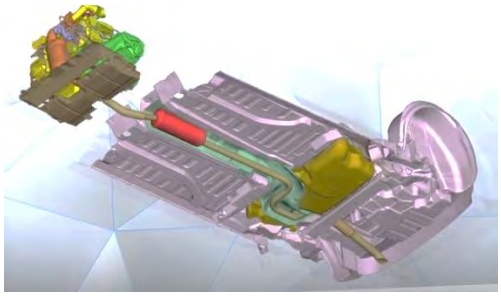
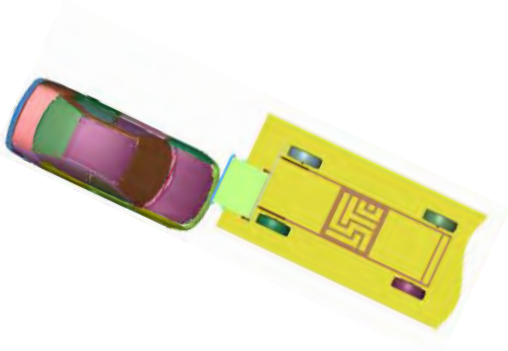
Volume 8, Issue 9, September 2019

www.lstc.com http://dalianfukun.com www.feapublications.com

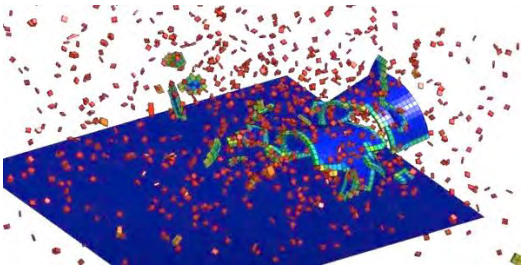
BETA CAE



d3VIEW



FEANTM



OASYS

1st French LS-DYNA User Forum 2019

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.

LSTC - Livermore Software Technology Corp.

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

www.lstc.com

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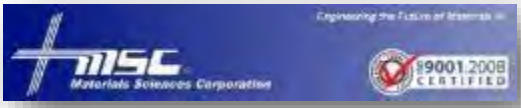
If you have any questions, suggestions or recommended changes, please contact us.

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

Platinum Particpants



Platinum Particpants

Table of contents

Announcements

ANSYS and LS-DYNA Creator Livermore Software Technology Corporation Sign Definitive Acquisition Agreement

NEWS PROVIDED BY ANSYS, Inc Sep 11, 2019, 18:39 ET

PITTSBURGH, Sept. 11, 2019 /PRNewswire/ -- ANSYS (NASDAQ: ANSS), the global leader and innovator of engineering simulation software, announced today that it has entered into a definitive agreement to acquire Livermore Software Technology Corporation (LSTC), the premier provider of explicit dynamics and other advanced finite element analysis technology. Once closed, the acquisition will empower ANSYS customers to solve a new class of engineering challenges, including developing safer automobiles, aircraft and trains while reducing or even eliminating the need for costly physical testing. Read more

"As an ANSYS partner for nearly 25 years, I am excited to formally join ANSYS and contribute to their place as the leader in engineering simulations," said John O. Hallquist, founder and CEO of LSTC. "ANSYS is the perfect home for LSTC's world-class team of scientists, mathematicians and engineers to continue advancing state-of-the-art, scalable and fully coupled, multiphysics computations. The ANSYS Workbench platform provides their customers with access to a uniquely broad portfolio of simulation technologies packaged into a user-friendly interface that is the envy of the industry. I expect that the combination of Workbench and LS-DYNA will expand our user base by at least an order of magnitude. Here at LSTC, nothing makes all of us happier than when our research enables more customers to imagine, design and implement ambitious projects that were previously impossible."

1st French LS-DYNA User Forum 2019

15th October 2019, Versailles, France

DYNAmore is pleased to organize the first LS-DYNA French User Forum. The event will take place on October 15, 2019 from 9am to 5pm in DYNAmore offices in Versailles.

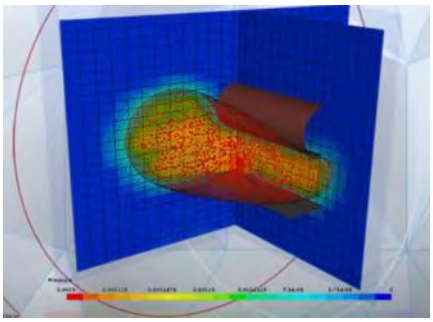
Contact: charlotte.keisser@dynamore.eu **More information:** www.dynamore.eu

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

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

Conference Website: conference.lsdyna-china.com/

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



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

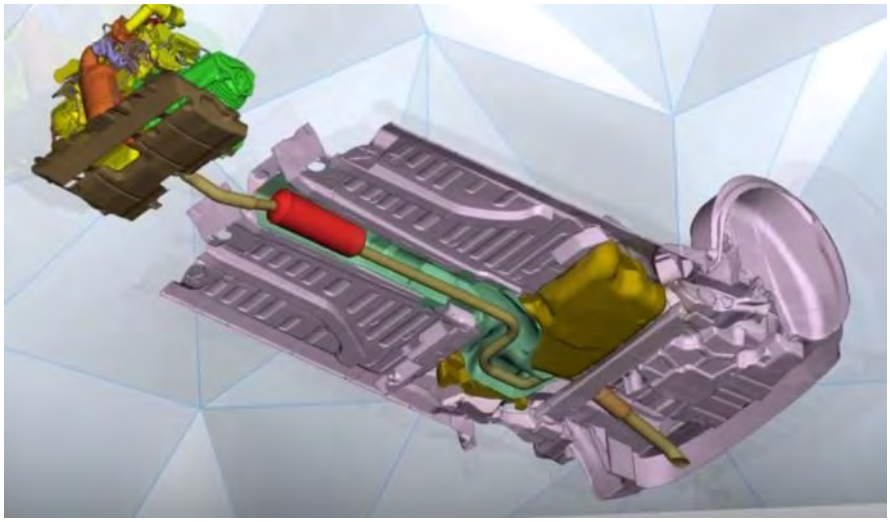
BETA CAE Systems International AG; Platz 4, 6039 Root D4, Switzerland

About this release:

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

Do not miss:

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



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

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

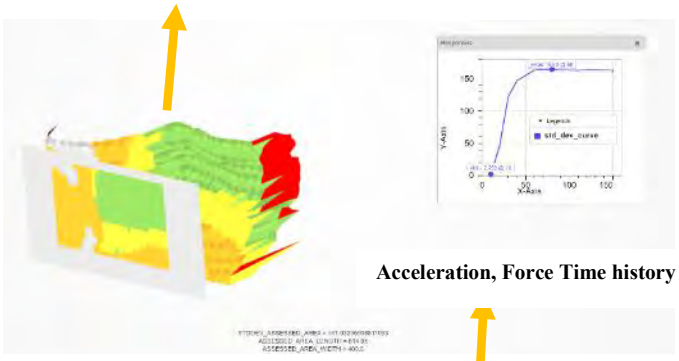
d3VIEW® Automated M-PDB Post Processing Template for Assessment

MPDB Barrier Assessment

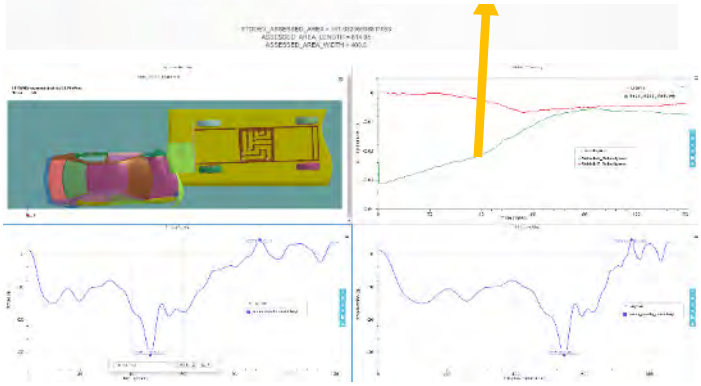
The M-PDB barrier (mobile progressive deformable barrier – Euro NCAP V1.1 TB022) is used by car manufacturers and test laboratories worldwide for the assessment of motor vehicle passenger protection in offset frontal impact test procedure according to 2020 European New Car Assessment Programme (Euro NCAP).

The frontal offset impact replicates a collision with another vehicle. In this test, 50% of the test vehicle, on the driver's side, initially makes contact with a crushable aluminum honeycomb barrier at the impact speed of 50 kph for both: test vehicle & M-PDB barrier mounted on trolley.

Built-in 3D Visualizer using Peacock3D



Acceleration, Force Time history



Automated Post Processing for M-PDB using d3VIEW

Using a Neon model and the LSTC M-PDB Barrier setup d3VIEW has been able to automate the parameters required to asses the vehicle performance in an M-PDB test scenario as well as scan and evaluate the barrier deformation to assess the vehicles sensitivity to nonstandard crash scenarios.

The scanned deformed barrier is assessed for indentation and the results stored in a proprietary 3d format to analyze and visualize. The vehicle performance parameters: Pulse, A-D Curve and OLC are then reported using the d3VIEW data visualizer SIMLYTIKS to complete a comprehensive Assessment package.

Author: Christian Frech christian.frech@dynamore.de

New look of service and support websites

The Service and Support Websites

In cooperation with LSTC, DYNAmore offers service and support websites on the web. The design of these websites has been redone and the new look is now online. We are pleased if you will use our services on the web.

www.dynasupport.com

- LS-DYNA support site
- Tutorials, release notes
- FAQs, HowTo´s

www.dynaexamples.com

- Comprehensive collection of examples of various LS-DYNA training seminars
- Images, animations, LS-DYNA input decks

www.dummymodels.com

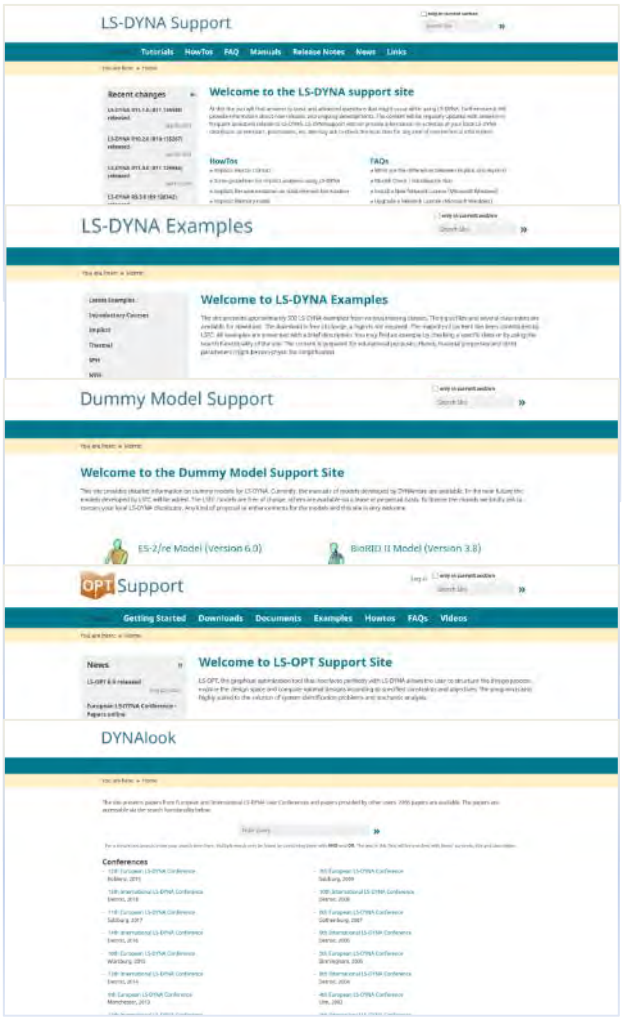
- Technical information about LS-DYNA dummy models

www.lsoptsupport.com

- LS-OPT support site
- Examples, documents
- FAQs, HowTo´s

www.dynalook.com

- More than 2,000 technical LS-DYNA papers to download



Author: Christian Frech christian.frech@dynamore.de

Register now!

1st French LS-DYNA User Forum 2019

15th October 2019, Versailles, France

Invitation

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

Free of charge!

Preliminary agenda

- 9:00 am: Welcome
- 9:15 am: Introduction
- 9:30 – 11:15: LS-DYNA user presentations
- 11:15 - 11:45: Break
- 11:45 – 12:45: DYNAmore France presentations
- 12:45 - 14:00: Lunch
- 14:00 – 15:45: LS-DYNA user presentations
- 15:45 – 16:15: Break
- 16:15 – 17:00: DYNAmore France presentations

Venue

DYNAmore France SAS
21 avenue de Paris
78000, Versailles

Registration

If you like to attend please register here.

Contact

charlotte.keisser@dynamore.eu

More information

www.dynamore.eu

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

VPS User Conference 2019

In October 2019, Czech Republic will be once again the place where the VPS community comes together. You will have again the opportunity to get an objective overview of many different applications of new version of Virtual Performance Solution.

Highlights of VPS User Conference:

new features of VPS 2019
latest innovations within Visual Environment
recent updates from crash & safety, NVH & interior acoustics
application of our software in everyday life, including advanced simulation methods and usage in engineer practise
discussions and experience sharing between VPS users
interactions with ESI product managers specializing in VPS and NVH

Who should attend:

users of Virtual Performance Solution
potential users, who would like to find out more about VPS application
experts but also beginners within crash testes modelling
all industries are welcomed
The language of this meeting will be Czech & English.

Call for Users Presentations

We encourage the attendees to submit abstract on VPS industrial deployment, optimization and unique applications.

Share your experiences with VPS and discuss best practises! Send your abstracts to Info.MecasESI@esi-group.com in Czech or in English language.

Your presentation will be provided together with all other materials to all attendees. The user presentation should last max. 15 mins (including the discussion). Don´t forget – participants with user presentation will be advantaged by lower registration fee.

Abstract sending deadline: 10.9. 2019 Full presentation sending deadline: 24.9. 2019

Website

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.

ETA Celebrates the Release of DYNAFORM 6.0

ETA celebrated the highly anticipated release of their flagship software, DYNAFORM version 6.0 on Tuesday, August 6th at Automation Alley in Troy, Michigan. ETA's President, Akbar Farahani opened the event with a glance inside ETA's software line-up and his vision for their future product landscape. This was followed by insightful keynotes from ETA's DYNAFORM partners, Dr. Li Zhang; LSTC, Peter Vogel; DYNAmore Germany and Eric Bragg; TST Software Technology.
The release event highlighted all of the new features and improvements that DYNAFORM 6.0 has to offer, such as:

- An Intuitive and Streamlined Interface
- Simulation Data Manager
- Customized Icon Grouping for Drop-down Menu Functions
- Minimum Geometry and Elements Operations
- New Material Library Window
- PowerPoint and Excel Based Automatic Formability Report Generation
  and much more!

In addition to the exciting improvements, the DYNAFORM team presented live demos and engaged in networking sessions with clients, global suppliers and OEM's.

ETA's Technology Roadshow Heads to Asia

The ETA team plans to head overseas this fall to present their latest technology and perform on-site training for their extensive lineup of software products – DYNAFORM 6.0, ACP OpDesign, VPG-Suite and ETA's AI/ML solutions. The roadshow will kick off in October at the LS-DYNA Conference in China and make its way through Korea and Japan before concluding in India.

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.

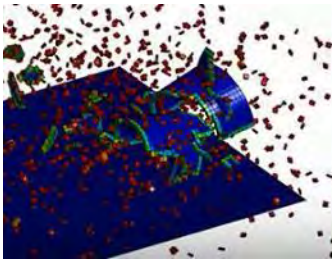
Start your Monday with coffee or tea reading our engineering blog, at the FEA Not To Miss coffee shop.
Postings every Monday on what you have missed

www.feantm.com

Monday 09/16/2019 -First, we updated the profile page. AND we have a new blend ANSYS/LSTC or JOH-AJ blend for a coffee of a great mix. All be calm, since it is really a good flavor!

In this case, using a sample helmet mesh, Dilip Bhalsod of LSTC used that helmet mesh with some standard LSTC automotive dummy models to create **a proof-of-concept collision between two football players.**

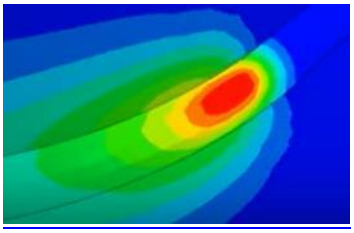
Monday 09/09/2019 Below is why I don't use glass coffee cups. SPLAT and what a waste of my coffee! Of course they are prettier then paper and you do save a tree not using paper BUT the fallout? NOPE, you get a paper to go cup with your Vanilla Mocha Cinammon Coffee and off to YouTube we go!



Simulation of glass falling to the floor in the LS-DYNA

LS-DYNA Demo License mv@feainformation.com

Monday 09/02/2019 - Below is Thermal by Yuri Novozilov. Which reminds me WHERE is Art Shapiro, you ask? Retired and OH yes, Art is my brother so I know where he is. WHAT? You never knew I'm related to Art! Now, if you need to contact him you can write to feaanswer@aol.com and just make the subject line Give to Art so he knows it's his. I am trying to get him back here to blog!



Thermal part of welding simplest simulation in LS-DYNA

LS-DYNA Demo License mv@feainformation.com

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

Shanghai Hengstar & Enhu Technology

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

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

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

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

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

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

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

Shanghai Hengstar Technology Co., Ltd

hongsheng@hengstar.com

http://www.hengstar.com

Shanghai Enhu Technology Co., Ltd

http://www.enhu.com

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

JSOL CAE Forum 2019

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

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

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

JSOL Corporation

Engineering Technology Division

JSOL CAE Forum Website

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

Interface for LS-DYNA supports large-deformation simulation

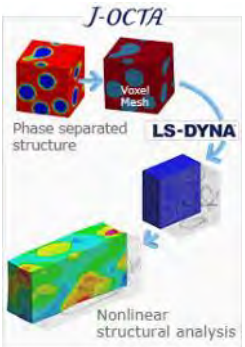
Recently, it is in high demand to estimate and evaluate the behavior during large deformation of micro-structured composites which contain phase separation and filler, by performing simulations.

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

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

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

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



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

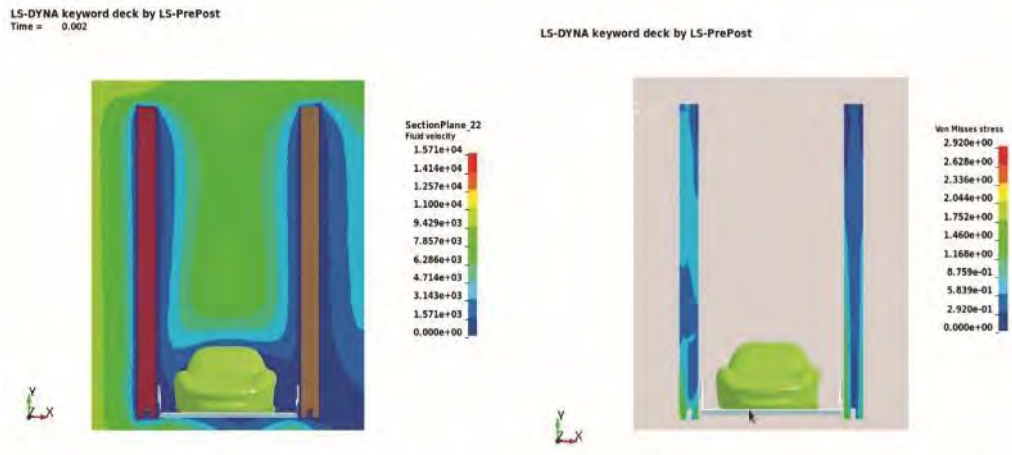
KAIZENAT
Keep Improving

Is this happened because of the heavy wind which blows at 70 mph this June?

"Oh!... Yes, I have seen this image on the Bulletin.

Then what about the car parking structure which I have designed?

Let's do the CFD analysis for my design using LS-DYNA.

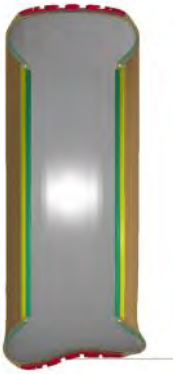


To know more about the simulation, please contact support@kaizenat.com

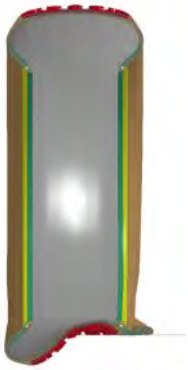
A team of engineers, mathematicians, & computer scientists develop LS-DYNA, LS-PrePost, LS-OPT, LS-TaSC, and LSTC's Dummy & Barrier models.

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

case1_static_flat_P235_55_R19.k
In this case, the Tire is first inflated which is followed by compression of the Tire using prescribed motion of a flat rigid plate

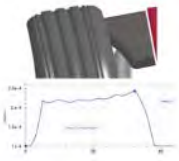


case2_static_flat_offset_P235_55_R19
In this case, the Tire is first inflated which is followed compression of the Tire using a prescribed motion of a flat rigid plate that is offset by 50%



case3_dynamic_iv_P235_55_R19.k
In this case, the Tire is first inflated which is followed by initial velocity of the Tire to impact a flat rigid plate. The wheel has lumped mass to increase the kinetic energy

Three new sample cases added now available in the Tire Files



Visit www.lstc.com or Email atds@lstc.com for more information

LS-DYNA® in Stamping Applications

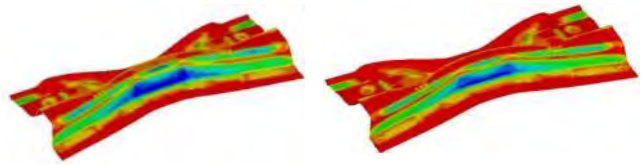
For more than three decades, the usage of LS-DYNA® in the simulation of sheet metal stamping has been steadily increasing with a reputation for prediction accuracy. During this period, state-of-the art constitutive models were added for simulating high strength steel and aluminum alloys now commonly used in the automotive industry. In addition, the much improved robustness, speed, and accuracy of the implicit solver has resulted in gravity loading, binder wrap, and springback calculations becoming routine. Die face compensation calculations in LS-DYNA® save money and time by eliminating the trial and error in die manufacturing. Many original and unique ideas are implemented to ensure reliable stamping simulations, which make LS-DYNA® an excellent choice for this manufacturing process.

Typical Applications:

- Sheet metal gravity loading, binder closing, deep-drawing (shells/solids)
- Springback prediction, and springback compensation (shells/solids)
- Trimming and lancing (shell/solids)
- Flanging and hemming
- Hydro-forming
- Magnetic forming and thermal forming
- Superplastic forming
- Denting
- Scrap trim and fall simulation
- Panel transfer in stamping press
- One-Step simulation for woven carbon fiber composite
- Roll forming

Features:

- Mesh adaptivity
- Advanced material models for aluminum alloy and high strength steels
- Smooth contact to minimize contact noise
- One-step fast forming method
- Un-flanging method in trimming curve development
- Parametric input
- Solid element results mapping
- Formability Index: more reliable forming limit prediction for non-linear strain path
- Carbon fiber: predict fiber orientations in the final part and initial blank size corresponding certain fiber orientation

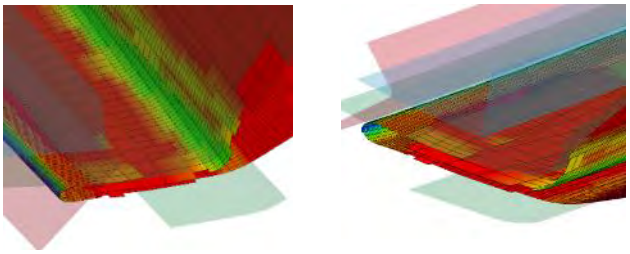


(a) Incremental solution (b) One-step result

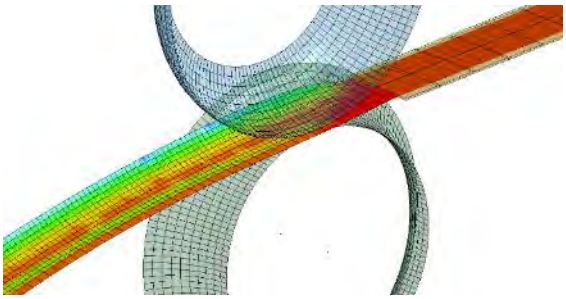
One step result vs. incremental result

(a) Before un-flanging (b) After un-flanging

Accurate un-flanging simulation for trimming curve development



Press hemming simulation



Roll forming simulation

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

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

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

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

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

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

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

Description:

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

Topics Covered in this Short Course:

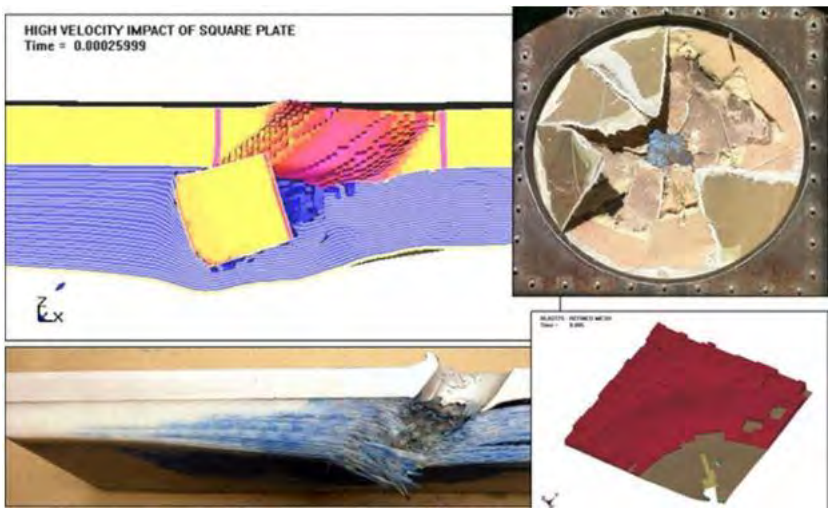
- Impact and Damage Modeling of Composites
  Application of MAT162 in Engineering and Research Problems
- Introduction to Composite Mechanics
  Introduction to Continuum Mechanics and Composite Mechanics

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

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

Engineering Services

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



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

17th Annual UK

Oasys LS-DYNA Users' Meeting

- 30th March 2020

We are pleased to announce that we will be hosting the 17th Annual UK Oasys LS-DYNA Users' Meeting on Monday 30th March 2020 at Ashorne Hill Conference Centre, Warwick.

Please be sure to hold this date for our conference which brings together over 100 UK users of the Oasys and LS-DYNA software. The day promises to provide information on the upcoming release of Oasys Suite 17.0 and LS-DYNA features, as well as enabling you to learn more about current and new applications.

Registration for attendance will be open in due course.

New Barrier Released

MPDB – Shell Model

Mobile Offset Progressive Deformable Barrier for frontal impact

In collaboration with Cellbond, Arup has developed a range of LS-DYNA finite element models based on the aluminum honeycomb barriers produced by Cellbond.

Our new MPDB Shell Model has been developed to take advantage of the latest developments in the LS-DYNA code and is designed to provide robust and efficient analysis.

To obtain this barrier model or for more information about a trial license contact dyna.support@arup.com or visit Oasys LS-DYNA website here.

Oasys Academic License for UK-based students

Access for students: The Oasys Suite is at the leading edge of pre- and post-processing software, enabling LS-DYNA users to prepare and comprehensively check their models, then visualize, process and report on the results.

To support you in becoming familiar with these tools, we are pleased to offer UK-based students limited licenses for LS-DYNA and the Oasys Suite.

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

For more information click here**.**

Webinars

Oasys and LS-DYNA team offers several free webinars

These are delivered by our software experts and provide opportunity to listen and ask questions from the comfort of your own desk.

Next two upcoming webinars are:

- 8th October 2019 - Oasys PRIMER: renumbering tools
- 6th November 2019 - Oasys FAST-TCF: an introduction

To view past and future webinars click here.

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

FINITE ELEMENT ANALYSIS
Predictive Engineering

Who We Are

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

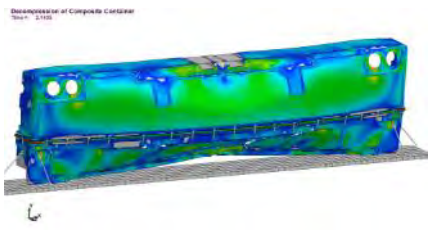
Our History

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

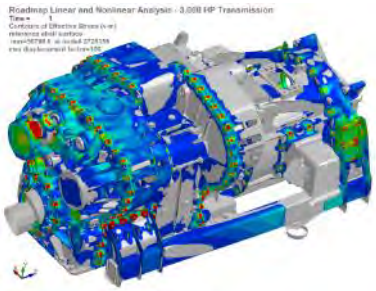
View our portfolio

FEA, CFD and LS-DYNA consulting projects

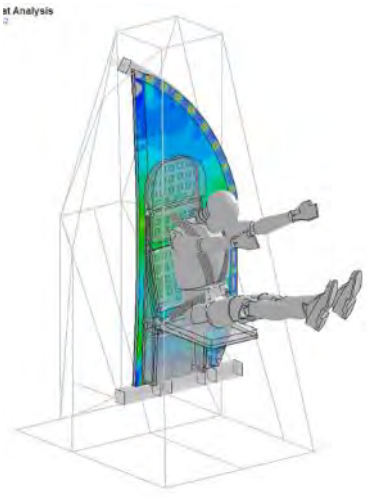
Composite Engineering



Nonlinear Dynamics



Aerospace



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COMSOL Conference 2019

October 2 – October 4

Join us in Boston this fall for the COMSOL Conference.

Register here.

Details
Start:
October 2
End:
October 4

Venue
Boston Marriott Newton
2345 Commonwealth Avenue
Boston, MA 02466 United States
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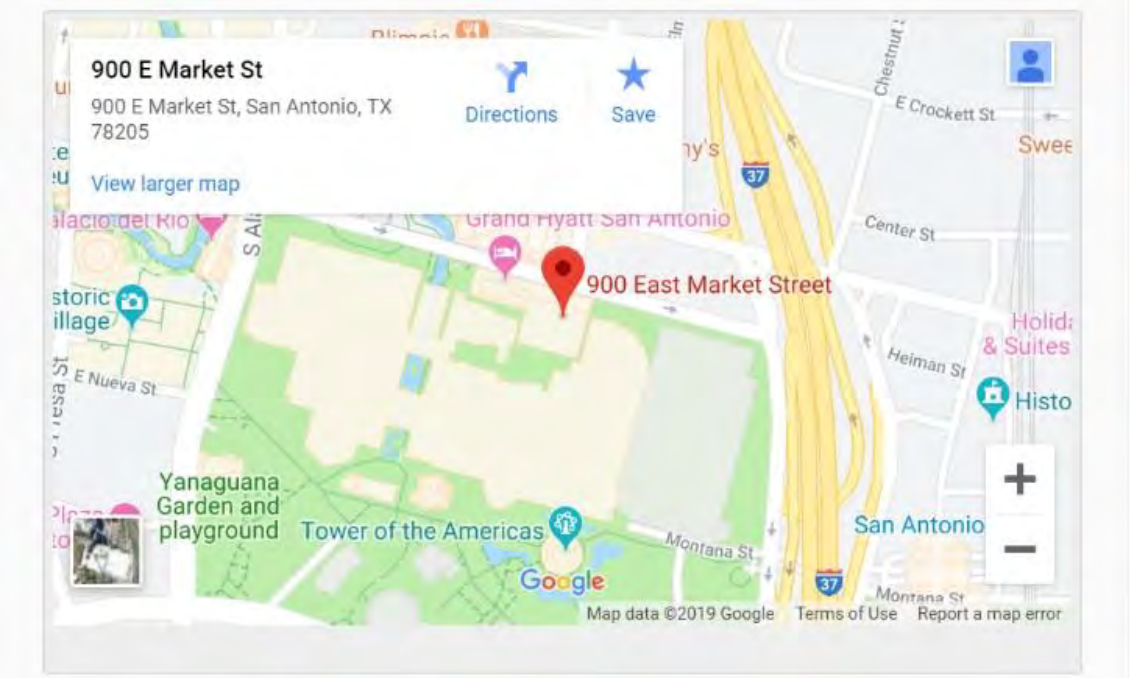


LS-DYNA China, as the master distributor in China authorized by LSTC, is fully responsible for the sales, marketing, technical support and engineering consulting services of LS-DYNA in China.

仿坤软件 LS-DYNA China

2019 4th China LS-DYNA Users' Conference

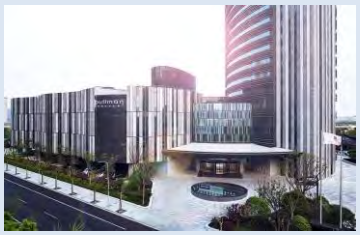
The 4th China LS-DYNA Users'Conference will be held on October 21st - 23rd, 2019 in Shanghai. During this conference LSTC will share the details of its latest product developments as well as its road map for the future. At this conference engineers and scientists from LSTC and customers from all over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

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

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

Hosts:	**Livermore Software Technology Corp. USA**
	Shanghai Fangkun Software Technology, Ltd. China
	Dalian Fukun Technology Development Corp. China
Date:	**October 21st- 23rd, 2019**
Location:	**Pullman Shanghai South Hotel** (http://www.pullmzxhotel.com/)
	No.1 Pubei Road, Xuhui District, Shanghai, China, 200235
Training:	There will have 8 training classes being held on Oct. 21st, 24th and 25th All training courses will be taught by senior engineers from LSTC

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


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

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

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

FE analysis

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

CFD analysis

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

EM analysis

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

Metal sheet

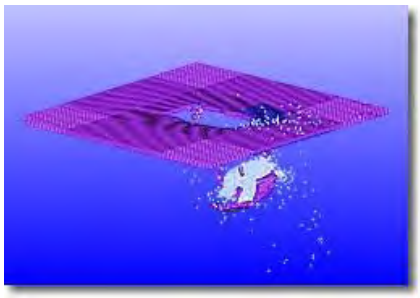
- JSTAMP is an integrated forming simulation system for virtual tool shop based on IT environment. JSTAMP is widely used in many companies, mainly automobile companies and suppliers, electronics, and steel/iron companies in Japan.

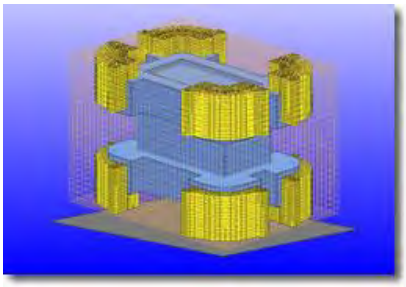
Pre/ Post

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

Biomechanics

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





Hawk30 solar-powered high-altitude platform system will serve as a stratospheric telecommunications platform for delivering next-generation global connectivity.

Unmanned Stratospheric Solar Aircraft Flies

by Mark Huber
- September 15, 2019, 4:12 AM

Hawk30 solar-powered high-altitude platform system will serve as a stratospheric telecommunications platform for delivering next-generation global connectivity.

Softbank unit HAPSMobile completed the first test flight of its unmanned Hawk30 solar-powered high-altitude platform system (HAPS) last week at NASA's California Armstrong Flight Research Center (AFRC). Hawk30 is designed to serve as a stratospheric telecommunications platform for delivering next-generation global connectivity.

"While this successful test flight represents just the first step, we're moving forward with tests in the stratosphere and long flight duration tests lasting several months up to half a year," said Junichi Miyakawa, CTO of SoftBank and HAPSMobile CEO. After operations at AFRC, Hawk30 will perform stratospheric test flights at the Hawaiian island of Lanai.

The Hawk30 has a wingspan of 256 feet and is equipped with wing-embedded solar panels that power electric motors driving 10 propellers. It flies at speeds of approximately 60 knots and is designed to stay airborne for months at a time. Softbank intends to use HAPS to build stable internet networks unserved by telecommunications, including in mountainous terrain, remote islands, and developing countries. Hawk30 is designed to use a system that does not interfere with terrestrial base station networks. The technology will enable connectivity for drone operations, contribute to the adoption of the Internet of Things and 5G, and provide stable communications networks regardless of situations on the ground, such as natural disasters, the company said. HAPSMobile anticipates launching Hawk30 commercial service in 2023.

Website click here

Automotive News - Jeep® Cherokee

Jeep® Cherokee Earns 2019 Top Safety Pick Rating

- Refreshed Jeep® Cherokee midsize SUV earns Top Safety Pick rating from Insurance Institute for Highway Safety (IIHS)
- Cherokee, the most capable SUV in its class, achieved highest possible ratings in each of the six IIHS crashworthiness tests
- Benefits from engineering upgrades that improve performance in certain frontal-impact tests
- Automatic Emergency Braking (AEB) technology graded "superior;" Forward Collision Warning-Plus one of more than 80 available safety and security features – all of which carry over to model-year 2020

September 13, 2019 , Auburn Hills, Mich. - The new-for-2019 Jeep® Cherokee midsize SUV has earned a Top Safety Pick rating from the Insurance Institute for Highway Safety (IIHS).

The rating applies to 2019 Jeep Cherokees produced after April of this year, when equipped with Jeep's available Automatic Emergency Braking (AEB) technology – Forward Collision Warning-Plus – and LED projector headlamps with optional automatic high-beam control.

These are among more than 80 available safety and security features that carry over to model-year 2020.

"This latest award is solid recognition for the Jeep Cherokee, an SUV that is not only recognized for being the most capable vehicle in its class, but also packed with more than 80 advanced safety and security features and benchmark 4x4 systems to help consumers tackle any terrain in all weather conditions," says Jim Morrison, Head of Jeep Brand – FCA North America. "Jeep Cherokee provides the confidence and security to handle any journey."

High-strength-steel upgrades to the 2019 Jeep Cherokee's A-pillar and hinge-pillar are among the key engineering changes that contribute to its Top Safety Pick rating. These factor into improved performance in the IIHS small-overlap tests, which simulate certain frontal impacts.

The Jeep Cherokee recorded "good" results – the highest possible crashworthiness rating – in all six crashworthiness tests, three of which simulate frontal impacts. The remaining tests inflict damage consistent with a side impact, rear impact and a rollover.

Forward Collision Warning-Plus was graded "superior," the highest possible rating awarded by IIHS in front crash prevention. The optional feature boasts sensor-fusion technology, which blends camera capability with radar detection to determine when an impact is imminent.

The system initially warns the driver to take action to avoid a collision. If the driver does not act in a timely manner, the system may activate the vehicle's brakes if collision risk remains.

The Top Safety Pick rating is also enabled by the Jeep Cherokee's standard-equipment LED projector headlamps with optional automatic high-beam control. The available feature switches headlamp modes between high- and low-beam function – depending on traffic conditions – without driver intervention.

The launch of the 2019 Jeep Cherokee also marked the debut of a premium design language and the model line's introduction of a 2.0-liter direct-injected inline four-cylinder engine that enhances performance and fuel efficiency.

Jeep Brand

Built on more than 75 years of legendary heritage, Jeep is the authentic SUV with class-leading capability, craftsmanship and versatility for people who seek extraordinary journeys. The Jeep brand delivers an open invitation to live life to the fullest by offering a full line of vehicles that continue to provide owners with a sense of security to handle any journey with confidence.

The Jeep vehicle lineup consists of the Cherokee, Compass, Gladiator, Grand Cherokee, Renegade and Wrangler. To meet consumer demand around the world, all Jeep models sold outside North America are available in both left and right-hand drive configurations and with gasoline and diesel powertrain options.

Contact: :
Eric Mayne Amy Grundman
Website: https://media.fcanorthamerica.com/newsrelease.do?id=21226&mid=1

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
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LS-DYNA OnLine - (Al Tabiei)	www.LSDYNA-ONLINE.COM
OASYS	www.oasys-software.com/training-courses
Predictive Engineering	www.predictiveengineering.com/support-and-training/ls-dyna-training

Training - Dynamore

Author: Christian Frech christian.frech@dynamore.de

Seminars 2019

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

Selection of trainings for October/November

Introduction	
Introduction to LS-DYNA	2-4 October (T) 21-23 October 12-14 November (I)
Crash	
Joining Techniques in LS-DYNA	4-5 November
Passive Safety	
CPM Airbag Modeling	20 November
Metal Forming	
Applied Forming Simulation with eta/DYNAFORM	4-5 November
Metal Forming with LS-DYNA	6-8 November
Introduction to Draping Simulation with LS-DYNA	21-22 November
Material	
Modeling Metallic Materials	11-12 November
Parameter Identification with LS-OPT	13 November
Material Failure	14-15 November
Advanced Damage Modeling: Orthotropic Materials	18 November
Implicit Capabilities	
Implicit Analysis using LS-DYNA	6-7 November (V)
High energy events	
Methods for Simulating Short Duration Events	8-9 October
Blast Modeling	10-11 October
Penetration Modeling	14-15 October
Optimization	
LS-OPT - Optimization & Robustness	14-16 October

Information days and Webinars (free of charge)

Information day: Simulation of Plastics	24 October
Information day: Composite Analysis	25 October

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

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

Training - LSTC

www.lstc.com

October 2019

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

November 2019

Date				Location	Course Title	Days	Instructor(s)
Nov 5	Nov 8	Tu	Fri	CA	Introduction to LS-DYNA®	4	B. Aminjikarai
Nov 6		Wed		***MI***	Introduction to LS-PrePost	1	P. Ho, Q. Yan
Nov 11	Nov 15	Mon	Fri	***MI***	Crashworthiness in LS-DYNA (This class is 4 days of instruction; the fifth day is a half day optional workshop.)	4 + 0.5	P. Du Bois, S. Bala

Sheet Metal Forming Simulation with IGA in LS-DYNA®

Stefan Hartmann
DYNAmore GmbH, Stuttgart, Germany
David J. Benson Liping Li Attila P. Nagy
Livermore Software Technology Corporation, Livermore, CA, USA

Abstract

In the last few years, numerous research work has been devoted to Isogeometric Analysis (IGA). IGA is a finite element technology in which computer-aided design (CAD) geometric description is invoked to perform numerical analysis. The most widely used mathematical description in CAD is non-uniform rational B-splines (NURBS) and therefore NURBS-based shell and solid finite elements have been implemented into LS-DYNA.

This paper describes the recent advances of the NURBS-based shell implementation in LS-DYNA to enable the IGA technology for the use in sheet metal forming applications. Necessary features like stress, strain, thickness, and history variable mapping from one stage to the other, the trimming of the formed part and other typical features used by the forming analysts have been enabled for the use with NURBS-shells. The new keywords will be explained and the multistage forming process will be analyzed by means of an example. A comparison with current state-of-the art methods is provided and further developments are outlined.

1 Introduction to Isogeometric Analysis

This section introduces the rather new finite element technology, called isogeometric analysis (IGA). The term IGA was introduced by Hughes et al. [1] in 2005, in analogy to the term “isoparametric”. While the standard “isoparametric” approach in finite element analysis indicates that the geometry representation as well as its deformed solution space is approximated using the identical shape functions, which are in general low order Lagrange polynomials. The “isogeometric” idea goes one step further and states that the geometry description used in the computer aided design (CAD) shall be used in the analysis as well. One of the largest initial motivations for developing IGA was the hope to better integrate the CAD-models with the subsequent finite element analysis in order to cut down significantly the labor time needed to reparametrize (mesh) the CAD geometry for doing the analysis. Although this particular possible advantage couldn’t be compellingly proven yet, the use of higher order shape functions, i.e. NURBS may yield better results while having the possibility of using larger element-sizes. Furthermore, the use of the IGA technology may help to reduce the discretization error that may result from the re-parameterization of the CAD design. A schematic comparison of the meshing procedure between standard finite elements and isogeometric analysis is shown in Fig.1. It can be seen that the geometry representation based on linear Lagrange polynomials will lead to a discretization error that can only be reduced to a tolerable value by doing mesh-refinement. With the IGA approach, the initial CAD geometry can be directly used for analysis and necessary mesh-refinements for enlarging the solution space will leave the geometry unchanged.

Various mathematical descriptions are used in the different CAD packages, but amongst them NURBS play a dominant role. That is why many researches in the area of IGA focus on NURBS and so does the IGA implementation in LS-DYNA.

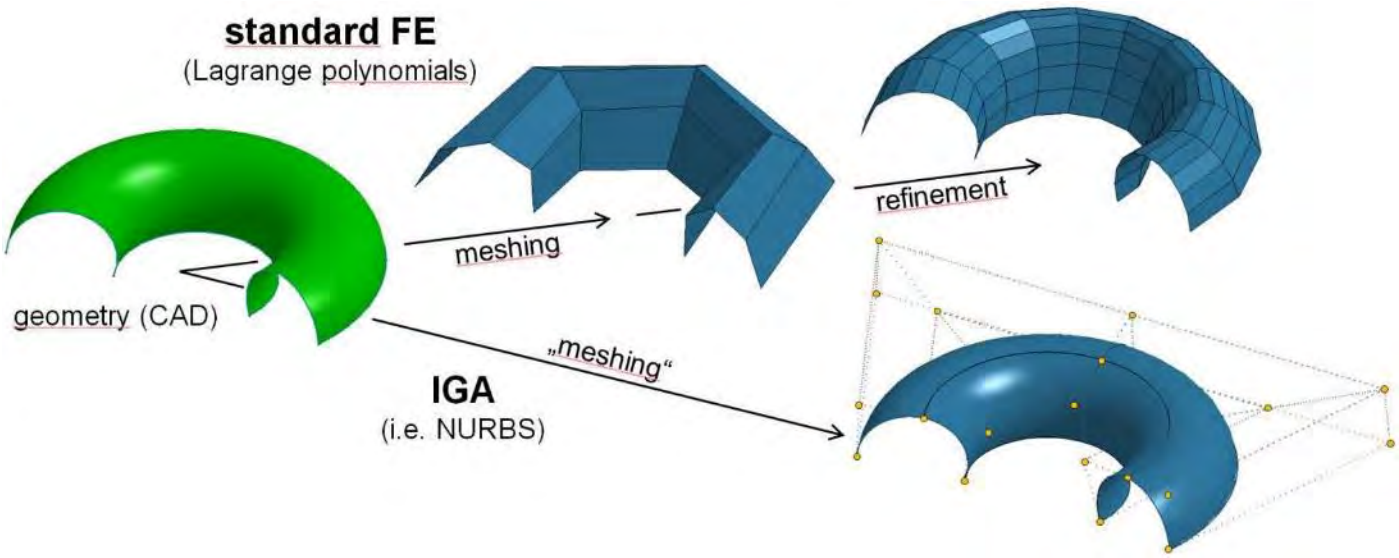

Fig.1: Comparison of meshing for standard finite elements and IGA

2 NURBS

Some basic properties of NURBS will be presented in order to be able to understand some significant differences of using NURBS instead of Lagrange polynomials for finite element analysis. As the few subsequent descriptions may only give a rough idea about NURBS, the interested reader is referred to the monograph by Piegl and Tiller [2].

2.1 B-Splines

Given the name Non-uniform rational B-Splines it is obvious that NURBS are built from B-Splines. B-Spline basis functions are constructed in a recursively manner, starting with a constant basis function and then increasing the order in every recursive step until the desired degree is reached (see Fig.2)

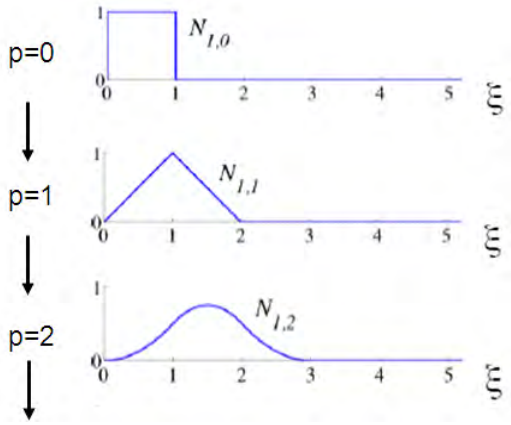

Fig.1: B-spline basis functions of order 0, 1 and 2 for uniform knot vector [3]

The recursion formula is given by

$$\text{for } p=0: \quad N_{i,0}(\xi)=\begin{cases}1 & \text{if } \xi_i \le \xi < \xi_{i+1}\\ 0 & \text{otherwise}\end{cases}$$

$$\text{for } p>0: \quad N_{i,p}(\xi)=\frac{\xi-\xi_i}{\xi_{i+p}-\xi_i}N_{i,p-1(\xi)}+\frac{\xi_{i+p+1}-\xi}{\xi_{i+p+1}-\xi_{i+1}}N_{i+1,p-1(\xi)} \qquad (1)$$

In here ξ_i is the ith knot of the so-called "knot-vector" $\Xi=\left[\xi_1,\xi_2,\ldots,\xi_{n+p+1}\right]$, which is a non-decreasing set of coordinates in the parametric space. The degree of the basis functions is given with p and finally n represents the number of basis functions defined through the knot-vector. It has to be noted that B-spline basis functions are always and everywhere positive regardless of their degree, which is a significant difference compared to higher order Lagrange Polynomials (see Fig.3). Furthermore B-Spline basis functions constitute the important partition of unity property and exhibit a Cp-1-continuity along the internal element boundaries if no multiple knot values are present in the knot-vector.

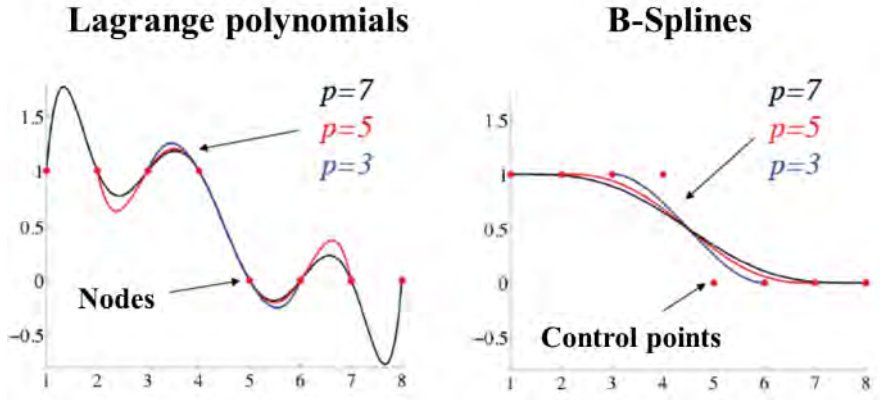

Fig.2: Comparison of Curves represented by Lagrange polynomials (left) and B-spline basis functions(right)given the same set of nodes and control points, respectively [3]

The construction of B-spline curves is similar to the way this is done using Lagrange polynomials, with one important difference. Instead of interpolating the curve through the nodal coordinates (see Fig.3 left), B-spline curves use so-called *control points*, which are used as coefficients of the B-spline basis functions. As can be

seen in Fig.3 (right), these control points are most of the time not a part of the actual geometry which is due to the non-interpolatory nature of the B-Spline basis functions. A B-spline curve $\boldsymbol{C}(\xi)$ is defined through a linear combination of the B-spline basis functions with the corresponding control points $\boldsymbol{B}_i$.

$$\boldsymbol{C}(\xi) = \sum_{i=1}^{n} N_{i,p}(\xi)\boldsymbol{B}_i \tag{2}$$

The step from B-splines to NURBS is achieved by introducing an additional parameter to every control point which is called a weight. Using the weights w_i at the control points, the NURBS basis functions $R_i^p(\xi)$ are constructed as follows:

$$R_i^p(\xi) = \frac{N_{i,p}(\xi)w_i}{W(\xi)} \quad with \quad W(\xi) = \sum_{i=1}^{n} N_{i,p}(\xi)w_i \tag{3}$$

A NURBS curve is then defined in the same way as a B-spline curve, by substituting the B-spline basis functions in Equ. (2) with the NURBS basis functions in Equ. (3).

2.2 NURBS surfaces

The step from defining NURBS curves to NURBS surfaces is straight forward and can be easily extended to define NURBS solids. Starting with the univariate B-spline basis functions discussed in the preceding section, the necessary NURBS basis functions to finally describe a NURBS surface are constructed using a tensor product on these univariate basis functions and combine them with the weights at the control points. In mathematical terms the bi-variate NURBS basis functions are defined as follows:

$$R_{i,j}^{p,q}(\xi,\eta) = \frac{N_{i,p}(\xi)M_{j,q}(\eta)w_{i,j}}{W(\xi,\eta)} \quad with \quad W(\xi,\eta) = \sum_{i=1}^{n}\sum_{j=1}^{m} N_{i,p}(\xi)M_{j,q}(\eta)w_{i,j} \tag{4}$$

Given the bi-variate NURBS basis functions, NURBS surfaces are then constructed in a similar way as NURBS or B-spline curves through a linear combination of these basis functions with their corresponding control points. A typical NURBS surface is shown in Fig. 4.

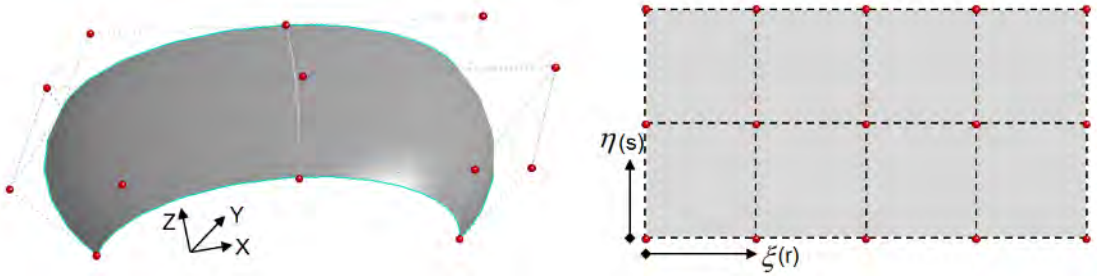

Fig.3: NURBS surface with the control points (red dots) in physical space (left) and in parametric space (right)

It can be seen, that in the parametric space a more or less regular grid of control points in a rectangular parametric space is defined. Mapping this into the physical space leads to some restrictions of defining any specific boundary of the surface or even digging holes into it. To circumvent this limitation, so-called trimmed NURBS are generally used in the CAD programs. Trimmed NURBS surfaces are defined by adding an unlimited number of so-called trimming curves, which actually define which part of the represented surface

shall be an actual part of the given geometry. Fig. 5 shows a trimmed NURBS surface that uses the exact same underlying representation of the NURBS surface shown in Fig. 4, just by adding two additional trimming curve definitions that specify the outer boundary of the actual geometry and a hole inside it.

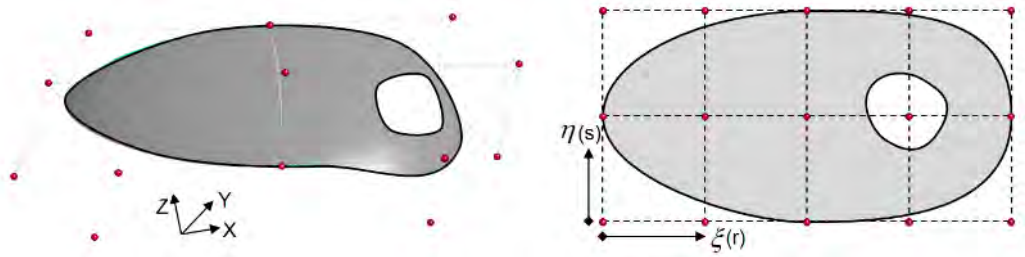

Fig.4: Trimmed NURBS surface with control points in physical space (left) and in parametric space (right)

Trimmed NURBS surfaces are a widely used standard in CAD programs, so the capability of doing isogeometric finite element analysis on trimmed NURBS surfaces is one of the key requirements. The NURBS shell implementation in LS-DYNA® supports the analysis on trimmed surfaces.

3 NURBS shells in LS-DYNA®

This section summarizes quickly the current possibilities of using NURBS surface representations for doing isogeometric finite element analysis in LS-DYNA®.

Starting off a FEA using NURBS shells necessitates the appropriate definition of NURBS surfaces, which are called NURBS patches in LS-DYNA®. The keyword to be used is ***ELEMENT_SHELL_NURBS_PATCH** or ***ELEMENT_SHELL_NURBS_PATCH_TRIMMED** in case of trimmed NURBS surfaces. Generally any material model available for standard shell elements may be used in combination with the NURBS shells. Currently there are five different NURBS shell formulations available, that differ basically in the way the normal of the shell is approximated. There are shell formulations based on the classical Kirchoff-Love shell theory as well formulations based on the shear-deformable Reissner-Mindlin theory. As basis functions with higher continuity across the element boundaries allow for element formulations that do not need any rotational degrees of freedom, also rotation free NURBS shells are available in LS-DYNA®. More information on the implemented shell formulations can be found in the papers from Benson et al. [4], [5]. Likewise it is done for standard shell elements, each NURBS patch will be assigned to an appropriate ***PART**, that defines the material model to be used (***MAT_XXX**) and the section properties of the shell (***SECTION_SHELL**). For doing an analysis with NURBS shells, the parameter **ELFORM** in ***SECTION_SHELL** has to be set to **201**.

In the previous section about NURBS it became obvious, that the control points are not necessarily a part of the actual geometry. This fact makes it a little bit more complicated to actually apply necessary boundary conditions at the spot they should be. To do so, the keyword ***CONSTRAINED_NODE_TO_NURBS_PATCH** is available, which allows to define a massless node at any location on the actual NURBS surface and tie it to the NURBS patch. Having defined this particular location on the NURBS surface one may apply either Neumann or Dirichlet boundary conditions at this spot.

For dealing with contact boundary conditions basically two options are available. The first one is based on so-called *interpolation elements*. When doing an isogeometric analysis, LS-DYNA® automatically creates a kind of background mesh consisting of standard bi-linear shell elements that are placed on the NURBS surface. The necessary *interpolation nodes* that are created for that are fully constrained to the underlying NURBS patch description. Having this interpolation mesh in place, any standard penalty based contact

formulation available in LS-DYNA® can be used directly. The second possibility actually uses the real smooth description of the NURBS surface in the sense of a Node-To-Surface contact description. For this, the interpolation nodes on the slave side are projected onto the master surface which is described by the NURBS basis functions. This second approach can be activated by setting **IGACTC=1** in ***CONTROL_CONTACT**.
From an analysis perspective, the NURBS-based finite shell elements are available for explicit as well as for implicit analysis. They are supported in SMP (shared memory parallel) and MPP (massive parallel processing). Furthermore a conventional type of mass scaling [6] has been implemented for the NURBS shell elements as well as the possibility to treat them as rigid bodies.

4 Sheet metal forming with NURBS shells

Making the finite element analysis with NURBS shells in LS-DYNA® a sound alternative in real world industrial-applications, numerous possibilities and features that have been developed over the last decades for standard finite elements must be made available for NURBS shells as well. In this section the focus is set on the recent advances of the NURBS shell implementation for the use in sheet metal forming application.
A more or less classical forming simulation consists of various steps that are generally analyzed within a multi-stage analysis. These stages may be deep-drawing, trimming, hemming, springback and others. No matter what the individual stage may look like, one major feature that needs to be supported by an analysis tool is to map the results achieved from one stage to the other. The results that are mainly mapped are the current stress and strain states, the equivalent plastic strain and the thickness variation due to the forming process. In LS-DYNA® this is typically done via a so-called DYNAIN-file using the keyword ***INTERFACE_SPRINGBACK**. So once the analysis of one stage is finished, the required data is written out to this particular file and then in the next stage, this file is read back in in order to reinitialize the necessary values. To support this approach with NURBS shells two new keywords have been added to LS-DYNA®, namely ***INITIAL_STRESS/STRAIN_SHELL_NURBS_PATCH** (see Fig.6).

***INITIAL_STRESS_SHELL_NURBS_PATCH**

	1	2	3	4	5	6	7	8
Card 1	EID	NPLANE	NTHICK	NHISV	LARGE			
Card 2	R	S	T					
Card 3	SIGXX	SIGYY	SIGZZ	SIGXY	SIGYZ	SIGZX	EPS	
Card 4	HISV1	HISV2	HISV3	HISV4	HISV5	HISV6	HISV7	HISV8
Card ...	...	...	...					

Fig.5: Keyword to support data mapping between various stages

When defining the keyword ***INTERFACE_SPRINGBACK** for a particular analysis stage, LS-DYNA® will automatically create a DYNAIN-file and write out for every NURBS-element (EID) the required solution values (stresses – SIGx, equivalent plastic strain – EPS and history variables - HISVx) at every integration point (NPLANE*NTHICK) using the keyword shown in Fig.6. The identical procedure can be made to map the strain values and the thickness variation.

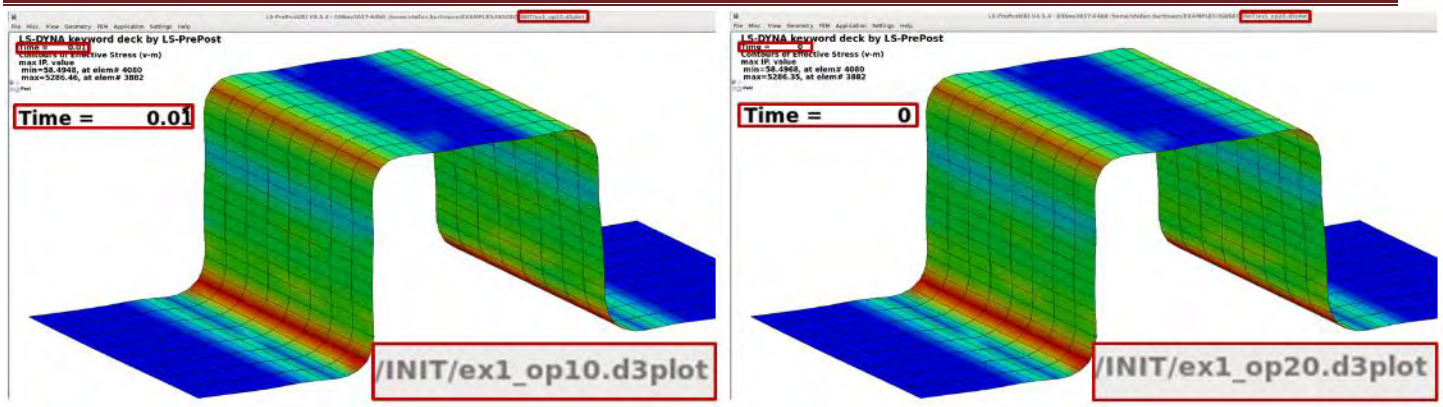

Fig.6: Von Mises Stress distribution: end of stage 1 (op10 - left) and beginning of stage 2 (op20 –right)

In Fig.7 you can see a little example that shows the von Mises Stress distribution at the end of the first stage and at the beginning of the second stage after reading back in the results file. Another important issue in forming applications is the trimming of the formed component. The support of this feature is currently under development for IGA shells and will be available soon (see Fig.8).

Fig.7: A deformed shell NURBS patch before (left) and after trimming (right)

5 Multistage forming process

Unfortunately the analysis of a multistage forming process to present the current capabilities and to compare it with respect to the current state-of-the art methods is still work in progress. These studies will be carried out until the date of the actual conference and presented there.

6 Conclusion

LSTC is working on adding more and more features that can be used together with Isogeometric NURBS shells in LS-DYNA®. The current paper mentioned some recent advances that have been implemented in the context of forming analyses. Although the very important mapping ability via ***INTERFACE_SPRINGBACK** is now supported there is still some work to do in order to make the IGA technology available for general use in

industrial applications. One standard feature that is generally used in forming applications is the possibility to do adaptive mesh refinement in all the areas where this is needed. This fundamental topic hasn't been addressed yet for NURBS shells and will be another important step to be done.

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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.

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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.

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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.

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LS-DYNA

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

LS-PrePost

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

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LS-TaSC

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

LSTC Dummy Models

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

LSTC Barrier Models

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

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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:

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Key benefits:

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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.

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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

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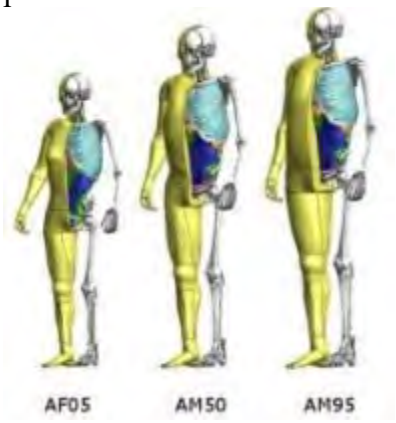
TOYOTA - Total Human Model for Safety – THUMS

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

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

and as standing model to represent pedestrians.



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

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

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

For information please contact: THUMS@lstc.com

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

LSTC – Dummy Models

LSTC Crash Test Dummies (ATD)

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

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

e-mail to: atds@lstc.com

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

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

Models In Development

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

Planned Models

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

LSTC – Barrier Models

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

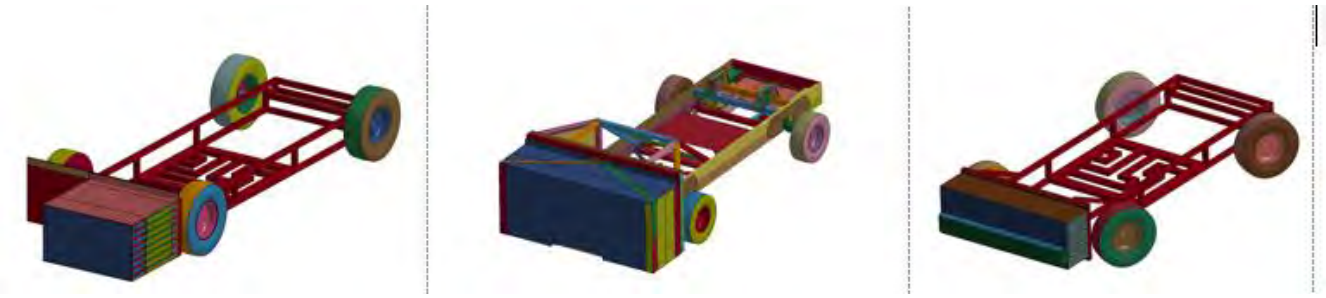
LSTC offers several Offset Deformable Barrier (ODB) and Movable Deformable Barrier (MDB) models:

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

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

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

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



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