fea INFORMATION Engineering Solutions

Ansys LST

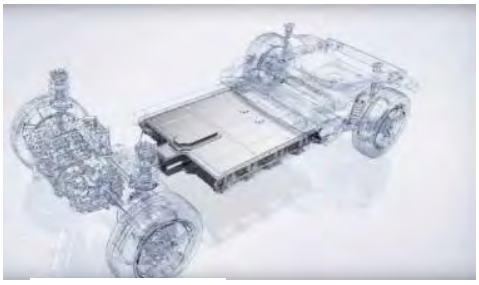
Issue 6, June

www.lstc.com www.ansys.com www.feapublications.com

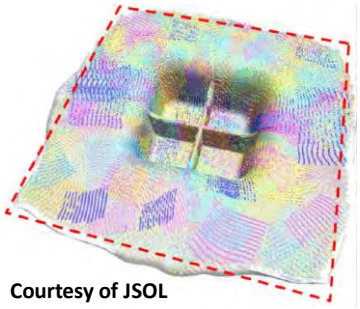
ANSYS

DYNAmore

ESI Group



LST



LS-DYNA New Feature and Application

Incompressible Smoothed Particle Galerkin (ISPG) Method for an Efficient Simulation of Surface Tension and Wall Adhesion Effects in the 3D Reflow Process

FEA Information Engineering Solutions

www.feapublications.com

The focus is engineering technical solutions/information.

FEA Information China Engineering Solutions

www.feainformation.com.cn

Simplified and Traditional Chinese

The focus is engineering technical solutions/information.

Livermore Software Technology, an ANSYS company

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

www.lstc.com

To sign up for the FEA News send an email - subject "subscribe" to news@feainformation.com
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.

Editor and Contact: Yanhua Zhao, Noi - news@feainformation.com

Platinum Particpants

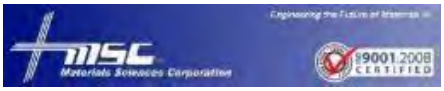


Table of contents

Ansys' Simulation World Attracts Massive Global Engineering Audience

Content from the largest virtual simulation event in the world is now available for on-demand viewing

PITTSBURGH, June 15, 2020 – More than 54,000 people from more than 160 countries registered for the inaugural Simulation World digital event hosted by Ansys (NASDAQ: ANSS) last week. Simulation World is the world's largest virtual event focused on engineering simulation and was held in conjunction with the 16th Annual LS-DYNA user group focused on finite element analysis. These events featured nearly 300 sessions and 200 speakers delivering 48 hours of continuous, cross-industry content across multiple time zones. All sessions are now available online for on-demand viewing through 2020.

Simulation World's executive-studded speaker lineup featured pioneering thought leaders from leading-edge Fortune 500 companies, startups, academic institutions and global news outlets. The speaker tracks covered emerging engineering topics including digital transformation, autonomy, digital twins, the Industrial Internet of Things (IIoT) and electrification. Sponsors included Microsoft at the diamond level, Autodesk, CADFEM and Hewlett Packard Enterprises at the platinum level, and 63 additional cutting-edge companies at the gold and silver levels.

The free and interactive virtual event also provided attendees with unique digital networking opportunities, connecting thousands of industry executives, engineers and manufacturing professionals across several digital networking lounges — sparking thoughtful engineering simulation discussions and suggestions for promoting diversity and inclusion within the engineering community. Additionally, attendees explored a virtual expo hall and engaged in live discussions with technology leaders from around the globe.

"For 50 years, Ansys customers have relied on our simulation solutions as their superpower for tackling the most demanding design challenges imaginable. From self-driving cars to smart factories to 5G connectivity, our customers are using Ansys to engineer what's ahead," said Ajei Gopal, CEO at Ansys. "Simulation World brought together the greatest minds in engineering to discuss, debate and showcase the limitless potential of simulation. The event surpassed our expectations and we were honored to provide educational and networking value to the engineering community virtually during a time when physical industry events around the world were cancelled or postponed."

Read from website

LS-DYNA User Survey

Please click link and complete this short survey to enter to win a raffle for an HTC Vive headset or a pair of Apple AirPods. Winners will be chosen post event and will be notified via email.

About ANSYS, Inc.

If you've ever seen a rocket launch, flown on an airplane, driven a car, used a computer, touched a mobile device, crossed a bridge or put on wearable technology, chances are you've used a product where ANSYS software played a critical role in its creation. ANSYS is the global leader in engineering simulation. Through our strategy of Pervasive Engineering Simulation, we help the world's most innovative companies deliver radically better products to their customers. By offering the best and broadest portfolio of engineering simulation software, we help them solve the most complex design challenges and create products limited only by imagination. Founded in 1970, ANSYS is headquartered south of Pittsburgh, Pennsylvania, U.S.A., Visit www.ansys.com for more information.

Published on May 27, 2020
by Wim Slagter
Automotive, High Performance Computing, Tips and Tricks
Autonomous Vehicles, High Performance Computing (HPC), Simulation

Why Simulation is a Driving Force for Autonomous Vehicles

Autonomous vehicles can improve driver safety and reduce traffic congestion. However, developing this new platform is rife with challenges. Chief among them remains the estimated 8.8 billion miles of road testing that would be required to ensure fully autonomous cars are safe enough to hit the road.

Autonomous vehicles can solve the safety, traffic and economic problems we face by eliminating human error

While these challenges are significant, the benefits autonomous vehicles offer, in terms of safety and productivity, could be enormous.

Each year, roughly 1.25 million people around the world die in traffic accidents, the vast majority of which are the result of human error. In addition to the loss of life, traffic accidents result in an annual economic costs of $277 billion.

Traffic congestion and delays also have high costs. Drivers waste more than 3 billion gallons of fuel because of congestion and spend nearly 7 billion extra hours in their cars. This costs North America roughly $160 billion in 2015.

By eliminating human error, autonomous vehicle technology can solve these safety, economic and congestion problems.

Simulations Cut the Development Time and Cost of Autonomous Vehicles

Simulations make the development of autonomous vehicles economical.

For automakers and suppliers to take advantage of the emerging opportunity in autonomous vehicles, they must be able to rapidly develop safe and reliable technology.

However, because autonomous vehicles must be trained and tested to respond to all driving situations, they must conduct millions of scenarios. This can be a challenge for even the most experienced of technology leaders.

That level of testing and training has extended development cycles. Remember, fully autonomous vehicles will require 8.8 billion miles of road testing. In comparison, Waymo, formerly Google's self-driving car project, has completed only 20 million miles of physical road tests.

How can this process be accelerated?

Simulation will play a key role. Vehicle designers can use advanced simulation tools to virtually test these scenarios quickly and cost effectively. This not only accelerates development but also reduces the need for physical road tests.

For example, model-based development tools help designers create software for autonomous vehicles that have proven to be far more robust, prone to less errors and safer on the road. These tools can also cut development time in half and shave about 40% off the costs of code validation and verification.

The Benefits of Simulated Road Testing

Because simulation is conducted in a virtual environment, it continues to be faster, less expensive and provides more insights into the underlying physics than physical prototyping.

It remains the only practical way to analyze autonomous vehicles' performance over the billions of miles of test driving, designed to ensure their safety. As a result, vehicle developers can:

Various simulations are needed to design, test and validate autonomous vehicles

- Accelerate time to market
- Reduce costs
- Improve product quality

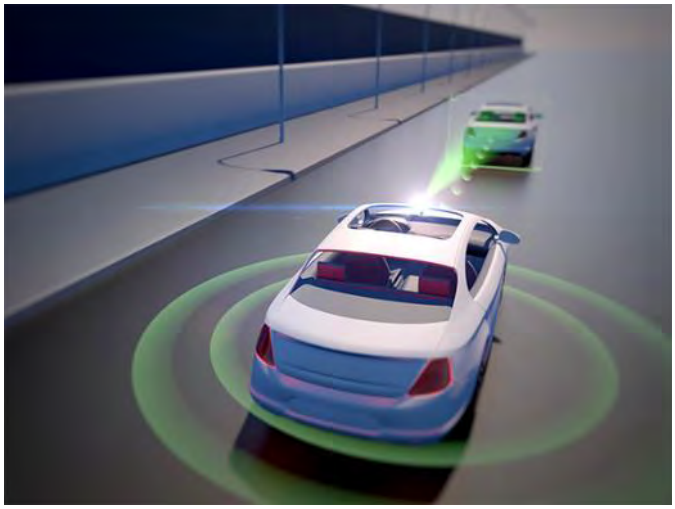
With simulation, companies can quickly and economically complete the design explorations needed to develop a wide array of technologies that are required for autonomous vehicles (such as lithium-ion batteries and LIDAR systems).

Simulation also solves a number of other challenges associated with autonomous vehicle development. It enables developers to virtually test millions of driving situations in order to validate the vehicle's high-fidelity sensors, actuators, LIDARs and cameras. Simulation can even drive the development and testing of complex automated driving control software.

Autonomous vehicle development continues to be a challenge of scale — both in terms of large fleets of vehicles and the compute resources required to crunch the data. Test fleets across the globe will generate petabytes of data on a daily basis. This data must be processed, sampled and utilized by multiple teams that work in parallel. Every update or change discovered during this development cycle can trigger additional design iterations. Simulation remains the best method for increasing the scale of development to meet these challenges.

Meeting the Autonomous Vehicle Challenge

The anticipated disruption that autonomous vehicles will create in the traditional automotive market presents a rare opportunity for companies to create a dominant market position.



Companies need to use simulations if they wish to become a market leader in autonomous vehicle technology.

Therefore, rapid development of these innovative and safe technologies will be critical. Simulation is the only effective and efficient way of addressing the myriad of challenges that companies will face while they develop and test these technologies.

At the recent Big Compute conference, Walt Hearn, regional vice president at Ansys, and Nidhi Chappell, head of product, Azure HPC/AI at Microsoft explained how advanced simulation tools are helping automotive companies overcome their development barriers. To learn more about how simulation can be leveraged in this emerging market, watch their presentation: Simulation Accelerates Vehicle Autonomy.

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

BETA CAE Systems announces the release of the v20.1.2 of its software suite

May 22, 2020

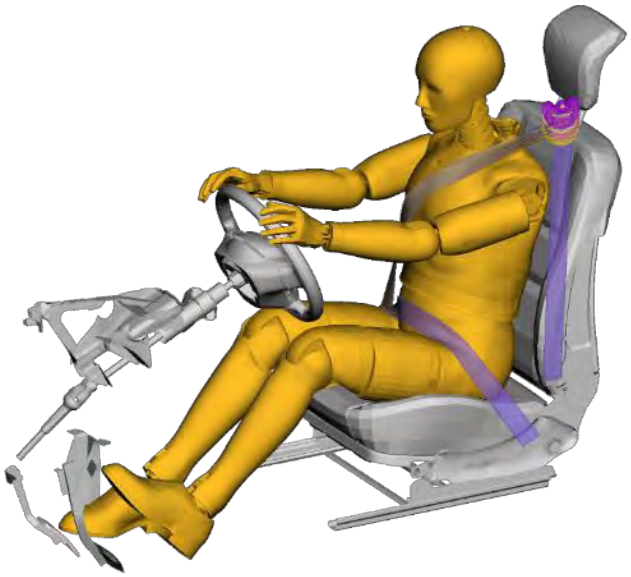
A number of code fixes but also enhancements has been introduced in this ANSA, EPILYSIS, META and KOMVOS second point release of the latest 20.1x branch or our software. The most important of those enhancements and fixes that were implemented appear in the announcement on our web site

Customers who are served directly by BETA CAE Systems, or its subsidiaries, may download the new software, examples and documentation from their account on our server. They can access their account through the "sign in" link at our web site. Customers who are served by a local business agent should contact the local support channel for the software distribution details. All the files that are required for the installation of this version reside in the folder named "BETA_CAE_Systems_v20.1.2" and are dated as of May 12, 2020.

DISCOVER **DOWNLOAD**

BETA CAE Systems International AG
Platz 4, 6039 Root D4, Switzerland
t: +41-41-545-3650 | e: ansa@beta-cae.com | www.beta-cae.com

Cutting-edge simulation tools for Crash and Safety simulations



Passive safety requirements are constantly updated becoming, year after year, more stringent. In the efforts to improve a vehicle's safety during a crash, engineering simulation has stepped in as an invaluable tool. This ever-increasing involvement of simulation from the early designing phase of new vehicles has created the need to study meticulously a vehicle's design and safety equipment. As a result, simulation models become more detailed and complex increasing the requirements in terms of time and expertise, making the need for advanced simulation software tools and automation capabilities vital.

Such tools and automation capabilities for complex modeling processes are offered by the ANSA pre-processor and the META post- processor of BETA CAE Systems. ANSA has become the industry standard solution for demanding crash & safety pre-processing. Its powerful functionality allows users to efficiently perform the required tasks in much less time at maximum levels of detail. In the same direction, the META post- processor eliminates results and report generation time while offers tools for further comprehension of models' behaviour.

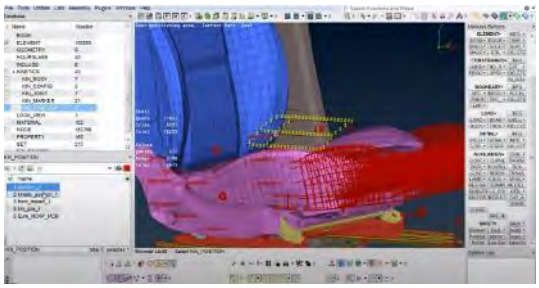
ANSA, in alliance with the suppliers of Crash Test Dummy models, accurately supports the commonly used dummy models and structure trees. ANSA offers the necessary functionality for:
- Positioning and articulation of Dummies, respecting the joints' rotation stop angles.
- Creation of Dummies' structure, in case of absence of structure and positioning data.
- Intuitive restraining for seatbelts systems definition and fitting.
- Dummy-seat depenetration.
- Coupling of dummy and seat allows the combined movement of both.

In addition, process automation and data management are extensively supported allowing for fast, repeatable, and robust model build-up and loadcase definition. Additional tools such as morphing and optimization coupling, leverage ANSA to a multipurpose software package that meets the needs of even the most demanding simulation cases.
ANSA supports all common solver keywords used in modern modeling techniques of crash & safety solvers. The innovative ANSA concept of interoperable decks allows a model to be easily converted from one solver input deck to another, providing superb flexibility.

META stands up to the modern crash-analysis challenges, such as the increasing model size and memory and numerous model comparisons, enabling easy and fast correlation studies with real videos and procedure automation. META features a complete integrated graph tool for 2D post-processing, time history results from most popular crash solvers, parallel 3D and 2D post-processing. Models handling, 2Dplot tool, cut planes, calculation of models' differences, and multiple statistics windows exhibit functionality that simplifies post-processing so as to be performed in just a few clicks.

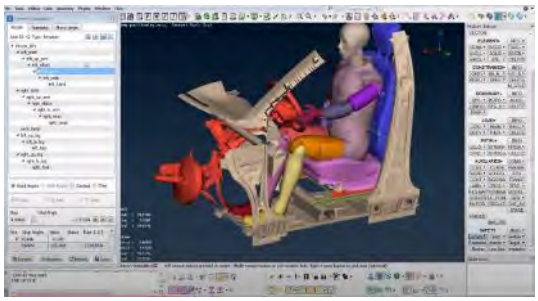
Check out the latest videos on solutions for crash and safety:

Seat Positioning capabilities in ANSA
A brief introduction to the Seat Positioning tools and their capabilities in ANSA.
Link



Dummy positioning in ANSA

This video demonstrates the tools of ANSA for dummy positioning.
More specifically, the Articulation tool for positioning the dummy model in ANSA and the Marionette tool for creating pre-crash simulation for dummy positioning in LS-DYNA/RADIOSS.
Link

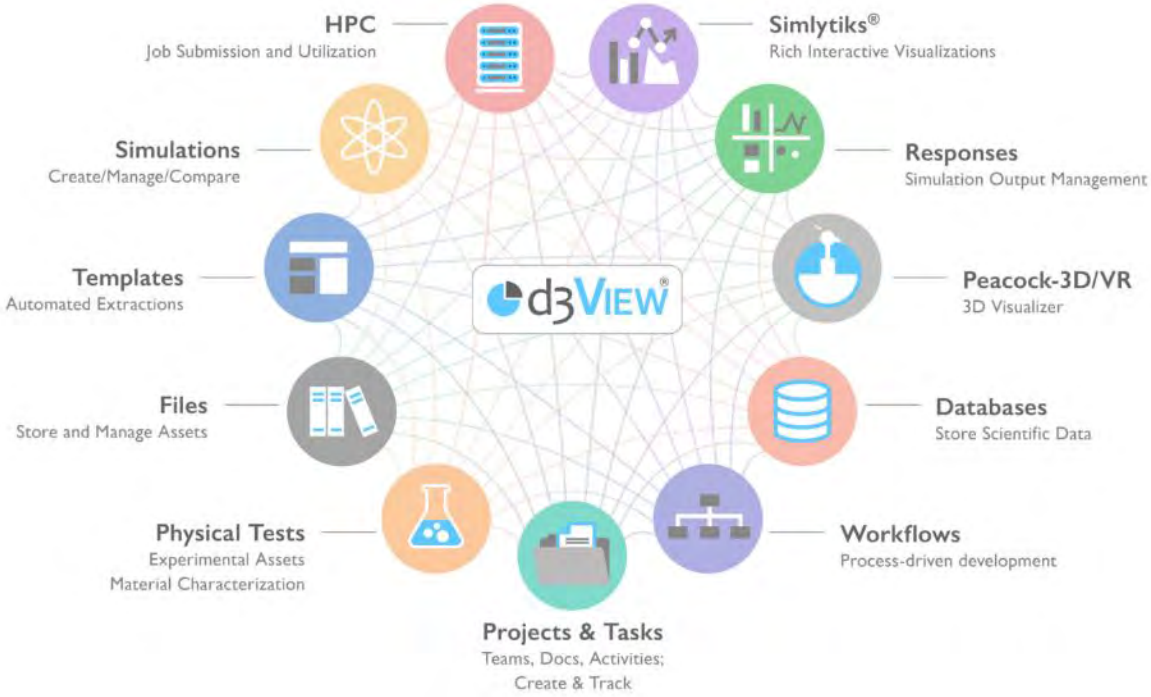


About BETA CAE Systems

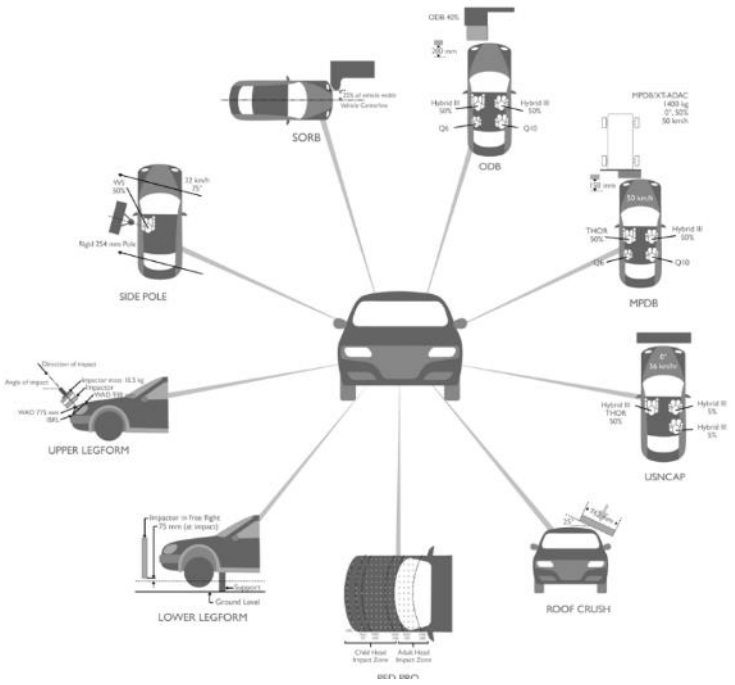
BETA CAE Systems transformed CAE by introducing revolutionary automation software tools and practices into Simulation and Analysis processes almost 30 years ago. Committed to our mission to enable engineers to deliver results of high value, we continue to offer state-of-the-art, high-performance software, and best-in-class services. Our simulation solutions liberate low risk and high Return-On-Investment innovation. The groundbreaking technology, the excellent services and our high standards of business values and ethics are the three pillars on which BETA was founded and grows since then.

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 Platform Components



d3VIEW Built-In Automotive Templates



www.d3view.com.

For more information email info@d3view.com

Author: Christian Frech christian.frech@dynamore.de

Our online training offers

More information: www.dynamore.de/seminars

DYNAmore Express webinar series
The free webinars of the „DYNAmore Express“ series, which last about one hour, are held by experienced DYNAmore engineers and external tutors to inform about current topics and trends in LS-DYNA. You can find the dates on our website at www.dynamore.de/ex2020-e, where you can also register for the respective webinar. The webinars already held are available on our YouTube channel at https://bit.ly/3bqPb2A.

Duration: approx. 1 hour
Dates: regularly
Fee: none
Registration: www.dynamore.de/ex2020
Youtube: https://bit.ly/3bqPb2A
(Playlist DYNAmore Express)

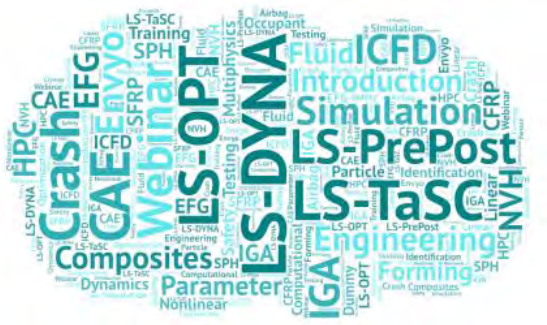
Webinar Series „LS-DYNA Compact“
The webinars of our series „LS-DYNA Compact“ take up the topics of our on-site seminars and offer a compact summary of the most important points. Scope and contents vary and are adapted to the respective webinar topic. Usually the single modules last about two hours. You can find a complete overview on our website at www.dynamore.de/compact.

Duration: approx. 2 hours per unit
Dates: regularly
Fee: 200 Euro plus VAT per unit
Registration: www.dynamore.de/compact

DYNAmore Video-Seminars
Our convenient video-seminars allow you to take part at our courses on your own computer and according to your own time preferences. The trainings are video recordings of the on-site seminars and correspond exactly to these in terms of content and scope. Please register via our website at www.dynamore.de/seminars.

Introduction to LS-DYNA
Scope: corresponds to 3 seminar days (11 chapters and 11 exercises)
Lecturers: Dr. Maik Schenke, Dr. Steffen Mattern (DYNAmore)
Date: anytime
Fee: 1,575 Euro plus VAT
Registration: www.dynamore.de/c2076e

Crashworthiness Simulation with LS-DYNA
Scope: corresponds to 4 seminar days (15 chapters)
Lecturer: Paul Du Bois (Consultant)
Date: anytime
Fee: 2,400 Euro plus VAT
Registration: www.dynamore.de/c2011



Contact
DYNAmore GmbH
Industriestr. 2, D-70565 Stuttgart, Germany
Tel. +49 (0) 7 11 - 45 96 00 - 0
E-Mail: info@dynamore.de
www.dynamore.de

Author: Christian Frech christian.frech@dynamore.de

Webinars and Video-Seminars 2020

Online trainings in July

Webinars DYNAmore Express (free of charge)	
Setting up DOE studies for Occupant Safety within ANSA and META	3 July
ANSA and META solutions on Interior impact simulation for Occupant protection	10 July
Tips and tricks for successful implicit analysis with LS-DYNA	17 July
LS-PrePost: News, Tips and Tricks	24 July
Beyond FEA - The Element-free Galerkin Method	31 July
Webinars LS-DYNA Compact	
Simulation of fiber-reinforced plastics (3 parts)	1 July
Introduction to LS-DYNA (3 Parts)	6 July
Implicit Analysis using LS-DYNA (2 parts)	9 July
Contact Modelling in LS-DYNA (2 Parts)	13 July
Damage and Failure Compact (2 Parts)	15 July
Joining Techniques in LS-DYNA (2 Parts)	20 July
Video-Seminars	
Introduction to LS-DYNA online	anytime
Crashworthiness Simulation with LS-DYNA	anytime

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

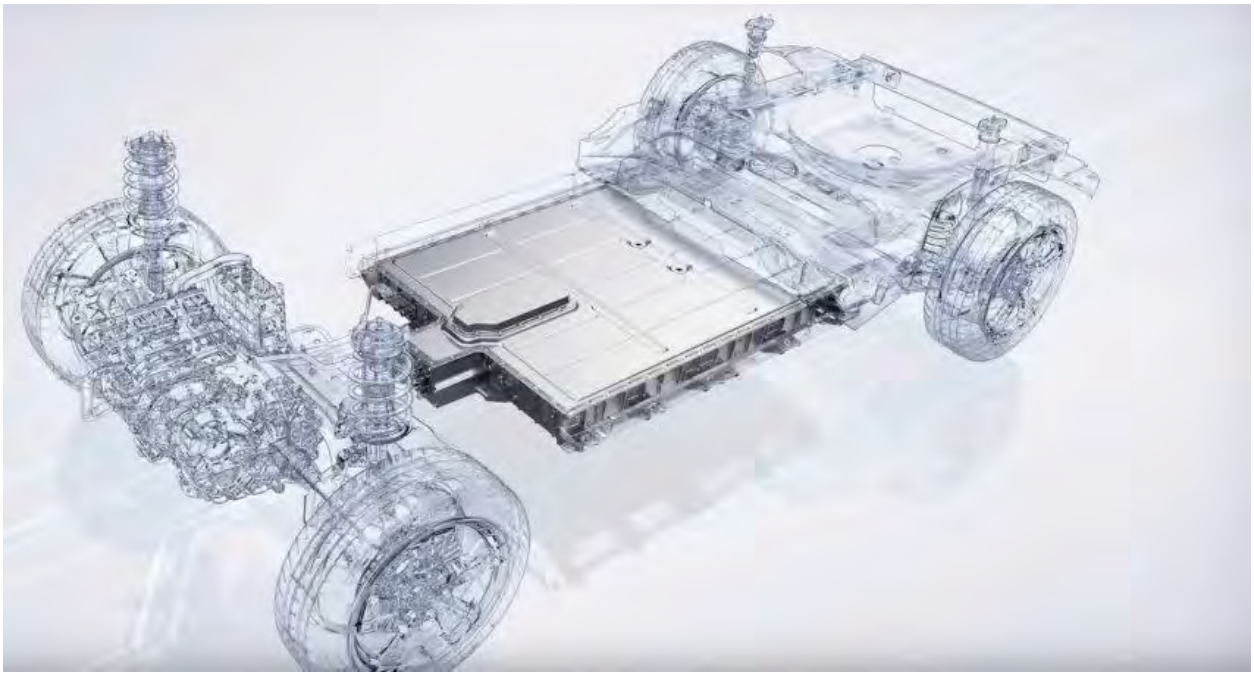
Visit the website for complete overview and registration www.dynamore.de/seminars

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.

How to Make Electric Vehicles Safer and Cheaper? Start by Analyzing the Battery

As the number of EVs on the road continue to grow, so do concerns on how to keep costs low and also, and more importantly, how to keep passengers safe. Read on to see how simulation replaces crash testing in the design of lithium-ion battery packs.

Friday, May 29, 2020 By Peiran Ding, Ph.D.



The number of electric and hybrid cars passed 5 million in 2018 and is expected to reach 44 million by 2030, according to a recent International Energy Agency report. A growing proportion of these vehicles (45 percent) were in China, Europe was in second place with 24 percent and the US pulled in third place with 22 percent. The main reason the numbers aren't higher may be simple economics.

The battery in an electric vehicle is its single most expensive component, says Dr. Peiran Ding, who leads ESI's software development for EV battery simulations. Replacement of the Li-ion battery pack in a Chevy Bolt battery pack, for example, will cost an estimated $15,000. Tesla's Model S 60 KW-hour battery is estimated to cost $35,000 in 2017, or over 40 percent of the car's sticker price. While that price may have gone down after Tesla built its own battery production facility, we expect the cost is still significant.

Clearly, a cheaper battery is needed so that EVs can get into the hands of more drivers.

Enter the pouch cell.

Most batteries are designed to be solid, with a built-in structure. In contrast, the pouch cell is designed with little structure, which promises a lighter weight, less material, and a 90 to 95 percent packing efficiency.

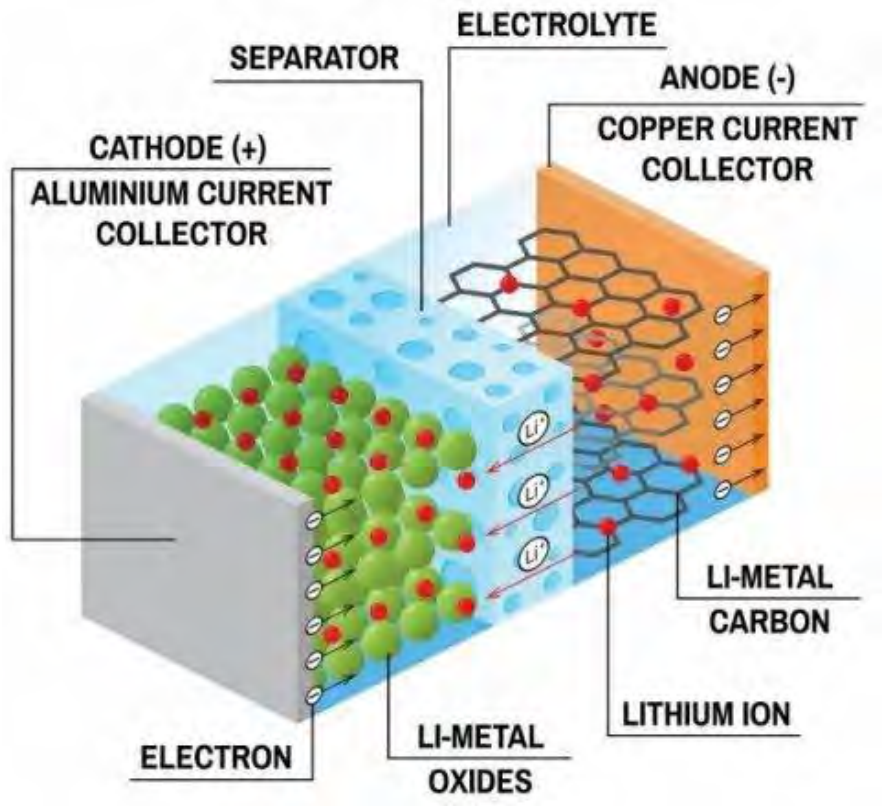
Most EVs sold in the US have an 8-year warranty on the batteries, and there is considerable interest by the EV car companies to make sure the batteries go the distance so they do not have to replace the batteries early.

Insurance companies are also interested in the integrity of EV Li-ion batteries and who has to pay for replacement costs, as well as cost and damages for injuries, loss of life and property damage resulting from EVs occasionally bursting into flame.

Though catching fire is a rare event for EVs, it gets a lot of media attention when it does occur, casting a long and lasting shadow on EVs. Ironically, gasoline-powered vehicles catch fire an average of 167 times a day in the US alone. Still, 31 percent of the general public worries about the safety of electric cars, according to recent research.

EV Battery Degradation and Short Circuits Can Cause Fires—Putting Passenger Lives at Risk

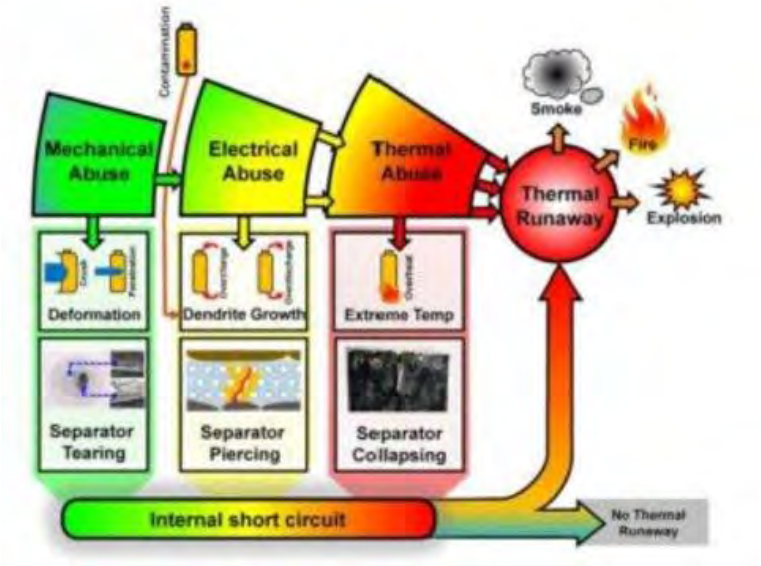
The reasons to replace batteries are mainly battery degradation or a short circuit that causes a thermal runaway.



Lithium-Ion cell discharging, showing separator. (Picture courtesy of OSHA)

A lithium-ion battery creates power by its positive lithium ions moving from a cathode through a separator to the anode. The separator is a thin polymer sheet that keeps the positive material from being in direct contact with the negative material. This separator is porous to the liquid electrolyte, however, which allows the lithium ions to pass back and forth as the battery charges and discharges.

A short circuit occurs when the separator fails, and the cathodes and anodes come into direct contact. This generates enough heat to cause a fire in the cell. Fire in one cell can damage the separators in neighboring cells, causing a thermal runaway.



Thermal runaway leading to smoke, fire, and explosion in an EV battery. (Picture courtesy of Tsinghua University, Beijing)

Separator failure can occur after a collision. The separators can tear from excessive deformation, such as the mechanical abuse from a crash or a road hazard.

Separators can also be pierced by dendrite growth inside the cells. Dendrites are microscopic lithium crystals that are thin as hairs and sharp as needles, and which grow from the anode during overcharging a lithium-ion battery.

Excessive temperature, such as from a fire, can melt or collapse the separators. All these failure mechanisms will cause a thermal runaway and lead to smoke, fire, or even an explosion.

Battery Safety versus Battery Weight—A Vicious Circle

Clearly battery and automotive manufacturers need a strategy to increase the safety of EVs – as well as ease the worry of the car-buying public. For Dr. Ding, this is a three-pronged approach:

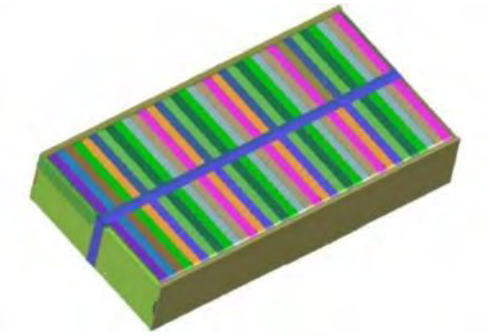
- The intrinsic safety of lithium-ion battery materials can be improved by material modification
- An early detection algorithm can warn the driver of an impending fault. For example, after a crash, the battery management system would sense rapid over-charging or discharging of the battery cells
- Countermeasures can be activated to reduce or slow down the fire hazard

To protect the consumer, government agencies have mandated minimum safety standards for EV battery cells, packs and whole vehicles with several test criteria, including external short circuits, abnormal charge, forced discharge, shock and vibration and temperature cycling. Depending on the governing agency—such as the UN, IEC or ISO—there could be additional criterium for impact, crushing, heating, drop and more.

An EV's battery is huge. A Tesla Model S, at 4,800 lbs. (2,200 kg) is one heavy car. By comparison, a Mercedes E350 is only 3,800 lbs. The difference is almost entirely the 1,200 lbs. battery. Slung underneath the vehicle, the weight makes for good stability, but the Tesla Model S has to bolt on a titanium shield to protect it against road hazards. Without protection, a rock, curb stone or debris could penetrate into the battery cells and cause a thermal runaway; however, the extra shielding makes the car even heavier. The car also needs additional structure to absorb impact, and heavy batteries means heavy-duty connection to the frame. This leads to extra weight, which in turn means the battery has to get bigger. It's a vicious circle.

Battery Simulation and Homogenized Cell Modeling Without Supercomputers

EV battery simulation occurs at scales as small as the physics of ions and the growth of dendrites. It occurs on the scale of cell components and is understood by the science of continuum mechanics and fracture mechanics. A structural analysis of the battery cell, modules and pack, can be done with finite elements on the macro scale. The whole vehicle's crash-worthiness usually takes place at a system scale.



Battery module. (Picture courtesy of Farasis)

The mechanical behavior of a battery pack or module, such as the displacement, stress and strain, depends on the mechanical behavior of its constitutional battery cells. This, in turn, depends on the behavior of the components of the cells—the anodes, separators, cathodes and plastic film. However, the number of elements required to have accurate cell model behavior could be in the millions. Modeling all the cells that exist in a battery pack or module with the same size of elements would result in hundreds of millions, or even billions of elements.

"Even supercomputers can't handle that size of a model," says Dr. Ding.

In order to overcome this challenge, experts from China's Tsinghua University and ESI have been collaborating to develop a method that would define a mechanical property of a single battery cell as an average of the properties of all of the components in the cell. Researchers at Tsinghua are currently calibrating the numerical method with test data. Homogenized cell modeling would bring down the size of the finite element model to where it could fit in available computer resources.

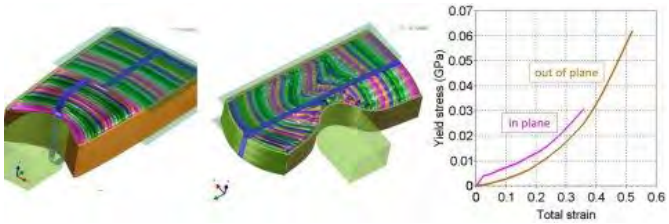
Farasis: No Cars Were Hurt in Our Testing

Farasis Energy, a Chinese-American lithium-ion battery developer, had secured $1 billion in financing and was looking for customers. This search led them to a German automotive OEM. Farasis used ESI's Virtual Performance Solution (VPS) to determine the behavior of the battery in vibration and in-vehicle crash situations. They used no physical prototypes, only digital prototypes, and it was a technical knockout. The OEM was impressed. No crash-test dummies, cars or batteries were hurt in the process. Farasis will be building a $660 million battery production facility in eastern Germany to produce lithium-ion batteries for the German automotive OEM.

"Halfway through the bidding process, the manufacturer actually decided to remove the physical prototype altogether – they would base their decision based on the virtual prototype only," said Dr. Matt Klein, Advanced R&D Director at Farasis Energy.

The crash tests that the Farasis battery had to withstand were brutal. Among them, the battery and vehicle had to survive a side impact with a pole. They had also to pass frequency and resonance tests, as well as shock in all directions. These tests are required by various national government agencies. A single battery model can thus be assessed in the statics, dynamic or vibration physics domain with ESI Virtual Performance Solution. This enables efficient iteration on casing geometry and materials, joint number and location to ensure a lean and lightweight battery design.

"The ability to build a single finite element model for crush, shock, vibration and swelling, led to a highly efficient workflow and ultimately a cost-effective solution for Farasis," says Dr. Ding.



Passing Strict National Regulations on Battery and EV Car Using Only Digital Prototypes—A Technical Breakthrough

A simulation of a lithium battery system, like that shown above, illustrates how the inside a lithium-ion battery cell is a honeycomb structure, which by its nature is stiff along one axis (longitudinal) and less stiff along the other axes. A metal thermal fin conducts heat to the outside of the battery module.

The simulation moves up to an analysis of the battery module which calls for a finite element model with 1.5 million solid and shell elements anywhere from 1 to 4 mm in size.

The simulation is only possible because averaging the mechanical properties and materials over a cell allows for a much smaller, more manageable and solvable model of 10,000 solid hexahedral elements per cell.

The simulation models the way the cells are packed into a 23-inch long battery module, which is used to model the module being rammed by a virtual pole against what would be the front and side directions of the vehicle.

The battery module is subjected to a 60G, 14 ms shock in all directions to make sure it will not break from its mounting points or suffer internal damage.

In order to overcome this challenge, ESI is leading a work package on AI-based design for crash in the frame of the Upscale project, which involved car manufacturers like Volkswagen and CRF, tests centers and universities. The objective of the Upscale project (Upscaling Product development Simulation Capabilities exploiting Artificial Intelligence for Electrified Vehicles) is to apply AI-methods to reduce the development time (20%) and increase the performance of electric vehicles (EVs).

A realistic kinematic load database will be built based on vehicle load cases from regulations to ensure suitable training data. A detailed cell model will be used for linking the load cases with stiffness and internal failure risk. Its results will enable to build a reduced model of the cell with AI. The reduced model will then be validated on full car crash simulations.

ESI has done considerable research in multiscaling, where equivalent material properties are applied to structurally complex structures of a lesser scale. Macroscale methods are key to solving battery module and pack models in the time available – or solving them at all. ESI's intent, achieved after much simulation and validation, is to make sure multiscaling is done accurately. Their reputation in the realm of crash testing depends on it.

ESI is a pioneer in crash simulation—one that is now relied on by most, if not all, of the major automotive companies to do virtual crash testing. Now, ESI appears to have extended its advantage to virtual crash testing of electric vehicle battery systems.

Originally published by Engineering.com

To learn more, visit the Future of Mobility

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.

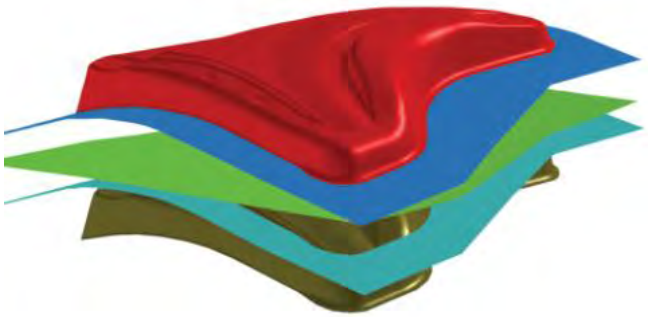
DYNAFORM

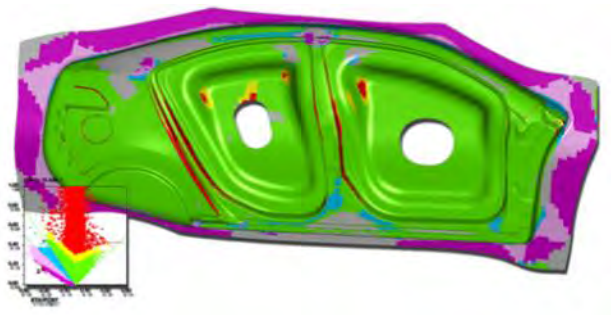
DYNAFORM is a simulation software solution, which allows organizations to bypass soft tooling, reducing overall tryout time, lowering costs, increasing productivity & providing complete confidence in die system design. It also allows for the evaluation of alternative and unconventional designs & materials.

DYNAFORM Version 6.0 is Now Available!

DYNAFORM 6.0 is the sixth-generation DYNAFORM product. It provides a user-friendly and intuitive interface with a streamlined design. The analysis process is fully based on the stamping process, which requires less CAE knowledge, and minimum geometry and element operations. This latest release offers the following features and improvements:

- Intuitive and Streamlined Interface
- Tree Structure to Manage Operation
- Simulation Data Manager
- Customized Icons Grouping for Drop-down Menu Functions
- Separate and Independent Application
- Unified Pre and Post Processing
- Multi-Window View
- Access Functions Using Right Mouse Button Clicks
- Supports Large Forming Simulation Models
- Geometry Manager
- Process Wizard for Blank Size Engineering
- Minimum Geometry and Elements Operations
- New Material Library Window
- New Drawbead Shape and Library
- Coordinate System Manager
- Instant Section Cut
- Tata Steel FLD
- Balloon Label
- PowerPoint and Excel Based Automatic Formability Report Generation





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.

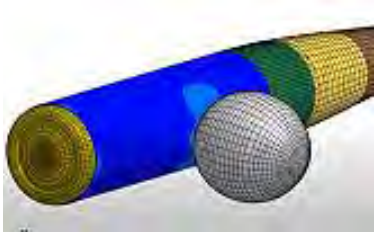
Start your Monday with coffee or tea reading our engineering blog, at the FEA Not To Miss coffee shop.
Postings every Monday on what you have missed

www.feantm.com

Monday 06/15/2020 - And grab that coffee cup and of course something this week cinnamon! HA! you all thought I would say chocolate? WRONG! Off we go to YouTube singing skip to my loo my darling!

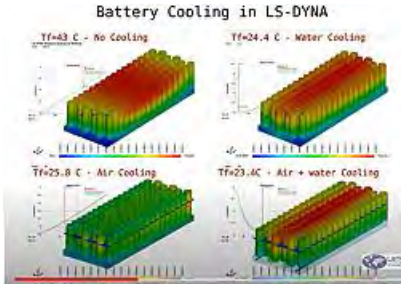
Kaizenat shares Motion Simulation of Hypocyclic Engine Using LS-DYNA | Ansys

Monday 06/08/2020 - Gotta love Predictive Engineering with their video below. SO, that said we will serve this week CC - Conference Coffee!!! GO US! AND now let's go watch the video.



ANSYS LST Conference 2020 LS-DYNA Exhibition Video - Predictive Engineering FEA Consulting Services

Monday 06/01/2020 - Being on the ranch battery cooling is important - then again anything I use that has a battery. SO we will have BC - battery coffee without the battery SO we will add chocolate! I bet you all knew I'd add chocolate.



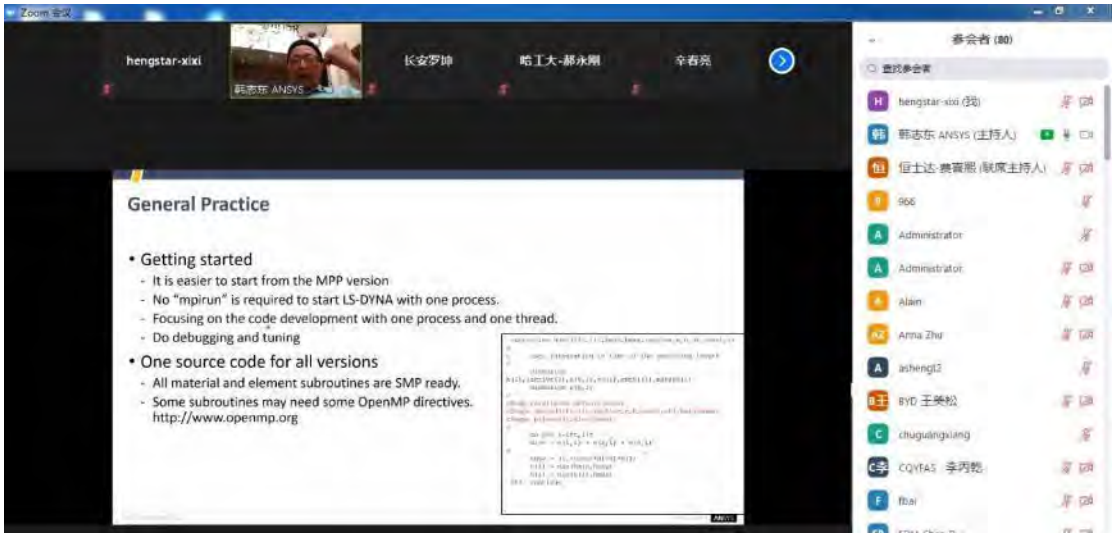
LS-DYNA -ICFD/EM: Battery cooling simulations

Shanghai Hengstar & Enhu Technology sells and supports LST'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.

Online Workshop on User Subroutine Development in LS-DYNA

Shanghai Hengstar Technology & LST Ansys organized an open online workshop for the CAE engineers about"User Subroutine Development in LS-DYNA"on May 29th 2020. Dr. Hanzhi Dong, from LST Ansys gave this 4 hours seminar with introducing the user subroutine package, its structure, and development environment in LS-DYNA. User defined material, user defined EOS, user defined element, user defined contact coefficient, and keywords such as *User_Loading, *User_Loading_Set are covered in the seminar. The development environment in LS-DYNA, Debugging & performance turning-up for the user subroutine, Dynamic loading and mapping are also discussed in the seminar. This training let users learning and understanding the powerful function of user subroutine development in LS-DYNA.

More than 80 CAE engineers from BYD, FAW, Autoliv (Shanghai), PATAC, JMC, Geely, Yanfeng, FAWFW, etc. attended the online seminar. All attendees agree that the workshop was very useful and successful.



Online Seminar on Contact Technology in LS-DYNA

Shanghai Hengstar Technology and LST Ansys will organize a web seminar of contact technology in LS-DYNA on July 1-2 2020.
This seminar will cover the following contents:

1. Characteristics and application of various contacts in LS-DYNA
   Node to surface contact, beam to beam contact, one-way contact, two-way contact, self contact, automatic contact, etc..
2. Definition of contact surface, projection, and the initial penetration
   Tied, tied-break, offset, beam-offset, IGNORE, FTORQ, SRNDE, etc.
3. Parallel algorithm and optimization
   Smp, mpp, groupable, non-blocking, region, contact cost
4. Contact modeling
   Small vs big contact, bucket sort frequency, tracking slave nodes, etc.
5. Contact Debugging
   Contact thickness & stiffness, damping, ISOFT=0/1Stability, TIEDID, Contact pair migration
6. Computational efficiency and optimization of the whole model

Instructor:

Dr. Zhidong Han received his Ph.D in the field of computational mechanics from Tsinghua University. He has been working on DYNA since 2004 and joined LSTC in 2011. He has been working on the MPP contact with the latest features such as groupable, consistency, non-blocking, and so on. He has also worked with other developers on various features in LS-DYNA, including the user subroutine package. His research interests lie in the disciplinary areas of: theoretical, applied, and computational mechanics of solids and other novel computational methods. A comprehensive list of his publications is available on his Google Scholar.

Time and Contact information:

July 1, 2020 (9:00AM-11:00AM Beijing Time)
July 2, 2020 (9:00AM-11:00AM Beijing Time)
Xixi Fei : Training@hengstar.com
Tel: 021-61630122
Cell: 13524954631

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.

J-SEATdesigner Features

LS-DYNA preprocessor for seat design with data management and auto assembling

The recent automotive crash simulation is associated with a direct evaluation of the dummy injury criteria. Appropriate setups for a seat model and/or restraints are required to improve the accuracy of that evaluation.

J-SEATdesigner (JSD) manages various simulation cases with the model files in the database and auto assembles appropriate models based on the determined conditions. A wide range of regulations/assessments stored in the database can be loaded instead of the user input value. Measurement of H-points and pre-simulations including seating simulation are also available.

In the automotive crash simulation, the model becomes complicated and large to achieve a more accurate result. J-SEATdesigner is a powerful integrated system for seat design, supporting design engineers' challenges.

J-SEATdesigner Functions

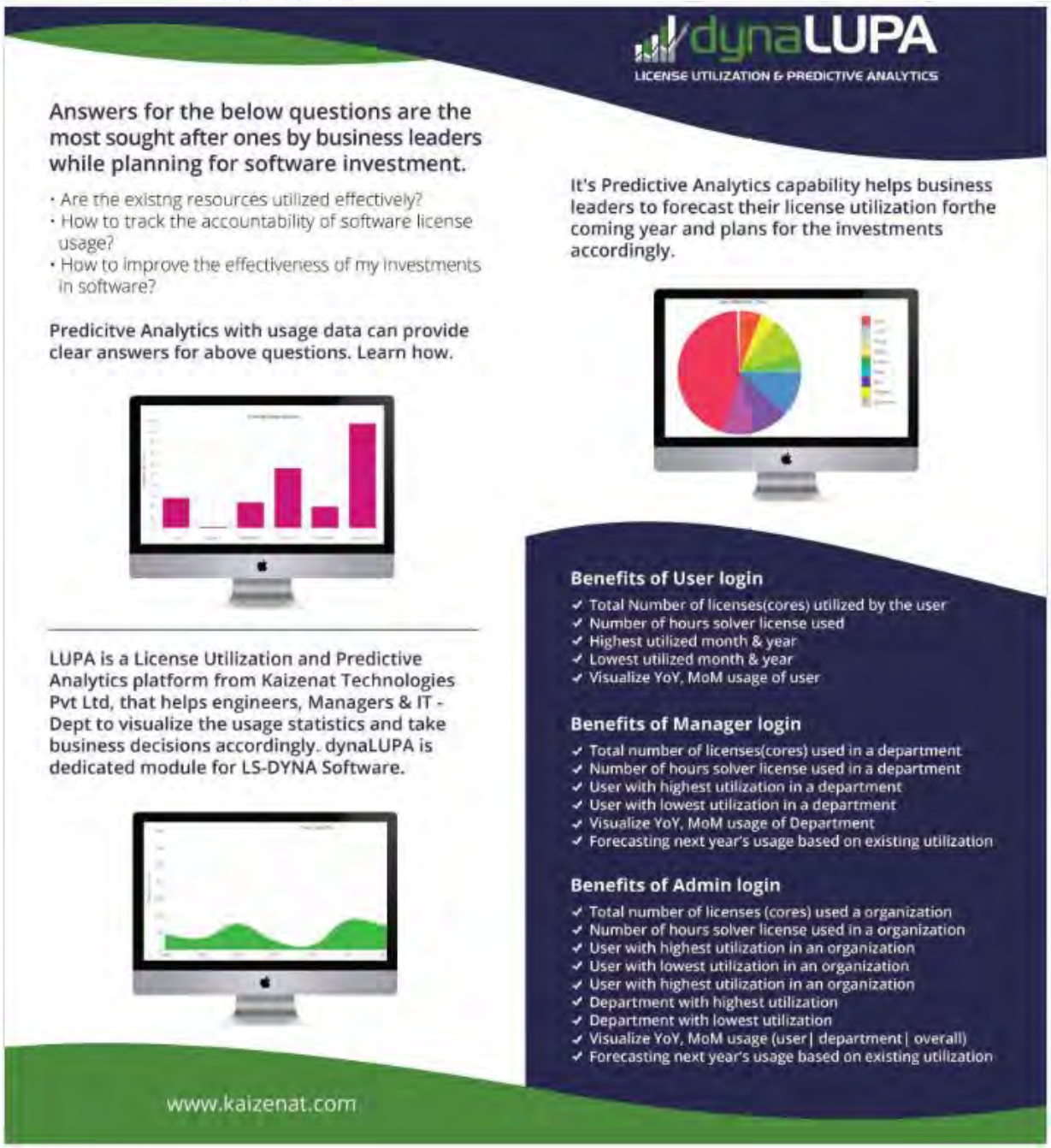
Auto assembly of the sled analysis model Unify management of the simulation cases in the database

J-SEATdesigner can reduce the hours and efforts of engineers building a sled analysis model. Users can access the database that stores and manages a wide range of simulation cases along with the model files via the GUI. The database also stores the dummy-boundary condition combinations that satisfy the regulation/assessment. Users can use the data instead of inputting corresponding values individually. J-SEATdesigner's auto assembly will build simulation models according to the simulation cases defined in the Assembly information and output the assembled model as an LS-DYNA input file. The capability of pre-simulation, including the H-point measurement simulation and seat simulation, is also implemented.

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.

KAIZENAT Keep Improving

LUPA



Contact
Email : support@kaizenat.com Phone: +91 80 41500008

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

LS-DYNA® Computational and Multiscale Mechanics

Intelligent Manufacturing, Advanced Material Design & Integrated Structural Analysis

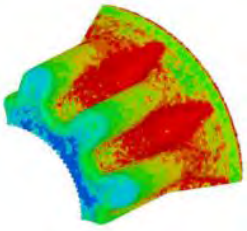
LS-DYNA® integrates advanced finite element and meshfree methods for solving some of the most challenging multiscale problems in manufacturing processes, material design, and structural analysis. Such problems typically involve large deformation, material failure and separation, and/or crack propagation phenomena. The materials covered in these applications could be brittle (glass), semi-brittle (concrete), ductile (metal), rubber / plastics, and composites. These methods can also be coupled with thermal, fluid, and electro-magnetic solvers in LS-DYNA to perform multi-physics analysis as needed.

Methodologies

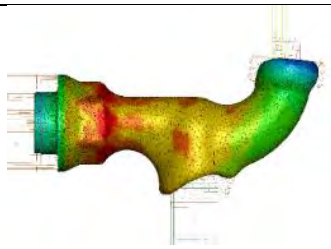
- Adaptive Finite Element Method (AFEM)
- Deep Material Network (DMN)
  - Mechanistic Machine Learning (MML)
- Element Free Galerkin (EFG)
  - Adaptive EFG (AEFG)
- eXtended Finite Element Method (XFEM)
- Meshfree Enriched FEM (MEFEM)
- Peridynamics (PERI)
- Representative Volume Element (RVE)
- Self-consistent Clustering Analysis (SCA)
- Smoothed Particle Galerkin (SPG)
  - Immersed SPG (ImSPG)
  - Incompressible SPG (ISPG)
  - Momentum Consistent SPG (MCSPG)
- Smoothed Particle Hydrodynamics (SPH)
  - Adaptive SPH (ASPH)
- Two-Scale Co-Simulation (TSCS)

Applications: non-failure

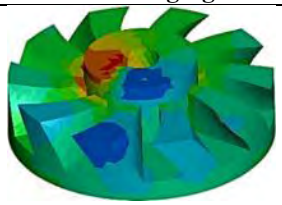
- Manufacturing: forging, extrusion, 3D printing, compression molding
  - AFEM, AEFG, ImSPG
- Material design: unidirectional composites, particle reinforced polymer, polycrystalline
  - RVE, SCA, DMN/MML



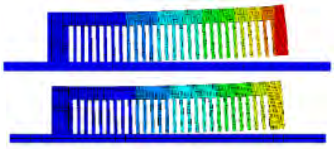
Gear forging



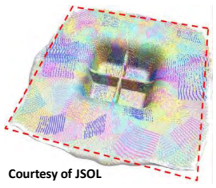
Extrusion of plastics



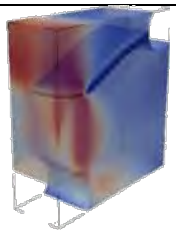
3D printing



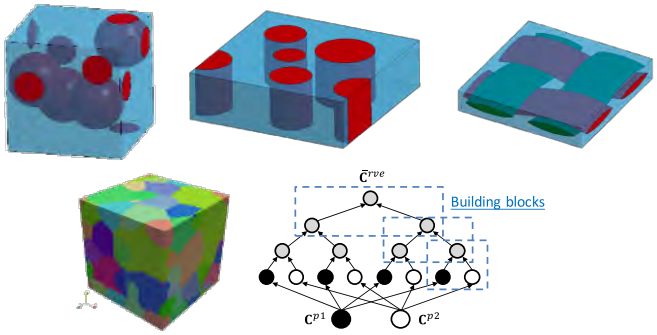
Distorsion prediction of 3D printed components



Compression molding of FRP



Crack in double-notched coupon using SCA



MML + RVE package

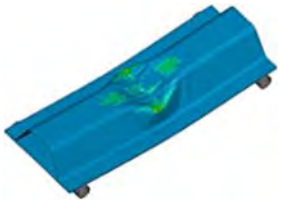
Group Website:
https://www.lstc-cmmg.org

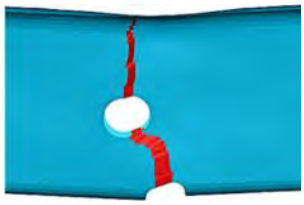
Applications: failure

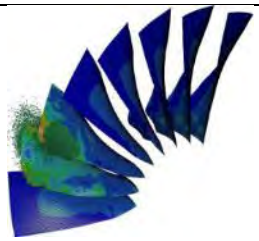
- Crack propagation: brittle (glass, composite) and ductile (metal) materials
  - PERI, XFEM
- Impact: bird strike, penetration
  - SPH, SPG
- Machining process: blanking, cutting, drilling, grinding
  - SPG, MCSPG, SPH
- Joining process: flow drill screwing (FDS), friction stir welding (FSW), self-piercing riveting (SPR), solder reflow
  - SPG, MCSPG, ImSPG, ISPG, SPH
- Structural failure: crash tube, joint strength
  - TSCS, SPG, MCSPG, ImSPG

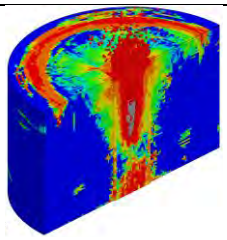
Features

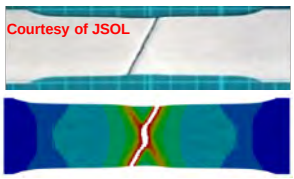
- Element formulations
  - Solid: AFEM, EFG/AEFG, MEFEM, PERI, RVE, SPG
  - Shell: EFG, XFEM
  - Mixed: TSCS (solid-in-shell/solid)
  - Discrete: SPH / ASPH
- Explicit and implicit solvers
  - Both: AFEM, EFG/AEFG, RVE
  - Explicit: PERI, SPG, SPH, TSCS, XFEM
- Multi-physics analysis
  - Coupled thermomechanical, fluid structure interaction
- Applicability
  - Small to extremely large deformations
  - Low to very high strain rate loadings
- Material failure and separation
  - Physics-based failure mechanism


CFRP laminate failure

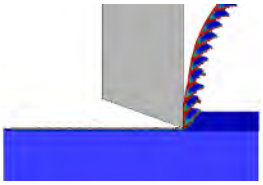

Ductile cracking in shell

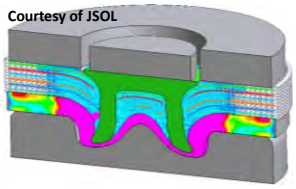

Bird strike


Penetration into concrete

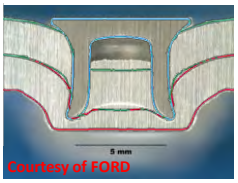


Shear band in uniaxial tension

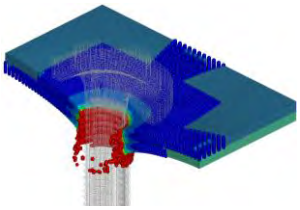

Chip segments in Ti6Al4V cutting

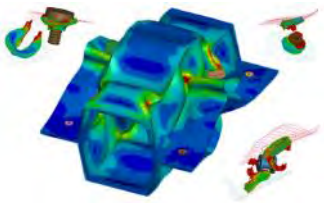


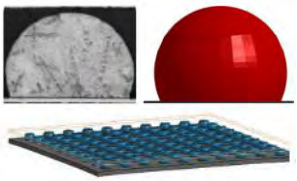
SPR: CFRP to steel

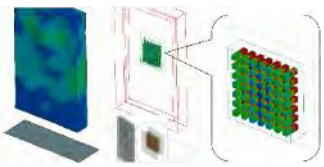


SPR: Al to Al


FDS joining steel plates


Crash tube


Solder reflow


IC drop test

Group Website:

https://www.lstc-cmmg.org

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

2020 Workshops

Webinar Course Dates
March 10, 2020
July 14, 2020
November 17, 2020

In House Course Dates
March 11, 2020
July 15, 2020
November 18, 2020

Cost:
In-House Class: $695 per person
Includes: Coffee, Lunch, Parking, USB with Course Content

email Corinne Hamed 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 Corinne Hamed your full name, and if you're attending in house or web conference.

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 LS-DYNA Update Webinars

While our physical Users' Meetings are postponed due to the COVID-19, you can learn about the exciting new features of the recently released Oasys Suite 17.0 as well as LS-DYNA developments through this series of webinars:

LS-DYNA Updates
Oasys Integrated Solutions
New features to accelerate your workflow with the Oasys LS-DYNA Environment
Oasys Suite – Latest expert tools for LS-DYNA models

Now available on our YouTube channel **here**

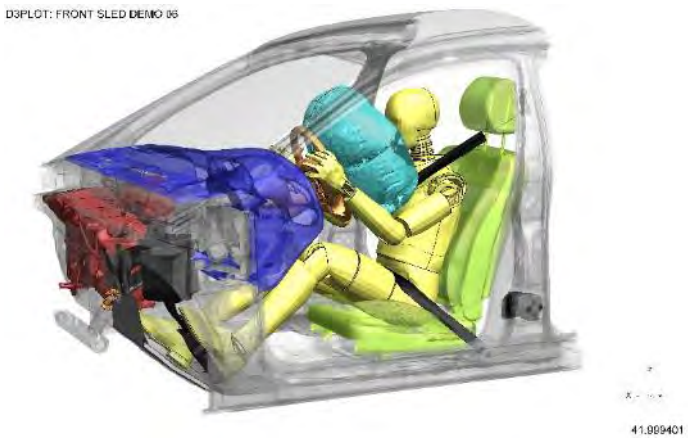
Webinar
1st July 2020
12:30 - 1:30 BST

Human Body Model Positioning using the Oasys LS-DYNA Environment

This webinar will demonstrate how to achieve realistic articulation and positioning of Human Body Models (HBMs) ready for simulation-based dummy positioning analysis in LS-DYNA.We will show how positioning of HBM models is possible using Oasys PRIMER-specific dummy trees developed for industry-leading THUMS and GHBMC models.

*Image shown above is GHBMC M50-O v5.1.1 model.

Register here



Webinar

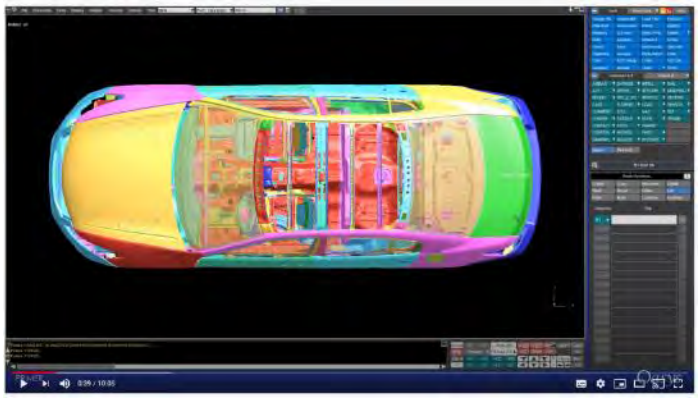
15th July 2020

11:30 – 12:30 IST

Deciphering LS-DYNA Contact Algorithms - Session 01

This is the first of a multi-monthly webinar series. The attendees would be given a walk through the contact algorithms in LS-DYNA by providing many theoretical and practical insights about their usage.

Register here



Top Tip video:

Oasys PRIMER selection modes

Did you know that the Oasys PRIMER has a range of built in selection tools to help you pick out just the entities that you require?

Click here to view it

Contact:

Address:
2512 SE 25th Ave
Suite 205
Portland, Oregon 97202
USA

Phone:
503-206-5571

Fax:
866-215-1220

E-mail:
sales@predictiveengineering.com

FINITE ELEMENT ANALYSIS
Predictive Engineering

Predictive Engineering – Western States ANSYS LS-DYNA Distributor – Your Free Coffee Cup is On Its Way!

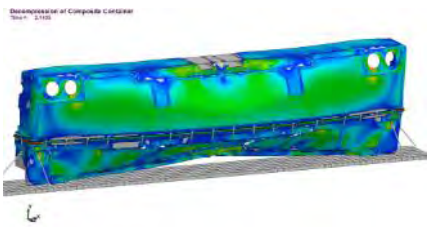
LS-DYNA has been one of Predictive's core analysis tools pretty much since we got started in 1995. It is an amazing numerical workhorse from the basic linear mechanics (think ANSYS or Nastran) to simulating well nigh the impossible. At least that is the way I feel at times when the model is not solving and spitting out arcane error messages and I'm basically questioning my sanity for accepting this project from hell that has a deadline at the end of the week. Which brings me to my favorite project management image – "trough of despair followed by wiggles of false hope then crash of ineptitude and finally the promised land" but I'll leave that for another blog.

For now, let's talk about those free coffee cups. Predictive is now the western states distributor of ANSYS LS-DYNA and provides complete sales, training and services for ANSYS LS-DYNA clients in this region. It is a continuation of our prior setup with LSTC (now ANSYS LST) with the addition of Predictive's ability to offer ANSYS Workbench with LS-DYNA and other ANSYS software tools. So where's my free coffee cup? If you are a current Predictive ANSYS LS-DYNA client, we'll be shipping'em out to you at the end of February and for our new client's – just send us an email or give us a call.

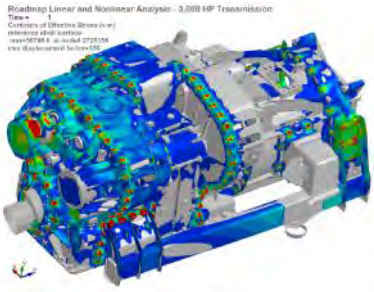
View our portfolio

FEA, CFD and LS-DYNA consulting projects

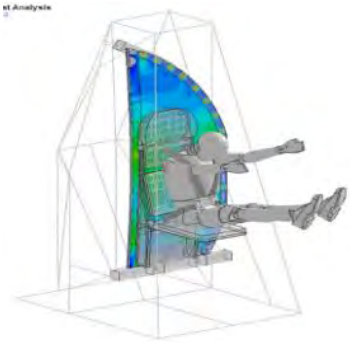
Composite Engineering



Nonlinear Dynamics



Aerospace



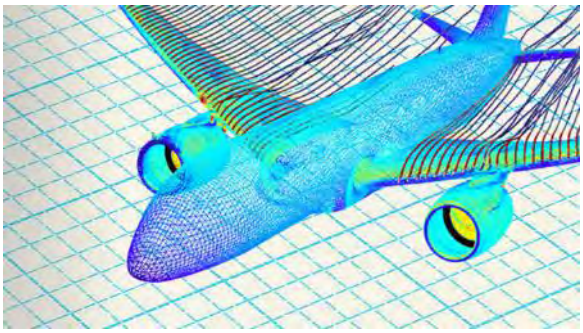
ITAR - Data Security For All Our Clients

June 2, 2020 George Laird

We are generalists at Predictive Engineering and it has its pros and cons. We cross-pollinate from medical (orthopedic to endoscopic), rail (transit to heavy locomotives), automotive (electric to Class 8 trucks to school buses), aviation (commercial, supersonic and military), space (hypervelocity missiles to satellites), marine (ships and submarines), civil (hydroelectric turbines to fish ladders to water treatment tanks) and, not to bore you too much, ASME Section VIII, Division 2, "Design-by-Analysis" pressure vessel work (beer kegs to nuclear waste processing vessels under seismic and fatigue). It is a long list and it just continues to grow.

Okay, why all this pre-amble? Our clients' intellectual property (IP) often represents their "crown jewels" and protection of this data is something we take very seriously. Although Predictive is ITAR-Registered, we treat all our clients' data as if it were ITAR data. What does this really mean at the end of the day? It means we use best practices to ensure that no harm comes to any data, for example, using the "Dutch Reach" method when opening a car door to prevent an accident (i.e., data loss) and likewise, being "Safe" with our data and having backups that are under "lock and key". It sounds a bit silly, but good data security is just about best practices and thinking of others, since how would you feel if someone infected you with COVID by not wearing a mask?

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.



Platform Updates and Software Release Notes

May June 11, 2020
Automotive, English, Product Info & Tutorials
Jolie Hales

Here are a few recent highlights:

NWChem 7.0.0 – A major version update for a premiere computational chemistry tool maintained at Pacific Northwest National Laboratory (PNNL). Notable additions include support of quantum computing and new state-of-the-art functionals. Read the full release notes here.

AutoForm TubeXpert – We onboarded AutoForm TubeXpert, a tool which simulates bending, forming, and hydroforming of tubes. We hope to continue expanding our partnership with AutoForm, a worldwide leader in manufacturing simulation software, with particular applicability to the automotive industry. Learn more here.

Code_Aster 14.5.13 – Code_Aster is free software for numerical simulation in structural mechanics, developed mainly by the Electrotechnical and Mechanics of Structures Department of the EDF Research and Development Department. This robust software is now available on the Rescale platform with MPI capability. Learn more here.

M-Star CFD 2.7.59 – M-Star CFD is a modeling and simulation tool that provides highly accurate and detailed insights into complex fluid flow. The tool is built to serve the needs of both engineering professionals and advanced researchers. This software is now available on the Rescale platform for both Linux batch workflows and Windows GUI simulations. Learn more here.

Siemens Simcenter STAR-CCM+ 2020r1 – Simcenter STAR-CCM+ is a complete multiphysics solution for the simulation of products and designs operating under real-world conditions. Version 15.02.009.

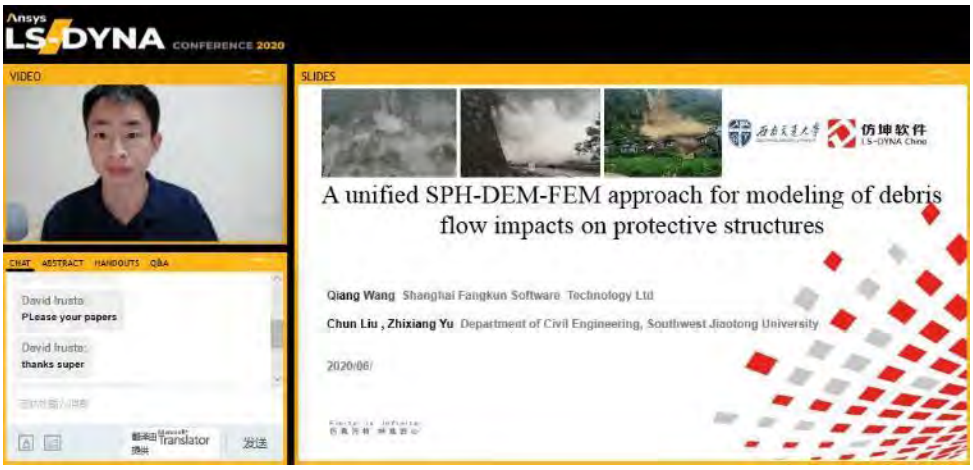
Orcina – OrcaFlex – 10.3b – OrcaFlex is a design and analysis package for marine systems developed by UK-based Orcina. Common applications include offshore dynamics, mooring systems, defense, seabed stability and many others. Rescale currently supports OrcaFlex and Distributed OrcaFlex workflows.

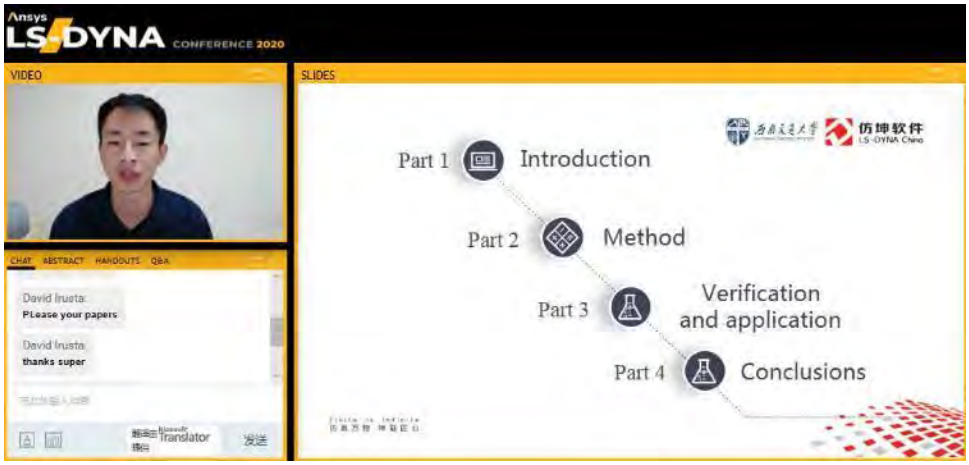
Our full software catalog is available here.

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

Shanghai Fangkun Presented at the 16th LS-DYNA Conference

The Simulation World and the 16th LS-DYNA Conference was successfully held by Ansys on 10th -11th, June. The session categories covered Aerospace, Automotive, Biomedical, Blast, Composites, Electromagnetics, FSI/ALE, ICFD, Implicit, NVH, SPG, SPH, etc. As a Silver Sponsor, Shanghai Fangkun presented at the "NVH/SIMULATION" session on the 16th LS-DYNA Conference with the topic "A unified SPH-DEM-FEM approach for modeling of debris flow impacts on protective structures" which gained attentions from attendees all around the world.





Through 2 days of events, more than thousands of participants who come from global various institutes, and academic users attended this events online. The events provided a platform for us to share knowledge, experience and industry application cases.

Contacts:
Tel.: 021-61261195 54152972
Email: marketing@lsdyna-china.com
Wechat ID "LSDYNA" and our website www.lsdyna-china.com.

2020 Annual Training & Workshop

Dear LS-DYNA users，

To help users to better understand LS-DYNA software and use LS-DYNA more efficiently, Shanghai Fangkun releases 2020 annual training and workshop plan as following tables. We welcome those who are interested to attend.

Date	Topic	City	Duration
20-21,Feb.	Introduction to LS-DYNA (basic training)	Shanghai	2 days
Mar.	Product design with LS-OPT	Shanghai	1 day
Apr.	Crashworthiness in LS-DYNA	Shanghai	2 days
May	Material models in LS-DYNA (composite, non-metal)	Shanghai	2 days
Jun.	Introduction to LS-DYNA (basic training)	Chongqing	2 days
Jun.	Restraint system in LS-DYNA	Shanghai	2 days
Jul.	Battery multi-physics simulation with LS-DYNA	Shanghai	1 day
Sep.	Implicit analysis in LS-DYNA	Shanghai	1 day
Oct.	Fluid structure interaction with LS-DYNA (ALE, ICFD)	Shanghai	2 days
Nov.	Introduction to LS-DYNA (basic training)	Beijing	2 days
Dec.	User-Defined Materials in LS-DYNA	Shanghai	1 day

2020 LS-DYNA online workshop plan			
Date	**Topic**	**Duration**	**Fee**
13rd Jan.	Introduction to MPDB	3 hours	Free
Apr.	Contact Modeling in LS-DYNA	2 hours	Free
May	SALE method in LS-DYNA	2 hours	Free
Jun.	Introduction to Q series dummies	2 hours	Free
Jul.	NVH, Fatigue, & Frequency Domain Analysis in LS-DYNA	2 hours	Free
Aug.	SPG method in LS-DYNA	2 hours	Free
Sep.	Introduction to LS-PrePost	2 hours	Free
Sep.	Introduction to LS-OPT	2 hours	Free
Oct.	Introduction to LS-Form & Stamp forming	2 hours	Free
Oct.	Performance analysis of bus with LS-DYNA	2 hours	Free
Nov.	LST Dummy & Barrier	2 hours	Free
Nov.	EM method in LS-DYNA	2 hours	Free
Dec.	Summary of fluid structure interaction method in LS-DYNA	2 hours	Free
Dec.	Virtual Proving Ground training	2 hours	Free

Contact: Elva Yu Tel.: 18221209107, 021-61261195 for more detail information
Email: Training@lsdyna-china.com

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

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

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

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

FE analysis

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

CFD analysis

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

EM analysis

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

Metal sheet

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

Pre/ Post

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

Biomechanics

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



Toyota Offers Free Access to THUMS Virtual Human Body Model Software

June 16, 2020

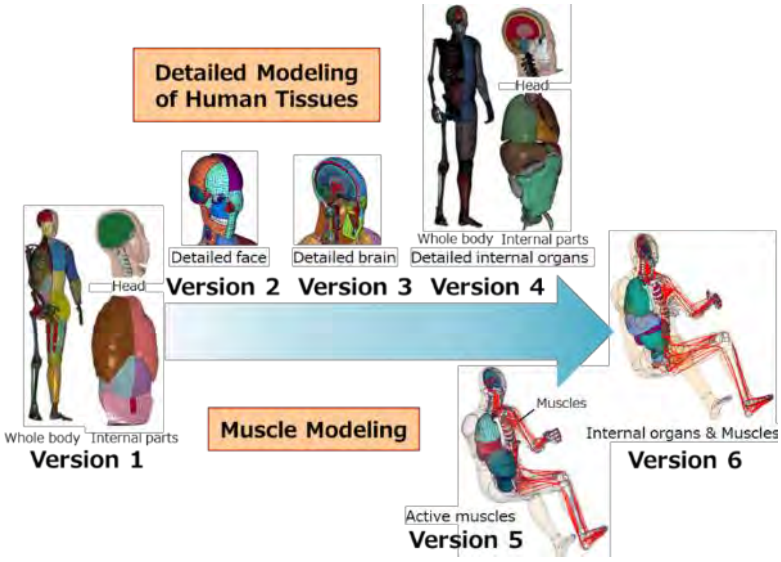
Greater use of THUMS for analysis of vehicle collision-related injuries to enhance vehicle safety

Toyota City, Japan (June 16, 2020) — Toyota Motor Corporation (Toyota) announced today that it will make its Total Human Model for Safety (THUMS) software freely available from January 2021 as part of its efforts toward a safe mobility society. THUMS is a virtual human body model software program for computer analysis of human body injuries caused in vehicle collisions. Free access to THUMS, and subsequent use by a wider variety of users, is expected to enhance vehicle safety.

Designed to aid vehicle safety technologies' research and development, and developed in cooperation with Toyota Central R&D Labs., Inc., THUMS was the world's first virtual human body model software when it launched in 2000. It enabled simulation and analysis of injuries caused in vehicle collisions. Since then, and up until the latest Version 6 was released last year, it has continually evolved to add a range of models with different genders, ages and physiques that include skeletal structures, brains, internal organs, and muscles. Compared to the physical crash dummies commonly used in vehicle collision tests, THUMS is able to analyze collision-related injuries in more detail, because it precisely models the shapes and durability of human bodies. Conducting simulations on computers also enables repeated analysis of a range of different collision patterns, while it can dramatically reduce development lead times and costs associated with collision testing

Evolution of THUMS

THUMS is currently used in vehicle safety research by over 100 vehicle manufacturers, suppliers, universities, research institutions and others, in Japan and overseas. It is being used to research and develop many different safety technologies, such as seatbelts, airbags, and vehicle structures that help reduce injury risks in vehicle collisions with pedestrians. Vehicle safety assessment organizations are also currently considering the use of THUMS for virtual testing in their future assessment plans.



Making THUMS freely available is expected not only to enable a greater number of people to use it in their vehicle safety research, but to also improve the usability of the software, as users make improvements to the model themselves and share the results with others.

Seigo Kuzumaki, Fellow at Advanced R&D and Engineering Company, offered the following comment about free access to THUMS:

"Since the very first launch of THUMS in 2000, we've been making ongoing improvements and avidly working to better reproduce the human anatomy and expand the variations of models. It has now become indispensable technology to Toyota's efforts in developing safety technologies and vehicles. We decided to make the software freely available to have more people use it, to further enhance vehicle safety across the entire automotive industry, and to help reduce traffic injuries and fatalities to create a safer society. We look forward to seeing it applied broadly in development sites and others, envisioning a mobility society with automated vehicles and other technologies, moving forward."

Software license sales through JSOL Corporation (Tokyo) and ESI Group (Paris) will come to an end during 2020, with the start of free access to THUMS.

Pedestrian Models

THUMS Version 4: Models

Models include detailed human anatomy (skeletal structures, brains, internal organs, etc.) in a range of genders, ages, physiques, and postures.

Note: Versions 4, 5, and 6 will be made available for free.

History of THUMS

Year	Progress	Details
1997	Toyota begins developing THUMS together with Toyota Central R&D Labs, Inc.	
2000	Version 1 released	Detailed modeling of bones added
2005	Version 2 released	Detailed modeling of faces added
2008	Version 3 released	Detailed modeling of the brain added
2010	Version 4 released	Detailed modeling of internal organs added
2011	A variety of different physiques added to Version 4	Small female, large male models added
2015	Version 5 released	Modeling of all body muscles added
2016	Child models added to Version 4	Child models aged 3, 6, and 10 years old added
2019	Version 6 released	Modeling of muscles added to modeling of internal organs
2020	Free access will be offered	Current release

Read in Website

LS-DYNA - Resource Links

LS-DYNA Multiphysics YouTube

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

FAQ LSTC

ftp.lstc.com/outgoing/support/FAQ

LS-DYNA Support Site

www.dynasupport.com

LS-OPT & LS-TaSC

www.lsoptsupport.com

LS-DYNA EXAMPLES

www.dynaexamples.com

LS-DYNA CONFERENCE PUBLICATIONS

www.dynalook.com

ATD –DUMMY MODELS

www.dummymodels.com

LSTC ATD MODELS

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

AEROSPACE WORKING GROUP

http://awg.lstc.com

Training - Webinars

Participant's Training Classes

Webinars

Info Days

Class Directory

Directory

BETA CAE Systems	www.beta-cae.com/training.htm
DYNAmore	www.dynamore.de/en/training/seminars
Dynardo	http://www.dynardo.de/en/wost.html
ESI-Group	https://myesi.esi-group.com/trainings/schedules
ETA	http://www.eta.com/training
KOSTECH	www.kostech.co.kr
ANSYS LST	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

Incompressible Smoothed Particle Galerkin (ISPG) Method for an Efficient Simulation of Surface Tension and Wall Adhesion Effects in the 3D Reflow Process

Xiaofei Pan[1], C. T. Wu[1], Wei Hu[1]
[1] *Computational and Multiscale Mechanics Group*
Livermore Software Technology, an Ansys Company, 7374 Las Positas Road, Livermore, CA 94551, USA

Abstract

A new numerical method in LS-DYNA, the incompressible smoothed particle Galerkin (ISPG) method, is developed for the simulation of shape evaluation of solder joints during the electronic reflow process. The ISPG method is a combination of several unique developments aim to suppress key numerical instabilities observed in the simulation of incompressible free surface fluid flow using Lagrangian particle methods. In ISPG method, a momentum-consistent velocity smoothing algorithm is utilized to offer the desired numerical stability associated with the fluid particle integration scheme. To stabilize the solution in pressure equations, a 2nd order generalized rotational incremental pressure-correction scheme is developed for the incompressible flows. To simulate the shape evolution of solder joints during the reflow process, a numerical procedure considering the surface tension and wall adhesion effects is introduced. Several numerical examples are studied to demonstrate the accuracy and the efficiency of the new method.

Keywords: Particle; ISPG; Momentum-consistent; Incompressible; Reflow

1. Introduction

Solder joints are used to provide both mechanical and electrical connection in electronic packaging for IC industry. The solder geometry such as standoff height, contact angle, and so on, has the significant influence on the quality of solder joints such as their fatigue life. Thus, the prediction of shape evolution of solder joints in the reflow process is very important in electronic applications.

Recently, the simulations of free surface flow based on Lagrangian frameworks have become increasingly popular. As the transport effect represented by the advective rate of change in the fluid flow can be fully bypassed in a Lagrangian system, numerical diffusion traditionally observed in Eulerian methods is minimized in Lagrangian particle methods. Additionally, since Lagrangian particles move with the fluid flow, free surfaces or interfaces can be easily tracked by identifying boundary particles. In comparison to Eulerian methods such as Finite Difference Method (FDM) [7] and Finite Volume Method (FVM) [8], Lagrangian particle methods can solve the fluid flow problems involving more complex geometry and physics with less numerical difficulties.

Lagrangian particle methods are also popular in modeling solid problems [10][11]. Recently, the smoothed particle Galerkin (SPG) method [12][13] was developed to suppress the tensile instability and spurious zero-energy mode in standard Lagrangian particle methods for solid mechanic applications. Different from conventional penalty approaches [14] which utilized a direct smoothing of velocity fields and stabilization terms in the weak formulation, a momentum-consistent stabilization algorithm was developed for SPG to generate the smoothed velocity field for stabilization and yet to preserve the conservation of linear momentum for the fully discretized equations. Since no additional stabilization term is needed, the new algorithm demands only one integration point per particle in the computation, and thus is computational efficient. Those nice properties of SPG prompt the development of new formulation for the high accuracy and efficient simulation of fluid flow problems.

In this paper, a new SPG formulation for the simulation of incompressible fluid flows with free surfaces is presented. It is shown that the momentum-consistent stabilization algorithm in the SPG method can provide the desired numerical stability for the particle integration scheme in the flow simulation. Additionally, the moving-least square approximation with the 1st order basis is used for the spatial discretization, and the 2nd order rotational incremental pressure-correction scheme is employed to impose the incompressible condition. Those numerical schemes enhance the consistent modeling of spatial discretization and incompressible condition and guarantee the conservation of fluid volume though the reflow simulation. To further simulate the shape evolution of solder joints during reflow process, the surface tension based on the surface curvature and the treatment of wall adhesion with contact angles are also considered in our new algorithm. Two numerical examples are studied to validate the accuracy and stability of the proposed method.

2. Preliminary

2.1 Governing equations

In the Lagrangian description, the Navier-Stokes equation which is comprised of the pressure term, the viscosity term and the gravity term can be written as

$$\frac{D\boldsymbol{v}}{Dt} = -\frac{1}{\rho}\nabla p + \frac{\vartheta}{\rho}\nabla^2\boldsymbol{v} + \boldsymbol{g} \tag{1}$$

where $\boldsymbol{v}$, ρ, p are fluid velocity, density and pressure, respectively. ϑ is the dynamic viscosity, t denotes the time, and $\boldsymbol{g}$ is the gravity. The incompressible condition is enforced using the continuity equation by:

$$\nabla \cdot \boldsymbol{v} = 0 \tag{2}$$

2.2 Projection scheme for incompressible flows

In our study, the generalized the rotational incremental pressure-correction scheme proposed by Guermond et al. [15] is used. Firstly, the first derivative of velocity with respect of time is approximated by using the qth-order backward difference formula denoted by $\frac{1}{\Delta t}(\beta_q \boldsymbol{v}^{n+1} - \sum_{j=0}^{q}\beta_j \boldsymbol{v}^{n-j})$, where,

$\beta_j (j = 0, \cdots, q)$ are the coefficients, and in particular one has

$$\begin{cases} \beta_0 = -1.0, \beta_1 = 1.0, & \text{if } q = 1 \\ \beta_0 = 0.5, \beta_1 = -2.0, \beta_2 = 1.5, & \text{if } q = 2 \end{cases} \tag{3}$$

Then, the pressure-correction schemes can be generalized into the following form:

$$\begin{cases} \dfrac{1}{\Delta t}\left(\beta_q \boldsymbol{v}^{n+1^*} - \sum_{j=0}^{q-1} \beta_j \boldsymbol{v}^n \right) = -\dfrac{1}{\rho}\nabla p^* + \dfrac{\vartheta}{\rho}\nabla^2 \boldsymbol{v}^{n+1^*} + \boldsymbol{g}, \boldsymbol{v}^{n+1^*}|_{\Gamma_v} = \overline{\boldsymbol{v}} \\ \dfrac{\beta_q}{\Delta t}\left(\boldsymbol{v}^{n+1} - \boldsymbol{v}^{n+1^*}\right) = -\dfrac{1}{\rho}\nabla\left(p^{n+1} - p^* + \chi\vartheta\nabla\cdot\boldsymbol{v}^{n+1^*}\right) \end{cases} \tag{4}$$

where p^* is a generalized pressure prediction, e.g.

$$p^* = \begin{cases} 0 & (r = 0) \\ p^n & (r = 1) \\ 2p^n - p^{n-1} & (r = 2) \\ \cdots & (r = 3) \end{cases} \tag{5}$$

and $\chi = 0$ or 1 is a user defined parameter.
As remarked by Guermond et al. [15], if one chooses $r = q$ in the generalized rotational incremental pressure-correction scheme, the consistency error in H^1-norm and the pressure in L^2-norm are both of the same order. In our study, $r = q = 1$ is chosen, which is the 2nd order generalized rotational incremental pressure-correction scheme. Subsequently, in the first sub step of the 2nd order GRIPC scheme, we have

$$\frac{1}{\Delta t}\left(\boldsymbol{v}^{n+1^*} - \boldsymbol{v}^n\right) = -\frac{1}{\rho}\nabla p^n + \frac{\vartheta}{\rho}\nabla^2 \boldsymbol{v}^{n+1^*} + \boldsymbol{g}, \boldsymbol{v}^{n+1^*}|_{\Gamma_v} = \overline{\boldsymbol{v}} \tag{6}$$

In the second sub step of the 2nd GRIPC scheme, the velocities are corrected through the following equation

$$\frac{1}{\Delta t}\left(\boldsymbol{v}^{n+1} - \boldsymbol{v}^{n+1^*}\right) + \frac{1}{\rho}\nabla\phi^{n+1} = 0, \boldsymbol{v}^{n+1}|_{\Gamma_v} = \overline{\boldsymbol{v}} \tag{7}$$

where the variable ϕ is defined as

$$\phi^{n+1} = p^{n+1} - p^n + \vartheta\nabla\cdot\boldsymbol{v}^{n+1^*} \tag{8}$$

The corrected velocity in Eq. (**Error! Reference source not found.**) must satisfy the divergence-free condition, which yields the following Poisson equation,

$$\nabla\cdot\boldsymbol{v}^{n+1^*} = \frac{\Delta t}{\rho}\nabla^2\phi^{n+1} \tag{9}$$

From Eq. (**Error! Reference source not found.**), it's observed that the Neumann boundary condition $\nabla\phi^{n+1}\cdot\boldsymbol{n}|_{\Gamma_v} = 0$. The Dirichlet boundary condition at the free surface can be induced from Eq. (**Error! Reference source not found.**), that is

$$\left(\phi^{n+1} + p^n - \vartheta \nabla \cdot \boldsymbol{v}^{n+1^*}\right)|_{\Gamma_p} = p^{\mathrm{fs}} \tag{10}$$

where Γ_p is the free surface boundary, and p^{fs} is the pressure at the free surfaces.

2.2 Surface tension

The surface tension causes a pressure jump $\sigma_\kappa^{\mathrm{fs}}$ at the interface between the liquid solder and air proportional to the mean curvature of the interface

$$\sigma_\kappa^{\mathrm{fs}} = \gamma\kappa \tag{11}$$

where γ is the surface tension coefficient, and $\kappa = -\nabla \cdot \boldsymbol{n}$ is the mean curvature, and $\boldsymbol{n}$ is the inward norm direction of the liquid solder surface. Subsequently, the pressure term applied at the essential pressure boundary condition can be calculated as

$$p^{\mathrm{fs}} = p^{\mathrm{air}} + \sigma_\kappa^{\mathrm{fs}} \tag{12}$$

2.3 Wall adhesion

When molten solder is in contact with the substrate, the solder liquid interface forms a contact angle θ with the wall boundary. If the angle θ is equal to static contact angle θ_{eq}, a state of static equilibrium is reached. If not, then a nonzero wall adhesion force tends to pull the interface to the equilibrium position. In our algorithm, the wall adhesion boundary condition can be expressed by the unit free surface normal $\boldsymbol{n}$ at the interface point $\boldsymbol{x}_{\mathrm{w}}$ shown in Figure 1

$$\boldsymbol{n}(\boldsymbol{x}_{\mathrm{w}}) = \boldsymbol{n}_{\mathrm{w}} \cos\left(\theta_{\mathrm{eq}}\right) + \boldsymbol{t}_{\mathrm{w}} \sin\left(\theta_{\mathrm{eq}}\right) \tag{13}$$

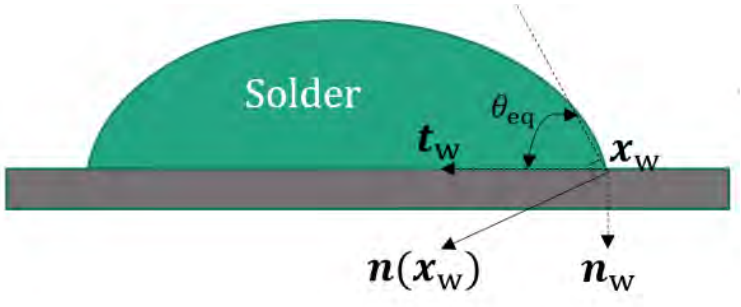


Figure 1. Illustration of the wall adhesion.

3. LS-DYNA keyword of ISPG

ISPG has been implemented in LS-DYNA as a new 3D element formulation (#49) in the keyword *SECTION_FPD for the semi-implicit dynamic analysis. In other words, ISPG solves the pressure equation implicitly while the velocity field is computed explicitly as that in SPG. The numerical advantages of utilizing semi-implicit analysis for the fully incompressible flow problem are the high accuracy and efficiency in which the numerical diffusion is improved, and critical time steps do not drop abruptly by implicitly solving the pressure equation. Because the momentum equations are well-preserved and the fully incompressible condition is met in the Navier-Stokes equation, the ISPG method is very suitable to simulate free surface flow problems. The ISPG nodes are automatically converted from those of the user's FEM model (8-noded solid element). The input deck of *SECTION_FPD for card 2 and card 3 is described as follows:

Card 2	**DX**	**DY**	**DZ**	ISPLINE	**KERNEL**	BOX	SMSTEP	SSTYPE
	1.8	1.8	1.8	0	0			
Card 3	**MCVISC**	VMAX						
	0.1							

DX,DY,DZ Normalized dilation parameters of the kernel function in X,Y and Z directions, the recommended range in ISPG is 1.4-1.8

KERNEL Kernel type. KERNEL=0 Updated Lagrangian (UL) kernel. Currently, only UL kernel is supported.

MCVISC Relaxation parameter to control the numerical dissipation used in Eq. (**Error! Reference source not found.**). Recommended range 0-1

The material property of the fluid in ISPG is defined with the keyword *MAT_IFPD, the card 1 is described as follows:

Card 1	**MID**	**RO**	**DYNVIS**	**SURFTEN**				
	1	**1.8**	**1.8**	**0**				

RO Fluid density

DYNVIS Dynamic viscosity of the fluid

SURFTEN Surface tension coefficient

The contact between fluid and solid is defined with the keyword *DEFINE_FP_TO_SURFACE_COUPLING, the card 1 and 2 are described as follows:

Card 1	**SLAVE**	**MASTER**	**STYPE**	**MTYPE**				
	1	**1**	**1**	**0**				
Card 2	**SBC**	**SCA**				**SFP**		
	0	**0.5**				**0.1**		

SLAVE	Slave part ID
MASTER	Master segment set ID
STYPE	Slave type, currently only **STYPE=1 (**slave part**)** is supported.
MTYPE	Master type, currently only **MTYPE=0** (segment set) is supported
SBC	Type of boundary condition. **SBC=0**, free-slip boundary; **SBC=1**, non-slip boundary.
SCA	Static (equilibrium) contact angle
SFP	Stiffness coefficient along the normal direction of the contact interface. **SFP<1.0**

4. Numerical Example

The following two examples are solved with the Beta version of LS-DYNA® [19].

4.1 Shape prediction of solder joint with fixed contact angles

In this example, the shape evolution of a cubic solder is simulated, and its final size is compared with the analytical solution. The original size of the cubic solder is $1mm \times 1mm \times 1mm$. The density and surface tension of the solder are $8.93 \times 10^{-6} g/mm^3$ and $4.985 \times 10^{-6} kN/mm$, respectively. The solder is discretized with 11 nodes in every direction shown in Figure 2, which leads to a model having a total of 1331 particles. For the contact between solder and pad, the free-slip boundary condition is applied. Two equilibrium contact angles $\pi/6$ and $\pi/3$ are used separately for the simulation. No gravity is considered in this study, and the total simulation time is 100ms.

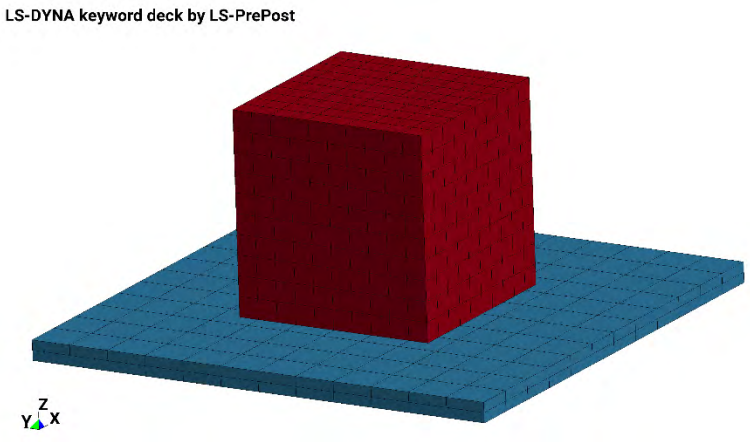
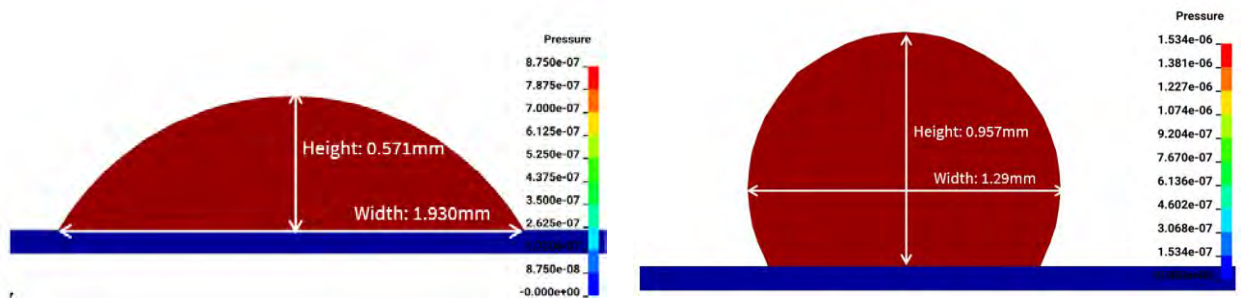


Figure 2. Discretization of the solder and pad

Figure 3 **a** and **b** give the final equilibrium configuration of the solder with the equilibrium contact angles $\pi/6$ and $\pi/3$, respectively. The comparison of final height and width is summarized in Table 1 and Table 2. The difference between the predicted size and the analytical solution is smaller than 5%, despite a very coarse resolution is used in our simulations.



a **b**

Figure 3. Mesh section view of the final equilibrium configuration of the solder. **a**, result with equilibrium static angle $\pi/6$; **b**, result with equilibrium static angle $\pi/3$

Table 1. Final solder geometry with equilibrium contact angle $\pi/6$

	Analytical [mm]	ISPG predicted [mm]	Difference
Height	0.576	0.571	0.87%
Width	1.995	1.930	3.26%

Table 2. Final solder geometry with equilibrium contact angle $\pi/3$

	Analytical [mm]	ISPG predicted [mm]	Difference
Height	0.985	0.957	2.84%
Width	1.313	1.290	1.17%

4.2 Prediction of the standoff height and width of the solder joints on BGA

The standoff height and the maximum width of the solder joints are very important in the design process, because they affect significantly the fatigue life of solder joints. In general, the standoff height and the maximum width of solder joints are related to the change of solder volume. In this study, different volumes of the solder are simulated, and the predicted standoff height and maximum with are compared with the experimental result. The solder pad and solder mask are shown in Figure 4. The material of solder pad is Ni-Au and the mask is made of epoxy. The equilibrium contact angles of the molten solder formed on the solder pad and mask are 5° and 148°, respectively. Five different volumes of solder are used for the simulations, and they are $0.0141mm^3, 0.0564mm^3, 0.1077mm^3, 0.1218mm^3$ and $0.2298mm^3$. The solders are discretized with 1365, 2299, 4389, 3355 and 3742 particles, respectively. The density and surface tension of the solder are $8.93 \times 10^{-6} g/mm^3$, $4.985 \times 10^{-6} kN/mm$, respectively. The gravity is $9.81 \times 10^{-3} mm/ms^3$.

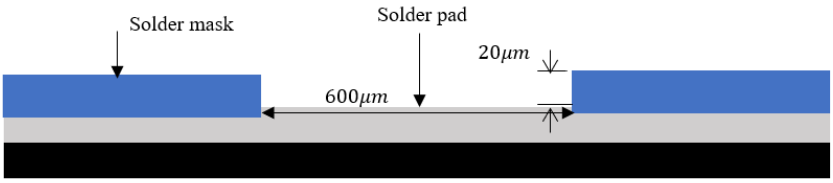
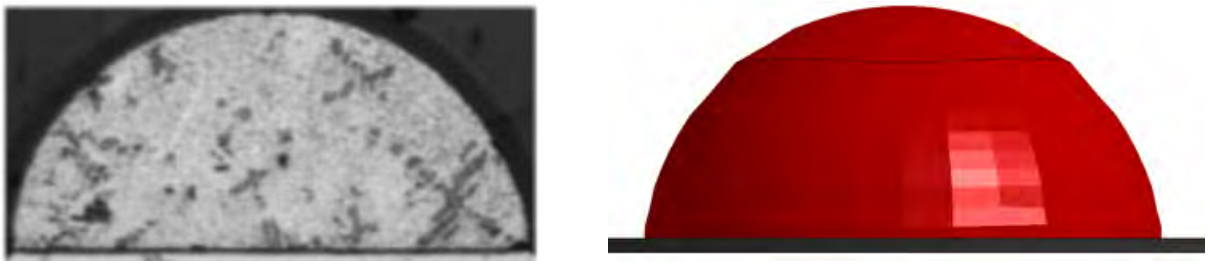


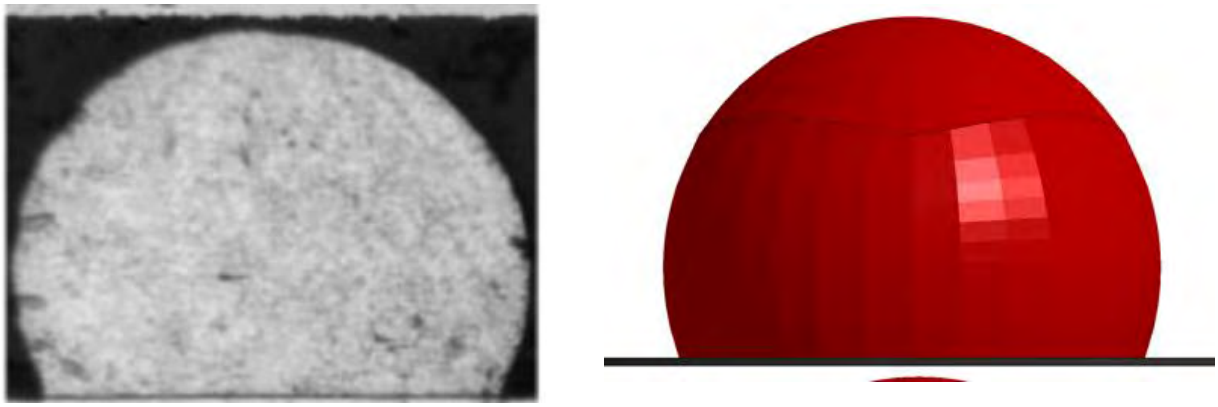
Figure 4. The cross section of BGA substrate.

Figure 5 compares the cross sections of solder joints between experimental observations [6] and simulation results. In general, they agree very well with each other. As shown in Figure 5, the contact angle formed in solder pads increases with the increase of solder volume.

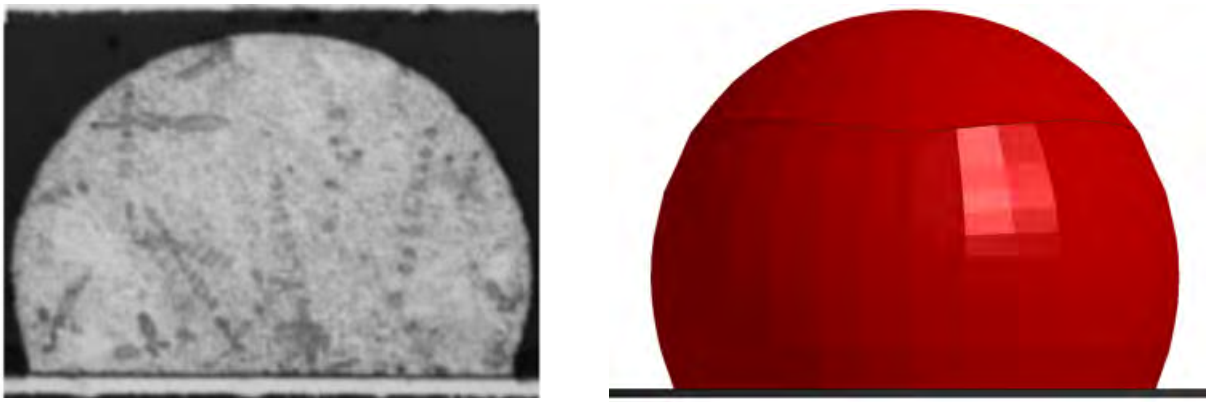
a, volume = $0.0141mm^3$



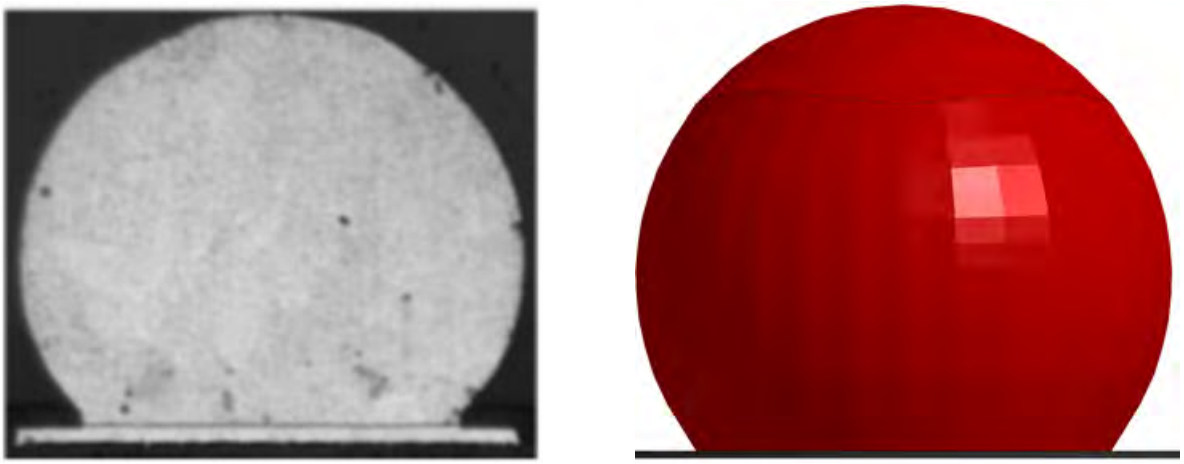
b, volume = $0.0564mm^3$



c, volume = $0.1077mm^3$



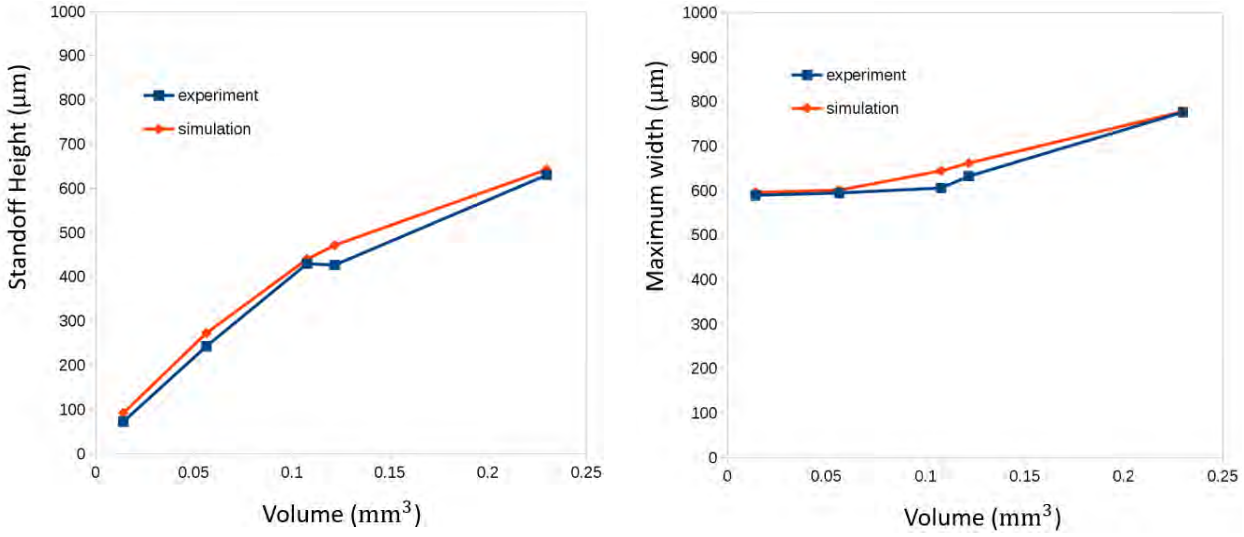
d, volume = $0.1218mm^3$



e, volume = $0.2298mm^3$

Figure 5. Comparison on the cross sections of the solder joints between the experimental observations and the simulation results. Left: experimental observations; right: simulation

Figure 6 compares the simulated standoff height and the maximum width of the solder joints between the simulated results and the experimental measurements [6], and the results match very well. `



a, standoff height vs. solder volume

b, maximum width vs. solder volume

Figure 6. Comparison of the standoff height and maximum width of the solder joints with experimental data.

5. Conclusions

In this paper, an incompressible smoothed particle Galerkin (ISPG) is developed for the simulation of shape evolution of solder joints in the reflowing process. Shape prediction with fixed contact angles shows that there is little difference between our simulated results and the analytical solution, which verifies that our method is very accurate. The prediction of the standoff height and the maximum width of solder joins on BGA shows that our simulation results agree with the experimental observation.

It is important to note that ISPG is not limited to the simulation of reflow problems. As a matter of fact, ISPG is a very promising method in the simulation of violent free surface fluid flows. Several numerical examples including liquid sloshing with large free surface deformation and dam breaking have been studied to demonstrate the accuracy and stability of the ISPG method in solving 2D fluid flow problems [18]. The application to three-dimensional free surface and thermal fluid flow problems will be presented in the near future.

Acknowledgements

The authors wish to thank Dr. John O. Hallquist of LSTC for his support to this research.

References

[1] Chiang KN, Yuan CA (2001) An Overview of Solder Bump Shape Prediction Algorithm with Validations. IEEE TRANSACTIONS ON ADVANCED PACKAGING 24:158-162

[2] Chiang KN, Chen WL (1998) Electronic packaging reflow shapes prediction for the solder mask defined ball grid array. Journal of Electronic Packaging 120:175–178.

[3] Heinrich SM, Liedtke PE, Nigro N J, Elkouh A F, Lee P S (1993) Effect of chip and pad geometry on solder joint formation in SMT. Journal of Electronic Packaging 115:433–439.

[4] Heinrich SM, Schaefer M, Schroeder S A, Lee P S (1996) Prediction of solder joint geometries in array-type interconnects. Journal of Electronic Packaging 118:114–121.

[5] Brakke KA (1994) Surface Evolver Manual, version 1.95. Minneapolis, MN: The Geometry Center.

[6] Chou YY, Chang HJ, Kuo JH, Hwang WS (2006) The simulation of shape evolution of solder joints during reflow process and its experimental validation. Materials Transactions 47(4):1186-1192.

[7] Smith G (1985) Numerical solution of partial differential equations: finite different methods. Oxford applied Mathematics and computing science series. Clarendon Press, Oxford.

[8] Versteeg H, Malalasekera W (2007) An introduction to computational fluid dynamics: the finite volume method. Pearson Education Limited, Singapore.

[9] Gingold RA, Monaghan JJ (1977) Smoothed particle hydrodynamics – Theory and application to non-spherical stars. Monthly Notices of the Royal Astronomical Society 181:375-389.

[10] Wu CT, Wu Y, Crawford JE, Magallanes JM (2017) Three-dimensional concrete impact and penetration simulations using the smoothed particle Galerkin method. International Journal of Impact Engineering 106:1-17.

[11] Wu CT, Bui TQ, Wu Y, Luo TL, Wang M, Liao CC, Chen PY, Lai YS (2018) Numerical and experimental validation of a particle Galerkin method for metal grinding simulation. Computational Mechanics 58:391-409.

[12] Pan X, Wu CT, Hu W, Wu Y (2019) A momentum-consistent stabilization algorithm for Lagrangian particle methods in the thermo-mechanical friction drilling analysis. Computational Mechanics 64(3):625-644.

[13] Wu CT, Wu Y, Lyu D, Pan X, Hu W (2019) The momentum-consistent smoothed particle Galerkin (MC-SPG) method for simulating the extreme thread forming in the flow drill screw-driving process. Computational Particle Mechanics. https://doi.org/10.1007/s40571-019-00235-2.

[14] Wu CT, Chi SW, Koishi M, Wu Y (2016) Strain gradient stabilization with dual stress points for the meshfree nodal integration method in inelastic analysis. International Journal for Numerical Methods in Engineering 107:3-30.

[15] Guermond JL, Minev P, Shen J (2006) An overview of projection methods for incompressible flows. Computational Methods in Applied Mechanics and Engineering 195:6011-6045.

[16] Belytschko T, Lu YY, Gu L (1994) Element-free Galerkin methods. International Journal for Numerical Methods in Engineering 37:229-256.

[17] Beissel S, Belytschko T (1996) Nodal integration of the element-free Galerkin method. Computational Methods in Applied Mechanics and Engineering 139:49-74.

[18] Pan X, Wu CT, Hu W (2019) An incompressible smoothed particle Galerkin formulation for free surface fluid flow simulations. Submitted to Journal of Computational Physics.

[19] Hallquist JO (2019) LS-DYNA® Keyword User's Manual, Livermore Software Technology Corporation, Livermore, California.

BETA
SIMULATION SOLUTIONS

BETA CAE Systems. www.beta-cae.com

BETA CAE Systems - ANSA

An advanced multidisciplinary CAE pre-processing tool that provides all the necessary functionality for full-model build up, from CAD data to ready-to-run solver input file, in a single integrated environment. ANSA is a full product modeler for LS-DYNA, with integrated Data Management and Process Automation. ANSA can also be directly coupled with LS-OPT of LST, an ANSYS company to provide an integrated solution in the field of optimization.

BETA CAE Systems μETA

Is a multi-purpose post-processor meeting diverging needs from various CAE disciplines. It owes its success to its impressive performance, innovative features and capabilities of interaction between animations, plots, videos, reports and other objects. It offers extensive support and handling of LS-DYNA 2D and 3D results, including those compressed with SCAI's FEMZIP software.

Solutions for:

Process Automation - Data Management – Meshing – Durability - Crash & Safety NVH - CFD - Thermal analysis - Optimization - Powertrain
Products made of composite materials - Analysis Tools -
Maritime and Offshore Design - Aerospace engineering - Biomechanics

ETA – Engineering Technology Associates www.eta.com
etainfo@eta.com

Inventium Suite™

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

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

PreSys

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

VPG

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

DYNAFORM

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

ESI Group www.esi-group.com

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

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

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

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

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

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

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

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

HYCRASH

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

JSTAMP/NV

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

JMAG

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

LST

Livermore Software Technology, an ANSYS Company
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 LST, an ANSYS company. 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.

LST, AN ANSYS COMPANY 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.

LST, AN ANSYS COMPANY Barrier Models

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

Material Sciences Corporation www.materials-sciences.com

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

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

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

MSC/LS-DYNA Composite Software and Database -

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

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

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

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

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

Oasys PRIMER

Key benefits:

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

www.oasys-software.com/dyna

Oasys D3PLOT

Key benefits:

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

www.predictiveengineering.com

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

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

Our History

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

恒士达科技
Hengstar Tech.

Shanghai Hengstar www.hengstar.com

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

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

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

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

Consulting

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

Cloud - HPC Services - Subscription JSOL

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

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

JSOL Corporation is cooperating with chosen cloud computing services

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

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

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

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

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

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

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

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

Platform Computation Cloud - CreDist.Inc.

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

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

Cloud - HPC Services - Subscription RESCALE

www.rescale.com

Rescale: Cloud Simulation Platform

The Power of Simulation Innovation

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

Using the power of cloud technology combined with LS-DYNA allows you to:

- Accelerate complex simulations and fully explore the design space
- Optimize the analysis process with hourly software and hardware resources
- Leverage agile IT resources to provide flexibility and scalability

True On-Demand, Global Infrastructure

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

Rescale has strategic/technology partnerships with infrastructure and software providers to offer the following:

- Largest global hardware footprint – GPUs, Xeon Phi, InfiniBand
- Customizable configurations to meet every simulation demand
- Worldwide resource access provides industry-leading tools to every team
- Pay-per-use business model means you only pay for the resources you use
- True on-demand resources – no more queues

ScaleX Enterprise: Transform IT, Empower Engineers, Unleash Innovation

The ScaleX Enterprise simulation platform provides scalability and flexibility to companies while offering enterprise IT and management teams the opportunity to expand and empower their organizations.

Rescale Cloud Simulation Platform

www.rescale.com

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

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

Industry-Leading Security

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

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

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

LSTC - DYNAmore GmbH JSOL Corporation

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

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

ESI Cloud Based Virtual Engineering Solutions

www.esi-group.com

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

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

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

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

Virtual Performance Solution:

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

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

The benefits of VPS hybrid on ESI Cloud include:

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

VPS On Demand

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

Key solution capabilities:

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

Result visualization

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

Key result visualization capabilities:

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

Collaboration

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

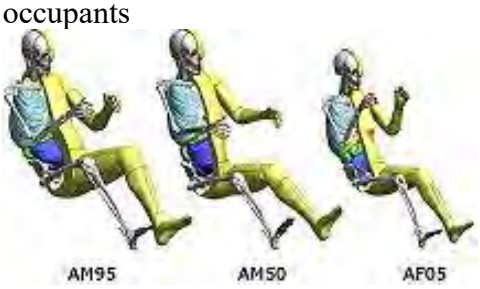
Key collaboration capabilities:

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

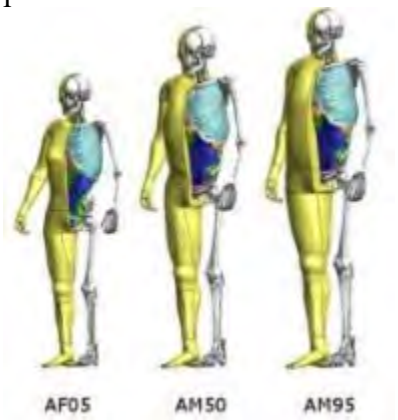
TOYOTA - Total Human Model for Safety – THUMS

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.

LST, An ANSYS Company – Dummy Models

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

LST, An ANSYS Company – 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.

Social Media

FACEBOOK

BETA CAE Systems
CADFEM
ESI Group

TWITTER

BETA CAE Systems
ESI Group
ETA
CADFEM

LINKEDIN

BETA CAE Systems
CADFEM
DYNAmore Nordic
ETA
ESI Group

YOUTUBE

YOUTUBE Channel	WebSite URL
BETA CAE Systems	www.beta-cae.com
CADFEM	www.cadfem.de
ESI Group	www.esi-group.com
ETA	www.eta.com
Lancemore	www.lancemore.jp/index_en.html

GOOGLE+

BETA CAE Systems