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LSTC Livermore Software Technology Corp.

Volume 8, Issue 4, April 2019

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BETA CAE

ESI Group

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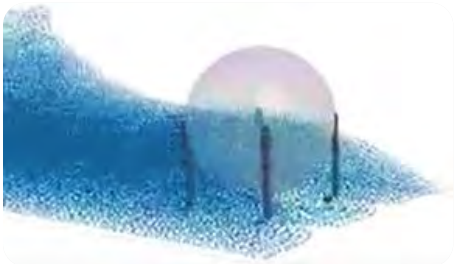

Rescale

12th European LS-DYNA Conference May 14 - 16 2019, Koblenz, Germany

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The focus is engineering technical solutions/information.

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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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To be removed from the FEA News send an email - subject "Remove" to news@feainformation.com

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

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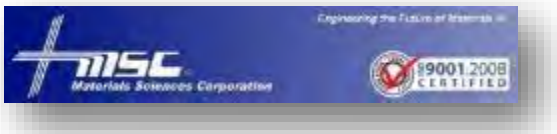
Platinum Particpants



Platinum Particpants

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Announcements

LSTC Executive Vice President

As of March 04, 2019 Nathan Asher Hallquist has been appointed Executive Vice President of LSTC.

We are pleased to announce the appointment of Nathan Asher Hallquist to the position of Executive Vice President, effective March 4, 2019. With this appointment LSTC renews its commitment to the business model that our customers and partners have long valued and come to expect.

http://www.lstc.com/corporate/announcements

The 8th biennial BEFORE REALITY Conference of BETA CAE Systems

The 8th biennial BEFORE REALITY International Conference of BETA CAE Systems will take place between May 20th and 22nd, 2019 at the Hilton Munich Park hotel.

Conference Website: https://www.beta-cae.com/conference08

12th European LS-DYNA Conference May 14 - 16 2019, Koblenz, Germany

We kindly invite all users of LS-DYNA, LS-OPT, and LS-TaSC to take advantage of this fantastic opportunity to showcase their work. The conference is your chance to talk with industry experts, catch up with colleagues and enjoy time exploring new ideas. In addition, attendees can meet with exhibitors to learn about the latest hardware and software trends as well as additional services relating to the finite element solver LS-DYNA, the optimization codes LS-OPT and LS-TaSC, and the pre- and postprocessor LS-PrePost. Training courses and workshops will take place in the week before, during and after the conference.

Conference Website: www.dynamore.de/conf2019

2019 Journals – Q2 *FEA Information Engineering Journal (FEAIEJ™)*

FEA Information Engineering Journal (FEAIEJ™) is a quarterly on line publication focusing on specific disciplines within Finite Element Analysis.

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…

The 8th biennial BEFORE REALITY Conference of BETA CAE Systems

May 20th and 22nd, 2019 at the Hilton Munich Park hotel.

JOIN ONE OF THE MOST ANTICIPATED EVENTS OF THE ENGINEERING SIMULATION COMMUNITY.

A unique place to find the most amazing ideas and stories in Simulation.Join us at the BEFORE REALITY Conference and be a part of the landscape where the major OEMs expose their secrets to success in Engineering Simulation. Be at the one place where recent advances and future trends in the analyses technologies, methods, and practices for solving problems of the modern industry are shared.

Download the list of scheduled presentations (as on April 9th)

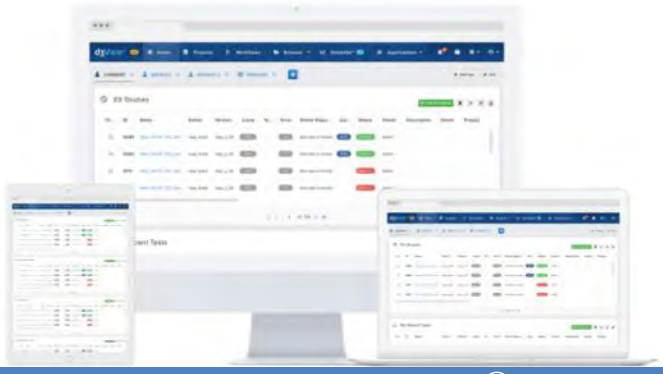
Download our Mobile Devices app to stay updated and build your schedule

Don't miss the opportunity and register today.

Looking forward to hosting you in Munich, Germany.

FOLLOW THIS PATH TO EVENT

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

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

Experiments
Manage Safety and NVH
Compare with Simulations
Search Historical data

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

Workflows
Build and deploy workflows
Characterize materials
Model sequential impacts

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!

12th European LS-DYNA Conference May 14 - 16 2019, Koblenz, Germany

Conference Website: www.dynamore.de/conf2019

Register now for the European LS-DYNA Conference

From 14-16 May 2019 the 12th European LS-DYNA Conference will take place in Koblenz, Germany. With renowned keynote-speakers from industry and academia, approximately 200 presentations and several workshops on various topics the conference is an ideal opportunity to exchange knowledge and discuss new solution approaches with other users. Register now and take the change to talk with industry experts and learn more about the software and its applications.

Venue

The Upper Middle Rhine Valley is one of the largest and oldest cultural landscapes in Europe and is the epitome of Rhine Romanticism. UNESCO acknowledged the wide variety and beauty of the Middle Rhine by making it a world heritage site in 2002.

Koblenz can be reached easily via Frankfurt and Düsseldorf International Airport.

Address:
Koblenz Kongress - Rhein-Mosel-Halle
Julius-Wegeler-Straße 4
56068 Koblenz, Germany
www.koblenz-kongress.de

Accommodation

A limited number of reduced rooms for conference participants can be ordered through a central hotel room booking service. Please use the booking form (pdf) on the conference website and proceed as described.

Exhibiting and sponsoring

In the accompanying exhibition, numerous hardware and software manufacturers offer an insight into the latest news and trends around
LS-DYNA. If you want to contribute, please request additional exhibitor and sponsoring information.

Accompanying Seminars

As usual we offer numerous accompanying seminars in Stuttgart and Koblenz. An overview and the registration can be found here.

Participant fees

Industry: 640 Euro[1)] / 690 Euro
Academic: 490 Euro[1)] / 540 Euro
[1)] Registration before 1 April 2019. All plus VAT.

Contact and registration

DYNAmore GmbH
Industriestr. 2, D-70565 Stuttgart, Germany
Tel. +49 (0) 7 11 - 45 96 00 - 0
E-Mail:conference@dynamore.de
www.dynamore.de/conf2019
(Images by U. Pfeuffer and T. Frey)

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.

Harnessing the Power of AR/VR To Tackle Assembly and Maintenance Challenges in Smart Factories

19 Mar 2019 Paris, France

----------ESI and Diota join forces to showcase their immersive solutions at Laval Virtual

Paris, France – March 19, 2019 – ESI Group, pioneer in Virtual Prototyping and creator of IC.IDO, the leading Virtual Reality (VR) solution for industrial applications, will exhibit at the 21st edition of Laval Virtual, March 20-24 in Laval, France. Along with Diota, a leader in Digital-Field software solutions for Industry, ESI will present for the first time a live demonstration of their common value proposition, combining VR and AR within an operator-centered digital continuity solution. Together, they will address challenges related to factory assembly and in-service maintenance through an end-to-end solution that efficiently leverages digital data to achieve improved productivity, quality and traceability while decreasing operational risk.

Manufacturers realistically experience and validate assembly and maintenance procedures in real-scale and real-time thanks to ESI's Virtual Reality solution IC.IDO. Image courtesy of ESI Group.

For manufacturing enterprises across all industries, digital transformation brings sizable opportunities to reduce cost and delays for product development and manufacturing. VR has made its way into product and process development, where it helps engineers identify design risks as early as possible in the product or process lifecycles. Used at Boeing, Bombardier, Fiat Chrysler Automobiles, Ford and Safran amongst other leading OEMs, ESI IC.IDO is the leading VR solution for industrial applications. At Laval Virtual, ESI will showcase several use cases with specific focus on human-centric assembly process validation – a critical aspect of Industry 4.0 where ergonomics and workflows need to be completely rethought for operators to deliver optimum efficiency whilst interacting with layers of new technologies.

Augmented Reality also delivers important benefits for manufacturing assembly, once on the shop floor. Diota's solutions help factory operators to better understand and carry out complex operations through step by step digital work instructions and contextualized contents visualized in their workspace.

As highlighted by ESI and Diota's partnership, the combined use of VR and AR provides a unique opportunity for companies to achieve digital continuity between the validation and distribution of manufacturing and maintenance procedures. At Laval Virtual, ESI and Diota will demonstrate how a joint usage of their solutions addresses issues arising in the definition and execution of procedural information by making sure factory operators access optimized and up-to-date product design information and work instructions whenever they need it, on-the-job or during training.

Experience AR/VR synergies at Laval Virtual!

Visitors to ESI's booth (E5) will immersively experience assembly steps to build an automotive engine in VR. Across the alley, on Diota's booth (E25), they will visualize and interact with the corresponding digital instructions on the real engine, just like an operator would.

A concrete way to have an overview of this seamless workflow and its benefits in terms of performance for highly complex processes involving human workers.

For more information on ESI's presence at Laval Virtual, to book a live demo or to organize a business meeting, please visit our event page.

ESI Group - Contacts
Media Relations
Celine Gallerne
+33 1 41 73 58 46

Casting the future of Mobility

Electrification is creating new market opportunities for the casting industry. To find the right balance between quality, cost, and range; engineers are rethinking die casting to achieve the best lightweight manufacturing strategy.

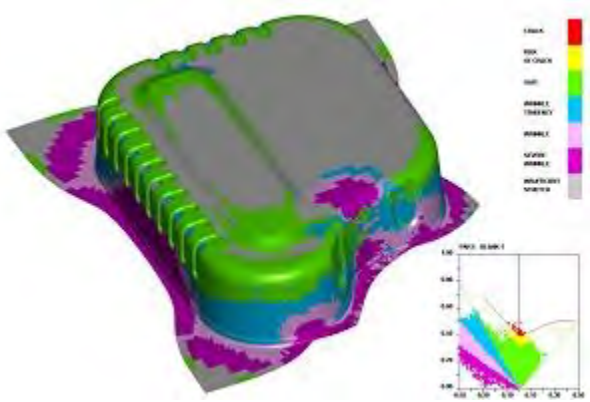
Designing as castings complex parts such as battery housing, electric motors or power electronics

Casting High Quality Lightweight components with new materials such as Aluminum

ESI ProCAST allows foundries to simulate the entire casting process and overcome the geometrical complexity and high production volumes challenges. Ultimately allowing foundries to become a key enabler of the E-Mobility Innovations as they innovate with confidence and deliver premium quality castings.

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.

Dynaform Modules - Formability Simulation



The Formability Simulation module uses LS-DYNA for accurate physics modeling, efficient calculation and in-depth simulation of the formability based on the die design. The FLD (forming limit diagram), thinning map, wrinkling, material draw-in, circular grid, light strip and skid mark results identify weaknesses of the die design.

New! Optimization Capability

With DYNAFORM Version 5.9, the engineer can more effectively design drawbeads that restrict the blank from wrinkling & splitting during the forming process, significantly reducing the time required to achieve a formable part. It streamlines the challenging and time consuming process of laying out drawbeads for large and complicated parts and guides the engineer to efficiently achieve optimum configurations for drawbead forces. This feature streamlines die design, improves product performance and reduces manufacturing time by using simulation iterations as a search engine for the best possible design solution. As a result, higher performing, higher quality products can be developed, while greater manufacturing efficiency is achieved.

MSTEP & QuickSetup

In this module, a one-step solution using MSTEP is included to perform a quick evaluation of part formability. FS includes a QuickSetup for standard single-stage draw die and springback simulations.

Autosetup and Multiple-Stage Simulations

AutoSetup is available for complicated multiple-stage forming setups for all formability applications of various die systems. The AutoSetup interface visually guides the user through the setup process. All travel curves are automatically generated and multiple-stations can be setup seamlessly.

Hydroforming Capabilities

FS can support tube bending, tube hydroforming and sheet hydroforming.

Springback & Springback Compensation Process (SCP)

Using the DYNAFORM SCP, the user can determine and simulate the amount of springback compensation; simply define the selected tool to be compensated in SCP.

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 4/15/2019 - We will give you a lid on your To Go Large Vanilla Coffee Latte, in a blue cup to match the blue car in the video. We saw what happened to a truck (past week 02/25/2019) and now we have a car. What does that mean you ask? It means no drinking coffee and driving! We do NOT waste our coffee Latte's on guard rails!

Numerical simulation of a TB32 crash. Impact conditions as prescribed by the norm EN1317 (110 Km/h - 20°) using LS-DYNA.
Performed at GDTech SA, Liège Belgium.

Monday 04/08/2019 - If you were holding a cup of coffee in this simulation, you wouldn't be holding it at the bottom of the stairs. It's also a murder mystery. The poor Hybrid is pushed down the stairs being hit by a pole. Someone, obviously, wanted his coffee!

Hybrid 3 Crash Test Dummy Falling downstairs

Monday 04/01/2019 - Water, water, everywhere and I'm running away with my coffee. I SO dislike Tsunami, Earthquake, Tornado, Hurricane and other disasters. Now, I did showcase the below simulation a while ago. It's a good video to watch again. GRAB that coffee and jog over to YouTube!

SPH tsunami with LS-DYNA
This simulation is done using LS-DYNA explicit solver, with SPH elements.

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.

Shanghai Hengstar & Enhu Technology

Sub-distributor and CAD/CAE/CAM consulting in China, especially for FEA needs for engineers, professors, students, consultants.

Contact us for our LS-DYNA training courses and CAD/CAE/CAM consulting service, such as

- Crashworthiness Simulation with LS-DYNA
- Restraint System Design with Using LS-DYNA
- LS-DYNA MPP
- Airbag Simulation with CPM
- LS-OPT with LS-DYNA

Our classes are given by experts from LSTC USA, domestic OEMs, Germany, Japan, etc. These courses help CAE engineers to effectively use CAE tools such as LS-DYNA to improve car safety and quality, and therefore to enhance the capability of product design and innovation.

Consulting - Besides solver specific software sales, distribution and support activities, we offer associated CAD/CAE/CAM consulting services to the Chinese automotive market.

Solutions - Our software solutions provide the Chinese automotive industry, educational institutions, and other companies a mature suite of tools - powerful and expandable simulation environment designed and ready for future multidisciplinary CAE engineering needs.

Shanghai Hengstar provides engineering CAD/CAE/CAM services, consulting and training that combine analysis and simulation using Finite Element Methods such as LS-DYNA.

Shanghai Hengstar Technology Co., Ltd

hongsheng@hengstar.com

http://www.hengstar.com

Shanghai Enhu Technology Co., Ltd

http://www.enhu.com

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.

The 2019 THUMS European Users' Meeting Friday, May 17th, 2019

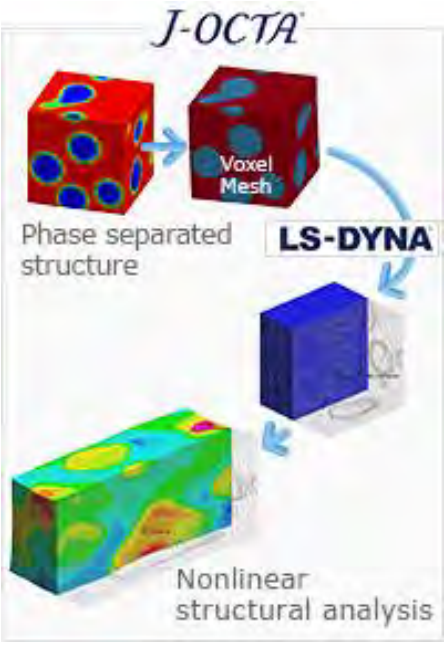
Participation:
THUMS users.
Customers who are interested in THUMS.
Venue:
Conference Center Koblenz
Koblenz Kongress - Rhein-Mosel-Halle
Julius-Wegeler-Straße 4,
56068 Koblenz, Deutschland
Contact:
Users Meeting Secretariat
JSOL Corporation, Engineering Technology Division
E-mail : event@sci.jsol.co.jp

https://www.jsol-cae.com/en/event/usersevent/2019/thums/

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.

Turbine Simulation using LS-DYNA ICFD

To evaluate the Fluid flow through the Turbines and also the stress existing on the Turbine due to the flow was studied in this Simulation. Here, the Turbine is modelled as a Steel part. Defining the velocity of the air at the inlet. Coupled Fluid and Structural Solution is obtained in this Simulation.
Also, please find below the important keywords used for this simulation.

- ICFD_CONTROL_FSI
- ICFD_BOUNDARY_PRESCRIBED_VELOCITY
- ICFD_BOUNDARY_NONSLIP
- MAT_ELASTIC

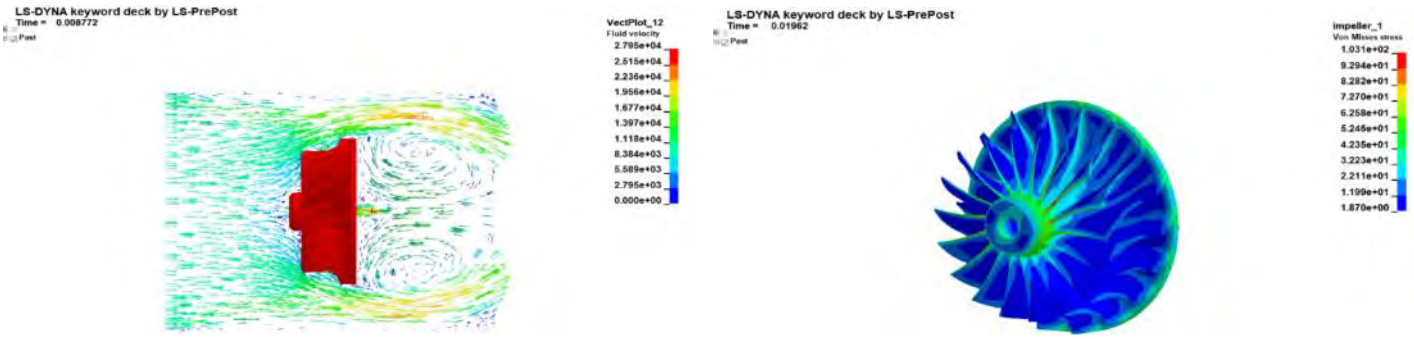


Figure: Turbine Simulation in LS-DYNA

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

New Address:

Kaizenat Technologies Pvt Ltd
B-1112, Signature Tower,
Brigade Golden Triangle,
Old Madras Road,
Kattamnallur Gate,
Bangalore -560049

Contact us:

support@kaizenat.com **for more information.**

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

LSTC Executive Vice President

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We are pleased to announce the appointment of Nathan Asher Hallquist to the position of Executive Vice President, effective March 4, 2019. With this appointment LSTC renews its commitment to the business model that our customers and partners have long valued and come to expect.

Nathan has been with LSTC for many years, and his credentials make him an excellent choice on both the technical and business levels for our continued success and growth.

In this position he will support our core mission of technical excellence while offering a fresh focus on overall user experience. He believes that the two keys to our ongoing success are, first, a commitment to produce a scalable, multi-physics, analysis solver implemented within a one-code, one-model, one-license, philosophy and, secondly, a commitment to continue our unique approach to relationships with distributors, customers, alliance partners, and the broader engineering and scientific communities.

www.lstc.com

LSTC Livermore Software Technology Corp.

Workshop on Meshfree Method and Advances in Computational Mechanics

By LSTC: Youcai Wu, Jane Hodge, Wei Hu

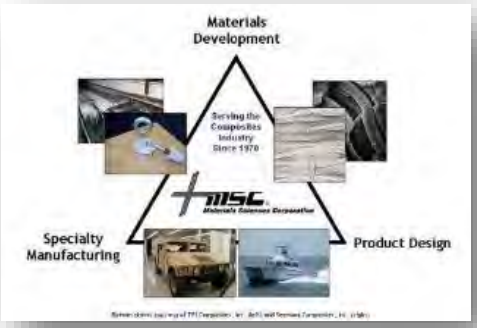
The Workshop "Meshfree Method and Advances in Computational Mechanics" was held on March 10-12, 2019 at the Pleasanton Marriott Hotel, Pleasanton, CA. This workshop was organized by Dr. John O. Hallquist, Dr. David Benson and Dr. C. T. Wu from LSTC.

The objective of this workshop was to bring together distinguished researchers in Meshfree Method and Computational Mechanics to share the state-of-the-art research works and application results. This workshop sought to bring more collaboration between industry and academia in the future, to identify the emergent needs in the industry, and to influence the academic research towards more rapid progress of computational mechanics for professional practice and challenging applications. The workshop was also a special event in recognition of Prof. J.S. Chen's (UC San Diego) contribution in the field of Computational Mechanics as well as in celebration of his 60th birthday. Several Prof. J.S. Chen's former students including LSTC employees Dr. C.T. Wu, Dr. Wei Hu, Dr. Youcai Wu and Dr. E. Yreux also attended the workshop.

The program included a welcome reception, 6 Plenary Lectures, 8 Technical Parallel Sessions, 4 coffee breaks, two lunches and a banquet. More than 63 invited participants including 6 plenary speakers and 42 session speakers took part in this scientific event. The Plenary Lectures were delivered by Prof. T.J.R. Hughes (The University of Texas at Austin), Prof. Z. Bazant (Northwestern University), Prof. C. Farhat (Stanford University), Prof. T. Zohdi (UC Berkeley), Prof. W.K. Liu (Northwestern University) and Prof. Y. Bazilves (Brown University). During the banquet, Dr. John O. Hallquist, Dr. C.T. Wu, Prof. J. McCartney (UCSD), Prof. W.K. Liu, Prof. Y. Bazilves and Prof. M. Hillman (Penn. State University) presented their birthday speeches to the audience. More than 75 people attended the workshop banquet.

Group photos were taken on the second day of the workshop. After the fruitful workshop presentations, participants enjoyed a local hospitality and dinner sponsored by Shanghai Hengstar Technology Ltd. Organizers would like to thank Dr. H.S. Lu from Shanghai Hengstar for his help with the dinner.

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
July 16, 2019 | 9am-5pm
November 19, 2019 | 9am-5pm

In House Course Dates
July 17, 2019 | 9am-5pm
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.

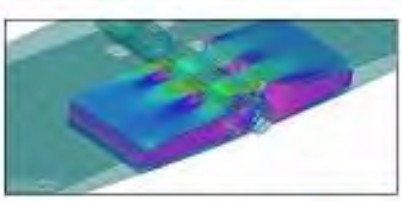
Topics Covered in this Short Course:

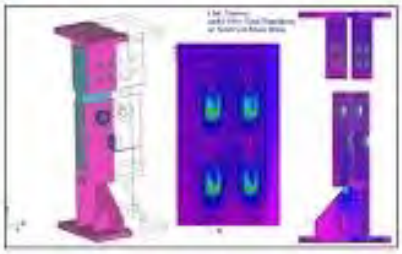
- Impact and Damage Modeling of Composites
  Application of MAT162 in Engineering and Research Problems
- Introduction to Composite Mechanics
  Introduction to Continuum Mechanics and Composite Mechanics

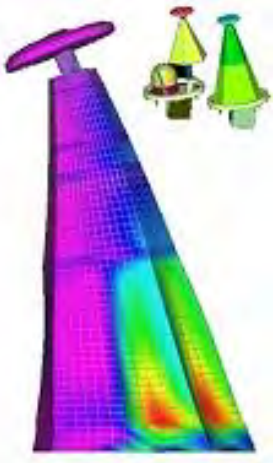
- Composite Material Models in LS-DYNA for Shell and Solid Elements
  Discussion on MAT2, MAT54, MAT59, & MAT162
- Theory and Practice in MAT162 Progressive Composite Damage Model for Unidirectional and Woven Fabric Composites
  MAT162 User Manual – Version 15A 2015
  Progressive Damage Modeling of Plain-Weave 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.

Oasys Suite version 16.0 now released

The Oasys Suite v16.0 includes a number of exciting new features and updates for PRIMER, D3PLOT, T/HIS, REPORTER and SHELL. Key highlights include:

PRIMER highlights:

Multiple stages can now be defined in simulation-based occupant positioning and seatsquash.
Full keyword support for R11 of LS-DYNA
Speed improvements for reading, writing and viewing models – now significantly faster for larger models
Morphing improvements – higher order morph boxes and integration with LS-OPT
Added the ability to mesh whole CAD components
New ICFD setup tool to allow easy creation of a CFD LS-DYNA analysis
Support for LS-DYNA IsoGeometric analysis models
Spotwelds and adhesive can now be created between solid parts and NURBs parts and well as shell parts
Speed improvements for model checking
New element quality checks added
New contouring options for forming analysis results, shell loading direction and element normals
Timestep information now read from the LS-DYNA output file for investigation within PRIMER along with error and warning messages

D3PLOT highlights:

New Material Attributes panel improves part-specific colour and lighting control
New capability to save and restore D3PLOT sessions
Loads can be displayed and contoured
Support for new database files and new data components added
Enhanced Measure menu
Enhanced Write menu
Support for rigid body data compression
Antialiasing

T/HIS highlights:

New capability to save and restore T/HIS sessions:
Extensive enhancements to the Curve Table
New data types and data components supported
Regression fit of data added
Block moving of curves
Antialiasing
Substantial enhancements to FAST-TCF and JavaScript functionality

REPORTER highlights:

Supports more fonts, giving you greater creative control over your reports, and allowing you to create templates that match your organisation's branding
Table and Autotable items can now be exported in Microsoft Excel format, complete with formatting (cell size, text alignment, font style, borders, colours, merged cells).
Various new functions have been added to the Item class of the JavaScript API to enable full control over Table and Autotable items. For example, it is now possible to:
Insert/delete/resize rows/columns
Merge/unmerge cells
Get/set cell properties (e.g. text, alignment, font, colour, border width)
Get/set cell conditions

Website:
https://www.oasys-software.com/dyna/news/oasys-suite-version-16-now-released/

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.

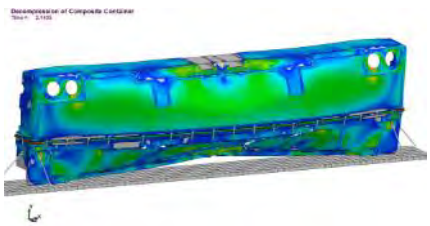
Our History

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.

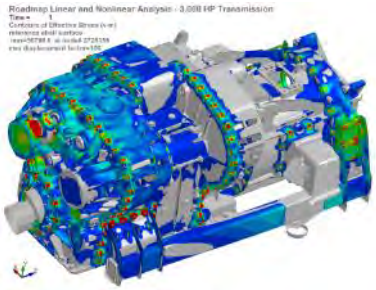
View our portfolio

FEA, CFD and LS-DYNA consulting projects

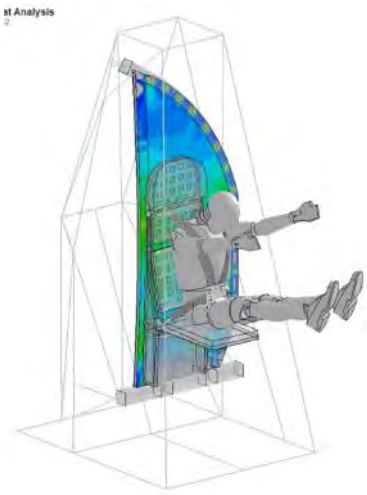
Composite Engineering



Nonlinear Dynamics



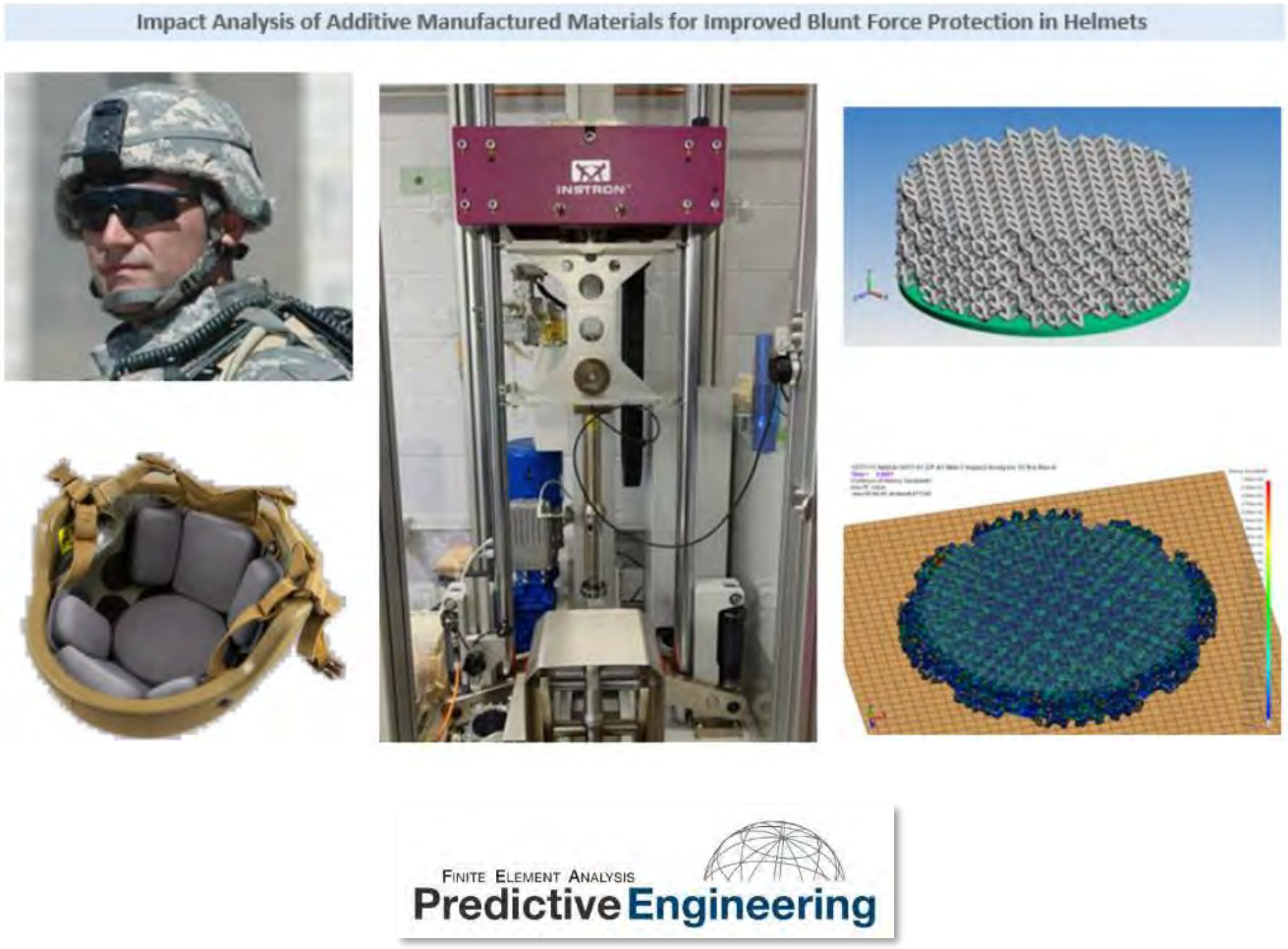
Aerospace



By George Laird

Impact Analysis of Additive Manufactured Lattice Structures

We are pleased to announced a year-long contract award from the US Army Natick Soldier Systems Center (NSSC) to continue the investigation of additive manufactured materials for improved blunt force protection in helmet systems. Our role is to work with Natick's engineering team to simulate the impact behavior of additive manufactured 3D lattice systems. In prior work (see our Case Study: Impact Analysis of Additive Manufactured Lattice Structures) we discovered that getting the material characterization correct was not easy. In this new work, we'll revisit that whole process and look into manufacturing variability of the additive materials from bulk samples down to thin noodle-like structures that are necessary to for the 3D lattice structures of the foam replacement pads.



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.

Big Compute Podcast: Optisys – Innovation in Antenna Design

April 11, 2019 Gabriel Broner

In this Big Compute Podcast episode, Gabriel Broner hosts Mike Hollenbeck, founder and CTO at Optisys. Optisys uses HPC in the cloud and 3D printing to design customized antennas which are smaller, lighter and higher performing than traditional antennas.

Overview and Key Comments

Optisys designs customized antennas for each customer. They simulate them using HPC in the cloud, and 3D print them, making antennas that are one piece instead of being built from hundreds of parts, which makes them light, small enough to fit on the palm of your hand, and very high performance. Their story is interesting from an antenna design perspective and also as a startup capturing technology shifts to disrupt an established category.

Traditional Antenna Design

"Antennas have historically been built using the manufacturing tools that were available at the time. These were subtractive manufacturing tools where you start from a giant block and remove material to get the structure you want. Since you need to be able to reach every part from the outside, you break the problem into individual parts you can manufacture. You need to design hundreds of smaller parts, hold them together to achieve a particular antenna function, and it's expensive to assemble."

Changes in the Industry

"At the time we started Optisys, there was a confluence of three key technologies that had evolved significantly: Big Compute or High Performance Computing in the cloud, simulation capabilities, and Additive Manufacturing. In the past you had to write your own interface to use an HPC system at a company. Now there are companies like Rescale that provide a wonderful interface. Ansys software enables us to design really complex structures. Metal additive manufacturing has significantly changed for electromagnetic structures in the last five years. Additive manufacturing is the same as 3D Printing."

The Beginning at Optisys

"The way most people were approaching additive manufacturing was to build what they had already designed. We instead looked at what we can build with additive manufacturing and design structures that had never been created before."

"The biggest challenge was convincing people that the little antenna structures we built worked and were made out of metal. We took a really complex antenna and reduced it from 100 parts to a single part, from 15 inches to 2, and from 15 pounds to two ounces. We dropped that on the palm of people's hands. Some people did not believe, others believed and were in shock. We had to prove this really can be done. It was an education process for the first year and a half. I view some of our earlier pieces as a work of art."

"We work on antennas that are used by government, defense and commercial, for airplanes, ships, and remote terminals carried by a soldier."

Working with customers

"We had to change the way companies work with antenna providers. People tend to ask for a part. We want to interact at the specification level as a partner to build the antenna that addresses their needs. We use 'Lego building blocks' we developed that we put together and then simulate the customer's antenna. We bring to market 'mass customization' of antennas and we approach the cost of traditional mass production."

Results

"We are seeing excellent results. We are able to produce structures that are orders of magnitude smaller and lighter. With traditional processes, adding complexity adds cost, weight and lead time. For us adding complexity reduces cost, because we simulate, we print one piece, so we are able to produce higher performing antennas at lower cost."

HPC in the Cloud

"We have a core belief not to reinvent the wheel. Our talent is additive manufacturing and RF design. We needed to use HPC as a simulation intensive company. If you want to buy hardware, you have to anticipate the largest problem you need to simulate, but you will use it 10% of the year. What HPC in the cloud allows us to do is to dynamically scale our resources to meet the demands of the day, focus on design, have cheap systems in house, and use Rescale for any heavy lifting or to free up our internal system. It's a spectacular solution."

Final Thoughts

"Often people learn how to do something and they keep doing it that way, even if it does not make sense. We should always think 'Is there a new tool at my disposal that enables me to work differently?'"

"I am excited for what the future holds for HPC in the cloud. People used to need a gigantic system. We dynamically scale our hardware capability every day. I'm excited for the possibilities HPC can bring to other areas."

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
Call for Paper

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

Overview. This conference covers all topics related to LS-DYNA. At this conference our developers will review the current developments and share their plans for the future. One of the major goals of this conference is to give users a chance to provide feedback, but most of all we hope that users, and especially students, will have an enjoyable opportunity to showcase the creative things that they are doing with LS-DYNA.

Topics. In the boxes below we list some of the topics that we expect submissions will cover. Topics not in the lists are also welcome. Authors of accepted submissions will be invited to present during the Technology and Application Sessions.

Submissions:

- Submit abstracts to http://conference.lsdyna-china.com/.
- Submission can be in Chinese or English. Submission of both Chinese and English versions is greatly appreciated but not mandatory.
- Elva Yu is responsible for processing submissions.

  Tel: 15001986675

  email: conf@lsdyna-china.com
- 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.

- One first prize will be awarded. The winner will receive RMB 5,000.00 and a free trip to the 2020 international LS-DYNA Users' Conference including round-trip ticket and hotel fee.
- Two second prizes will be awarded. The winners will receive RMB 3,000.00.
- Three third prizes will be awarded. The winners will receive RMB 2,000.00.

Applications

- Automotive crashworthiness
- Occupant safety and CPM airbags
- Metal forming
- Optimization
- Composites and other materials
- Robustness
- Spotwelding, bonding
- Implicit
- Pedestrian safety
- Impact, drop test
- Ballistics and penetration
- Fluid Structure Interaction and ALE
- Computational Fluid Dynamics
- CAE process integration
- Vibration, noise and fatigue
- Heat transfer
- Electromagnetics
- DEM and SPH
- Cloud computing
- Simulation data management

Industry Fields

- Automotive Engineering
- Aerospace
- Manufacturing Processes
- Biomechanics
- Civil Engineering
- Nuclear Engineering
- Seismic Engineering
- Marine Engineering
- Transportation
- Daily consumer goods
- Locomotives
- General machinery
- Electronics

Hotel location

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.

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.

Article courtesy of defense-aerospace

Eurofighter Typhoon

Wikipedia

The Eurofighter Typhoon is a highly agile aircraft, designed to be a supremely effective dogfighter in combat.[10] Later production aircraft have been increasingly better equipped to undertake air-to-surface strike missions and to be compatible with an increasing number of different armaments and equipment, including Storm Shadow and the RAF's Brimstone. The Typhoon had its combat debut during the 2011 military intervention in Libya with the UK's Royal Air Force and the Italian Air Force, performing aerial reconnaissance and ground-strike missions. The type has also taken primary responsibility for air-defence duties for the majority of customer nations.

The Typhoon is a highly agile aircraft at both supersonic and low speeds, achieved through having an intentionally relaxed stability design. It has a quadruplex digital fly-by-wire control system providing artificial stability, as manual operation alone could not compensate for the inherent instability. The fly-by-wire system is described as "carefree", and prevents the pilot from exceeding the permitted maneuver envelope. Roll control is primarily achieved by use of the wing elevons. Pitch control is by operation of the fore planes and elevons, the yaw control is by rudder.[102] Control surfaces are moved through two independent hydraulic systems, which also supply various other items, such as the canopy, brakes and undercarriage; powered by a 4,000 psi engine-driven pumps.[103] Engines are fed by a chin double intake ramp situated below a splitter plate.

The Typhoon features lightweight construction (82% composites consisting of 70% carbon fibre composite materials and 12% glass fibre reinforced composites)[104] with an estimated lifespan of 6,000 flying hours.[105] The permitted lifespan, as opposed to the estimated lifespan, was 3,000 hours.

FIAT Kicks Off Convertible Season With Introduction of New 2019 124 Spider Urbana Edition

- Urbana Edition offers sporty, unique look and feel with Piano Black-painted exterior elements and Matte Gray interior accents
- 124 Spider Urbana Edition is available for $995 on 2019 124 Spider Classica models, which start at $25,190 U.S. Manufacturer's Suggested Retail Price (MSRP) — the most affordable roadster in its class
- 2019 Fiat 124 Spider offers a number of class-leading features:
  - ▪Most powerful four-cylinder turbo engine in its class
  - ▪FIAT is now the only lineup in the market that provides turbocharged power standar
  - ▪Best-in-class cargo volume
  - ▪Class-exclusive turbo engine
  - ▪Class-exclusive quad exhaust tips
  - ▪Both automatic and manual transmission offerings provide best-in-class highway fuel economy of 36 and 35 miles per gallon (mpg)
- •Italian-designed, fun-to-drive 2019 Fiat 124 Spider lineup is available in three models: Classica, Lusso and performance-tuned Abarth
- •2019 Fiat 124 Spider Urbana Edition is now available in FIAT studios
- •2019 marks 120th anniversary of the FIAT brand and 70th anniversary of Abarth

Just in time for the spring convertible season, the FIAT brand announced today the new 2019 Fiat 124 Spider Urbana Edition.

The Urbana Edition will offer another option for Fiat 124 Spider customers to customize their roadster with dark exterior and interior accents that create a sporty appearance. This latest addition to the Fiat Urbana lineup will be on display this month at the New York International Auto Show.

"With the most powerful four-cylinder turbo engine in its class, our Italian-designed Fiat 124 Spider offers an authentic top-down roadster experience with fun-to-drive dynamics," said Steve Beahm, Head of Passenger Car Brands - Dodge, SRT, Chrysler and FIAT, FCA - North America. "The new Urbana Edition offers a head-turning, custom appearance for the Fiat 124 Spider."

Based off the Classica model, the Urbana Edition includes Black Diamond 17-inch aluminum wheels with performance tires, dual bright exhaust tips and Piano Black exterior accents, plus a Gloss Black finish on the front pillar bar bezel, seat-back pillar and mirror caps.

FEA Not To Miss

YouTube
Tutorials
Webinars
Workshops

New showcased:

LS-TaSC	LS-TaSC An introduction Laura Crespo
EFG	LS-DYNA: Implicit element-Free Galerkin (EFG) - Cutting Simulation Corp Channel Tutorial
SPH	Modeling Splashing and Sloshing in LS-DYNA using Smoothed Particle Hydrodynamics (SPH) Erik Svenning

Previous

Implicit	Intro to the use of implicit analysis in LS-DYNA
Composite	Intro to LS-DYNA composites modelling
FSI	Setting up a simple FSI problem set up with ICFD-LS-DYNA
EM	LS-DYNA EM : Tutorial for Metal forming application (Part I)
Occupant	Occupant Modeling Workshops
Getting Started	Getting started With LS-DYNA (pdf)

Start your Monday with coffee or tea reading our engineering blog, at the FEA Not To Miss coffee shop.
www.feantm.com

mv@feainformation.com

Locations:
Livermore Software Technology Corp.
7374 Las Positas Rd. Livermore, CA 94551
1740 West Big Beaver Road Troy, MI 48084

Contact: classes@lstc.com
www.lstc.com/training

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7374 Las Positas Rd. Livermore, CA 94551
1740 West Big Beaver Road Troy, MI 48084 Contact: classes@lstc.com
www.lstc.com/training

Nonlinear Implicit Analysis

The goal of this one-day seminar is to present a brief, practical introduction to some of the implicit capabilities in LS-DYNA with a focus on typical nonlinear structural analysis. This class is a condensed version of the two-day class “Implicit Analysis with LS-DYNA” and thus, topics related to eigenvalue, modal, and buckling analysis as well as frequency response functions and implicit/explicit switching are omitted.

LS-DYNA Comprehensive ALE & Structured-ALE Modeling Methods & Applications Seminar

The ALE section, will be a review of its fundamental theories. To develop a hands-on application knowledge, we will go through discussing & constructing many complex example models in detail. Among the discussions will be model fine-tuning and procedures for debugging, such as ways to deal with FSI leakage, Boundary and initial conditions, mesh resolution design. A similar approach will also be dedicated for the SALE section.

LS-DYNA - Resource Links

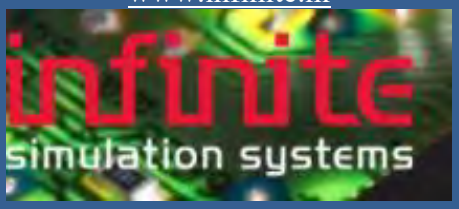
mv@feainformation.com

LS-DYNA Multiphysics YouTube	LS-DYNA Frequently Asked Questions
LS-DYNA Examples Site	LS-DYNA Conference Publications
LS-DYNA Support Site	LS-OPT & LS-TaSC Support Site
ATD - Dummy Models	LSTC ATD Models
Aerospace Working Group	LS-DYNA Yahoo Group

mv@feainfomation.com

www.fujitsu.com/jp

www.infinite.nl



www.dynamax-inc.com

www.dynasplus.com

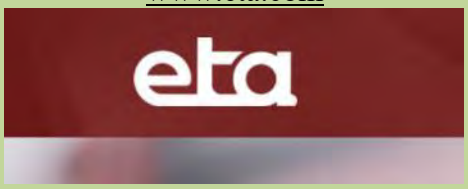
www.beta-cae.com

www.dynamore.de

www.materials-sciences.com

www.kaizenat.com

www.eta.com



www.lancemore.jp/index_en.html

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

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 April/May

Introduction	
Introduction to LS-DYNA	7-9 May 20-22 May (V) 4-6 June
Introduction to Isogeometric Analysis with LS-DYNA	27 May
Introduction to Simulation Technology	28 May
Crash	
Contact Definitions	10 May
Crash Analysis	25-28 June
Metal Forming	
Introduction to Welding Simulation	24 June
Material	
Modeling Metallic Materials	20-21 May
Advanced Damage Modeling: Orthotropic Materials	27 May
Implicit Capabilities	
Implicit Analysis using LS-DYNA	28-29 May
Particle Methods	
Smoothed Particle Hydrodynamics	27-28 June

Conference Accompanying Seminars in Stuttgart and Koblenz, Germany

ICFD Incompressible Fluid Solver Composite Analysis	9-10 May
NVH, Frequency Domain, Fatigue	13 May (Ko)
Introduction to SPG Method for Manufacturing and Material Failure Analysis	13 May (Ko)
Resistive Heating and Battery Modeling	13 May (Ko)
Element Types & Nonlinear Aspects	17 May (Ko)
Simulation of Reinforced Composites	17 May (Ko)
Explosives Modeling for Engineers	17 May (Ko)
Concrete and Geomaterial Modeling	20-21 May
Paramter Identification with LS-OPT	22 May
Material Failure	

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

May 2019

Date				Location	Course Title	Days	Instructor(s)
May 2	May 3	Th	Fri	CA	Fracture, Failure, and Damage in LS-DYNA®	2	A. Tabiei
May 7		Th		MI	Nonlinear Implicit Analysis	1	N. Karajan
May 8	May 9	Wed	Th	CA	Rubber, Foam, and Viscoelastic Materials in LS-DYNA®	2	A. Tabiei
May 13	May 14	Mon	Tu	CA	Plasticity, Plastics, and Viscoplastic Materials in LS-DYNA®	2	A. Tabiei
May 14	May 17	Tu	Fri	MI	Introduction to LS-DYNA®	4	B. Aminjikarai
May 15	May 16	Wed	Th	CA	Composite Materials in LS-DYNA®	2	A. Tabiei
May 20	May 21	Mon	Tu	CA	User Defined Materials in LS-DYNA®	2	A. Tabiei
May 29	May 30	Wed	Th	MI	Comprehensive ALE and Structured-ALE Modeling Methods and Applications	2	I. Do, H. Chen

June 2019

Date				Location	Course Title	Days	Instructor(s)
Jun 5		Wed		MI	Airbag Particle Method (APM) Modeling	1	A. Gromer
Jun 10	Jun 11	Mon	Tu	CA	Blast using LS-DYNA®	2	A. Tabiei
Jun 12	Jun 13	Wed	Th	CA	Penetration in LS-DYNA®	2	A. Tabiei
Jun 18	Jun 21	Tu	Fri	MI	Introduction to LS-DYNA®	4	S. Adya

DynaS+

Complementary tools

LSTC Livermore Software Technology Corp.

OUT-06

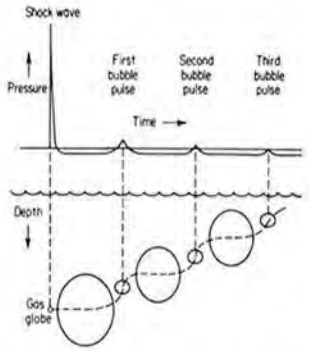
Underwater Shock Analysis with USA/LS-DYNA

Goal

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

Contents

1. Introduction
2. Doubly Asymptotic 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

Cardiac electrophysiology using LS-DYNA

Pierre L'Eplattenier1, Sarah Bateau-Meyer1, Dave Benson1, Vikas Kaul2, Carl Schu2
Mark Palmer2, Darrell Swenson2, Joshua Blauer2
1Livermore Software Technology Corporation, Livermore, California 94551
2Medtronic plc, Minneapolis, Minnesota 55432

Abstract

Heart disease is among the leading causes of death in the Western world; hence, a deeper understanding of cardiac functioning will provide important insights for engineers and clinicians in treating cardiac pathologies. However, the heart also offers a significant set of unique challenges due to its extraordinary complexity. In this respect, some recent efforts have been made to be able to model the multiphysics of the heart using LS-DYNA.

The model starts with electrophysiology (EP) which simulates the propagation of the cell transmembrane potential in the heart. This electrical potential triggers the onset of cardiac muscle contraction, which then results in the pumping of the blood to the various organs in the body. The EP/mechanical model can be coupled with a Fluid and Structure Interaction (FSI) model to not only study the clinically relevant blood flow parameters as well as valves or cardiac devices. This paper concentrates on the EP part of the model. Other papers in this conference will present the mechanical and FSI parts.

Different propagation models, called "mono-domain" or "bi-domain", which couple the diffusion of the potential along the walls of the heart with ionic equations describing the exchanges between the inner and the outer parts of the cells have been implemented. These models were first benchmarked against published results obtained from other EP research codes on a simple cuboid heart tissue model. Other simulations were then performed on more realistic geometries. Since the potential diffusion is highly orthotropic, with much larger diffusion coefficients along the fibers of the tissue than transversally, it is important to correctly model these fibers, which creates models with very large numbers of elements (several tens to hundreds of millions of elements). We thus implemented capabilities to be able to handle such large-scale models. Some EP models will be presented and first results will be shown.

1-Introduction

A cardiac computational model can give biomedical researchers an additional source of information to understand how the heart works. Simulation can be the base of theoretical studies into the mechanisms of cardiac pathologies, provide diagnostic value or can be used to assist in therapy planning. The goal of LSTC is to be able to simulate the pumping heart, with a coupling scheme between the EP equations describing the propagation of the transmembrane potential, the mechanical deformations triggered by this electrical potential, and the blood flow in this pumping heart.

Section 2 will present the EP models introduced in LS-DYNA, section 3 will show some benchmarks between LS-DYNA and other EP codes, and in section 4, we will show an example of spiral wave development in a ventricle.

2-Presentation of the model

The wall of the heart has three layers: epicardium, myocardium and endocardium. The endocardium and epicardium are thin layers consisting primarily of collagen and elastic tissue. In the middle layer, the myocardium, the cells that constitute the muscle show electrical excitability. These specialized cells, called myocytes, are organized into parallel cardiac fibers giving the muscle the striated appearance. The fibers form sheets which are connected by a collagenous network [1].

A cardiac cell (myocyte) is typically 10 to 20 μm in diameter and 80 to 125 μm in length. The cell membrane acts as an electrical insulator and contains ion channels which transport electrical current by diffusion. The potential difference across the membrane is called the transmembrane potential. Initially, a cardiac cell is at rest, with a potential difference across the membrane. The potential inside the cell is negative compared to the external, with a potential difference around 80mV. If the membrane potential rises to a certain threshold value (close to 40 mV) a rapid process occurs, during which different ions, mainly Na^+, K^+, and Ca^{2+}, are exchanged between the inner and the outer part of the cell, creating a fast depolarization, an early repolarization, a plateau and a final repolarization. The complete cycle of depolarization and repolarization lasts around 300 ms and is called "action potential". It is shown in Figure (1). This action potential diffuses from cell to cell through a network of gap junctions, creating a wave of depolarization and repolarization through the myocardium [1].

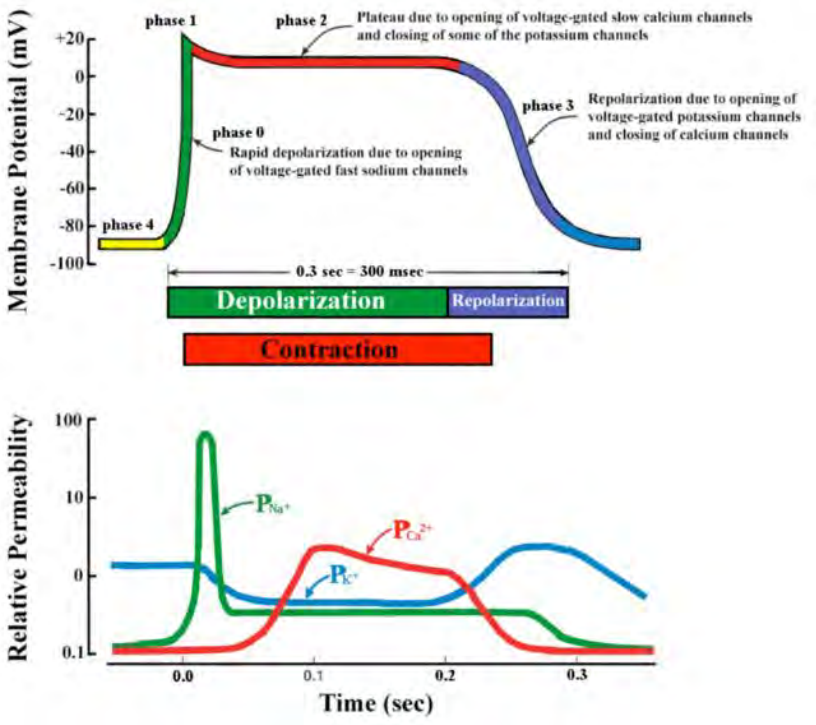


Figure 1: A typical action potential of a ventricular myocyte and the underlying ion currents. The resting membrane potential is approximately ~80 mV (phase 4). The rapid depolarization is primarily due to the voltage gated Na+ current (phase 0), which results in a relatively sharp peak (phase 1) and transitions into the plateau (phase 2) until repolarization (phase 3). Also indicated are the refractory period and timing of the ventricular contraction. Modified from Tortora GJ, Grabowski SR. Principles of Anatomy and Physiology, ninth edition. New York: John Wiley & Sons, Inc., 2000

2-1 The bidomain model

Since describing the whole heart, or even part of it like a ventricle, at the cell level would be computationally too expensive, continuous approximations are made, where the inner part of the cells is treated as one continuum "domain" with an inner potential $\phi_i(\vec{x},t)$, and the outer part as another domain with an external potential $\phi_e(\vec{x},t)$. Each domain is characterized by a conductivity tensor, called respectively σ_i and σ_e. These tensors are usually highly non-isotropic, with factors that can be as high as 5 to 10 between the conductivity along the fibers and the one across the fibers. Therefore, it is very important to correctly model the fiber orientation, which can be consumed from an imaging technique called the diffusion tensor MRI. A transmembrane current with surface density I_m flows between the two domains hence the so called "bi-domain" equations [2]:

$$\nabla \cdot (\sigma_i \nabla \phi_i) = \beta I_m \qquad (1)$$
$$\nabla \cdot (\sigma_e \nabla \phi_e) = -\beta I_m \qquad (2)$$

where β is the membrane surface to volume ratio.
This transmembrane current density I_m consists of a capacitive part, an ionic part generated by the cell membrane I_{ion}, and an imposed stimulation current density I_{stim}:

$$I_m = C_m \frac{\partial V_m}{\partial t} + I_{ion} + I_{stim} \qquad (3)$$

where C_m is the membrane capacity per unit area, and we introduced the transmembrane potential:

$$V_m = \phi_i - \phi_e \qquad (4)$$

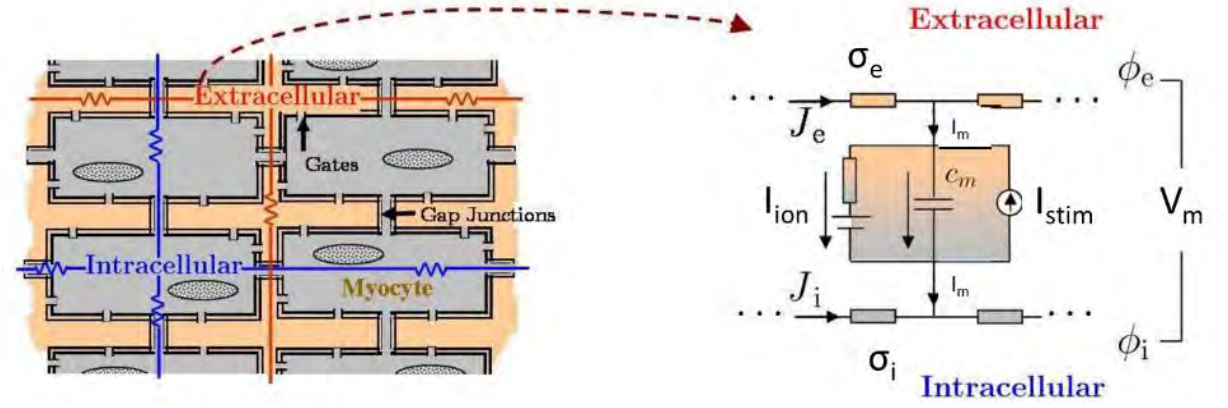


Figure 2: Illustration of the bidomain method (adapted from "Multiscale forward electromagnetic model of uterine contractions during pregnancy", La Rosa et al. BMC Medical Physics 2012, 12:4.).

Using (3) and (4), we can rewrite equations (1) and (2) in terms of V_m and ϕ_e as:

$$\beta C_m \frac{\partial V_m}{\partial t} + \beta I_{ion}(V_m, u) - \nabla \cdot (\sigma_i \nabla V_m) - \nabla \cdot (\sigma_i \nabla \phi_e) = \beta I_{stim}(\vec{x},t) \qquad (5)$$
$$\nabla \cdot (\sigma_i \nabla V_m) + \nabla \cdot ((\sigma_i + \sigma_e)\nabla \phi_e) = 0 \qquad (6)$$

In equation (5), we wrote $I_{ion}(V_m, u)$, to indicate that the ionic current density depends not only on the transmembrane potential V_m, but also on an extra set of variables that we represent by u. The number of such variables and their time evolution depend on the cell model chosen, which we write, in a general way:

$$\frac{\partial u}{\partial t} = f(u, V_m) \qquad (7)$$

These cell models locally describe the exchange of ions through the cell membrane, as schematically shown in Figure 1. Depending upon the question of interest, one can select from a wide class of ionic models, ranging from the FitzHugh-Nagumo model [3][4] with two variables or the Fenton-Karma model with 3 variables [5] to the one discussed in this paper, the ten Tusscher and Panfilov model [6] with 19 variables.
Projecting equations (5) and (6) onto the FEM basis functions, we get:

$$\beta C_m M \frac{\partial V_m}{\partial t} + \beta I_{ion} - S_i V_m - S_i \phi_e = \beta I_{stim} \quad (8)$$

$$S_i V_m - S_{ie} \Phi_e = 0 \quad (9)$$

where

$$M(i,j) = \int_\Omega \varphi_i \varphi_j \, d\Omega \quad (10)$$

Is the mass matrix, and

$$S_i(i,j) = \int_\Omega \sigma_i \overrightarrow{\nabla \varphi_i} \, \overrightarrow{\nabla \varphi_j} \, d\Omega \quad (11)$$

and

$$S_{ie}(i,j) = \int_\Omega (\sigma_i + \sigma_e) \overrightarrow{\nabla \varphi_i} \, \overrightarrow{\nabla \varphi_j} \, d\Omega \quad (12)$$

are diffusion stiffness matrices corresponding to different conductivities.

In order to solve the coupled diffusion equations (8)-(9) with the ionic one (7), we use a so called "Spiteri-Ziaratgahi" operator splitting [7] where the advance from time t to time t+1 reads:

$$u(t+1) = u(t) + dt \, f(u(t), V_m(t), t) \quad (13)$$

$$\begin{bmatrix} \frac{\beta C_m}{dt} M + S_i & S_i \\ S_i & S_{ie} \end{bmatrix} \cdot \begin{bmatrix} V_m(t+1) \\ \phi_e(t+1) \end{bmatrix} = \begin{bmatrix} \frac{\beta C_m}{dt} M V_m(t) - \beta M I_{ion}(u(t+1), V_m(t), t) + \beta M I_{stim} \\ 0 \end{bmatrix} \quad (14)$$

2-2 The monodomain model

The monodomain model makes the extra hypothesis that the inner and outer conductivity tensors are proportional: $\sigma_e = \lambda \sigma_i$. We introduce a mean conductivity [2]:

$$\sigma = \frac{\sigma_i \sigma_e}{\sigma_i + \sigma_e} \quad (15)$$

or

$$\sigma_i = (1+\lambda)\sigma \quad (16)$$

$$\sigma_e = \frac{1+\lambda}{\lambda} \sigma \quad (17)$$

Equation (6) gives:

$$\nabla \cdot (\sigma_i \nabla \phi_e) = -\frac{\lambda}{1+\lambda} \nabla \cdot (\sigma_i \nabla V_m) \quad (18)$$

which gives, when using it in (5), an equation on V_m only:

$$\beta C_m \frac{\partial V_m}{\partial t} + \beta I_{ion}(V_m, u) - \nabla \cdot (\sigma \nabla V_m) = \beta I_{stim}(\vec{x}, t) \quad (19)$$

This is the monodomain equation.

When projecting equation (19) onto the FEM basis functions, we get:

$$\beta C_m M \frac{\partial V}{\partial t} + \beta I_{ion} - \mathrm{SV} = \beta I_{stim} \quad (20)$$

with

$$S(i,j) = \int_\Omega \sigma \overrightarrow{\nabla \varphi_i} \, \overrightarrow{\nabla \varphi_j} \, d\Omega \quad (21)$$

And M is defined by (10).

3-Benchmark against other EP codes

3-1 Presentation of the benchmark

The benchmark we decided to perform is described in detail in [8], where 11 codes were compared on the same diffusion test case. Their main characteristics are presented in table 1.

Index	Code/developer	Home institute	Numerical method	Element type
A	CHASTE	University of Oxford	FEM	hexahedra
B	CARP	University of Graz	FEM	tetrahedra
C	Sander Land	University of Oxford	FEM	hexahedra
D	Richard Clayton	University of Sheffield	FDM	regular grid
E	EMOS	University of Zaragoza	FEM	hexahedra
F	OpenCMISS	University of Auckland	FEM	hexadreha
G	Alan Garny	University of Oxford	FDM	regular grid
H	FEniCS/PyCC	Simula	FEM	tetrahedra
I	acCELLerate	Karlsruhe Inst. Tech.	FDM	regular grid
J	Alan Benson	University of Leeds	FDM	regular grid
K	E.M Cherry	Rochester Inst. Tech.	FDM	regular grid

Table 1. Code index, name and developers. Abbreviations: FDM, finite difference method; FEM, finite element method. See more details in [8].

The test case consists in a 20mm x 7mm x 3mm cuboid part of tissue which is stimulated by injecting a current at one corner. The diffusion of the transmembrane potential through the tissue is studied.

Figure (3) represents the simulation domain. The cardiac electrical activation or stimulus, is applied within a 1.5 mm cube placed at the bottom left corner of the domain around point P_1, at time t=0. As mentioned, the ten Tusscher & Panfilov ionic ventricular cell model [6] is used. The conductivity tensor is anisotropic with a higher conductivity in the y-direction where the cuboid is the longest (20mm), in units of $S.m^{-1}$:

$$\sigma = \begin{bmatrix} \sigma_T = 0.017606 & 0 & 0 \\ 0 & \sigma_L = 0.133418 & 0 \\ 0 & 0 & \sigma_T = 0.017606 \end{bmatrix} \quad (22)$$

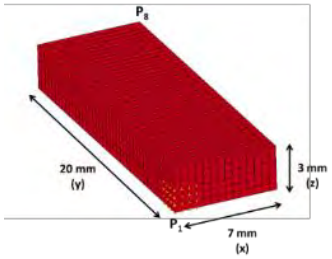


Figure 3: Simulation domain for the benchmark: the stimulation is specified at point P_1 (see yellow node set), and propagates towards the opposite corner at point P_8

The benchmark proposes to solve the problem at three spatial resolutions (dx = 0.5, 0.2 and 0.1 mm) and with three different time-steps (dt = 0.05, 0.01 and 0.005 ms) for a total of 9 simulations. The following presents the simulation results obtained first using the monodomain model and then with the bidomain model.

dt1 (ms)	dt2 (ms)	dt3 (ms)
0.05	0.01	0.005

dx1 (mm)	dx2 (mm)	dx3 (mm)
0.5	0.2	0.1

Table 2: Time-steps and mesh sizes used in the benchmark model

3-2 Monodomain results

In the first set of simulations, we used the explicit Qu-Garfinkel Operator Split integration scheme ([10], [11] and Appendix A). Eight simulations succeeded but the 9th one, with the smallest discretization dx = 0.1 mm and the largest time-step dt = 0.05 ms has a time-step over the limit of the Courant-Friedrichs-Lewy (CFL) condition, and did not converge. The CFL condition is given by [9] as:

$$dt \leq \frac{\beta C_m dx^2}{2(\sigma_L \sigma_T)} \quad (23)$$

With the smaller discretization dx = 0.1 mm the equation gives dt_{max} = 0.046 ms, which is inferior to the largest benchmark time-step.

For the second set of simulations, we developed three others integration schemes (Appendices B, C, and D) with the goal of solving the issue of the CFL condition and reducing the computation time. The second integration scheme, explicit first order operator split (Appendix B), did not solve the CFL issue of the case 9, but the two implicit integration schemes (Appendices C and D) succeeded and gave an accurate result.

Figure 4 shows the activation time at node P_8 for all 9 simulations. It is compared to the activation time given by the 11 codes used for benchmark in [8]. According to [8] the actual solution lies between 42.5 and 43 ms as the eleven codes compared in [8] mostly converge towards such values. One can see that LS-DYNA gives results in this range.

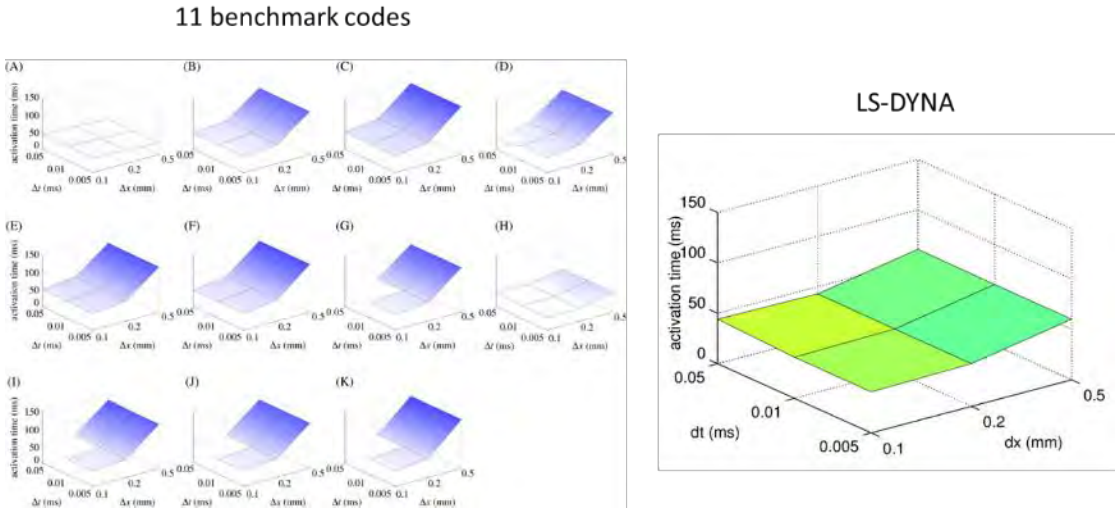


Figure 4: Activation time at P_8 for every combination of spatial and temporal refinement in monodomain (11 benchmark codes on the left, LS-DYNA on the right)

Figure 5 shows the activation time along the line from P_1 to P_8, compared with the results from the other 11 benchmark codes. One can see that as soon as we have $dx \leq 0.2\ mm$, LS-DYNA gives very accurate results. Only code (A) in the 11 benchmarks code manages to get an accurate result even for $dx \leq 0.5\ mm$.

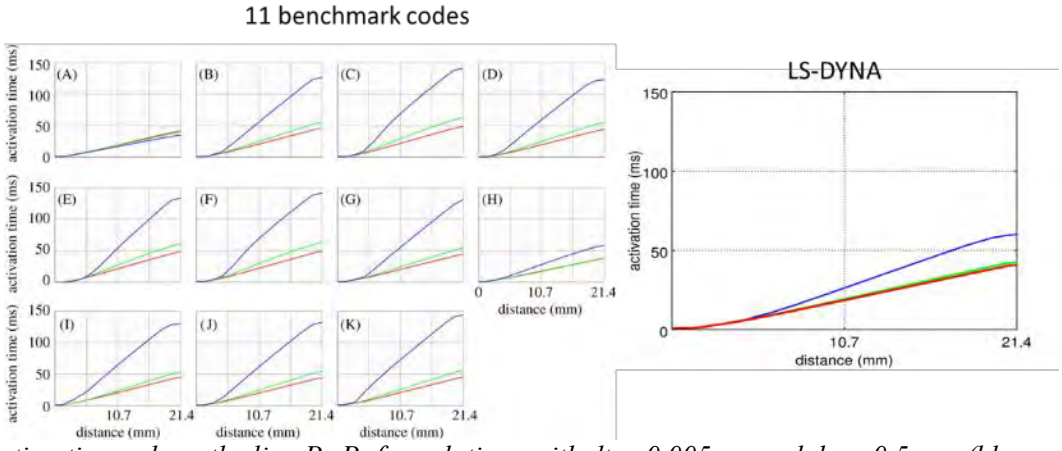


Figure 5: Activation times along the line P_1-P_8 for solutions with dt = 0.005 ms and dx = 0.5 mm (blue line), 0.2 mm (green line) and 0.1 mm (red line) in monodomain. The results of the 11 benchmark codes are on the left, and the LS-DYNA results on the right.

Figure 6 shows the activation time propagation on a plane going through P_1 and P_8. The figure may be compared to [8]-Figure 4.
from dark blue (0 ms) to red (130 ms) with contour bands at 10 ms intervals.

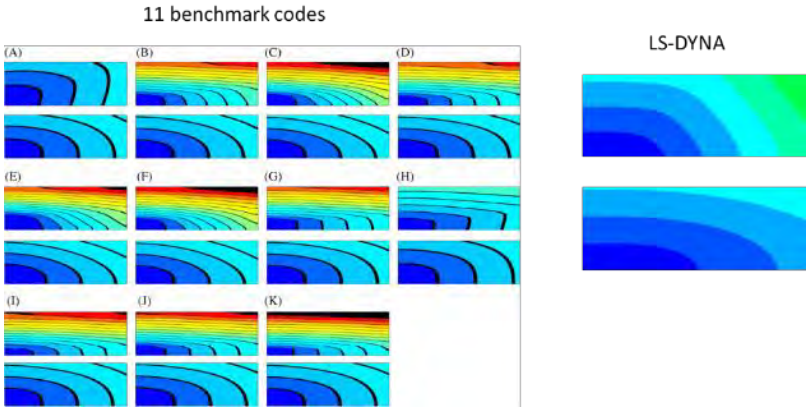


Figure 6. Activation times on a plane ***containing*** *P_1 and P_8, for the benchmark codes (left) and LS-DYNA (right). For each code, the upper and lower planes correspond to the solutions with dx =0.5mm, dt =0.005 ms and dx =0.1mm, dt =0.005 ms, respectively. The activation times are represented by the color map from dark blue (0 ms) to red (130 ms) with contour bands at 10 ms intervals.*

3-3 Bidomain results

The Spiteri-Ziaratgahi Operator Split [7] (Appendix E) is used in this case. We repeated all 9 simulations which were all successful. For internal and external conductivities, we used:

$$\sigma_i = \begin{bmatrix} 0.019 & 0 & 0 \\ 0 & 0.17 & 0 \\ 0 & 0 & 0.019 \end{bmatrix} \quad (24) \qquad \text{And} \qquad \sigma_e = \begin{bmatrix} 0.24 & 0 & 0 \\ 0 & 0.62 & 0 \\ 0 & 0 & 0.24 \end{bmatrix} \quad (25)$$

Note that the monodomain electrical conductivity (22) was taken as an average of the internal and external bidomain conductivities (24) and (25) in the sense of equation (15).

Figures 7 and 8 show the results, which again show activation times very similar to the ones in the benchmark codes.

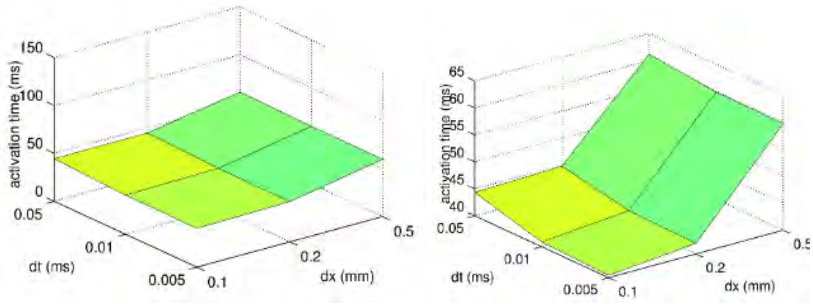


Figure 7: Activation time at P9 for every combination of spatial and temporal refinement in bidomain (same scale as benchmark paper on the left, zoomed scale in the z direction on the right)

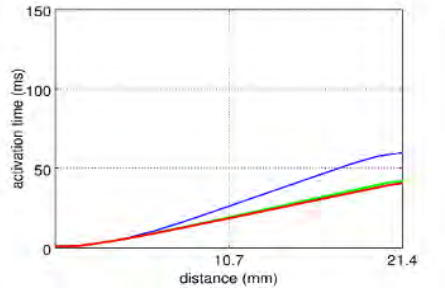


Figure 8: Activation times along line P1-P8 for solutions with dt = 0.005 ms and dx = 0.5 mm (blue line), 0.2 mm (green line) and 0.1 mm (red line) in bidomain

3-4 Results summary

The following table gives the activation times at P_8 obtained for the different simulations performed.

		dt1-dx1	dt1-dx2	dt1-dx3	dt2-dx1	dt2-dx2	dt2-dx3	dt3-dx1	dt3-dx2	dt3-dx3
monodomain	A	60.79	42.95	X	60.21	42.42	40.82	60.12	42.36	40.75
	B	60.54		X				60.09		
	C	61.49		44.21				60.19		
	D	61.94		46.09				60.22		
bidomain	E	61.16	44.8	44.36	59.89	42.3	40.89	59.7	41.97	40.42

Table 3: Activation times at P_8 (in ms) for each simulation. The X indicates that the simulation did not converge, and an empty block that the simulation was not done.

3-4 Large models

The geometry presented in [8] was also used to generate much larger meshes than the one corresponding to dx=dx3, which has 420,000 elements. As already mentioned, the electrical conductivity is much larger along the fibers than across them, so it will be important to have the fiber orientation represented accurately. Also, it is important to capture the first rapid depolarization of the action potential (see Figure 1) in the wave propagation, which necessitates extremely fine meshes. We thus increased the mesh density step by step, and after some changes in the code to better handle the initial MPP decomposition of the model in terms of memory and computation time, a case with 100 million elements on 8 nodes of one of our machine that has 96 GB and 12 cores per node was successfully run to completion. The run was done using the monodomain method with an implicit first order operator-split (Appendix B) and a Pre-Conditioned Gradient (PCG) method, with a time-step dt=0.01ms. It gave the same results as the case dt3-dx3 above.

4-Spiral waves and arrhythmia in a ventricle

The propagation of electrical waves through cardiac tissue is a very important phenomenon to study since those waves activate the mechanisms for cardiac contraction, responsible to pump blood to the body. In a healthy heart, an electrical wave of action potential propagates in a regular way through the various regions of the heart. Figure 9, which corresponds to a monodomain simulation on a 3D mesh with about 160,000 elements with the size and the shape of a ventricle, and where a stimulus was applied at the bottom, shows such a regular propagation.

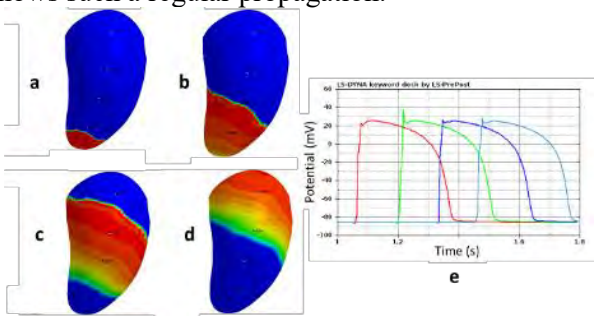


Figure 9: Propagation of the transmembrane potential in a healthy ventricle. The plots on the left show the fringe components of the potential at time 1050 ms (1), 1200 ms (b), 1400 ms (c), and 1600 ms (d). € shows time evolution of the potential at the 4 elements marked on the plots.

One of the proposed mechanisms involved in the development of certain type of arrhythmias are spiral waves, which are symptomatic of functional reentry [6]. Spiral waves are self-sustained waves of excitation that rotate freely or around an obstacle, reactivating the same area of tissue at a higher frequency than normal, increasing the normal heartbeat rate (tachycardia). In the worst-case scenario, a spiral wave might break up into smaller spiral waves giving uncoordinated contractions of the heart in a phenomenon known as fibrillation. When this phenomenon occurs in the ventricles, the heart quivers and loses capacity to pump blood to the body leading to immediate cardiac arrest. Figure 10 shows the development of such a spiral wave on the same model as the one used for Figure 9. In this case, the spiral was triggered by adding a second stimulus at a certain location of the ventricle just after the normal wave had passed through this location. One can clearly see the spiral on the fringe components, and the reactivations of the pulse at higher frequencies on the potential vs time plot, where the chaotic dynamics can also be seen.

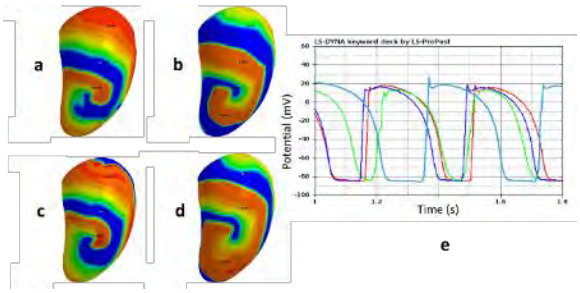


Figure 10: propagation of the transmembrane potential in a ventricle where a spiral wave has developed. The plots on the left show the fringe components of the potential at time 1050 ms (1), 1200 ms (b), 1400 ms (c), and 1600 ms (d). (e) shows time evolution of the potential at the 4 elements marked on the plots.

Conclusion

An EP solver was introduced in LS-DYNA. Both monodomain and bidomain methods have been developed, with different algorithms for each of them. At this point, these 2 models are coupled to a ten Tusscher and Panfilov cell model. The model was compared to a benchmark case on a cuboid tissue and shows good agreement with the other codes. The model was then used on a ventricular geometry, where the formation of spiral waves was observed.

In terms of EP, future work will consist of adding more cell models, and the capability to handle bath loading to account for the electrical conductive properties of the blood surrounding the heart. In terms of heart simulation in general, future work will consist of coupling the EP solver with the mechanical one, along with realistic tissue models, to simulate a heart pulse, and the ICFD solver to solve the blood flow.

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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

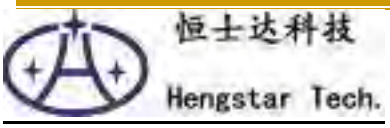
www.predictiveengineering.com

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.



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

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	
	LS-DYNA LS-OPT		LS-PrePost	
			LS-TAsc Barrier/Dummy Models	
United States	**DYNAMAX**		sales@dynamax-inc.com	
	www.dynamax-inc.com			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models		LSTC Barrier Models	
United States	**Livermore Software Technology Corp**		sales@lstc.com	
	LSTC www.lstc.com			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	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		

United States	**Predictive Engineering**		info@predictiveengineering.com	
	www.predictiveengineering.com			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Barrier Models		LSTC Dummy Models	
	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	
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	DYNAFORM	VPG	MEDINA	
	LSTC Dummy Models		LSTC Barrier Models	
France	**DYNAmore France SAS**		sales@dynamore.eu	
	www.dynamore.eu			
	LS-DYNA, LS-PrePost	LS-OPT	Primer	DYNAFORM
	DSDM Products		LSTC Dummy Models	FEMZIP
	LSTC Barrier Models		DIGIMAT	
Germany	**CADFEM GmbH**		lsdyna@cadfem.de	
	www.cadfem.de			
	ANSYS	LS-DYNA	optiSLang	
		AnyBody		
	ANSYS/LS-DYNA			
Germany	**DYNAmore GmbH**		uli.franz@dynamore.de	
	www.dynamore.de			
	PRIMER	LS-DYNA	FTSS	VisualDoc
	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	
	www.infinite.nl			
	ANSYS Products	CivilFem	CFX	Fluent
	LS-DYNA	LS-PrePost	LS-OPT	LS-TaSC
Russia	**Limited Liability DynaRu**		office@lsdyna.ru	
	http://lsdyna.ru/			
	LS-DYNA	LS-TaSC	LS-OPT	LS-PrePost
	LSTC Dummy Models		LSTC Barrier Models	
Spain	**DYNAmore France SAS**		sales@dynamore.eu	
	www.dynamore.eu			
	LS-DYNA, LS-OPT	LS-PrePost	Primer	DYNAFORM
	DSDM Products		LSTC Dummy Models	FEMZIP
	LSTC Barrier Models		DIGIMAT	
Sweden	**DYNAmore Nordic**		marcus.redhe@dynamore.se	
	www.dynamore.se		Oasys Suite	
	ANSA	µETA	LS-DYNA	LS-OPT
	LS-PrePost	LS-TaSC	FastFORM	DYNAform
	FormingSuite		LSTC Dummy Models	
			LSTC Barrier Models	
Switzerland	**DYNAmoreSwiss GmbH**		info@dynamore.ch	
	www.dynamore.ch			
	LS-DYNA		LS-OPT	LS-PrePost
	LS-TaSC		LSTC Dummy Models &	Barrier Models

UK	**ARUP**	dyna.sales@arup.com		
	www.oasys-software.com/dyna		TOYOTA THUMS	
	LS-DYNA		LS-OPT	LS-PrePost
	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

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	
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	TOYOTA THUMS	

Japan	**FUJITSU**			
	http://www.fujitsu.com/jp/solutions/business-technology/tc/sol/			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	CLOUD Services	
	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			

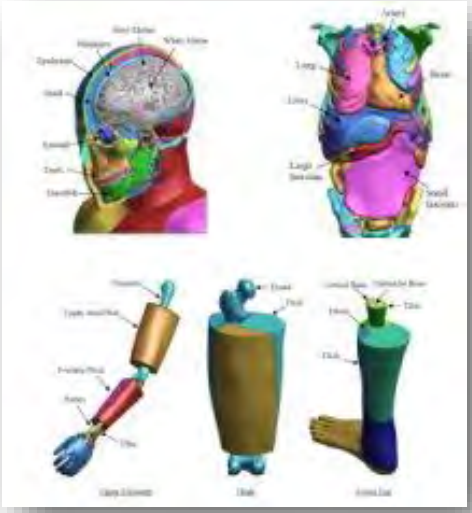
Korea	**KOSTECH**	young@kostech.co.kr		
	www.kostech.co.kr			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	eta/VPG	FCM
	eta/DYNAFORM	DIGIMAT	Simuform	Simpack
	AxStream	TrueGrid	FEMZIP	

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

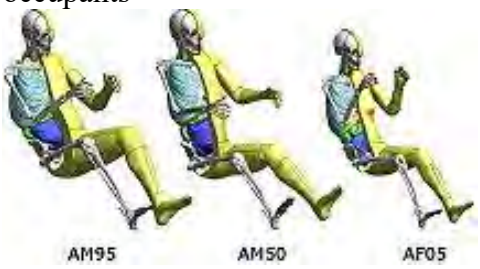
Taiwan	**SiMWARE Inc..**			
	www.simware.com.tw			
	LS-DYNA	LS-OPT	LS-PrePost	LS-TaSC
	LSTC Dummy Models	LSTC Barrier Models	eta/VPG	FCM

TOYOTA - Total Human Model for Safety – THUMS

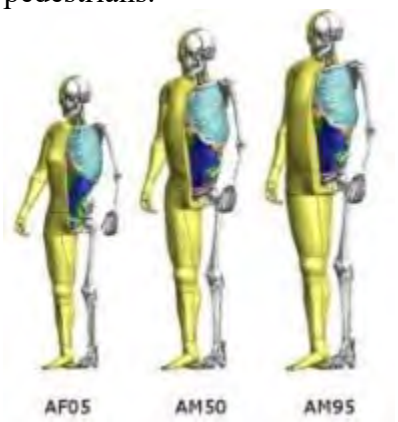


The Total Human Model for Safety, or THUMS®, is a joint development of Toyota Motor Corporation and Toyota Central R&D Labs. Unlike dummy models, which are simplified representation of humans, THUMS represents actual humans in detail, including the outer shape, but also bones, muscles, ligaments, tendons, 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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