision platform that provides out-of-the box data extraction, transformation and interactive visualizations. Using d3VIEW, you can visualize, mine and analyze the data quickly to enable faster and better decisions.

d3VIEW™



Turn LS-DYNA® data into decisions

HPC
Job Submission
Live Preview
Reporting and Statistics
On-premise and Cloud

LS-DYNA
Extract data from any file
Perform DOE using LS-OPT
Web-based 3D Visualization
Explicit and Implicit

Analytics
40+ Visualizers
Identify patterns in Data
Reporting to PDF/PPT

Workflows
Build and deploy workflows
Characterize materials
Model sequential impacts

Experiments
Manage Safety and NVH
Compare with Simulations
Search Historical data

Templates
400+ Math Expressions
Import from Library
Safety and NVH

http://www.d3view.com
contact marsha@lstc.com for more information

Author: Christian Frech christian.frech@dynamore.de

Register now!

1st French LS-DYNA User Forum 2019

15th October 2019, Versailles, France

Invitation

We are pleased to organize the first LS-DYNA French User Forum. The event will take place on October 15, 2019 from 9am to 5pm in our offices in Versailles. We are looking forward to numerous registrations.

Free of charge!

Preliminary agenda

- 9:00 am: Welcome
- 9:15 am: Introduction
- 9h30 - 11h15: LS-DYNA user presentations
- 11:15 - 11:45: Break
- 11h45 - 12h45: DYNAmore France presentations
- 12:45 - 14:00: Lunch
- 14h00 - 15h45: LS-DYNA user presentations
- 15h45 - 16h15: Break
- 16h15 - 17h00: DYNAmore France presentations

Venue

DYNAmore France SAS
21 avenue de Paris
78000, Versailles

Registration

If you like to attend please register here.

Contact

charlotte.keisser@dynamore.eu

More information

www.dynamore.eu

A leading innovator in Virtual Prototyping software and services. Specialist in material physics, ESI has developed a unique proficiency in helping industrial manufacturers replace physical prototypes by virtual prototypes, allowing them to virtually manufacture, assemble, test and pre-certify their future products.

Share buyback program

Press Release Paris, August 1, 2019

In accordance with the provisions of European Regulation No. 596/2014 of April 16, 2014 on market abuse, Articles 241-1 et seq of the General Regulations of the "Autorité des Marchés Financiers" and Articles L.225- 209 and following the objectives and modalities of ESI Group's share buyback program, as authorized by the Combined Annual General Meeting held on July 18, 2019 and implemented by the Board of Directors during its meeting held the same day.

This new program ends the previous one authorized by the Combined General Meeting of July 18, 2018.

• Shares concerned

Shares issued by ESI Group, listed on Euronext Paris (ISIN code FR0004110310).

• Objectives of the buyback program

i. stimulate the secondary market or the liquidity of ESI Group shares through a liquidity contract signed with an investment service provider and compliant with the AMAFI's Code of Ethics dated September 23, 2008 and approved by the French Financial Markets Authority (AMF),

ii. fulfill its share issue obligations, in accordance with the terms and conditions set forth by law, undertaken as part of the following:

- plans granting stock options for the purchase of existing shares by the Group's employees or corporate officers,
- employee profit-sharing plans under which these shares would be granted to employees and/or corporate officers,
- free share grants to the Group's employees and corporate officers,
- shares provided upon exercise of the rights attached to securities giving access to shares by any means, whether immediately or in the future, under the conditions set forth by the AMF and at any time deemed appropriate by the Board of Directors,

iii. retain shares to subsequently use them in exchange or as payment for future business acquisitions,

iv. cancel shares by a reduction in share capital.

• Maximum purchase price

The maximum purchase price is set at €60 per share.

The maximum amount that the company would be likely to pay under this share buyback program is set at €13,000,000.

- **Buy-back terms and conditions**

The shares may be purchased or retained at the discretion of the Board of Directors by any means by trading on or off the market, or on an over-the-counter market, on one or more occasions. All shares purchased under the authorized share buyback pro-gram may be acquired in the form of blocks of shares. Such transactions may be carried out at any time, including during public offering periods, in accordance with the regulations in force.

- **Duration of the buy-back program**

18 months from July 18, 2019, i.e. until January 17, 2021.

The Board of Directors will inform the shareholders in its management report of the acquisitions and disposals made in application of this authorization.

- **Treasury shares held as of July 18, 2019**

As at July 18, 2019, the company held 393,509 shares representing 6.5% of its share capital, including 5151 shares via the AMAFI liquidity contract.

The Group favors an allocation of shares to cover employee share ownership plans and potential acquisitions.

- **Maximum proportion of share capital**

10% of the share capital (i.e. 601,789 shares to date), it being specified that this limit is assessed at the date of buy-backs in order to consider any capital increase or reduction that may occur during the program. The number of shares taken into account to calculate this limit corresponds to the number of shares purchased, less the number of shares resold during the program as part of the purpose of liquidity.

As the company cannot hold more than 10% of its share capital, considering the number of shares already held of 393,509 (i.e. 6.5% of the share capital), the maximum number of shares that may be purchased will be 208,280 shares (i.e. 3.5% of the share capital) unless to sell or cancel the shares already held.

Upcoming events

Half Year Sales and Results
September 19, 2019

Q3 FY19 revenue
November 19, 2019

FY19 revenue (11 months)
February 13, 2020

Contacts

ESI Group Florence Barré press@esi-group.com 33 1 49 78 28 28
SHAN – Press *Esigroup@shan.fr* *+33 6 61 85 10 05*

ETA has impacted the design and development of numerous products - autos, trains, aircraft, household appliances, and consumer electronics. By enabling engineers to simulate the behavior of these products during manufacture or during their use, ETA has been involved in making these products safer, more durable, lighter weight, and less expensive to develop.

Engineering Technology Associates, Inc. Announces The Release of All New Die System Simulation Solution (DYNAFORM® 6.0)

Troy, MI – Engineering Technology Associates, Inc. (ETA), an engineering and software innovator with 36 years in the automotive engineering community, announces the latest release of its LS-DYNA® based, DYNAFORM® Version 6.0 die system simulation solution software.

DYNAFORM 6.0 offers an all new graphic user interface with combined pre- and post-processing capabilities. Users may quickly conduct sheet metal stamping simulations to estimate the blank cost and formability of stamping parts using guided process wizards.

In addition, new features are included, such as simulation data manager and Microsoft PowerPoint® based automatic report generation. DYNAFORM 6.0 consists of simplified as well as advanced customized features that reduce the set up time.

"DYNAFORM 6.0 will improve the efficiency and productivity of stamping engineers with no prior experience in stamping simulation. I am very excited about the new release," said Dr. Akbar Farahani, CEO of ETA.

More information, as well as an opportunity to sign up to be among the first to try DYNAFORM 6.0, can be found by visiting dynaform.com.

FEA Not To Miss, is a weekly internet blog on helpful videos, tutorials and other Not To Miss important internet postings. Plus, a monthly email blog.

Start your Monday with coffee or tea reading our engineering blog, at the FEA Not To Miss coffee shop.
Postings every Monday on what you have missed

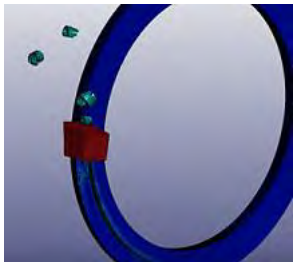
www.feantm.com

Monday 08/19/2019 Meteorite Coffee! It has a certain crashing flavor, of course also vanilla or it isn't my coffee. So let's grab our To Go Cups and run over (to burn calories) to YouTube.

meteorite impact with LS-DYNA

LS-DYNA Demo License mv@feainformation.com

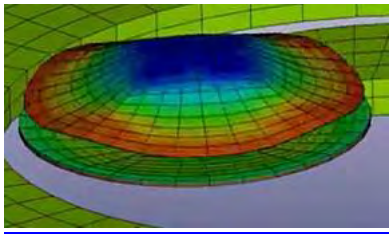
Monday 08/12/2019 First - What do electric cars and a GREAT tie have in common? I really like both of them, AND if you missed it, here is Ajei Gopal, on future of self-driving cars and coffee (I lied, no coffee is mentioned)



Simulation of turning cutting process in LS-DYNA

LS-DYNA Demo License mv@feainformation.com

Monday 08/05/2019 - We are doing Coffee Layers! Hmmm first layer is coffee, then vanilla, then cream, then MORE vanilla and coffee. OR we can just go to YouTube and watch metallic layers. AND bring our own layered coffee!



Separation the metallic layers of material by the EM module in LS-DYNA

LS-DYNA Demo License mv@feainformation.com

Shanghai Hengstar & Enhu Technology sells and supports LSTC's suite of products and other software solutions. These provide the Chinese automotive industry a simulation environment designed and ready multidisciplinary engineering needs, and provide a CAD/CAE/CAM service platform to enhance and optimize the product design and therefore the product quality and manufacture.

New MBTA Orange Line Train Goes Live by CRRC on August 14

The first six Orange Line cars go into service Wednesday, August 14, 2019 on the Massachusetts Bay Transportation Authority in Boston. The cars were designed and manufactured by CRRC, and Shanghai Hengstar serviced as an important consulting partner with carbody crash energy management and crashworthiness simulation, carbody strength and fatigue.

According to the MBTA, the six new cars have run over 7,000 miles during qualification testing last year. The cars completed a 40-hour reliability demonstration in which they operated in simulated revenue service.

CRRC demonstrated a prototype car for the Boston metro orange line at Boston city hall square in April 2017. The MBTA plans to replace the entire existing Orange Line fleet with 152 new trains by December 2021.

JSOL supports industries with the simulation technology of state-of-the-art. Supporting customers with providing a variety of solutions from software development to technical support, consulting, in CAE (Computer Aided Engineering) field. Sales, Support, Training.

JSOL CAE Forum 2019

JSOL Corporation is holding the "JSOL CAE Forum" to provide our users with the latest and most comprehensive simulation technologies and case studies for various JSOL CAE packages including LS-DYNA. Until last year, we had held user's events individually for each package, like LS-DYNA & JSTAMP Forum, J-OCTA Users Conference, and Moldex3D technology exchange. In 2019, we decided to hold a comprehensive and unified event called "JSOL CAE Forum" at Shinagawa, Tokyo, from November 6 through 8. During the three-day event we will showcase a wide range of information to our structural, manufacturing, and material CAE package users all together.

We will start accepting applications in late September. A detailed program will be published on this page around the same time.

We encourage our users to take advantage of this opportunity and look forward to your attendance at the event.

JSOL Corporation

Engineering Technology Division

JSOL CAE Forum Website

J-OCTA Feature enhancement: Finite Element Method (FEM) simulation

Interface for LS-DYNA supports large-deformation simulation

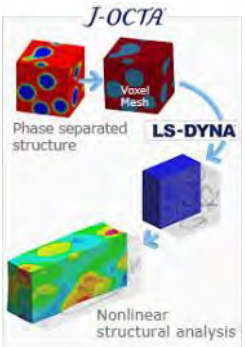
Recently, it is in high demand to estimate and evaluate the behavior during large deformation of micro-structured composites which contain phase separation and filler, by performing simulations.

Existing FEM engine of J-OCTA, "MUFFIN-Elastica" is for elastic simulation and is specialized for the behavior during a small deformation.

To extend its applicability to FEM simulation, the updated J-OCTA 4.1 version will provide the interface for a multi-purpose nonlinear structural analysis engine "LS-DYNA".

The phase-separated structure computed by "COGNAC or "SUSHI" can be output as a mesh data for LS-DYNA simulation. After the user specifies the material properties for each component and deformation (boundary) condition, LS-DYNA simulation can be started from J-OCTA directly. As a material model being appropriate for nonlinear structural simulation, materials including elastoplastic, viscoelastic, and hyperplastic such as rubber are available for use.

From version 4.1, J-OCTA can deal a large-deformation FEM calculation of a multi-phase structure which contains phase separation and filler dispersed structure.



KAIZENAT Technologies Pvt Ltd is the leading solution provider for complex engineering applications and is founded on Feb 2012 by Dr. Ramesh Venkatesan, who carries 19 years of LS-DYNA expertise. KAIZENAT sells, supports, trains LS-DYNA customers in India. We currently have office in Bangalore, Chennai, Pune and Coimbatore.

Shock Absorber Simulation in LS-DYNA

To validate the strength of design, we have done structural analysis for Shock Absorber. This simulation gives us an idea to model the helical spring stiffness or strength through the analysis stress results. Important keywords to model this simulation are,

- CONTACT_AUTOMATIC_SINGLE_SURFACE
- BOUNDRAY_PRESCRIBED_MOTION_RIGID
- MAT_PLASTIC KINAMETIC
- CONSTRAINED_NODAL_RIGID_BODY_SPC

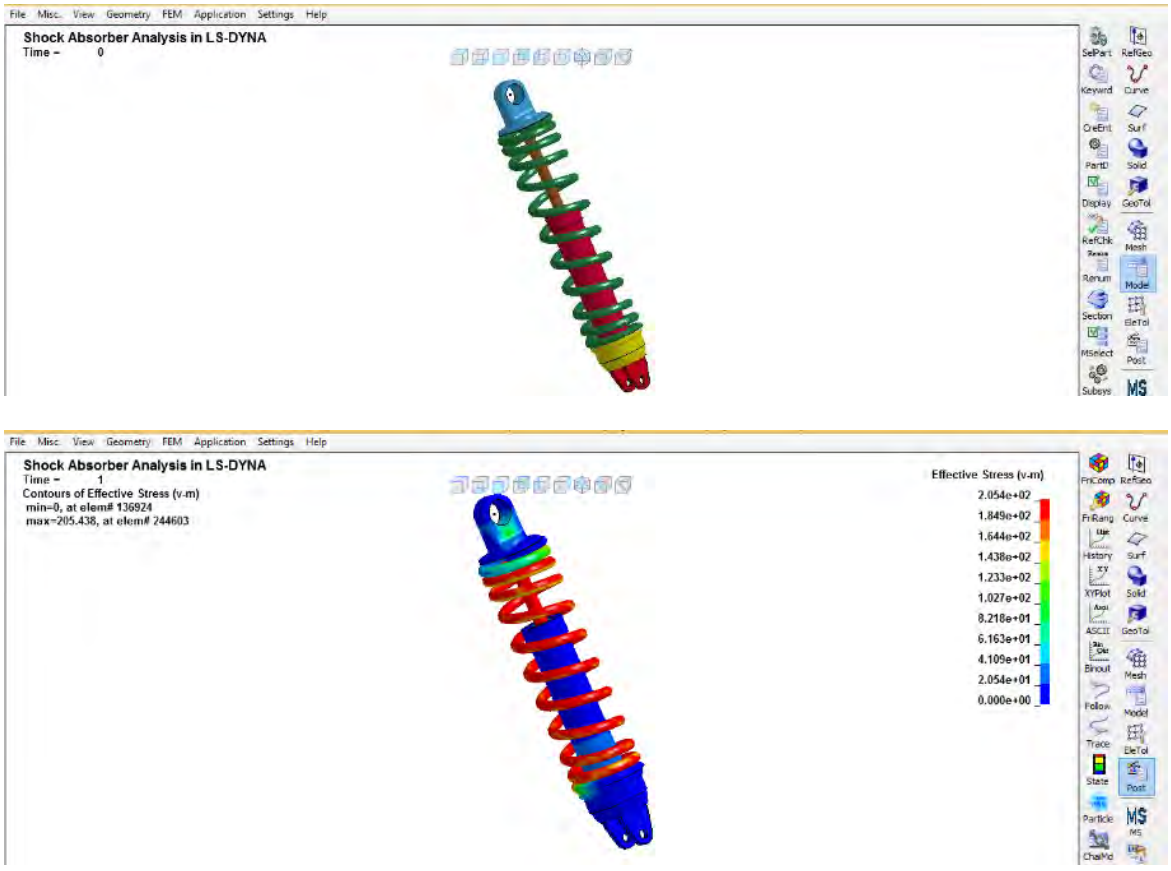


Figure: Shock Absorber Simuaton in LS-DYNA

To know more about the simulation, please contact support@kaizenat.com

A team of engineers, mathematicians, & computer scientists develop LS-DYNA, LS-PrePost, LS-OPT, LS-TaSC, and LSTC's Dummy & Barrier models.

LSTC_FCA Tire Finite Element Models for Crashworthiness Applications in LS-DYNA®

About

The LSTC_FCA Tire models, jointly developed with FCA(Fiat Chrysler Automobiles), is based on a series of material, verification and component level tests.

The finite element mesh was developed based on 2D CAD data of the Tire section.

Difference Tire sizes were developed using geometry-based morphing using reference data

Air-loss is modeled using a combination of SENSORS and porosity and venting

Tire Model Features

- 240,000 elements hexahedron solid elements element formulation -2
- Inflation is based on *AIRBAG_HYBRID
- Deflation is based on *SENSOR
- Plug-and-Play with using *INCLUDE with no additional user input required
- Elastomers are modeled using *MAT_SIMPLIFIED_RUBBER with rate-dependency
- Plies are modeled using *MAT_ORTHOTROPIC_ELASTIC
- Mounting on the wheel is modeled using *LOAD_THERMAL_VARIABLE

Visit www.lstc.com for more information

LS-DYNA Conference 2020 & Call for Papers

Conference Dates

- **Sunday 5/31/2020**
  Registration, Exhibition Booths, Pre-Conference Classes, and Reception
- **Monday 6/1/2020**
  Registration, Exhibition Booths, Plenary, Keynote, Paper Presentations, and Banquet
- **Tuesday 6/2/2020**
  Registration, Exhibition Booths, Paper Presentations, and Closing
- **Wednesday-Thursday 6/3/2020-6/4/2020**
  Post-Conference Classes

***LS-DYNA Conference 2020 website*:**
http://www.lstc.com/2020

At a Glance:

- **Date:** May 31 - June 2
- **Hotel:** Detroit Marriott at the Renaissance Center (book by May 20)
- **Courses:** May 31 and June 3 - 4
- **Pricing:** $650, $325 (students)
- **Contact:** conference@lstc.com
- **Registration:** Register by May 20
- **Abstract Submission Deadline:** Oct 30, 2019
- **Paper Submission Deadline:** Feb 15

Call for Papers:

Session Categories

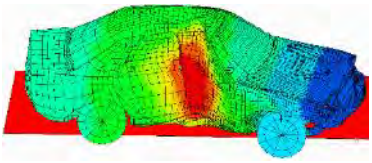
- Aerospace
- Automotive
- Biomedical
- Blast
- Composites
- Computing Technology
- Constitutive Modeling
- Connections
- Electromagnetics
- FSI/ALE
- ICFD
- Implicit
- Isogeometric Analysis (IGA)
- Metal Forming
- Modeling
- NVH
- Occupant Modeling
- Occupant Protection
- Optimiziation
- Post-Processing
- Simulation
- SPG
- SPH
- Thermal
- THUMS
- Topology & Optimization
- Other (please specify)

Submit abstract: https://www.dynamore.de/en/training/conferences/upcoming/ls-dyna-2020

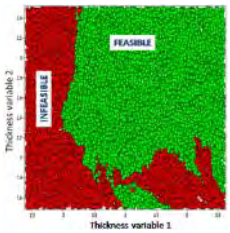
LS-OPT® NEW RELEASE VERSION 6.0

LS-OPT Version 6.0 provides major new features as follows:

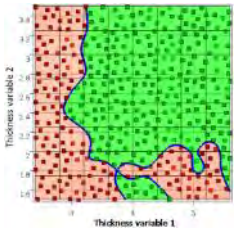
1. *Classifiers* have been introduced to provide a new constraint handling approach. In this method a decision boundary based on the pre-defined feasibility criteria is constructed in the design space that predicts whether a design is feasible or not (instead of predicting the response value itself). The support vector classification algorithm is available to approximate the boundaries. This approach is especially attractive for discontinuous or binary responses, and for handling multi-disciplinary failure/feasibility criteria.



Actual feasibility based on FE simulations

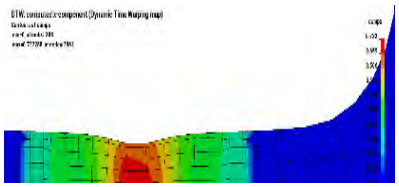


Feasibility based on classifier

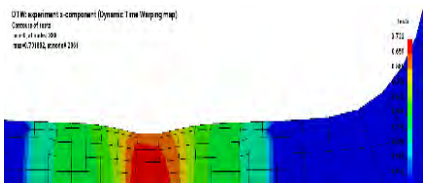


2. Parameter Estimation

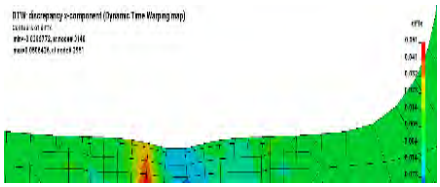
   a. *Digital Image Correlation (DIC).* Multi-point histories and crossplots (MPH) have been introduced to accommodate full-field spatial response. The MPH are defined at coordinates, e.g. from digital imaging. An interface is available for the gom/ARAMIS system and the GenEx parser has been extended for spatial data. Clustering methods and binary databases speedily handle high-volume DIC data. DIC data is mapped to the FE mesh and can be compared using LS-PrePost® selected from LS-OPT.



FEM (LS-DYNA®)



DIC mapped to FE mesh



Difference (magnified)

   b. *Similarity measures for curve comparison.* The Dynamic Time Warping (DTW) similarity measure has been added to compute the distance between any two multi-point curves for the purpose of parameter estimation. DTW addresses a deficiency to accommodate combined noise (e.g. failure models) and hysteresis.

3. *Interactive tables*. Simple static tables for design data have been enhanced to assume a more spreadsheet-like behavior. Tables, which interact with plots, now allow new design point generation in a selected region of interest as well as the simulation of newly generated points. The *point categories* feature has been enhanced while highlighting of infeasibility and interactive row sorting are possible.

4. *Stage library.* For standardization of a design problem setup, solver stages or process groups can be imported and exported to and from user-specified locations.

Efficient Global Optimization (EGO) has been added as an optimization strategy, *LS-TaSC* has been added as a solver option and the *Taguchi Method* is now available.

New version download: **http://ftp.lstc.com/user/ls-opt/6.0.0**

Providing engineering services to the composites industry since 1970. During this time, we have participated in numerous programs that demonstrate our ability to perform advanced composite design, analysis and testing; provide overall program management; work in a team environment; and transition new product development to the military and commercial sectors.

Progressive Composite Damage Modeling in LS-DYNA (MAT162 & Others)

Bazle Z. (Gama) Haque, Ph.D.
Senior Scientist, University of Delaware Center for Composite Materials (UD-CCM)
Assistant Professor of Mechanical Engineering, University of Delaware, Newark, DE 19716
P: (302) 690-4741 | E: bzhaque@udel.edu

2019 Workshops:
Webinar Course Dates
November 19, 2019 | 9am-5pm

In House Course Dates
November 20, 2019 | 9am-5pm

Cost: **In-House Class:** $695 per person
Includes: Coffee, Lunch, Parking, USB with Course Content
Email Robin Mack for driving direction.

Web Conference: $695 per person
Includes: CD with Course Content

Description:

Progressive damage modeling of composites under low velocity impact, and high velocity impact is of interest to many applications including car crash, impact on pressure vessels, perforation and penetration of thin and thick section composites. This course will provide a comparison between available composite models in LS-DYNA for shell and solid elements, e.g., MAT2, MAT54, MAT59, & MAT162. Among these material models, rate dependent progressive composite damage model MAT162 is considered as the state of the art. This short course will include the theory and practice of MAT162 composite damage model with applications to low and intermediate impact velocities, understanding the LS-DYNA programming parameters related to impact-contact, damage evolution, perforation and penetration of thin- and thick-section composites. Printed copies of all lecture notes will be provided along with a CD containing all example LS-DYNA keyword input decks used in this short course.

Topics Covered in this Short Course:

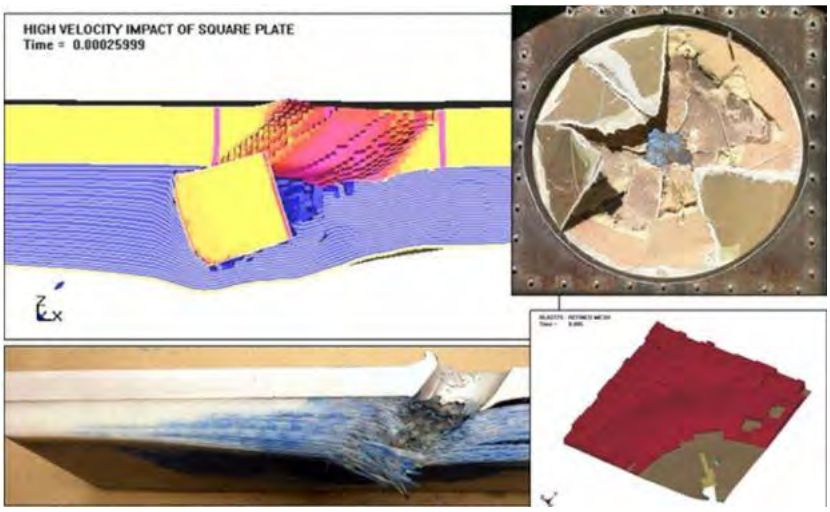
- Impact and Damage Modeling of Composites
  Application of MAT162 in Engineering and Research Problems
- Introduction to Composite Mechanics
  Introduction to Continuum Mechanics and Composite Mechanics

- Composite Material Models in LS-DYNA for Shell and Solid Elements
  Discussion on MAT2, MAT54, MAT59, & MAT162
- Theory and Practice in MAT162 Progressive Composite Damage Model for Unidirectional and Woven Fabric Composites
  MAT162 User Manual – Version 15A 2015
  Progressive Damage Modeling of Plain-Weave Composites using LS-Dyna Composite Damage Model MAT162
  Unit Single Element Analysis
- Comparison between Different LS-DYNA Composite Models
  Sphere Impact on Composite SHELL & SOLID Plates
- Low Velocity Impact and Compression after Impact Applications
  Modeling the Low Velocity Impact and Compression after Impact Experiments on Composites Using MAT162 in LS-DYNA
- Perforation Mechanics of 2-D Membrane and Thin Composites
- Penetration Mechanics of Composites and Soft-Laminates
- Introduction to LS-DYNA (Document Only)

To register, email Robin Mack your full name, and if you're attending in house or web conference.

Engineering Services

MSC brings a long-range perspective to its engineering services clients. We understand the history of our core technologies, and can project likely new developments, and seek to provide innovation. A keen appreciation of the materials and structures state-of-the-art gives us the ability to create a development roadmap that efficiently reaches the clients goal, while taking full advantage of what already exists. We have an unusually broad exposure to materials applications; we have been involved with everything from infrastructure applications to spacecraft. This broad perspective allows us to draw on approaches and trends in one application area, and apply it to another. This helps our clients avoid pitfalls, and make exceptionally rapid technological progress. The same broad reach allows us the opportunity to interact with, and evaluate a wide range of suppliers.



Oasys Ltd is the software house of Arup and distributor of the LS-DYNA software in the UK, India and China. We develop the Oasys Suite of pre- and post-processing software for use with LS-DYNA.

New Barrier Model Released

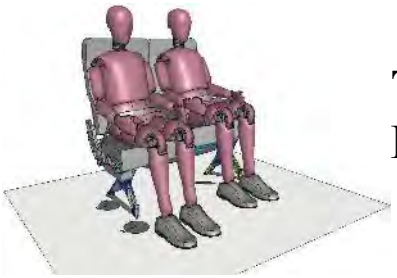
NHTSA Side and Rear Impact Barrier

Arup in collaboration with Cellbond has developed the LS-DYNA Shell model of NHTSA Side and Rear Impact Barrier.

The model is an upgrade of the already available solid model, not only showing good force-displacement correlations compared with test results but also offer a more realistic barrier deformation behaviour.

This was achieved through extensive material calibration and component/full barrier validation (facilitated by a comprehensive testing campaign).

To obtain this barrier model or for more information about a trial license contact dyna.suport@arup.com



Training Class:
Introduction to LS-DYNA Implicit

2 Oct, 2019 One day

The Arup Campus, Blythe Valley Park, Solihul

Course Outline:

The course is an introduction to the use of implicit analysis in LS-DYNA. The main focus is on the different types of linear and non-linear static analysis. The required input cards for each one of them are discussed.

- Course Content:
- Implicit vs. explicit
- Memory
- Time / Timesteps
- Element formulation
- Material models
- Contacts
- Control cards
- Dynamic Relaxation
- Control / Database Cards
- Linear Static Analysis
- Non-Linear Static Analysis
- Intermittent Eig. Analysis
- Freq. Response Analysis
- Buckling Analysis
- Other

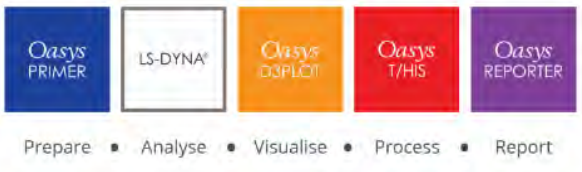
Oasys Academic License for UK-based students

Access to Oasys LS-DYNA Environment for UK-based students

At Oasys Ltd., we're committed to providing academic institutions access to industry-leading software tools.

Access for students: The Oasys Suite is at the leading edge of pre- and post-processing software, enabling LS-DYNA users to prepare and comprehensively check their models, then visualize, process and report on the results.
To support you in becoming familiar with these tools, we are pleased to offer UK-based students limited licenses for LS-DYNA and the Oasys Suite.

- LS-DYNA is charged at £65 +VAT per year; a license can be purchased through our software shop.
- Oasys Suite is free of charge; a license can be requested by completing the form on this page of our website.



Please note:

- software support is not included with the limited license but students can access our tutorial resources and webinars.
- limited licenses are only limited in model size (to 10,000 elements); there is no limit on the functionality of the software.

For more information click here**.**

Department-wide license: A department-wide annual license is available for non-commercial use of the Oasys LS-DYNA Environment software. This allows full access for students and staff for teaching or research purposes. An optional software support contract is also available which provides access to our technical support team for teaching staff.

If you are studying or work at a UK university and would like to discuss any of the above, please get in touch via dyna.support@arup.com

Predictive Engineering provides FEA and CFD consulting services, software, training and support to a broad range of companies.

FINITE ELEMENT ANALYSIS
Predictive Engineering

Who We Are

We are experienced simulation engineers that have successfully analyzed and validated hundreds and hundreds of finite element analysis (FEA) projects. With decades of experience in FEA and CFD, we know how to optimize your design to deliver every last bit of performance and to ensure that it will meet your service requirements whether in Aerospace, Marine, Energy, Automotive, Medical or in Consumer Products.

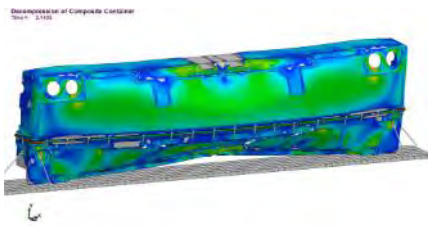
Our History

Since 1995, Predictive Engineering has continually expanded its client base. Our clients include the total spectrum from large Fortune 500 companies to start-ups looking to launch the next generation of satellites. We are also proud of work in the renewable energy fields from wind to solar. Over the years, one of our core strengths is in the vibration analysis of composite structures, aerospace electronic components and large industrial machinery. What has set us apart from the competition is our experience in the successful completion of more than 800 projects.

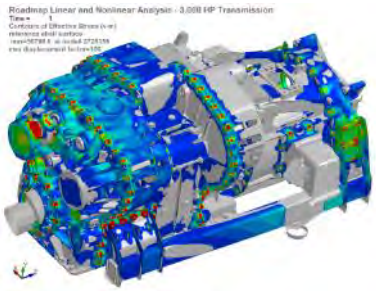
View our portfolio

FEA, CFD and LS-DYNA consulting projects

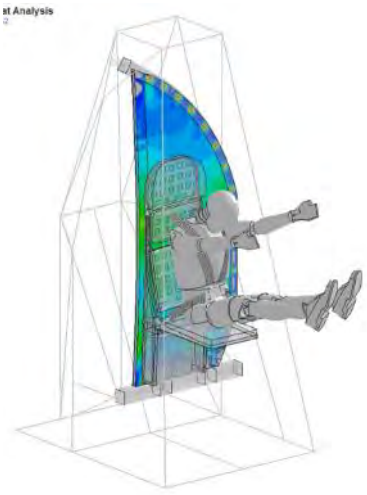
Composite Engineering



Nonlinear Dynamics



Aerospace



How to Become a Journeyman Simulation Engineer

July 26, 2019 In: News, Blogs and Updates Posted By: George Laird

It is an inside joke among simulation engineers about how long does it take to be considered a "journeyman" simulation engineer. The answer is about five years since it takes that long for your mistakes to catch up with you! It is a brutal profession since everyone is human but the price of failure is especially high when your FEA results are used to build prototypes that cost hundreds of thousands of dollars. Which leads to another saying: "What is the difference between a design engineer and a simulation engineer? A design engineer gets a second chance." Thus, we were pleased to hear from our client that their composite container passed mobility testing with flying colors. Not only did it pass, the group doing the testing at Aberdeen said that it was the first time that such container had passed all tests at 100% from drop test, rail impact, heavy lift to land transport. If you would like to read about more about our FEA work on this container, please take a look at: 026_Jensen, Broad-Spectrum Stress and Vibration Analysis of Large Composite Container.pdf.

Offering industry-leading software platforms and hardware infrastructure for companies to perform scientific and engineering simulations. Providing simulation platforms that empower engineers, scientists, developers, and CIO and IT professionals to design innovative products, develop robust applications, and transform IT into unified, agile environments.

Society of Exploration Geophysicists

September 15 - September 20

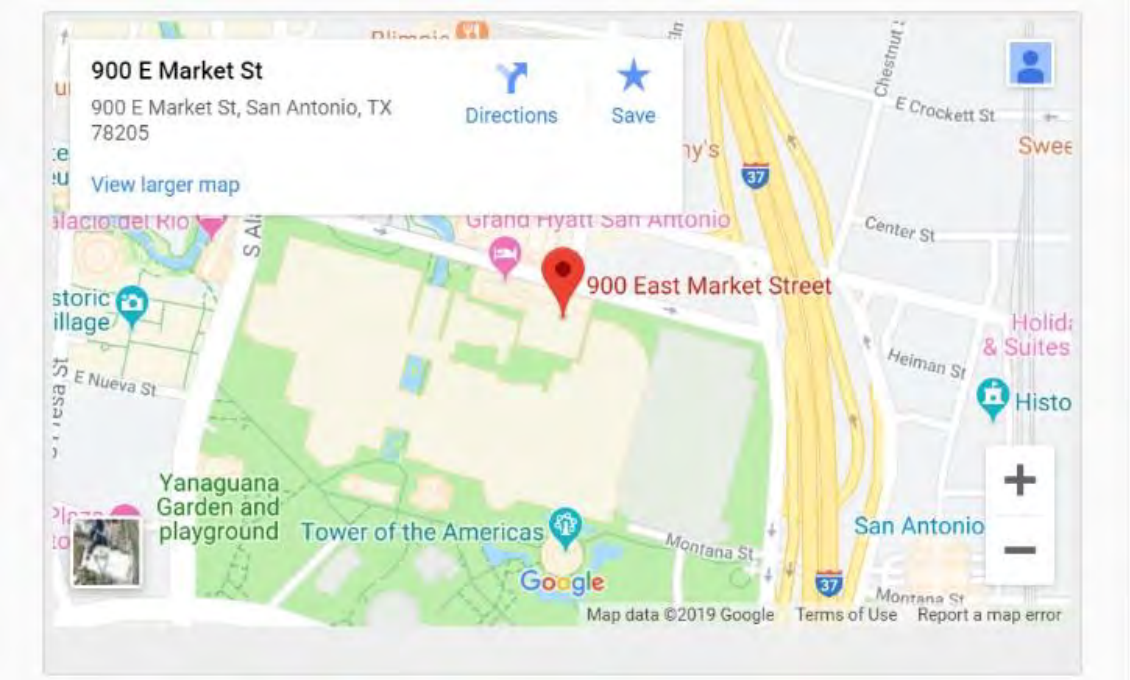
Join us at Society of Exploration Geophysicists this summer in San Antonio. Rescale will be at booth #2047.

Register here.

Details
Start:
September 15
End:
September 20

Venue

Henry B Gonzalez Convention Center
900 E Market Street
San Antonio, TX 78205 United States



LS-DYNA China, as the master distributor in China authorized by LSTC, is fully responsible for the sales, marketing, technical support and engineering consulting services of LS-DYNA in China.

仿坤软件 LS-DYNA China

2019 4th China LS-DYNA Users' Conference

The 4th China LS-DYNA Users'Conference will be held on October 21st - 23rd, 2019 in Shanghai. During this conference LSTC will share the details of its latest product developments as well as its road map for the future. At this conference engineers and scientists from LSTC and customers from all over the world will meet to share their experiences and successful cases with LS-DYNA, to discuss the latest features and developments in LS-DYNA, and to explore industrial development trends.

This conference aims to promote interaction and communication among developers and end users. Therefore, we call for papers with topics covered but not limited to the automotive industry, aerospace and aeronautics, electronics industry, daily consumer goods, biomechanics, locomotive, shipbuilding, civil engineering, and general machinery.

LSTC, Shanghai Fangkun Software Technology, Ltd., and Dalian Fukun Technology Development Corporation wholeheartedly welcome your paper submission and attendance.

Hosts: **Livermore Software Technology Corp. USA**
Shanghai Fangkun Software Technology, Ltd. China
Dalian Fukun Technology Development Corp. China

Date: **October 21st- 23rd, 2019**

Location: **Pullman Shanghai South Hotel** (http://www.pullmzxhotel.com/)
No.1 Pubei Road, Xuhui District, Shanghai, China, 200235

Training: There will have pre and post-conference training classes being held on Oct. 21st, 24th and 25th.

Conference Website: **http://conference.lsdyna-china.com/**
Contact us: conf@lsdyna-china.com

Call for Paper

- **Abstract submission deadline — 20th August 2019**
- **Notice of acceptance deadline — 1st September 2019**
- **Full paper submission deadline — 20th September 2019**

Excellent Paper Awards. We will be giving prizes for the best papers. Award winners will be announced at the banquet on October 22nd. The best paper in English will be published in the English edition of FEA Information Engineering Journal (ISSN #2167-1273) and the best paper in Chinese will be published in the FEA Information Chinese edition.

Conference Website: http://conference.lsdyna-china.com/
Contact us: conf@lsdyna-china.com

CAE software sale & customer support, initial launch-up support, periodic on-site support. Engineering Services. Timely solutions, rapid problem set up, expert analysis, material property test Tension test, compression test, high-speed tension test and viscoelasticitiy test for plastic, rubber or foam materials. We verify the material property by LS-DYNA calculations before delivery.

TERRABYTE Co.,Ltd.
Customer Satisfaction by Computer Solution & Computer Simulation

CAE consulting - Software selection, CAE software sale & customer support , initial launch-up support, periodic on-site support.

Engineering Services - Timely solutions, rapid problem set up, expert analysis - all with our Engineering Services. Terrabyte can provide you with a complete solution to your problem; can provide you all the tools for you to obtain the solution, or offer any intermediate level of support and software.

FE analysis

- LS-DYNA is a general-purpose FE program capable of simulating complex real world problems. It is used by the automobile, aerospace, construction, military, manufacturing and bioengineering industries.
- ACS SASSI is a state-of-the-art highly specialized finite element computer code for performing 3D nonlinear soil-structure interaction analyses for shallow, embedded, deeply embedded and buried structures under coherent and incoherent earthquake ground motions.

CFD analysis

- AMI CFD software calculates aerodynamics, hydrodynamics, propulsion and aero elasticity which covers from concept design stage of aerocraft to detailed design, test flight and accident analysis.

EM analysis

- JMAG is a comprehensive software suite for electromechanical equipment design and development. Powerful simulation and analysis technologies provide a new standard in performance and quality for product design.

Metal sheet

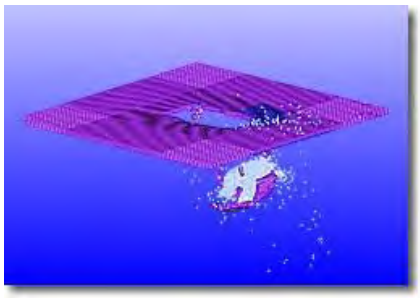
- JSTAMP is an integrated forming simulation system for virtual tool shop based on IT environment. JSTAMP is widely used in many companies, mainly automobile companies and suppliers, electronics, and steel/iron companies in Japan.

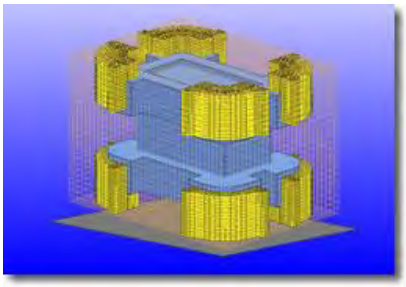
Pre/ Post

- **PreSys** is an engineering simulation solution for FE model development. It offers an intuitive user interface with many streamlined functions, allowing fewer operation steps with a minimum amount of data entry.
- **JVISION** - Multipurpose pre/post-processor for FE solver. It has tight interface with LS-DYNA. Users can obtain both load reduction for analysis work and model quality improvements.

Biomechanics

- **The AnyBody Modeling System™** is a software system for simulating the mechanics of the live human body working in concert with its environment.





Aerospace News - Collins Aerospace

Collins Aerospace to enhance CRIIS software and operator consoles for Air Force, Navy and Army test ranges

CEDAR RAPIDS, Iowa (Aug. 8, 2019) – Collins Aerospace Systems, a unit of United Technologies Corp. (NYSE: UTX), has been awarded multiple task orders totaling more than $7.6 million to update computer operating systems (OS) and operator consoles of the Common Range Integrated Instrumentation System (CRIIS) for U.S. Air Force, Navy and Army test ranges. This effort resolves OS obsolescence, improves system security and incorporates lessons learned to enhance system operator workflow.

CRIIS is replacing legacy Department of Defense (DoD) test range systems including Advanced Range Data System (ARDS) and Air-to-Air Range Infrastructure (AARI) systems in use at major U.S. military ranges. The system supports the DoD's vision of a common test and training infrastructure for improved operational realism by providing:

- Accurate time, space and position information under highly-dynamic aircraft conditions with an extended area control of air, land and sea participants
- Real-time tracking of air exercise participants up to approximately 430 nautical miles
- Open architecture design to support range flexibility
- Multiple Independent Levels of Security (MILS) architecture
- Standardization of interface protocols including Test and Training Enabling Architecture (TENA)
- Software-defined radio for waveform and frequency agility
- Support for synthetic threats and forces

Collins Aerospace's CRIIS includes operator consoles for mission setup, datalink network control, real-time evaluation, post-mission data analysis and system maintenance. With the new updates, a single, common operating system configuration for all system computers will be in place to greatly reduce the life-cycle cost to perform updates over time.

“By updating the user interface consoles, we’re able to streamline operator’s workload for all phases that lead to easier pre-mission setup and improved user experience during real-time operations," said Brad Haselhorst, vice president and general manager, Training and Mission Solutions for Collins Aerospace.
In addition to the traditional data collection capability of an instrumentation system, CRIIS includes the ability to uplink and downlink ground and aircraft data. This enables seamless interaction between live and synthetic participants for highly-realistic test or training missions.

About Collins Aerospace:

Collins Aerospace Systems, a unit of United Technologies Corp. (NYSE: UTX), is a leader in technologically advanced and intelligent solutions for the global aerospace and defense industry. Created in 2018 by bringing together UTC Aerospace Systems and Rockwell Collins, Collins Aerospace has the capabilities, comprehensive portfolio and expertise to solve customers’ toughest challenges and to meet the demands of a rapidly evolving global market. For more information, visit CollinsAerospace.com.

About United Technologies Corporation: United Technologies Corp., based in Farmington, Connecticut, provides high-technology systems and services to the building and aerospace industries. By combining a passion for science with precision engineering, the company is creating smart, sustainable solutions the world needs. For more information about the company, visit our website at www.utc.com or follow us on Twitter: @UTC.

Automotive News - 2020 Chevrolet Corvette

Tonawanda-Built Next Gen 6.2L Small Block V-8 to Power All-New 2020 Chevrolet Corvette Stingray

- **First production mid-engine Corvette**
- **Most horsepower and torque of any entry Corvette**

TONAWANDA, New York — General Motors Co. (NYSE: GM) today confirmed its Tonawanda, New York, engine plant will build the company's next-generation 6.2L Small Block V-8 engine that will power the all-new 2020 Chevrolet Corvette Stingray. Production of the 2020 Corvette Stingray begins at GM's Bowling Green, Kentucky assembly plant in late 2019.

This news follows the reveal of the 2020 Corvette last week in Tustin, California.

Powered by the Tonawanda-built next-gen 6.2L Small Block V-8 LT2 engine, the 2020 Stingray will offer customers the most horsepower and torque of any entry Corvette: SAE-certified to 495 hp and SAE-certified to 470 lb.-ft. of torque (when equipped with performance exhaust.

"The 2020 Stingray is Chevrolet's first production mid-engine Corvette – the fastest, most powerful entry Corvette ever - offering new levels of performance, technology and craftsmanship," said Mark Reuss, GM president, during a visit to the plant to meet with employees and community leaders. "The Tonawanda team is up to the challenge to build this new LT2 engine at world-class quality levels that Corvette customers have come to expect."

Tonawanda currently builds a variety of award-winning engines used in a wide range of GM products including:

- 2.0L Turbo/2.5L – Chevrolet Camaro, Malibu, Colorado, Equinox, Traverse and Impala; Buick Regal, GMC Canyon, Acadia and Terrain and Cadillac ATS and CTS.
- 4.3L V-6, 5.3L V-8; 6.2L V-8 – Chevrolet Silverado, Suburban and Tahoe, GMC Yukon/Yukon Denali and Cadillac Escalade.
- 6.6L HD Small Block gas V-8 – 2020 Chevrolet Silverado HD and GMC Sierra HD.

In 2016, GM announced it would invest nearly $300 million in the Tonawanda plant to prepare the facility for future engine production. The next-gen 6.2L V-8 completes the work related to the investment. GM has invested more than $23 billion in its U.S. manufacturing operations over the past decade.

mv@feainformation.com

LS-DYNA Multiphysics YouTube

https://www.youtube.com/user/980LsDyna

FAQ LSTC

ftp.lstc.com/outgoing/support/FAQ

LS-DYNA Support Site

www.dynasupport.com

LS-OPT & LS-TaSC

www.lsoptsupport.com

LS-DYNA EXAMPLES

www.dynaexamples.com

LS-DYNA CONFERENCE PUBLICATIONS

www.dynalook.com

ATD –DUMMY MODELS

www.dummymodels.com

LSTC ATD MODELS

www.lstc.com/models www.lstc.com/products/models/mailinglist

AEROSPACE WORKING GROUP

http://awg.lstc.com

Training - Webinars

Participant's Training Classes

Webinars

Info Days

Class Directory

Directory

BETA CAE Systems	www.beta-cae.com/training.htm
DYNAmore	www.dynamore.de/en/training/seminars
Dynardo	http://www.dynardo.de/en/wost.html
ESI-Group	https://myesi.esi-group.com/trainings/schedules
ETA	http:///www.eta.com/training
KOSTECH	www.kostech.co.kr
LSTC - (corporate)	www.lstc.com/training
LS-DYNA OnLine - (Al Tabiei)	www.LSDYNA-ONLINE.COM
OASYS	www.oasys-software.com/training-courses
Predictive Engineering	www.predictiveengineering.com/support-and-training/ls-dyna-training

Training - Dynamore

Author: Christian Frech christian.frech@dynamore.de

Seminars 2019

Visit the website for complete overview and registration www.dynamore.de/seminars

Selection of trainings for September/October

Introduction	
Introduction to LS-DYNA	17-19 September (Tr) 24-26 September 2-4 October (T)
Introduction to Simulation Technology	30 September
Introduction to Isogeometric Analysis with LS-DYNA	24 October
Crash	
Contact Definitions	27 September
Passive Safety	
Introduction to Passive Safety	19-20 September
Implicit Capabilities	
Implicit Analysis using LS-DYNA	16-17 September
Particle Methods	
Smoothed Particle Hydrodynamics	19-20 September
Multiphysics	
ALE and FSI	17-18 September
ICFD Incompressible Fluid Solver	17-18 October
High energy events	
Methods for Simulating Short Duration Events	8-9 October
Blast Modeling	10-11 October
Penetration Modeling	14-15 October
Optimization	
LS-OPT - Optimization & Robustness	24-26 September (V) 14-16 October

Information days and Webinars (free of charge)

Webinar: New Features in LS-DYNA	13 September
Information day: Simulation of Plastics	24 October
Information day: Composite Analysis	25 October

We hope that our offer will meet your needs and are looking forward to welcoming you at one of the events.

If not otherwise stated, the event location is Stuttgart, Germany. Other event locations are:
A = Aachen, Germany, Ba = Bamberg, Germany, G = Gothenburg, Sweden; Ko = Koblenz, Germany;
L = Linköping, Sweden, V = Versailles, France; T = Turin, Italy, Tr = Traboch, Austria, Z = Zurich, Switzerland

www.lstc.com

September 2019

Date				Location	Course Title	Days	Instructor(s)
Sep 5	Sep 6	Th	Fri	MI	SPH and SPG Methods for Fluid and Solid Applications	2	J. Xu, Y. Wu
Sep 9	Sep 13	Mon	Fri	CA	Crashworthiness in LS-DYNA®(This class is 4 days of instruction; the fifth day is a half day optional workshop.)	4 + 0.5	P. DuBois, S. Bala
Sep 10	Sep 13	Tu	Fri	MI	Introduction to LS-DYNA®	4	H. Devaraj
Sep 16		Mon		CA	Overview of Contacts in LS-DYNA®	1	S. Bala
Sep 26	Sep 27	Th	Fri	MI	Occupant Simulation	2	H. Devaraj

October 2019

Date				Location	Course Title	Days	Instructor(s)
Oct 7	Oct 9	Mon	Wed	CA	NVH, Fatigue, and Frequency Domain Analysis with LS-DYNA®	3	Y. Huang
Oct 8	Oct 9	Tu	Wed	MI	Airbag Folding	2	R. Chivukula
Oct 10	Oct 11	Th	Fri	MI	Airbag Modeling in LS-DYNA®	2	A. Nair
Oct 14	Oct 15	Mon	Tu	MI	Introduction to LS-OPT	2	I. Gandikota
Oct 16	Oct 18	Wed	Fri	MI	Advanced LS-OPT: Deterministic and Probabilistic Optimization	3	A. Basudhar
Oct 21		Mon		CA	EM: Eddy Current Applications	1	I. Caldichoury
Oct 22		Tu		CA	EM: Battery Modeling, Spot Welding, and Resistive Heating Applications	1	I. Caldichoury
Oct 23	Oct 24	Wed	Fri	CA	Introduction to ICFD	2	I. Caldichoury
Oct 29	Nov 1	Tu	Fri	MI	Introduction to LS-DYNA®	4	S. Adya
Oct 30	Oct 31	Wed	Th	CA	Comprehensive ALE and Structure-ALE Modeling Methods and Applications	2	I. Do, H. Chen

DynaS+

Complementary tools

LSTC Livermore Software Technology Corp.

OUT-06

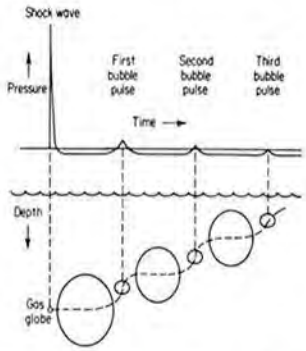
Underwater Shock Analysis with USA/LS-DYNA

Goal

Be able to run underwater explosions analysis with USA software and understand the underlying theory

Contents

1. Introduction
2. DoublyAsymptotic Approximation (DAA) Field Solver
3. Nonreflecting Boundary (NRB) Solver
4. Miscellaneous Topics
5. Optional - Cavitating Acoustic Fluid Element (CAFÉ and CASE) Field Solver



The key points of the training will be illustrated with practical exercises.

Audience

CAE Engineers / Researchers

Prerequisites

Operationnal knowledge of LS-DYNA *(Preliminary follow-up of the course* ***BASE-01*** *or* ***BASE-03*** *advised)*

Specific registration conditions submitted to the agreement of American Defence Department for USA software use

Duration

3 days

Trainers

External expert
(Tom LITTLEWOOD –LSTC)

The training being provided by an external expert, DynaS+ reserves right to cancel within the 2 weeks notice if there is not enough attendees.

Training provided in English, English course material

DynaS+ Catalogue Formation 2018 v2.0 - Réf : T/DIV/CMI/DYNAT/17/0238/2.0

Contact information:

Training Manager: **Charlotte MICHEL** E-mail: c.michel@dynasplus.com

Tel: +33 5 61 44 54 98 / Fax: +33 5 61 44 74 88 Website: www.dynasplus.com

Address: 5, avenue Didier Daurat - 31 400 TOULOUSE

Verification & validation of LS-DYNA@ Simulations

Al Tabiei, PhD
atabiei@lsdyna-online.com
October 2, 2019

Course Outline

- Introduction
- Definitions of Verification versus Validation (V&V)
- Differences Between V&V
- Verification & Validation Methods; Steps; Procedures
- Can I Bet The Farm on Simulation Results?

VERIFICATION

- Variability in Simulation Results:
  - Things You Have Control Over
  - Things You Do Not Have Control Over
- How to Tell if Your Solution is Correct?
  - Things to Look For
  - Useful Outputs: D3hsp & Message File
- Simulation Results on Different Machines
  - Single Precision vs Double Precision
  - Truncation Errors & Round Off Errors
- MPP vs SMP Results
  - Introduction to MPP
- Mesh Convergence Criterion
- Mesh Convergence and Erosion Criteria

VALIDATION

- Quantitative vs Qualitative Validation
- Experimental Data and The Lack of It, and V&V
  - Test Repeatability
- Experimental Outputs for V&V
- Validation Metrics
  - Magnitude-Phase (MPC) Metrics
  - Single-Value Metrics
  - Analysis of Variance (ANOVA) Metrics
- Validation in the Frequency Domain

About Tabiei : Dr. Al Tabiei has been a consultant on the use of large scale finite element simulation for more than 25 years to more than 80 large and small companies and government labs in the US and abroad. He was the director of the Center of Excellence in DYNA3D Analysis at the University of Cincinnati (1997-2001). He has more than 150 journal, refereed reports, and conferences papers
For the past 25 years Dr. Tabiei lectures 12 different short courses on the use of LS-DYNA for various applications to many government and industrial research centers and companies nationally and internationally. He lectured at nearly 20 countries. He also does code development for LSTC. Several of LS-DYNA material models, composite shell, and others are his development and implementation. He was consultant to the US government on the use of simulation for home land security problems. He was also on a NASA team for the return to the moon program to investigate different landing scenarios (2006-2010).

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Multiscale Simulations of Material with Heterogeneous Structures Based on Representative Volume Element Techniques

Zeliang Liu[1], C. T Wu[1], Bo Ren[1], Wing Kam Liu[2], Roger Grimes[1]
[1] *Livermore Software Technology Corporation, Livermore, CA 94551*
[2]*Northwestern University, Evanston, IL 60208*

Abstract

This paper presents a concurrent multiscale simulation framework for materials with heterogeneous structures (e.g. composite). This avoids the burdens of finding the macroscale phenomenological models and tedious calibration processes by directly establishing the connection between the microstructure and macro-response through computational homogenization. In the homogenization process, the model links every macroscopic integration point to a Representative Volume Element (RVE) of the microstructure, and macroscopic response is obtained by solving the RVE boundary value problem. Direct numerical simulation (DNS) techniques (e.g. FEM) for RVE analysis are capable of providing accurate high-fidelity material response data for complex phase morphology and behavior. Meanwhile, it is necessary to accelerate the RVE analysis using advanced model reduction techniques to enable efficient concurrent simulations.

RVE analysis package based on the FEM implicit analysis has been developed for 2D and 3D problems. Both smp and mpp are enabled. Instead of using separated pre- and post-processing packages for other FEA software, we have integrated the whole RVE analysis processes into LS-DYNA®, including preparing boundary conditions, FE analysis of the boundary value problem and RVE homogenization. Some key features of the RVE analysis package are 1) automatically assign boundary conditions to a given RVE mesh, such as periodic BC and uniform BC; 2) non-matching meshes on the faces can be considered; 3) arbitrary loading directions, such as uniaxial and shear; 4) output the RVE homogenization results to LS-DYNA® database, for both small-strain and finite-strain problem.

*All the above functions are now covered by two new keywords in LS-DYNA®, *RVE_ANALYSIS_FEM and *DATABASE_RVE. Some numerical benchmarks will be utilized to demonstrate the capability of the RVE package. The linkage of the RVE package and the development of data-driven model reduction techniques will also be discussed.*

1. Introduction

Materials are hierarchical in nature; hence, they involve an inter-play between simple small-scale constituents that together form elaborate compounds that can span multiple time- and length-scales. On the other hand, advanced manufacturing techniques, such as 3D printing [1-3], allow us to make hierarchically structured composites from nano- to macro-scale, which exhibit advantageous thermal, electrical or mechanical properties [4]. This multi-scale nature of heterogeneous materials poses a continuing challenge in computational modeling of macroscopic structures. Ideally, efficient and accurate predictions of the macroscopic behavior of heterogeneous materials should be uniquely obtained from the material behavior of each separate constituent (material phase) and from the information about the material microstructure [5].

Traditional phenomenological constitutive relations [6-8] characterize the average behaviors of the material, i.e. the contributions from all the material phases are not accounted for as an individual interaction of separate constituents. These laws regard materials as ``black boxes'', implying the need for burdensome experimental characterization and tedious calibration. In addition, they are problem-dependent and tend to fail when capturing highly localized microstructure-induced nonlinear material behavior, such as plasticity, damage and fatigue. Generalized continuum mechanics, also known as higher-gradient theories, have been proposed to incorporate the microscopic information by introducing higher order gradient of deformation [9]. The first known generation is micromorphic continuum developed by Toupin [10], Mindlin [11] and Eringen [12], and it is further generalized with arbitrary number of extra strain gradients by Liu and co-workers [13]. A current challenge of high-gradient theories is the determination of the large number of coefficients associated with higher-order tensors [14]. The strain gradient is usually not directly informed by the microstructure, making the model phenomenological and requiring extra effort to calibrate those coefficients.

Concurrent multiscale methods [15,16] avoid the calibration process in the phenomenological models by directly establishing the connection between the microstructure and the macro-response of materials using the so-called homogenization method. In the homogenization process, these concurrent methods link every macroscopic point of a structure to a Representative Volume Element (RVE) of the microstructure, and the macroscopic response (e.g. stress) is obtained through averaging inside the RVE. For a material with random microstructure, its true macroscopic properties are obtained as converged values only if the size of the RVE becomes sufficiently large, or the RVE should be a statistically representative sample of the material. Based on the DNS RVE analysis using FEA or FFT-methods, model reduction techniques can be then applied to accelerate the concurrent simulations. Figure 1 shows an example of concurrent simulation using a data-driven method called self-consistent clustering analysis (SCA) [17,18].

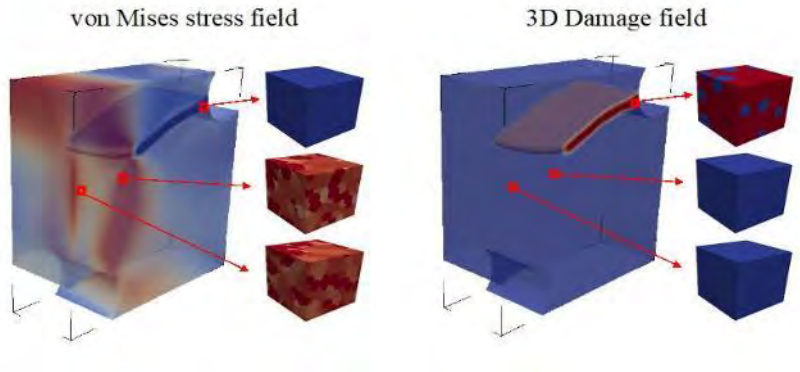


Figure 1 Illustration of a concurrent multiscale simulation based on RVE analysis and data-driven methods. The macroscopic material responses are driven by microscale RVE boundary value problem. The RVE package introduced in the paper will serve as the basis for the concurrent simulation.

In this paper, the recent developed RVE package in LS-DYNA® will be presented. In Section 2, the general homogenization theory is discussed, including the definition of an RVE. Different choices of the boundary conditions and the treatment of non-matching meshes are presented in Section 3. All the functions of the RVE

package are covered by two new keywords in LS-DYNA®, **RVE_ANALYSIS_FEM and *DATABASE_RVE,* which are introduced in Section 4. In Section 5, the RVE package are validated by several numerical examples. Based on the RVE-analysis package, a large amount of RVE response data can be generated for training our data-driven material models, using machine learning techniques. The on-going research regarding this topic will be briefly discussed in Section 6.

2. Homogenization theory

First-order homogenization, which will be mainly used in this dissertation, can be defined by assuming scale-separation and vanishing external body force inside the RVE. Let us introduce $\mathcal{U}$ as the space of admissible microscopic displacements $\mathbf{u}$ inside an RVE domain Ω with boundary Γ. It can be proved that under classical first-order boundary conditions, such as displacement boundary conditions (DBC), traction boundary condition (TBC) and periodic boundary conditions (PBC), the following equation is satisfied under small strain assumption,

$$\langle \boldsymbol{\sigma} \rangle_\Omega : \langle \delta \boldsymbol{\varepsilon} \rangle_\Omega = \langle \boldsymbol{\sigma} : \delta \boldsymbol{\varepsilon} \rangle_\Omega, \quad \forall \delta \mathbf{u} \in \mathcal{U} \tag{1}$$

where $\boldsymbol{\sigma}$ and $\boldsymbol{\varepsilon}$ are the Cauchy stress and infinitesimal strain, respectively. Moreover, $\langle \dots \rangle_\Omega$ is defined as volume average inside the RVE,

$$\langle \dots \rangle_\Omega = \frac{1}{\Omega} \int_\Omega \dots d\Omega \tag{2}$$

Eq. (1) is the so-called Hill-Mandel macro-homogeneity condition [19,20], which is equivalent to the statement that the virtual work density on the macroscale equals that of the microscale. It also ensures that the homogenized strain and stress are admissible variables in the macroscale constitutive relation.

For finite strain problem, the Hill-Mandel condition can be rewritten as

$$\langle \mathbf{P} \rangle_\Omega : \langle \delta \mathbf{F} \rangle_\Omega = \langle \mathbf{P} : \delta \mathbf{F} \rangle_\Omega, \quad \forall \delta \mathbf{u} \in \mathcal{U} \tag{3}$$

The finite strain formulation is more general and can be degenerated to Eq (1) under small strain assumption. As a result, the current RVE package uses the finite strain formulation with the deformation gradient $\mathbf{F}$ and first Piola-Kirchhoff stress $\mathbf{P}$ as the strain and stress measures.

In terms of the size of RVE, it should be large enough so that sufficient statistical microstructural information of the material can be included. Theoretically, it is always beneficial to have a larger RVE in order to obtain accurate homogenization results. However, in practice, the RVE size cannot be too large due to the limit of computational cost. The best way to determine the appropriate RVE size is to do a convergence study and select the smallest size that satisfies the tolerance (e.g. 5%).

Direct Numerical Simulation (DNS) is the most accurate and flexible homogenization method for solving the RVE problem, e.g. Finite Element Method and Fast Fourier Transformation (FFT)-based micromechanics method [21]. The current RVE package developed in LS-DYNA® is based on FEM, due to its flexibility of treating complex geometries and non-uniform mesh. If the RVE has a large number of degrees of freedom,

DNS can be very time-consuming. The time issue can be more serious in a concurrent multiscale simulation, since each integration point is associated with a RVE model. Thus, it is necessary to use model reduction techniques to accelerate the RVE analysis. Some on-going research topics of developing new machine learning techniques to enable fast and accurate multiscale simulations will be discussed in Section 6.

3. RVE boundary conditions

Given the macroscopic constraints of stress or strain, different types of boundary conditions can be prescribed on the RVE. Currently, the periodic boundary conditions and displacement boundary conditions have been implemented in LS-DYNA®. The illustrations of these two types of boundary conditions are shown in Figure 2 under uniaxial tension loading. It has been demonstrated in the literature that the periodic BC needs a smaller RVE size to get converged RVE homogenization results, and the displacement BC usually yields a stiffer response since all the faces are forced to be flat as shown in the figure. However, if the RVE size is large enough, the influence of the BC type is trivial.

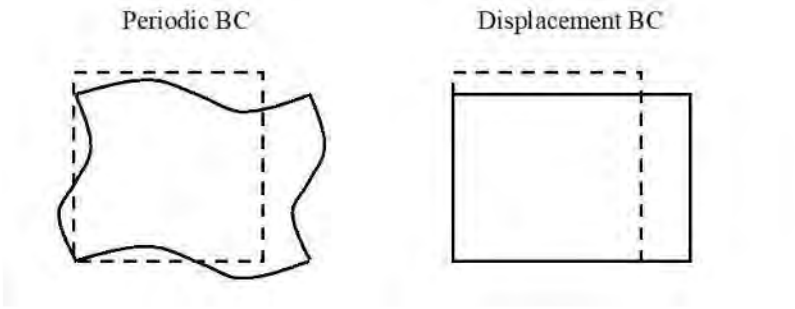


Figure 2 Illustrations of periodic and displacement BCs with the same macroscopic strain constraint on the RVE.

For both periodic and displacement BCs, the macroscopic strain constraint on the RVE is prescribed though the so-called control points, which are additional points to the original RVE model. In a 2D problem, there are in total two control points, while there are three control points for a 3D problem. The relationships between the displacement of control points and macroscopic strain is shown in the figure below.

2D problem

	u_x	u_y
c^1	$(\bar{F}_{xx}-1)\Delta x$	$\bar{F}_{yx}\Delta x$
c^2	$\bar{F}_{xy}\Delta y$	$(\bar{F}_{yy}-1)\Delta y$

3D problem

	u_x	u_y	u_z
c^1	$(\bar{F}_{xx}-1)\Delta x$	$\bar{F}_{yx}\Delta x$	$\bar{F}_{zx}\Delta x$
c^2	$\bar{F}_{xy}\Delta y$	$(\bar{F}_{yy}-1)\Delta y$	$\bar{F}_{zy}\Delta y$
c^3	$\bar{F}_{xz}\Delta z$	$\bar{F}_{yz}\Delta z$	$(\bar{F}_{zz}-1)\Delta z$

c: control point; u: displacement; $\bar{F}$: deformation gradient

Figure 3 The relationship between displacements of the control nodes and macroscopic deformation gradient in both 2D and 3D

When the deformation gradients of the RVE are not fully constrained in the shear direction, the solution is not unique and would cause numerical problems. Thus, additional constraints are provided for the off-diagonal components (shown for a general 3D case),

$$\bar{F}_{yx} = \bar{F}_{xy}, \qquad \bar{F}_{zx} = \bar{F}_{xz}, \qquad \bar{F}_{yz} = \bar{F}_{zy}, \tag{4}$$

which indicates that the averaged deformation gradient is symmetric. In terms of the displacement components, we have

$$u_y^{c^1}\Delta y = u_x^{c^2}\Delta x, \qquad u_z^{c^1}\Delta z = u_x^{c^3}\Delta x, \qquad u_z^{c^2}\Delta z = u_y^{c^3}\Delta y, \tag{5}$$

where $(\Delta x, \Delta y, \Delta z)$ represent the dimensions of the RVE. Note that it is not necessary that all the dimensions should be the same. For an arbitrary RVE mesh, the dimensions will be automatically measured by the program and stored for related calculations.

The RVE boundary value program is solved using the implicit solver in LS-DYNA®. After the FE analysis, the RVE needs to be homogenized to get the macroscopic material responses. Instead of taking the volume averaging based on Eq. (1) and (3), a more efficient way is to directly extract the macroscopic quantities on the control points. The relationship between the reaction forces on the control points and macroscopic stress is shown in the figure below.

2D problem

	f_x	f_y
c^1	$\bar{P}_{xx}\Delta y\Delta z$	0
c^2	$2\bar{P}_{xy}\Delta x\Delta z$	$\bar{P}_{yy}\Delta x\Delta z$

3D problem

	f_x	f_y	f_z
c^1	$\bar{P}_{xx}\Delta y\Delta z$	0	0
c^2	$2\bar{P}_{xy}\Delta x\Delta z$	$\bar{P}_{yy}\Delta x\Delta z$	0
c^3	$2\bar{P}_{xz}\Delta x\Delta y$	$2\bar{P}_{yz}\Delta x\Delta y$	$\bar{P}_{zz}\Delta x\Delta y$

c: control point; f: reaction force; $\bar{P}$: first Piola-Kirchhoff stress

Figure 4 The relationship between reaction force of the control nodes and macroscopic first Piola-Kirchhoff stress in both 2D and 3D

Under the constraints in Eq. (4), the first Piola-Kirchhoff stress is also symmetric,

$$\bar{P}_{yx} = \bar{P}_{xy}, \qquad \bar{P}_{zx} = \bar{P}_{xz}, \qquad \bar{P}_{zy} = \bar{P}_{yz}, \tag{6}$$

Once the homogenized deformation gradient and first Piola-Kichhoff stress are determined, other strain and stress measures (e.g. infinitesimal strain and Cauchy stress) can be easily calculated. All the macroscopic quantities will automatically be collected by the program and output to the database per users' request.

For displacement boundary conditions, a vertex of the RVE is chosen as the origin and fixed to remove rigid body motion. The displacement of a node on the faces $\mathbf{u}'$ with coordinate $\mathbf{X} = \{x, y, z\}$ is constraint by

$$\mathbf{u} = \bar{\mathbf{F}} \cdot \mathbf{X} \tag{7}$$

The situation of periodic boundary condition is more complex. For a pair of nodes $\{\mathbf{u}^1, \mathbf{u}^2\}$ on the x-y plane, the following constrain equations need to be satisfied,

$$u_x^2 - u_x^1 = u_x^{c^1}, \qquad u_y^2 - u_x^1 = u_y^{c^1}, \qquad u_x^2 - u_x^1 = u_y^{c^1} \tag{8}$$

Similarly, the constraint equations for nodes on the y-z and x-z planes can also be derived. Moreover, a node inside the RVE is fixed to get rid of rigid body motion.

Non-matching mesh problem for periodic boundary condition are solved by the concept of master and slave faces. For each pair of faces, the one with less number of nodes is chosen as the master face, and the other one becomes the slave face. As shown in Figure 5, the nodes (denoted by i, j, k) on the slave face are projected to the master surface. The projected nodes are then constrained by the nodes on the master face. For example, if the projected node j' of node j falls into the element with nodes I, J, K, the displacement of node j' is constrained by

$$\mathbf{u}^{j'} = \mathbf{N}^I \mathbf{u}^I + \mathbf{N}^J \mathbf{u}^J + \mathbf{N}^K \mathbf{u}^K, \tag{9}$$

where $\mathbf{N}^I$ is the element shape function of node I at the position of node j'.

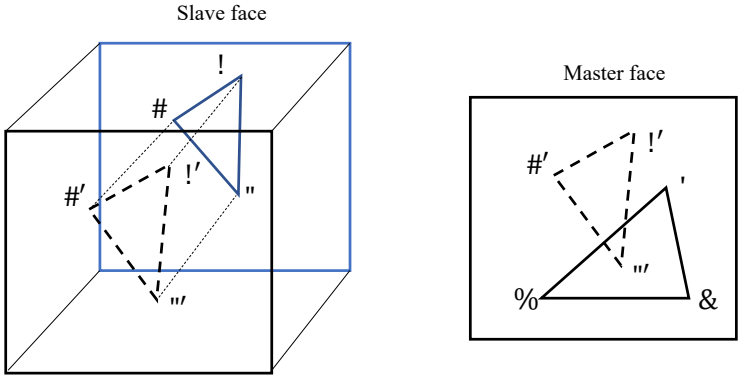


Figure 5 Treatment of non-matching meshes

The method based on master and slave faces still have issues of unbalanced force and may affect the accuracy of the prediction. Therefore, if possible, a matching RVE mesh is always preferred. However, when it is hard or impossible to obtain a good matching mesh, this method based on slave and master faces can be utilized to apply the periodic boundary conditions.

4. LS-DYNA® keywords for RVE analysis

The RVE package can be accessed through two new keywords in the LS-DYNA®, "*RVE_ANALYSIS_FEM" and "*DATABASE_RVE. In this section, we will introduce these two keywords in detail.

"*RVE_ANALYSIS_FEM" is the main keyword for the RVE analysis, and its input options are provided in Figure 6.

Card 1	1	2	3	4	5	6	7	8
Variable	MESHFILE							
Type	A80							
Default	None							

Card 2	1	2	3	4	5	6	7	8
Variable	INPT	OUPT	LCID	IDOF	BC	IUNI		
Type	I	I	I	I	I	I		
Default	0	1	None	None	0	1		

Card 3	1	2	3	4	5	6	7	8
Variable	E11	E22	E33	E23	E13	E12		
Type	F	F	F	F	F	F		
Default	None	None	None	None	None	None		

Figure 6 Input options for keyword *RVE_ANALYSIS_FEM

"MESHFILE" is the name of the user input file which contains the mesh info of the RVE. "INPT" identifies whether the boundary condition file is given by the user. If not (INPT=0), the program will generate a new file named "RVE_MESHFILE" which includes the input for the boundary conditions. "LCID" is loading curve id specified by the keyword "*DEFINE_CURVE". "IDOF" is the RVE dimension (2 or 3). "BC" identifies the type of boundary condition. Currently, the package support periodic boundary conditions (BC=0) and displacement boundary conditions (BC=1). "IUNI" tells the program whether the given RVE has a matching mesh (IUNI=1). Note that the algorithm of generating periodic BC is more efficient for IUNI=1. The input options in Card 3 are the components of strain prescribed on the RVE,

$$E_{ii} = F_{ii} - 1, \qquad E_{ij} = F_{ij} (i \neq j) \tag{10}$$

If the input for a strain component is empty, stress-free condition will be applied in that direction. For 2D problems (IDOF=2), inputs for E33, E23, E13 are ignored.

"*DATABASE_RVE" is keyword for the output of the RVE analysis. The input options are shown in Figure 7.

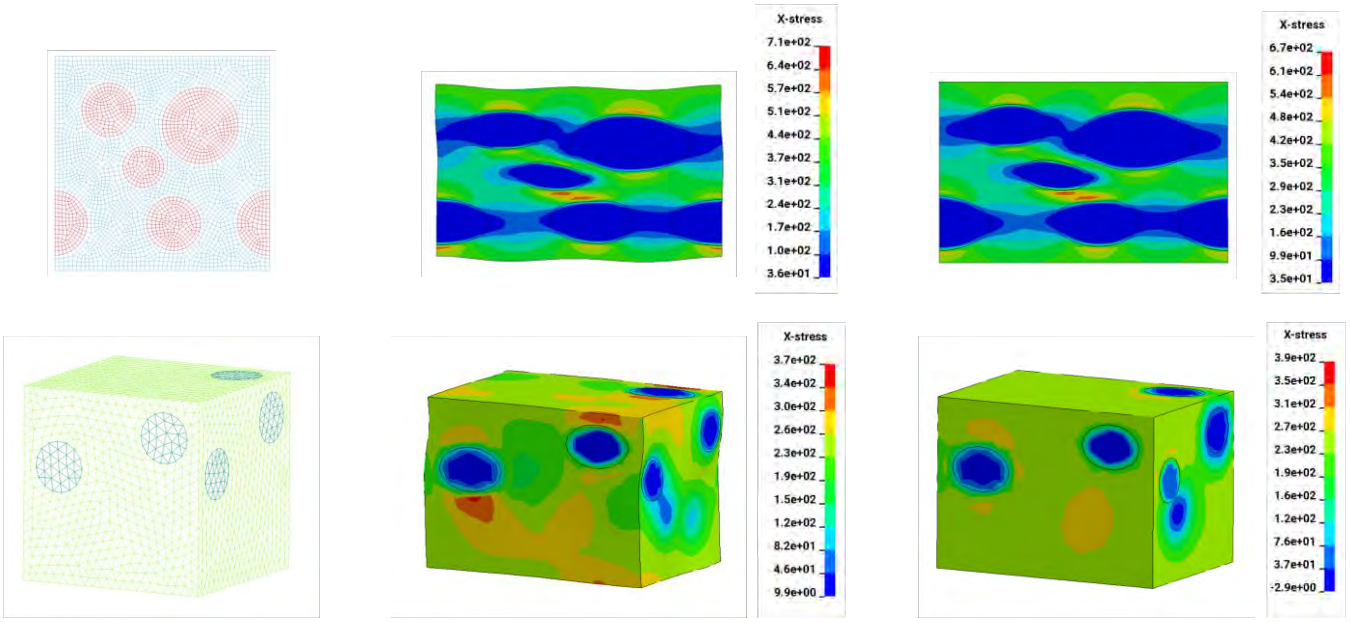
Card 1	1	2	3	4	5	6	7	8
Variable	DT	BINA						
Type	F	I						
Default	None	0						

Figure 7 Input options for keyword *DATABASE_RVE

"DT" stands for the time interval of database output. "BINA" determine whether the program will output the homogenization results to a ASCII database file named "rveout" (BINA=0) or to the LS-DYNA® binary database (BINA=1).

5. Numerical examples

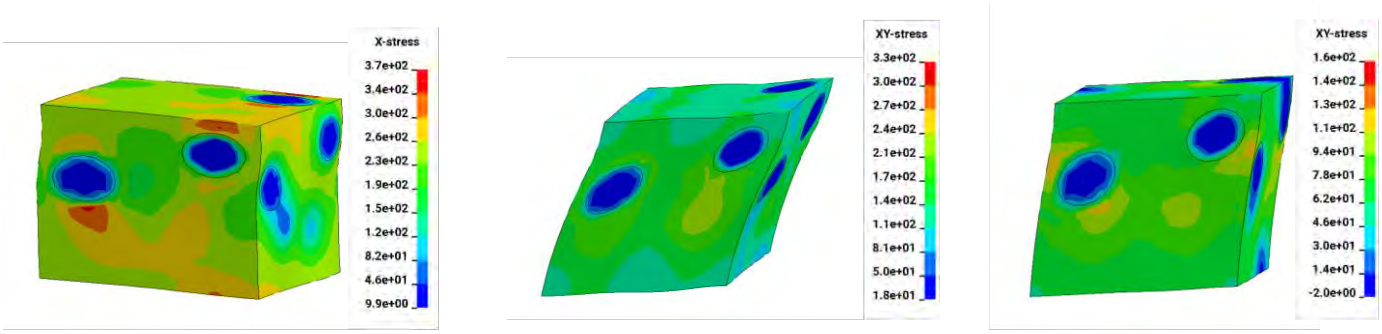
Several numerical examples are presented to validate the capability of the RVE package in both 2D (plane strain) and 3D. First, 2D and 3D RVEs with inclusions embedded in the matrix are investigated under finite deformation. Both matrix and inclusion materials are chosen to be isotopically hypoelastic. The elastic material constants are $E_{matrix} = 100MPa, E_{inclusion} = 1GPa$ and $\nu_{matrix} = 0.3, \nu_{inclusion} = 0.3$. The results under periodic and displacement BCs are provided in Figure 8.



a) 2D and 3D Meshes b) Periodic BC c) Displacement BC

Figure 8 RVE analysis results under uniaxial tension ($E11 = 0.4$) for periodic and displacement BCs.

With the control points, we can easily prescribe various loading conditions on the RVE. Figure 9 shows the 3D simulation results under uniaxial tension, shear and mixed loadings.



a) E11=0.4 b) E12=0.25 c) E11=0.2, E22=0.2, E12=0.1, E23=0.1

Figure 9 Simulation results under uniaxial, shear and mixed loading conditions

Finally, the RVE package is used to simulate carbon fiber reinforced woven composite. The matrix material is chosen to be isotropic elastic, with material constant $E_{matrix} = 3GPa$ and $\nu_{matrix} = 0.2$. The yarn can be considered as a composite with unidirectional fiber embedded in the matrix material, so the yarn material is assumed to be orthotropic elastic. The properties of the yarn in the fiber directions are $E_a = 200GPa, E_b = 10GPa, E_c = 10GPa, \nu_{ba} = 0.02, \nu_{ca} = 0.02, \nu_{cb} = 0.4, G_{ab} = 5GPa, G_{bc} = 5GPa, G_{ca} = 5GPa$. Periodic BC is applied on the RVE. The simulations results under uniaxial tension (E11=0.01) are shown in Figure 10.

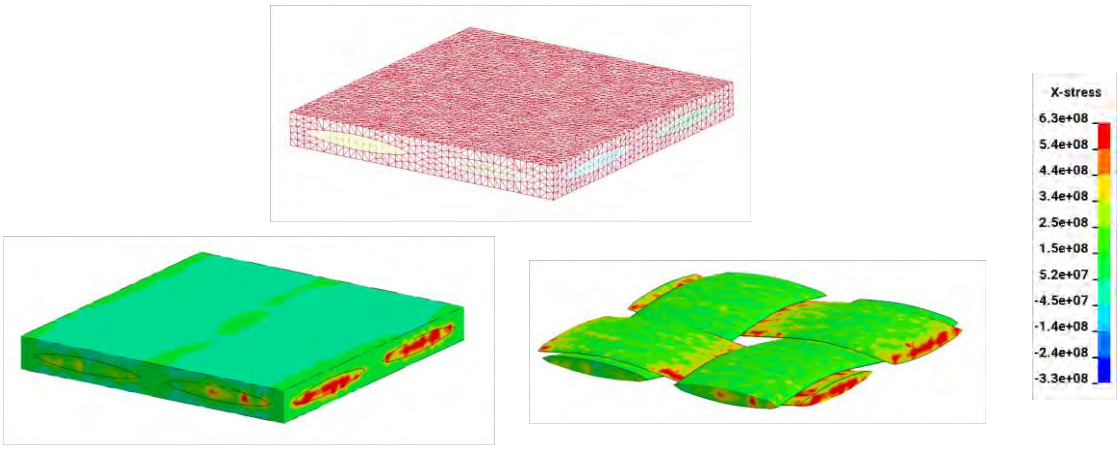


Figure 10 Simulation results of woven composites under uniaxial tension E11=0.01.

6. On-going research on data-driven material modeling

The modelling complexity from the interaction between the microstructures in the microscale propagates to the macroscale, and it becomes challenging to describe the macroscale behavior using a closed-form phenomenological constitutive law. The new RVE package in LS-DYNA® is a good tool for generating high-fidelity macroscopic material property data from microstructural information. However, in order to the conduct a multiscale concurrent simulation, the RVE analysis relies on DNS is still very time consuming. Thus, one of our on-going research topics is on data-driven material modeling and exploring new ways of constructing multiscale material database. It will be a combination of mechanistic homogenization theory and machine learning approach based on a large number of data generated from RVE analysis.

Meanwhile, current machine learning techniques (e.g. deep learning) has achieved great successes in broad areas of computer engineering, such as computer vision, gaming, and natural language processing. Although these techniques are able to construct models for complex input-output relations, their applications to mechanics of materials are still limited. Issues like material history dependency and physical invariance are not naturally resolved, mainly due to the loss of physics in the current learning models. The difficulty of finding the responses of a heterogeneous material becomes apparent when material nonlinearity (e.g. hyperelastic, plasticity, damage) and arbitrary loading path are considered. Now we are studying on new mechanistic machine learning models with less loss of physics for RVE property predictions. It is also possible to adopt similar models to other areas of computational mechanics where information transmission across scales is important, such as manufacturing and crash simulations.

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Core competencies include mechanical, thermal and flow properties of materials with a focus on precision properties for use in product development and R&D.

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ETA – Engineering Technology Associates www.eta.com

etainfo@eta.com

Inventium Suite™

Inventium Suite™ is an enterprise-level CAE software solution, enabling concept to product. Inventium's first set of tools will be released soon, in the form of an advanced Pre & Post processor, called PreSys.

Inventium's unified and streamlined product architecture will provide users access to all of the suite's software tools. By design, its products will offer a high performance modeling and post-processing system, while providing a robust path for the integration of new tools and third party applications.

PreSys

Inventium's core FE modeling toolset. It is the successor to ETA's VPG/PrePost and FEMB products. PreSys offers an easy to use interface, with drop-down menus and toolbars, increased graphics speed and detailed graphics capabilities. These types of capabilities are combined with powerful, robust and accurate modeling functions.

VPG

Advanced systems analysis package. VPG delivers a unique set of tools which allow engineers to create and visualize, through its modules--structure, safety, drop test, and blast analyses.

DYNAFORM

Complete Die System Simulation Solution. The most accurate die analysis solution available today. Its formability simulation creates a "virtual tryout", predicting forming problems such as cracking, wrinkling, thinning and spring-back before any physical tooling is produced.

ESI Group www.esi-group.com

Visual-Environment is an integrative simulation platform for simulation tools operating either concurrently or standalone for various solver. Comprehensive and integrated solutions for meshing, pre/post processing, process automation and simulation data management are available within same environment enabling seamless execution and automation of tedious workflows. This very open and versatile environment simplifies the work of CAE engineers across the enterprise by facilitating collaboration and data sharing leading to increase of productivity.

Visual-Crash DYNA provides advanced preprocessing functionality for LS-DYNA users, e.g. fast iteration and rapid model revision processes, from data input to visualization for crashworthiness simulation and design. It ensures quick model browsing, advanced mesh editing capabilities and rapid graphical assembly of system models. Visual-Crash DYNA allows graphical creation, modification and deletion of LS-DYNA entities. It comprises tools for checking model quality and simulation parameters prior to launching calculations with the solver. These tools help in correcting errors and fine-tuning the model and simulation before submitting it to the solver, thus saving time and resources.
Several high productivity tools such as advanced dummy positioning, seat morphing, belt fitting and airbag folder are provided in **Visual-Safe,** a dedicated application to safety utilities.

Visual-Mesh is a complete meshing tool supporting CAD import, 1D/2D/3D meshing and editing for linear and quadratic meshes. It supports all meshing capabilities, like shell and solid automesh, batch meshing, topo mesh, layer mesh, etc. A convenient Meshing Process guides you to mesh the given CAD component or full vehicle automatically.

Visual-Viewer built on a multi-page/multi-plot environment, enables data grouping into pages and plots. The application allows creation of any number of pages with up to 16 windows on a single page. These windows can be plot, animation, video, model or drawing block windows. Visual-Viewer performs automated tasks and generates customized reports and thereby increasing engineers' productivity.

Visual-Process provides a whole suite of generic templates based on LS-DYNA solver (et altera). It enables seamless and interactive process automation through customizable LS-DYNA based templates for automated CAE workflows.

All generic process templates are easily accessible within the unique framework of Visual-Environment and can be customized upon request and based on customer's needs.

Visual*DSS* is a framework for Simulation Data and Process Management which connects with Visual-Environment and supports product engineering teams, irrespective of their geographic location, to make correct and realistic decisions throughout the virtual prototyping phase. Visual*DSS* supports seamless connection with various CAD/PLM systems to extract the data required for building virtual tests as well as building and chaining several virtual tests upstream and downstream to achieve an integrated process. It enables the capture, storage and reuse of enterprise knowledge and best practices, as well as the automation of repetitive and cumbersome tasks in a virtual prototyping process, the propagation of engineering changes or design changes from one domain to another.

JSOL Corporation www.jsol.co.jp/english/cae/

HYCRASH

Easy-to-use one step solver, for Stamping-Crash Coupled Analysis. HYCRASH only requires the panels' geometry to calculate manufacturing process effect, geometry of die are not necessary. Additionally, as this is target to usage of crash/strength analysis, even forming analysis data is not needed. If only crash/strength analysis data exists and panel ids is defined. HYCRASH extract panels to calculate it's strain, thickness, and map them to the original data.

JSTAMP/NV

As an integrated press forming simulation system for virtual tool shop the JSTAMP/NV meets the various industrial needs from the areas of automobile, electronics, iron and steel, etc. The JSTAMP/NV gives satisfaction to engineers, reliability to products, and robustness to tool shop via the advanced technology of the JSOL Corporation.

JMAG

JMAG uses the latest techniques to accurately model complex geometries, material properties, and thermal and structural phenomena associated with electromagnetic fields. With its excellent analysis capabilities, JMAG assists your manufacturing process.

Livermore Software Technology Corp. www.lstc.com

LS-DYNA

A general-purpose finite element program capable of simulating complex real world problems. It is used by the automobile, aerospace, construction, military, manufacturing, and bioengineering industries. LS-DYNA is optimized for shared and distributed memory Unix, Linux, and Windows based, platforms, and it is fully QA'd by LSTC. The code's origins lie in highly nonlinear, transient dynamic finite element analysis using explicit time integration.

LS-PrePost

An advanced pre and post-processor that is delivered free with LS-DYNA. The user interface is designed to be both efficient and intuitive. LS-PrePost runs on Windows, Linux, and Macs utilizing OpenGL graphics to achieve fast rendering and XY plotting.

LS-OPT

LS-OPT is a standalone Design Optimization and Probabilistic Analysis package with an interface to LS-DYNA. The graphical preprocessor LS-OPTui facilitates definition of the design input and the creation of a command file while the postprocessor provides output such as approximation accuracy, optimization convergence, tradeoff curves, anthill plots and the relative importance of design variables.

LS-TaSC

A Topology and Shape Computation tool. Developed for engineering analysts who need to optimize structures, LS-TaSC works with both the implicit and explicit solvers of LS-DYNA. LS-TaSC handles topology optimization of large non-linear problems, involving dynamic loads and contact conditions.

LSTC Dummy Models

Anthropomorphic Test Devices (ATDs), as known as "crash test dummies", are life-size mannequins equipped with sensors that measure forces, moments, displacements, and accelerations.

LSTC Barrier Models

LSTC offers several Offset Deformable Barrier (ODB) and Movable Deformable Barrier (MDB) model.

Material Sciences Corporation www.materials-sciences.com

Materials Sciences Corporation has provided engineering services to the composites industry since 1970. During this time, we have participated in numerous programs that demonstrate our ability to: perform advanced composite design, analysis and testing; provide overall program management; work in a team environment; and transition new product development to the military and commercial sectors. MSC's corporate mission has expanded beyond basic research and development now to include transitioning its proprietary technologies from the research lab into innovative new products. This commitment is demonstrated through increased staffing and a more than 3-fold expansion of facilities to allow in-house manufacturing and testing of advanced composite materials and structures.

Materials Sciences Corporation (MSC) MAT161/162 - enhanced features have been added to the Dynamic Composite Simulator module of LS-DYNA.

This enhancement to LS-DYNA, known as MAT161/162, enables the most effective and accurate dynamic progressive failure modeling of composite structures to enable the most effective and accurate dynamic progressive failure modeling of composite structures currently available.

MSC/LS-DYNA Composite Software and Database -

Fact Sheet: http://www.materials-sciences.com/dyna-factsheet.pdf

- MSC and LSTC have joined forces in developing this powerful composite dynamic analysis code.
- For the first time, users will have the enhanced ability to simulate explicit dynamic engineering problems for composite structures.
- The integration of this module, known as 'MAT 161', into LS-DYNA allows users to account for progressive damage of various fiber, matrix and interply delamination failure modes.
- Implementing this code will result in the ability to optimize the design of composite structures, with significantly improved survivability under various blast and ballistic threats.

MSC's LS-DYNA module can be used to characterize a variety of composite structures in numerous applications—such as this composite hull under blast.

Oasys Ltd. LS-DYNA Environment www.oasys-software.com/dyna

The Oasys Suite of software is exclusively written for LS-DYNA® and is used worldwide by many of the largest LS-DYNA® customers. The suite comprises of:

Oasys PRIMER

Key benefits:

- Pre-Processor created specifically for LS-DYNA®
- Compatible with the latest version of LS-DYNA®
- Maintains the integrity of data
- Over 6000 checks and warnings – many auto-fixable
- Specialist tools for occupant positioning, seatbelt fitting and seat squashing (including setting up pre-simulations)
- Many features for model modification, such as part replace
- Ability to position and depenetrate impactors at multiple locations and produce many input decks automatically (e.g. pedestrian impact, interior head impact)
- Contact penetration checking and fixing
- Connection feature for creation and management of connection entities.
- Support for Volume III keywords and large format/long labels
- Powerful scripting capabilities allowing the user to create custom features and processes

www.oasys-software.com/dyna

Oasys D3PLOT

Key benefits:

- Powerful 3D visualization post-processor created specifically for LS-DYNA®
- Fast, high quality graphics
- Easy, in-depth access to LS-DYNA® results
- Scripting capabilities allowing the user to speed up post-processing, as well as creating user defined data components

www.predictiveengineering.com

Predictive Engineering provides finite element analysis consulting services, software, training and support to a broad range of engineering companies across North America. We strive to exceed client expectations for accuracy, timeliness and knowledge transfer. Our process is both cost-effective and collaborative, ensuring all clients are reference clients.

Our mission is to be honest brokers of information in our consulting services and the software we represent.

Our History

Since 1995, Predictive Engineering has continually expanded its client base. Our clients include many large organizations and industry leaders such as SpaceX, Nike, General Electric, Navistar, FLIR Systems, Sierra Nevada Corp, Georgia-Pacific, Intel, Messier-Dowty and more. Over the years, Predictive Engineering has successfully completed more than 800 projects, and has set itself apart on its strong FEA, CFD and LS-DYNA consulting services.

恒士达科技
Hengstar Tech.

Shanghai Hengstar www.hengstar.com

Center of Excellence: Hengstar Technology is the first LS-DYNA training center of excellence in China. As part of its expanding commitment to helping CAE engineers in China, Hengstar Technology will continue to organize high level training courses, seminars, workshops, forums etc., and will also continue to support CAE events such as: China CAE Annual Conference; China Conference of Automotive Safety Technology; International Forum of Automotive Traffic Safety in China; LS-DYNA China users conference etc.

On Site Training: Hengstar Technology also provides customer customized training programs on-site at the company facility. Training is tailored for customer needs using LS-DYNA such as material test and input keyword preparing; CAE process automation with customized script program; Simulation result correlation with the test result; Special topics with new LS-DYNA features etc..

Distribution & Support: Hengstar distributes and supports LS-DYNA, LS-OPT, LS-Prepost, LS-TaSC, LSTC FEA Models; Hongsheng Lu, previously was directly employed by LSTC before opening his distributorship in China for LSTC software. Hongsheng visits LSTC often to keep update on the latest software features.

Hengstar also distributes and supports d3View; Genesis, Visual DOC, ELSDYNA; Visual-Crash Dyna, Visual-Process, Visual-Environment; EnkiBonnet; and DynaX & MadyX etc.

Consulting

As a consulting company, Hengstar focuses on LS-DYNA applications such as crash and safety, durability, bird strike, stamping, forging, concrete structures, drop analysis, blast response, penetration etc with using LS-DYNA's advanced methods: FEA, ALE, SPH, EFG, DEM, ICFD, EM, CSEC..

www.lenovo.com

Lenovo is a USD 39 billion personal and enterprise technology company, serving customers in more than 160 countries.

Dedicated to building exceptionally engineered PCs, mobile Internet devices and servers spanning entry through supercomputers, Lenovo has built its business on product innovation, a highly efficient global supply chain and strong strategic execution. The company develops, manufactures and markets reliable, high-quality, secure and easy-to-use technology products and services.

Lenovo acquired IBM's x86 server business in 2014. With this acquisition, Lenovo added award-winning System x enterprise server ortfolio along with HPC and CAE expertise.

Cloud - HPC Services - Subscription JSOL

Contact: JSOL Corporation Engineering Technology Division cae-info@sci.jsol.co.jp

Cloud computing services
for
JSOL Corporation LS-DYNA users in Japan

JSOL Corporation is cooperating with chosen cloud computing services

JSOL Corporation, a Japanese LS-DYNA distributor for Japanese LS-DYNA customers.

LS-DYNA customers in industries / academia / consultancies are facing increased needs for additional LS-DYNA cores

In calculations of optimization, robustness, statistical analysis, we find that an increase in cores of LS-DYNA are needed, for short term extra projects or cores.

JSOL Corporation is cooperating with some cloud computing services for JSOL's LS-DYNA users and willing to provide short term license.

This service is offered to customers using Cloud License fee schedule, the additional fee is less expensive than purchasing yearly license.

The following services are available (only in Japanese). HPC OnLine:

NEC Solution Innovators, Ltd. - http://jpn.nec.com/manufacture/machinery/hpc_online/

Focus - Foundation for Computational Science
http://www.j-focus.or.jp

Platform Computation Cloud - CreDist.Inc.

PLEXUS CAE
Information Services International-Dentsu, Ltd. (ISID) https://portal.plexusplm.com/plexus-cae/

SCSK Corporation - http://www.scsk.jp/product/keyword/keyword07.html

Cloud - HPC Services - Subscription RESCALE

www.rescale.com

Rescale: Cloud Simulation Platform

The Power of Simulation Innovation
We believe in the power of innovation. Engineering and science designs and ideas are limitless. So why should your hardware and software be limited? You shouldn't have to choose between expanding your simulations or saving time and budget.

Using the power of cloud technology combined with LS-DYNA allows you to:
- Accelerate complex simulations and fully explore the design space
- Optimize the analysis process with hourly software and hardware resources
- Leverage agile IT resources to provide flexibility and scalability

True On-Demand, Global Infrastructure
Teams are no longer in one location, country, or even continent. However, company data centers are often in one place, and everyone must connect in, regardless of office. For engineers across different regions, this can cause connection issues, wasted time, and product delays.

Rescale has strategic/technology partnerships with infrastructure and software providers to offer the following:
- Largest global hardware footprint – GPUs, Xeon Phi, InfiniBand
- Customizable configurations to meet every simulation demand
- Worldwide resource access provides industry-leading tools to every team
- Pay-per-use business model means you only pay for the resources you use
- True on-demand resources – no more queues

ScaleX Enterprise: Transform IT, Empower Engineers, Unleash Innovation
The ScaleX Enterprise simulation platform provides scalability and flexibility to companies while offering enterprise IT and management teams the opportunity to expand and empower their organizations.

Rescale Cloud Simulation Platform www.rescale.com

ScaleX Enterprise allows enterprise companies to stay at the leading edge of computing technology while maximizing product design and accelerating the time to market by providing:

- Collaboration tools
- Administrative control
- API/Scheduler integration
- On-premise HPC integration

Industry-Leading Security

Rescale has built proprietary, industry-leading security solutions into the platform, meeting the needs of customers in the most demanding and competitive industries and markets.

- Manage engineering teams with user authentication and administrative controls
- Data is secure every step of the way with end-to-end data encryption
- Jobs run on isolated, kernel-encrypted, private clusters
- Data centers include biometric entry authentication
- Platforms routinely submit to independent external security audits

Rescale maintains key relationships to provide LS-DYNA on demand on a global scale. If you have a need to accelerate the simulation process and be an innovative leader, contact Rescale or the following partners to begin running LS-DYNA on Rescale's industry-leading cloud simulation platform.

LSTC - DYNAmore GmbH JSOL Corporation

Rescale, Inc. - 1-855-737-2253 (1-855-RESCALE) - info@rescale.com

944 Market St. #300, San Francisco, CA 94102 USA

ESI Cloud Based Virtual Engineering Solutions

www.esi-group.com

ESI Cloud offers designers and engineers cloud-based computer aided engineering (CAE) solutions across physics and engineering disciplines.

ESI Cloud combines ESI's industry tested virtual engineering solutions integrated onto ESI's Cloud Platform with browser based modeling,

With ESI Cloud users can choose from two basic usage models:

- An end-to-end SaaS model: Where modeling, multi-physics solving, results visualization and collaboration are conducted in the cloud through a web browser.
- A Hybrid model: Where modeling is done on desktop with solve, visualization and collaboration done in the cloud through a web browser.

Virtual Performance Solution:

ESI Cloud offers ESI's flagship Virtual Performance Solution (VPS) for multi-domain performance simulation as a hybrid offering on its cloud platform. With this offering, users can harness the power of Virtual Performance Solution, leading multi-domain CAE solution for virtual engineering of crash, safety, comfort, NVH (noise, vibration and harshness), acoustics, stiffness and durability.

In this hybrid model, users utilize VPS on their desktop for modeling including geometry, meshing and simulation set up. ESI Cloud is then used for high performance computing with an integrated visualization and real time collaboration offering through a web browser.

The benefits of VPS hybrid on ESI Cloud include:

- Running large concurrent simulations on demand
- On demand access to scalable and secured cloud HPC resources
- Three tiered security strategy for your data
- Visualization of large simulation data sets
- Real-time browser based visualization and collaboration
- Time and cost reduction for data transfer between cloud and desktop environments
- Support, consulting and training services with ESI's engineering teams

VPS On Demand

ESI Cloud features the Virtual Performance Solution (VPS) enabling engineers to analyze and test products, components, parts or material used in different engineering domains including crash and high velocity impact, occupant safety, NVH and interior acoustics, static and dynamic load cases. The solution enables VPS users to overcome hardware limitations and to drastically reduce their simulation time by running on demand very large concurrent simulations that take advantage of the flexible nature of cloud computing.

Key solution capabilities:

- Access to various physics for multi-domain optimization
- Flexible hybrid model from desktop to cloud computing
- On demand provisioning of hardware resources
- Distributed parallel processing using MPI (Message Passing Interface) protocol
- Distributed parallel computing with 10 Gb/s high speed interconnects

Result visualization

ESI Cloud deploys both client-side and server-side rendering technologies. This enables the full interactivity needed during the simulation workflow along with the ability to handle large data generated for 3D result visualization in the browser, removing the need for time consuming data transfers. Additionally ESI Cloud visualization engine enables the comparisons of different results through a multiple window user interface design.

Key result visualization capabilities:

- CPU or GPU based client and server side rendering
- Mobility with desktop like performance through the browser
- 2D/3D VPS contour plots and animations
- Custom multi-window system for 2D plots and 3D contours
- Zooming, panning, rotating, and sectioning of multiple windows

Collaboration

To enable real time multi-user and multi company collaboration, ESI Cloud offers extensive synchronous and asynchronous collaboration capabilities. Several users can view the same project, interact with the same model results, pass control from one to another. Any markups, discussions or annotations can be archived for future reference or be assigned as tasks to other members of the team.

Key collaboration capabilities:

- Data, workflow or project asynchronous collaboration
- Multi-user, browser based collaboration for CAD, geometry, mesh and results models
- Real-time design review with notes, annotations and images archiving and retrieval
- Email invite to non ESI Cloud users for real time collaboration

Distribution, Consulting

Canada	**Metal Forming Analysis Corp MFAC** galb@mfac.com www.mfac.com			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	eta/VPG	
	eta/DYNAFORM	INVENTIUM/PreSys		
Mexico	**COMPLX**		Armando Toledo	
	www.complx.com.mx /		armando.toledo@complx.com.mx	
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			LS-TAsc Barrier/Dummy Models	
United States	**DYNAMAX**		sales@dynamax-inc.com	
	www.dynamax-inc.com			
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	LSTC Dummy Models		LSTC Barrier Models	
United States	**Livermore Software Technology Corp**		sales@lstc.com	
	LSTC www.lstc.com			
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	LSTC Dummy Models	LSTC Barrier Models	TOYOTA THUMS	
United States	**ESI Group N.A** **info@esi-group.com**			
	www.esi-group.com			
	PAM-STAMP			
	QuikCAST	SYSWELD	PAM-COMPOSITES	CEM One
	VA One	CFD-ACE+	ProCAST	
		Weld Planner	Visual-Environment	IC.IDO
United States	**Engineering Technology Associates – ETA** etainfo@eta.com			
	www.eta.com			
	INVENTIUM/PreSy	NISA	VPG	LS-DYNA
	LS-OPT	DYNAform		

Distribution, Consulting

United States	**Predictive Engineering**		info@predictiveengineering.com	
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	Distributor for Siemens PLM Software at www.AppliedCAx.com (FEMAP, NX Nastran, STAR CCM+, NX CAD/CAM/CAE)			
France	**DynaS+**		v.lapoujade@dynasplus.com	
	www.dynasplus.com		Oasys Suite	
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	LSTC Barrier Models		DIGIMAT	
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		AnyBody		
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Germany	**DYNAmore GmbH**		uli.franz@dynamore.de	
	www.dynamore.de			
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	LS-OPT	LS-PrePost	LS-TaSC	DYNAFORM
	Primer	FEMZIP	GENESIS	Oasys Suite
	TOYOTA THUMS		LSTC Dummy & Barrier Models	

Netherlands	**Infinite Simulation Systems B.V**		j.mathijssen@infinite.nl	
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	LSTC Dummy Models		LSTC Barrier Models	
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	LS-PrePost	LS-TaSC	FastFORM	DYNAform
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			LSTC Barrier Models	
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UK	**ARUP**	dyna.sales@arup.com		
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	LS-TaSC		PRIMER	D3PLOT
	REPORTER	SHELL	FEMZIP	HYCRASH
	DIGIMAT	Simpleware	LSTC Dummy Models	
			LSTC Barrier Models	

China	**Shanghai Fangkun Software Technology Ltd.**		
	www.lsdyna-china.com		
	LS-DYNA	LS-TaSC	LSTC Barrier Models
	LS-PrePOST	LS-OPT	
	LSTC Dummy Models		

India	**Oasys Ltd. India**		lavendra.singh@arup.com	
	www.oasys-software.com/dyna			
	PRIMER D3PLOT	T/HIS		
		LS-OPT	LSTC Dummy Models	LS-PrePost
		LS-DYNA	LSTC Barrier Models	LS-TaSC

India	**CADFEM India**		info@cadfem.in	
	www.cadfem.in			
	ANSYS	VPS	optiSLang	
	LS-DYNA	LS-OPT	LS-PrePost	

India	**Kaizenat Technologies Pvt. Ltd**		support@kaizenat.com	
	http://kaizenat.com /			
	LS-DYNA	LS-OPT	LSTC Dummy Models	LS-PrePost
	Complete LS-DYNA suite of products		LSTC Barrier Models	LS-TaSC

Distribution, Consulting

Japan	**CTC**	LS-dyna@ctc-g.co.jp		
	www.engineering-eye.com			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	CmWAVE	
Japan	**JSOL**			
	www.jsol.co.jp/english/cae		Oasys Suite	
	JSTAMP	HYCRASH	JMAG	
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Japan	**FUJITSU**			
	http://www.fujitsu.com/jp/solutions/business-technology/tc/sol/			
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	Inventium PreSys	ETA/DYNAFORM	Digimat	
Japan	**LANCEMORE**	info@lancemore.jp		
	www.lancemore.jp/index_en.html			
	Consulting			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models		
Japan	**Terrabyte**	**English:**		
	www.terrabyte.co.jp	www.terrabyte.co.jp/english/index.htm		
	Consulting			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	AnyBody	

Korea	**THEME**	wschung7@gmail.com		
	www.lsdyna.co.kr		Oasys Suite	
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	eta/VPG	Planets
	eta/DYNAFORM	FormingSuite	Simblow	TrueGRID
	JSTAMP/NV	Scan IP	Scan FE	Scan CAD
	FEMZIP			

Korea	**KOSTECH**	young@kostech.co.kr		
	www.kostech.co.kr			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	eta/VPG	FCM
	eta/DYNAFORM	DIGIMAT	Simuform	Simpack
	AxStream	TrueGrid	FEMZIP	

Taiwan	**AgileSim Technology Corp.**			
	http://www.agilesim.com.tw			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	eta/VPG	FCM

Taiwan	**Flotrend**			
	www.flotrend.com.tw			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	eta/VPG	FCM

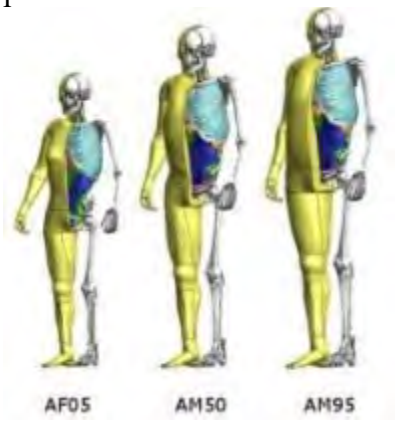
Taiwan	**SiMWARE Inc..**			
	www.simware.com.tw			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	eta/VPG	FCM

TOYOTA - Total Human Model for Safety – THUMS

The Total Human Model for Safety, or THUMS®, is a joint development of Toyota Motor Corporation and Toyota Central R&D Labs. Unlike dummy models, which are simplified representation of humans, THUMS represents actual humans in detail, including the outer shape, but also bones, muscles, ligaments, tendons, and internal organs. Therefore, THUMS can be used in automotive crash simulations to identify safety problems and find their solutions.

Each of the different sized models is available as sitting model to represent vehicle occupants

and as standing model to represent pedestrians.



The internal organs were modeled based on high resolution CT-scans.

THUMS is limited to civilian use and may under no circumstances be used in military applications.

LSTC is the US distributor for THUMS. Commercial and academic licenses are available.

For information please contact: THUMS@lstc.com

THUMS®, is a registered trademark of Toyota Central R&D Labs.

LSTC – Dummy Models

LSTC Crash Test Dummies (ATD)

Meeting the need of their LS-DYNA users for an affordable crash test dummy (ATD), LSTC offers the LSTC developed dummies at no cost to LS-DYNA users.

LSTC continues development on the LSTC Dummy models with the help and support of their customers. Some of the models are joint developments with their partners.

e-mail to: atds@lstc.com

Models completed and available (in at least an alpha version)

- Hybrid III Rigid-FE Adults
- Hybrid III 50th percentile FAST
- Hybrid III 5th percentile detailed
- Hybrid III 50th percentile detailed
- Hybrid III 50th percentile standing
- EuroSID 2
- EuroSID 2re
- SID-IIs Revision D
- USSID
- Free Motion Headform
- Pedestrian Legform Impactors

Models In Development

- Hybrid III 95th percentile detailed
- Hybrid III 3-year-old
- Hybrid II
- WorldSID 50th percentile
- THOR NT FAST
- Ejection Mitigation Headform

Planned Models

- FAA Hybrid III
- FAST version of THOR NT
- FAST version of EuroSID 2
- FAST version of EuroSID 2re
- Pedestrian Headforms
- Q-Series Child Dummies
- FLEX-PLI

LSTC – Barrier Models

Meeting the need of their LS-DYNA users for affordable barrier models, LSTC offers the LSTC developed barrier models at no cost to LS-DYNA users.

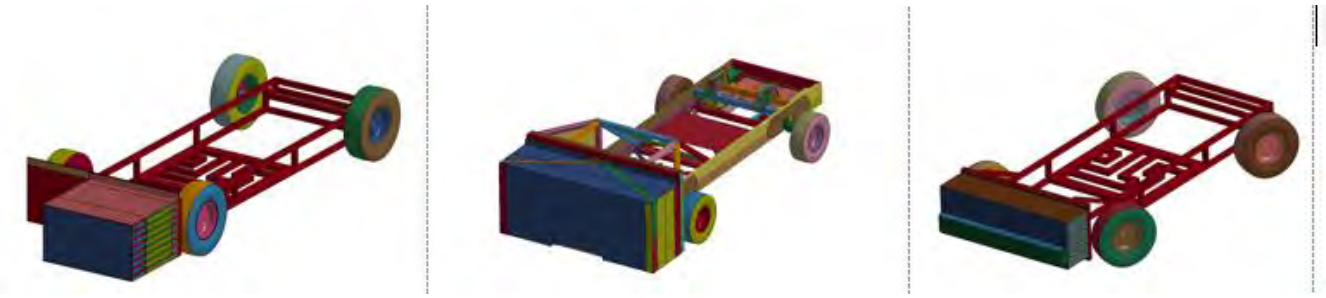
LSTC offers several Offset Deformable Barrier (ODB) and Movable Deformable Barrier (MDB) models:

- ODB modeled with shell elements
- ODB modeled with solid elements
- ODB modeled with a combination of shell and solid elements
- MDB according to FMVSS 214 modeled with shell elements
- MDB according to FMVSS 214 modeled with solid elements
- MDB according to ECE R-95 modeled with shell elements
- AE-MDB modeled with shell elements
- IIHS MDB modeled with shell elements
- IIHS MDB modeled with solid elements
- RCAR bumper barrier
- RMDB modeled with shell and solid elements

LSTC ODB and MDB models are developed to correlate to several tests provided by our customers. These tests are proprietary data and are not currently available to the public.

All current models can be obtained through our webpage in the LSTC Models download section or through your LS-DYNA distributor.

To submit questions, suggestions, or feedback about LSTC's models, please send an e-mail to: atds@lstc.com. Also, please contact us if you would like to help improve these models by sharing test data.



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ETA	www.eta.com
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