the CertaSim SOLUTION™

Featuring:
Mine Blast Experiments to Calibrate an ATD

Q3
2016

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CertaSIM, LLC is the official distributor of the IMPETUS Afea Solver® in North, Central and South America and provides technical support and training for the IMPETUS suite of software.

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News and Events

New Articles Extending the Use of the IMPETUS Afea Solver® to a Larger Range of Applications.

The IMPETUS Afea Solver® has found its place in the world of simulation because efficiency, accuracy and user friendliness are key to getting the job done. Although many users cannot publish their results a significant number of papers have been published and results presented at international conferences.

Dr. Milan Toma from Wallace H. Coulter Department of Biomedical Engineering, Georgia Institute of Technology and Emory University co-authored the paper: "Fluid-Structure Interaction Analysis of Ruptured Mitral Chordae Tendineae". It is published in Annals of Biomedical Engineering (2016) with the reference DOI: 10.1007/s10439-016-1727-y. It describes experimental and numerical work done on the Mitral Valve. The numerical part of the research was done with the IMPETUS Afea Solver®, using both the Finite Element and SPH Solvers, the latter of which was used to model the fluid.

Annals of Biomedical Engineering (© 2016)
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Fluid-Structure Interaction Analysis of Ruptured Mitral Chordae Tendineae

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"INNOVATIVE LAGRANGIAN NUMERICAL APPROACH FOR NATURAL FRAGMENTATION MODELING" is the title on a paper by Anthony Collé from IMPETUS Afea, SAS and his colleagues at MBDA France, both located in France. It was presented at: 29TH INTERNATIONAL SYMPOSIUM ON BALLISTICS EDINBURGH, SCOTLAND, UK, MAY 9–13, 2016. The paper demonstrates how the IMPETUS high order elements give accurate results for modeling the various geometric configurations including warhead fragmentation. The results were compared with experimental data.

29TH INTERNATIONAL SYMPOSIUM ON BALLISTICS
EDINBURGH, SCOTLAND, UK, MAY 9–13, 2016

INNOVATIVE LAGRANGIAN NUMERICAL APPROACH FOR NATURAL FRAGMENTATION MODELING

Anthony Collé[1], Jérôme Limido[1], Jean-Luc Lacome[1] and Frédéric Paintendre[2]
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Research at Nammo Raufoss and FFI, both located in Norway shows that modeling soil and sand with IMPETUS Discrete Particle Method (iDPM) is accurate and robust. They obtained excellent agreement between experiments and results from IMPETUS for a bullet impacting sand. The work was published in a paper presented at 29TH INTERNATIONAL SYMPOSIUM ON BALLISTICS EDINBURGH, SCOTLAND, UK, MAY 9–13, 2016.

29TH INTERNATIONAL SYMPOSIUM ON BALLISTICS
EDINBURGH, SCOTLAND, UK, MAY 9–13, 2016

IMPACT IN SAND, SIMULATIONS AND EXPERIMENTS

Gard Oedegaardstuen[1], Anne Kathrine Prytz[1] and John F. Moxnes[2]
[1]Nammo Raufoss AS, Norway
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2016 Ground Vehicles Survivability Training Symposium (GVSTS) November 15-17, 2016 – Ft. Benning, Columbus, GA.

CertaSIM, LLC will attend the TARDEC conference on ground vehicles (GVSTS 2016). Dr. Morten Rikard Jensen will present work co-authored with Dr. Terry J. Hause and Mr. Madan V. Vunnam both from the United States Army Tank Automotive Research, Development and Engineering Center (TARDEC). The paper is entitled "Calibration, verification and numerical sensitivity study of high explosive in buried mine blast events". The paper investigates how to calibrate High Explosive (HE) in the IMPETUS Afea Solver®. An example shows the procedure for calibration of C-4 with experimental data obtained from Lawrence Livermore National Laboratory (LLNL). After a successful calibration the results are verified with a cylindrical charge by comparison with the Chapman-Jouguet pressure. With this as the Baseline Model a sensitivity study was carried out to show the sensitivity of the HE parameters. The calibrated HE is used in a set-up reflecting a real mine blast event performed at Defence Research and Development Canada (DRDC) Valcartier. The numerical results are compared with experimental data, in this case the center deflection of the plate which shows excellent agreement.

We hope to see you there or at some of the other conference functions.

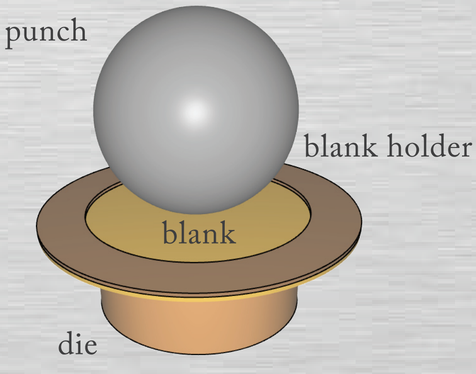
MODELING EARRING IN CONVENTIONAL DEEP DRAWING

Legacy codes have for many years have been used to model Sheet Metal Forming applications with one-point integration shell elements. This means accepting the error due to possible hour-glassing and the assumption of plane stress. The reason comes down to choosing speed over accuracy. This approach has even been applied to forming of thicker parts and hydroforming applications which is obviously wrong since shells cannot capture the true 3 dimensional stress state. IMPETUS models everything with fully integrated high order solid elements so none of these issues are a concern. Computational efficiency is also not a problem when GPU Technology provides massively parallel processing that is always load balanced. CertaSIM, LLC is moving into the Metal Forming area, including Sheet Metal Forming applications. As an example consider the situation of a conventional deep drawing of an anisotropic deep drawing steel. This anisotropic material behavior can be seen as "earring" in drawn cups.

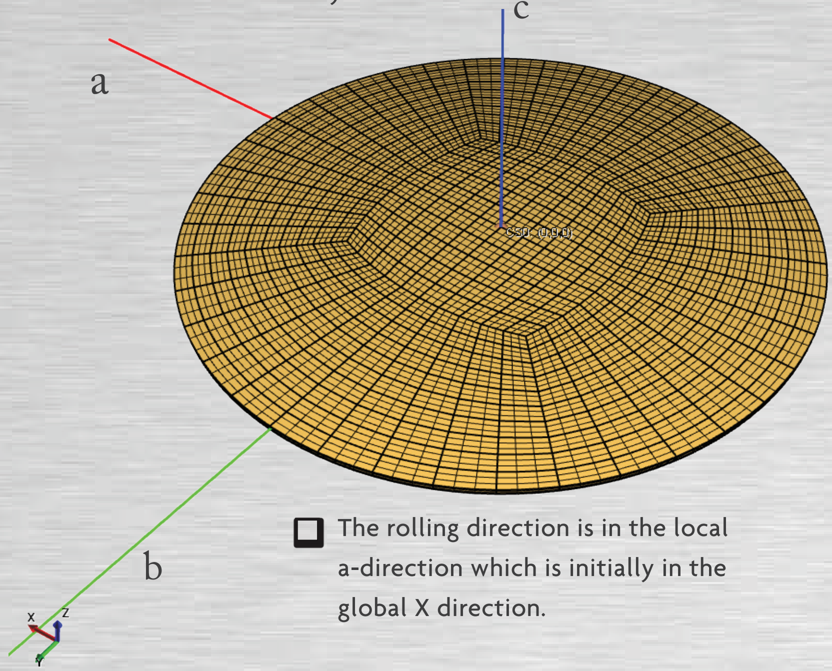
A measurement to quantify how anisotropic a material behaves are the R-values, also referred to as the Lankford coefficients. They are R_{00}, R_{45} and R_{90} and are taken into account in the constitutive model if the material cannot be treated as isotropic. The R-value is the strain in the width divided by the thickness strain when performing a standard uni-axial tensile test. It should be noted that the R values are not necessarily constant during the deformation, thus they are often plotted against the effective plastic strain. In IMPETUS the *MAT_FORMING_R takes the R-values into account. The input for *MAT_FORMING_R is primarily based on standard experimental data with the exception of the kinematic hardening.

```
*MAT_FORMING_R
mid, ρ, E, ν, did, tid
cid, ξ, R00, R45, R90
```

ρ is the density, E Young's modulus, ν Poisson's ratio, ***did*** is the ID for damage if included and ***tid*** is used as reference to thermal properties. ***cid*** refers to the ID of a *CURVE or *FUNCTION that defines yield stress versus effective plastic strain. ξ is a Kinematic hardening parameter ranging from 0 to 1 with 0 being pure isotropic hardening which is the default setting. R_{00} is the R-value in the rolling direction, R_{45} is the R-value for 45° to the rolling direction and R_{90} is the R-value for 90° to the rolling direction. Since *MAT_FORMING_R depends on the local material directions these have to be specified by the user. This can be done in different ways using *INITIAL_MATERIAL_DIRECTION_***option***. Typically, the rolling direction would be defined as the local x-direction. The kinematic hardening option can be important if there is reverse loading in the simulated process. The kinematic hardening parameter and the three R-values can all be defined as a function of the effective plastic strain. To illustrate the use of this constitutive model consider the set-up of a conventional deep drawing of a circular plate using a spherical punch, including a draw die and a blank holder. The blank holder is fully constrained so the material flow is controlled by a fixed blank holder gap.



Local material coordinate system



❑ The rolling direction is in the local a-direction which is initially in the global X direction.

The R-values can be used to predict the “earring” behavior. The following equation is a useful measurement for this purpose:

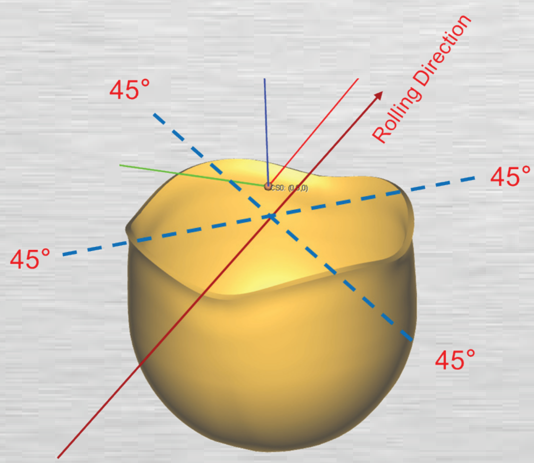
$$\Delta R = \frac{R_{00} + R_{90} - 2R_{45}}{2}$$

Based on the value of ΔR the following can be predicted:

- More earring is expected for larger values of ΔR. If ΔR is zero earring will not occur.
- A positive value indicates earring in the rolling and the 90° directions.
- A negative value indicates earring in the 45° direction.

Consider the following R-values: R_{00}=0.4, R_{45}=1.8 and R_{90}=0.6. This will give ΔR = -1.3, which would lead to earring at 45° to the rolling direction. A simulation was performed and the results shown below.

The result is as expected!



More information about modeling metal forming with the IMPETUS Afea Solver® is available by contacting support@certasim.com. The model showcased here is available for CertaSIM’s customers.

Modeling of M795 Artillery Shell as IED

CertaSIM's, Dr. Morten Rikard Jensen presented work related to mine blast at 2016 NDIA Ground Vehicle Systems Engineering and Technology Symposium (GVSETS), August 2-4, 2016 – Novi, Michigan. The work was a collaboration with Senior Technical Specialist Jim Rasico and Chief Engineer Craig Newman both from Navistar Defense. The final goal for this R&D work was to develop a procedure to model the complex situation where an artillery shell is used as an IED. This involves modeling of a shell in soil, the fragmentation of the shell as it detonates, the mix of fragments, HE and soil followed by the impact of these with a deformable structure. The scenario was further complicated by adding a seated 50th percentile Hybrid III ATD inside the structure. The work was split into two parts, first a sensitivity study of fragmentation of a cylinder using data from Lawrence Livermore National Laboratory which is publicly available. This was done to obtain knowledge about the fragmentation process. A positive aspect of the project which benefited IMPETUS customers were new output options for the Solver. It is now possible to have a fragmentation file generated with information about the number of fragments, mass, position and velocity. The results can easily be visualized from the GUI and in particular to plot the Number of Fragments versus Fragment mass. The second part of the study involved modeling the buried mine blast event. This work was further split into three stages:

1. Modeling of fragmentation of the M795 artillery shell. Finding material models for the High Fragmentation Steel (HF1). Investigate mesh density, node splitting, element types, damage softening, initial damage setting, pressure smearing for the HE interaction, etc.

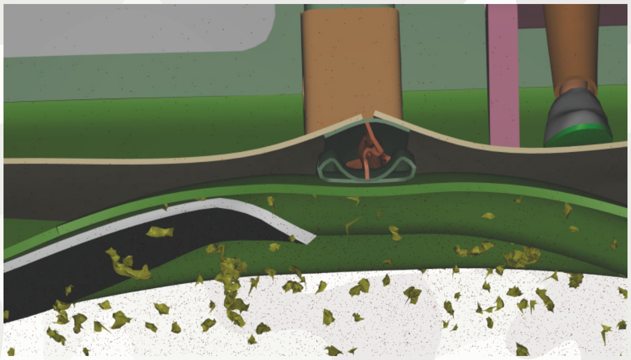
2. Buried M795 in the soil. Determine the soil type, find soil parameters, investigate the contact between soil and the structure of the shell, element types and mesh density, etc.

3. Complete scenario where the TARDEC Generic Vehicle Hull is used as the structure including the IMPETUS Afea Hybrid III 50th percentile ATD. Seating of the dummy, contact of fragments to the structure, contact between structure and the HE/Soil.

In the first part the work by Goto [1] at LLNL is used as experimental data and an IMPETUS model developed based on work by IMPETUS Afea SAS, France. The model is used as the Baseline Model for the sensitivity study. The Node Splitting Algorithm in IMPETUS is used to model the fragmentation. It is necessary to use node splitting and not element erosion when modeling fragmentation. Good agreement was obtained between IMPETUS results and experiments.

The sensitivity study included nine design variables and how the number of fragments depends on the mesh density. It was found that the blast smearing impulse parameter is a very sensitive parameter and can have a significant influence on the fragmentation process, illustrated by the number of fragments.
Modeling of the M795 is a challenge in itself since the basic geometry is not readily available in the public domain not to mention strength and damage parameters for the High Fragmentation steel that the shell is made of. However, different references were found that helped to define an approximate shape and material behavior. All three stages were successfully modeled and the procedure to do so is illustrated in the paper. The final model is very impressive since it shows the detonation, fragmentation, moving of the soil and impact with the structure. As is stated by the authors in the conclusion:

"Importantly, the authors believe that this paper provides modeling techniques to evaluate the blast and fragmentation effects of complex shaped IED's on a myriad of structures...... Ultimately, the learnings from these studies will lead to blast and fragmentation mitigating structures better able to protect military and civilian personnel from harm."



The full paper can be downloaded from:
http://files.certasim.com/download/file/tech-info/publications/Modeling_Fragmentation_of_a_155MM_Artillery_Shell_IED_in_a_Buried_Mine_Blast_Event.pdf

Reference:
[1] D. M. Goto et. al., "Investigation of the Fracture and Fragmentation of Explosive Driven Rings and Cylinders", International Journal of Impact Engineering 35 (2008) 1547-1556.

ACKNOWLEDGEMENT
"Many unclassified studies from past researchers have utilized fictitious vehicle geometry due to the non-availability of realistic information. Due to the sensitive nature of the work performed by the Department of Defense, data generated from testing military vehicles is usually classified, making it difficult to share data in the public domain. In order to increase the operational relevance of studies performed by the wider scientific community, the US Army Tank Automotive Research, Development and Engineering Center (RDECOM-TARDEC) has fabricated a generic vehicle hull to help evaluate blast mitigation technologies, and also shared an FEA model of the same for purposes of this research." It was necessary to develop a new model for the IMPETUS Afea Solver® and the authors would like to thank TARDEC, in particular, Dr. Ravi Thyagarajan, Mr. Madan Vunnam, and Dr. Bijan Shahidi for supporting the effort to develop the model.

The IMPETUS model of the fragmentation cylinder used for the sensitivity study was provided by Dr. Jérôme Limido and Mr. Anthony Collé, IMPETUS Afea SAS, France. Further, the authors would like to thank Dr. Limido for the many helpful discussions.
Eric Lee, IMPETUS AB, Sweden created the FE model of the M795 artillery shell based on very crude dimensions and other limited information available in the public domain. The authors are thankful for his assistance.

David M. Gerst, Navistar Defense, is gratefully acknowledged for sharing literature and for general discussions regarding fragmentation.

New Material Models in the IMPETUS Afea Solver®

The IMPETUS R&D group is constantly adding new features to the Solver which naturally includes new constitutive models. This is a high priority for the IMPETUS Blast ATD suite, where several new material models have been implemented. Another critical area for development is for applications related to the Defense Industry. Here are the most recent additions to the material library.

***MAT_ZA**

Zerilli-Armstrong strength model. There are several versions of this model but the one chosen to implement is the general form. The constitutive model is based on dislocation mechanics and one application is for modeling ballistics.

***MAT_BERGSTROM-BOYCE:**

This model is used to simulate polymers. It is based on the work by Bergstrom where two networks, A and B, are considered. Network A is hyperelastic which includes damage and network B is purely viscous. However, the IMPETUS implementation handles viscous effects differently than what is done in the original work by Bergstrom.

***MAT_CABLE:**

In order to accurately model ropes or steel cables *MAT_CABLE was developed. This model was required for the development of the IMPETUS ATD Model. It is a purely elastic model with higher stiffness in tension than in shear/compression. The user defines Young's Modulus and the fiber stiffness. Here again is a model that was conceived and developed by the IMPETUS team and one which you won't find in the open literature. Remember the IMPETUS Solver is based on solid elements only and so modeling of cables is done with **solid elements** NOT "beam elements". This is particularly important for the cable interaction with rubber parts in the ATD so that accurate contact is achieved.

***MAT_HOEK-BROWN:**

IMPETUS customers that work in the field of Geomechanics requested that the Hoek-Brown constitutive model be implemented for modeling tunnels, etc. This will be available for all users in the next official release. It is normally used in a context with small deformations. The model has a rock disturbance factor and the shear strength is dependent upon the pressure and Lode angle. Since it is widely used in the geomechanics community there is a significant amount of material parameters available in the open literature.

Live Blast Tests at Edgefield, SC

CertaSIM, LLC sponsored live blast tests at the General Dynamics Land Systems test facility in Edgefield, South Carolina. This is a part of the effort to develop a suite of ATD's especially calibrated for blast loading. The first ATD in this suite is the 50th percentile Hybrid III Dummy. The Finite Element Model was built based on the CAD files for the physical ATD. It is validated to the SAE crash specifications and IMPETUS documentation is currently being written. However, more interesting is to take this FE ATD one step further and calibrate it according to mine blast tests to be used in the product development phase of military vehicles. CertaSIM, LLC decided to allocate a portion of its R&D funding in 2016 to obtain our own experimental data and provide this to the IMPETUS Group in order to properly calibrate the ATD for mine blast. "We believe that providing a fully calibrated ATD for Blast simulations is essential to develop better military vehicles to protect our warfighters and so we feel it is our duty to provide that capability to our customers", states CertaSIM's Director of Sales and Marketing, Dr. Wayne Mindle.

Three days of testing were performed at Edgefield as well as additional shots performed afterwards. The staff at GDLS are the ultimate professionals and the care taken to accurately setup the tests to have repeatable results was very impressive. The result was excellent experimental data. Attending the event were several staff engineers from General Dynamics Land Systems, as well as CTO Dr. Lars Olovsson, IMPETUS AB, Sweden together with Dr. Wayne L. Mindle and Dr. Morten Rikard Jensen from CertaSIM, LLC.

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The 50th percentile ATD was strapped in a seat that is bolted to a fixture. A burried cylindrical charge is detonated and the fixture is free to move. A High speed camera captured the motion and all the standard sensor data for the ATD were recorded during the blast event, e.g., the force on the pelvis.

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Currently, the ATD calibration has also required a need for new development, an example is the rigid body joint options significantly extended and new constitutive models have been added. The calibration against the blast data is expected to be completed in the fall with documentation ready in Q1 2017.

Wayne L. Mindle, Ph.D. - Director of Sales & Marketing, CertaSIM, LLC

As the Editor of the CertaSIM Solution Journal I would like to thank everyone that takes the time to read our quarterly publication. We strive to create a quality publication with useful and pertinent information so that users of the IMPETUS Afea Suite of solvers can use the software more effectively.

In this section of the journal we invite experts in their field to write a short review to explain a particular technology. This time it is my turn. My expertise is in finite element technology and I have spent my 30+ year career working in academia, at major aerospace companies, a consulting company for the FAA and 15 years with one of our competitors (many of you know me from my time there) and now at CertaSIM for the last 5 years. What I would like to discuss is innovation in "Simulation Technology."

In May 2006 a very important report was released, it was titled, "Revolutionizing Engineering Science through Simulation". It was compiled by the National Science Foundation (NSF) Blue Ribbon Panel on Simulation-Based Engineering Science (SBES). The panel consisted of the most renowned academic experts in all areas of computational mechanics including my Ph.D. advisor, Professor Ted Belytschko, certainly one of the most respected researchers in the area of finite elements and explicit solver technology. Let's start with a few conclusions from the report:

Realizing the full potential of SBES will require a revolution in simulation technology.

> *Many contemporary engineering communities regard simulation software as a commodity that vendors provide for well-defined, specific, and independent domains of application.* ***Occasionally, these long-lived codes for engineering analysis receive incremental improvements****, usually in the form of functional extensions. This leisurely approach to software development will not support the next generation of engineering problems —multiscaling with real-time data interaction and abundant uncertainties in the data.*
>
> *Tomorrow's SBES software requires extraordinary degrees of robustness, efficiency, and flexibility.*

The report goes further to talk about the past success of simulation software and makes this very important statement:

> ***At the heart of these successes, however, are simulation methodologies that are decades old, too old to meet the challenges of new technology****. In many ways, the past successes of computer simulation may be its worst enemies, because the knowledge base, methods, and practices that enabled its achievements now threaten to stifle its prospects for the future.*
>
> *The need for shorter design cycles also applies to our national defense and security. World events are often unpredictable; our defense industry must be able to design, modify, and manufacture equipment in quick response to military and police agencies. A case in point is the unanticipated need to reinforce armored vehicles in Iraq after several such vehicles were destroyed by improvised explosive devices.*

Lastly the goal of new simulation technology which goes to the heart of this discussion about innovation:

> *Finally, we need methods for rapidly generating high-fidelity models of complex geometries and material properties.*

What is interesting is that the development of the IMPETUS Afea Solver started in 2007, not long after this report was released, purely a coincidence, because I asked Dr. Lars Olovsson (CTO of IMPETUS and the architect behind the development) if he had seen the report and he had not. He saw the same need to develop something new and revolutionary:

> Accurate and robust high order solid element technology (ASET™ Element Technology) that can handle very large deformation, a Discrete Particle Method (iDPM) for air, soil and HE to move away from the inaccuracies of an ALE approach that requires massive computer resources to solve real world problems and lastly embracing GPU Technology to achieve massively parallel processing on an unprecedented scale with just a standard workstation.

As the report highlights, innovation has been stifled by "legacy" companies with legacy solvers. The cost of innovation is more than just the pure cost of development; it is the integration with the old infrastructure and the quality assurance (QA) required to insure compatibility with the old methods. What we see in legacy codes is exactly what the report stated, "incremental improvements" which usually come by way of improvements to the GUI interface to mask the 30+ year old solver technology and the incredibly complex command structure required to create a working model.

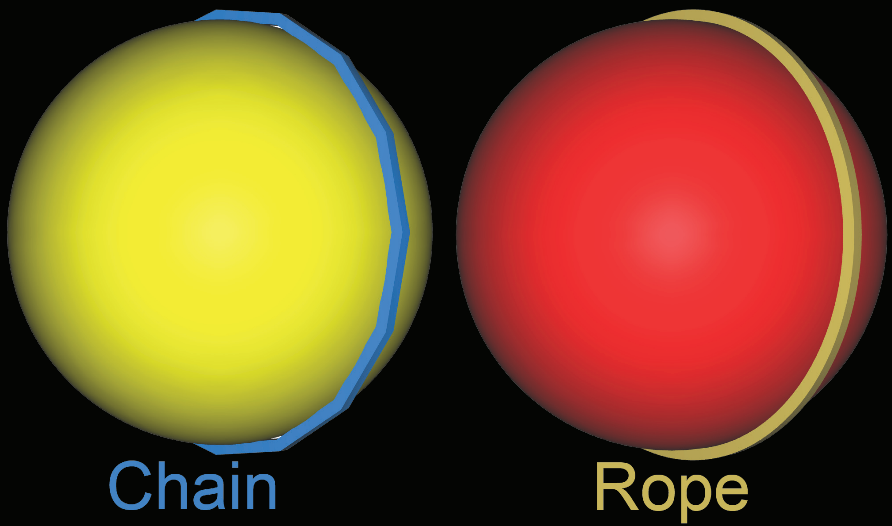
Innovation comes from small companies willing to step outside the box and look at totally new ways to solve problems, create products, etc. Long established companies tend to buy innovation not create it themselves. One cannot imagine trying to compete with legacy companies 20 years ago, the cost of the hardware alone made it unrealistic for a start-up company because one had to be able to port software to the various UNIX platforms, but today is a very different story, anyone with the time and ability can compete and that is what we see.

The challenge for innovation in engineering software is "legacy users", no one likes change and as engineers we develop methodologies to use what we have available to solve our problems! But the purpose of engineering analysts is to support design and manufacturing and to stay competitive they have to be on the forefront of innovation. An obvious example is the automobile and the innovation in technology in manufacturing that was necessary to produce today's cars compared to the 1960's. Look at the shape of a telephone from the 60's compared to what is manufactured today. Innovation in design is inherently tied to geometry and for the analysts that means element technology. How important is geometry to accurate simulations? We were fortunate to have Dr. Karl Merkley of csimsoft write the last "In Review" and it is worth restating a few points that he made:

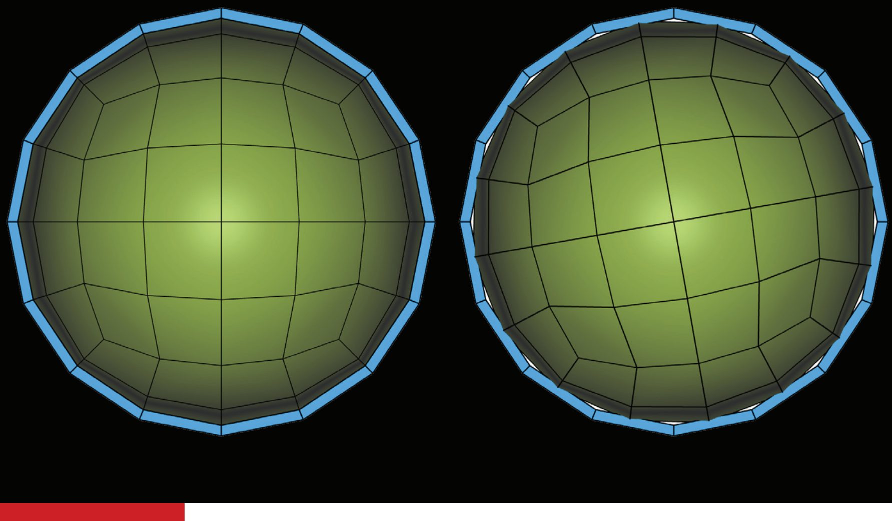
> *The appropriate mesh depends upon the physics of the problem you are solving. The mesh that is appropriate for solving a simple thermal problem is probably not adequate for solving a non-linear contact problem.*
>
> *Linear tetrahedral elements are not appropriate for solving elasticity problems.*
>
> *Quadratic tetrahedral elements give very good results for both linear and non-linear elasticity problems."*

The first question to ask is "What is meant by accurate geometry." From the perspective of the IMPETUS Solver you must start with "solid elements" because beam and shell elements do not represent the true 3D stress state. And that leads to the necessity of high order elements as an essential part of accurate geometry. But more importantly accurate geometry means "accurate contact" and good contact is everything!

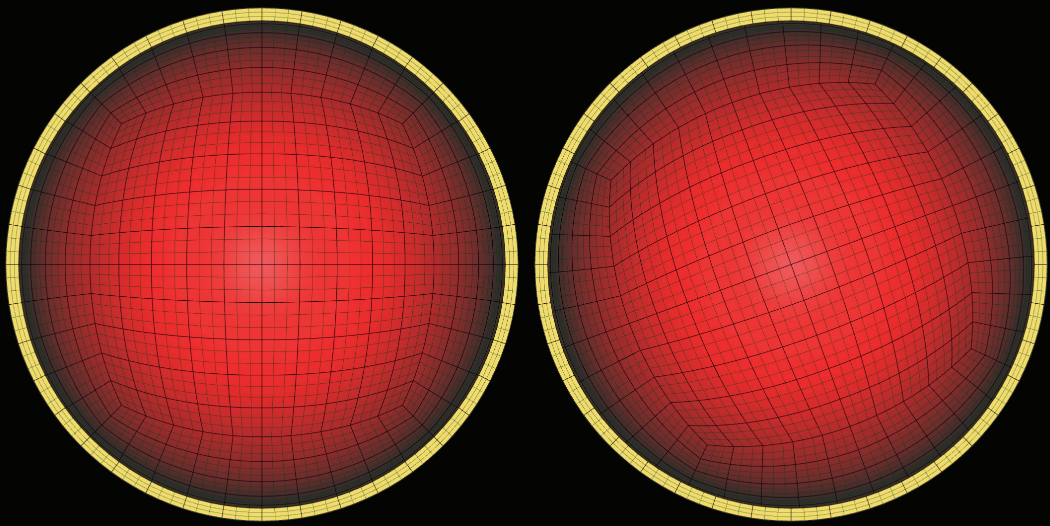
I can illustrate a very complicated problem with a simple sphere to show how geometry is related to contact. If a sphere is modelled with linear elements the outside surface is facetted. We can increase the number of elements to minimize the facets but the reality of using linear elements is that our surfaces are always going to be facetted. I like to think of a connection of linear elements as a chain with many links. Imagine taking a chain and wrapping it around a sphere there will always be gaps between the chain and the sphere at the joints between the links. Use a finer chain and you still have gaps. Now take a rope and wrap it around the same sphere and there are no gaps anywhere along the rope.



To avoid the gaps we can align the mesh of the chain with the sphere but look what happens if the sphere rotates relative to the chain, again gaps appear and unrealistic penetration. This is exactly what happens when modeling a bullet travelling down a gun barrel. The barrel has rifling which consists of helical grooves, on the order of 1mm in width and depth, designed to spin the bullet. However using linear elements results in unrealistic penetration and causes numerical problems with contact. Again, refining the mesh for the sphere does not eliminate the gaps.



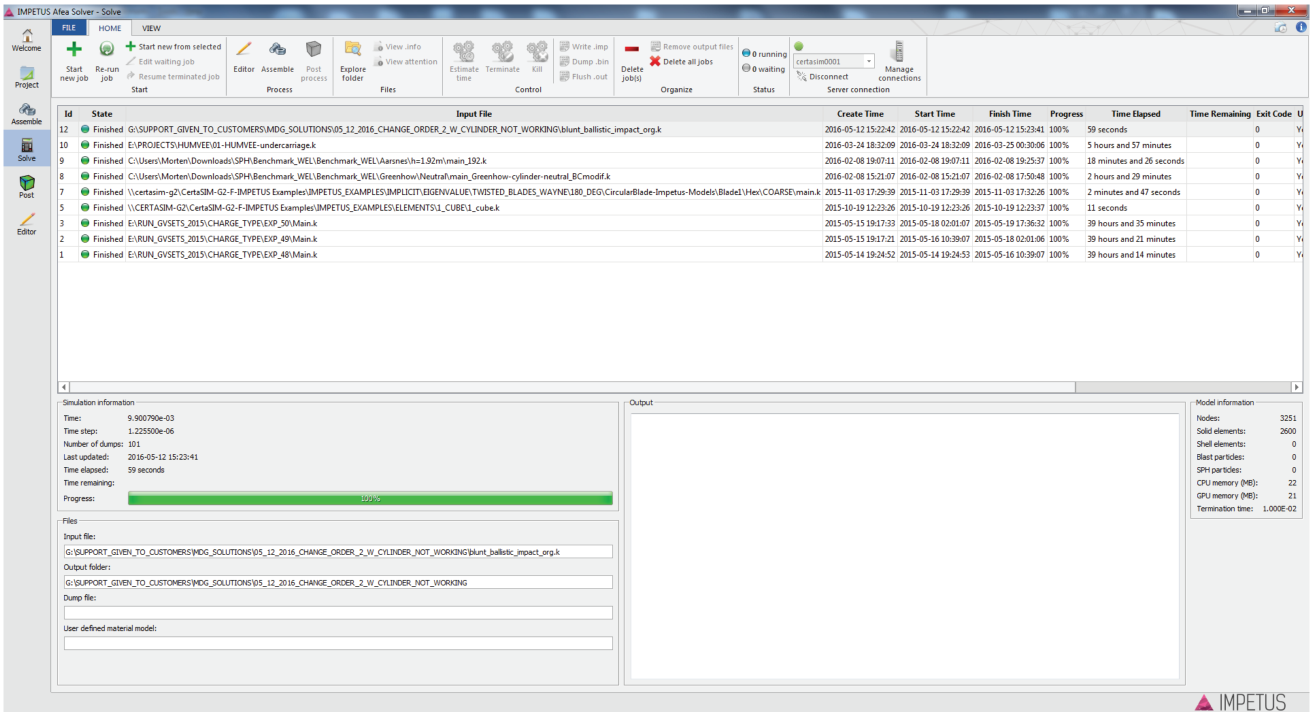
With higher order elements this is not a problem. In this case the mesh consists of cubic hex elements which have been smoothed at runtime by the IMPETUS Solver to capture the exact shape of the sphere. The contact surface is the cubic surface resulting in smooth contact no matter how the sphere rotates.

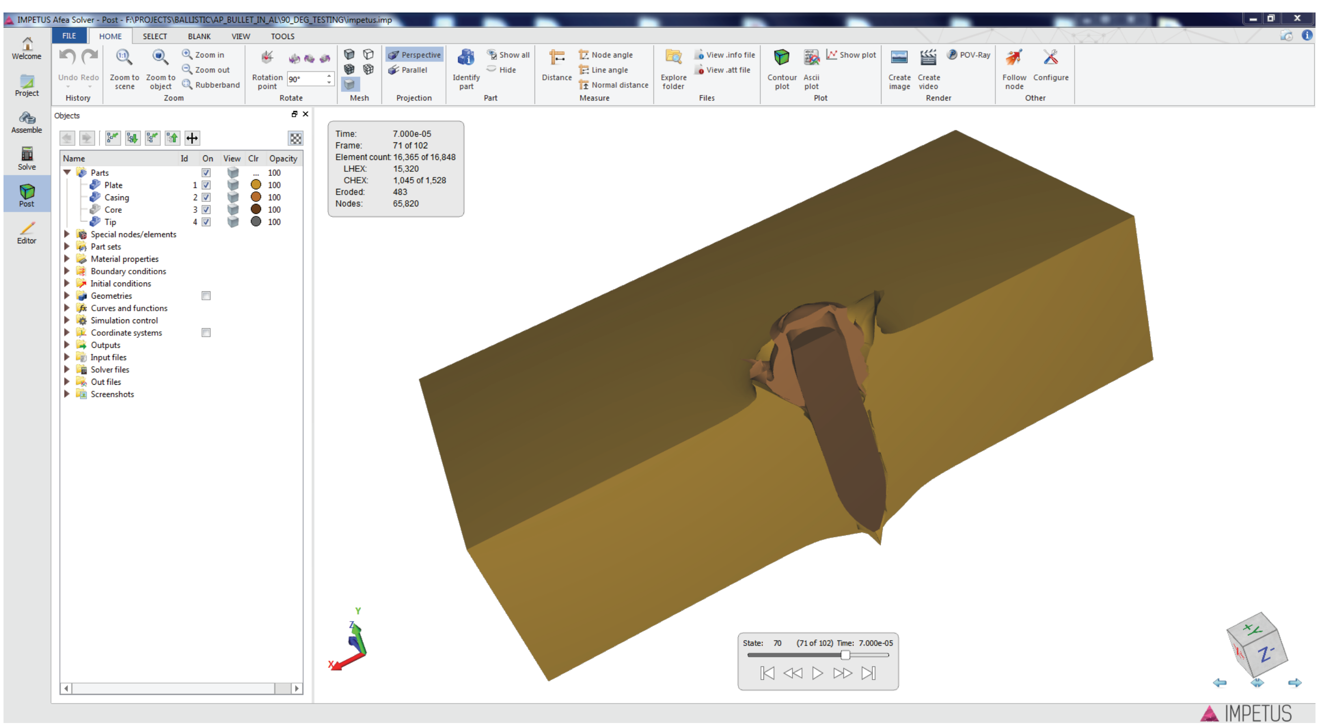


I will leave you with these thoughts. There are so many assumptions made in analysis, geometry should not be one of them. Of all the parameters geometry is something that can be measured accurately and is simple enough to do, there is no reason to introduce error when it is not necessary. The IMPETUS Afea Solver was developed based upon the principal that accurate geometry is the key to accurate simulations and accurate geometry is only achievable with high order solid element technology!

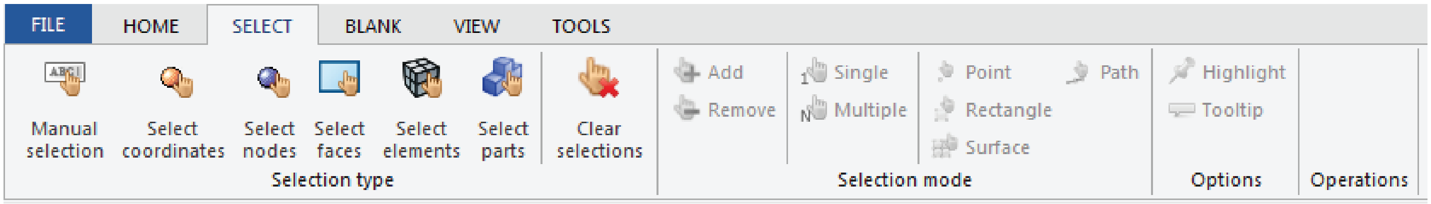
New Features in IMPETUS Afea Solver GUI

The look and feel of the IMPETUS Afea Solver GUI has changed! We like it and we hope you do too! It follows the Windows Ribbon protocol which helps to make use of the limited real estate available when designing a GUI interface. The new interface is even more modern while keeping the same streamlined navigation and functionality. One advantage of the Ribbon paradigm instead of toolbars and menus is that the commands are organized in logical groups which makes it easier to find the appropriate command. The new format is in all modules: Solve, Post, Editor, Aseemble, etc.

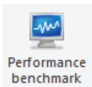




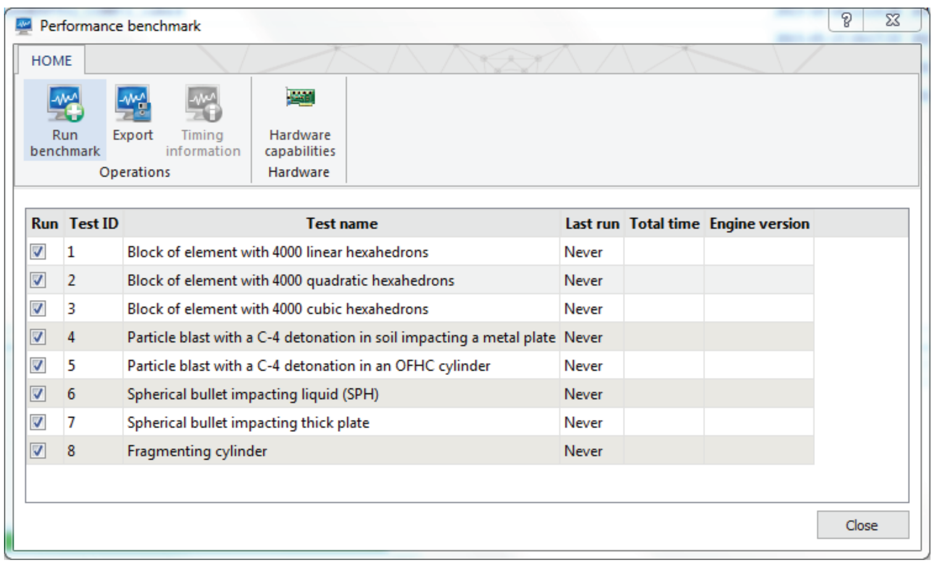
Each of the tabs have commands listed, e.g., the SELECT option has the different options associated with that entity.



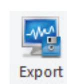
The customers that have tested the new version are very impressed with the modern look and how easily it is to navigate through the options. It truly gives the look and feel of "Next Generation" and what our users expect from the "Next Generation" IMPETUS Afea Solver.

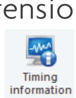
A new feature called the "Benchmark option" was just added. The primary goal is to build a database of performance based upon the various hardware platforms that are being used. Many users have already submitted their test results to the development team. If you want to participate and add your data you can send the results file to support@certasim.com. The Benchmark feature is located under the View option in Solve. 

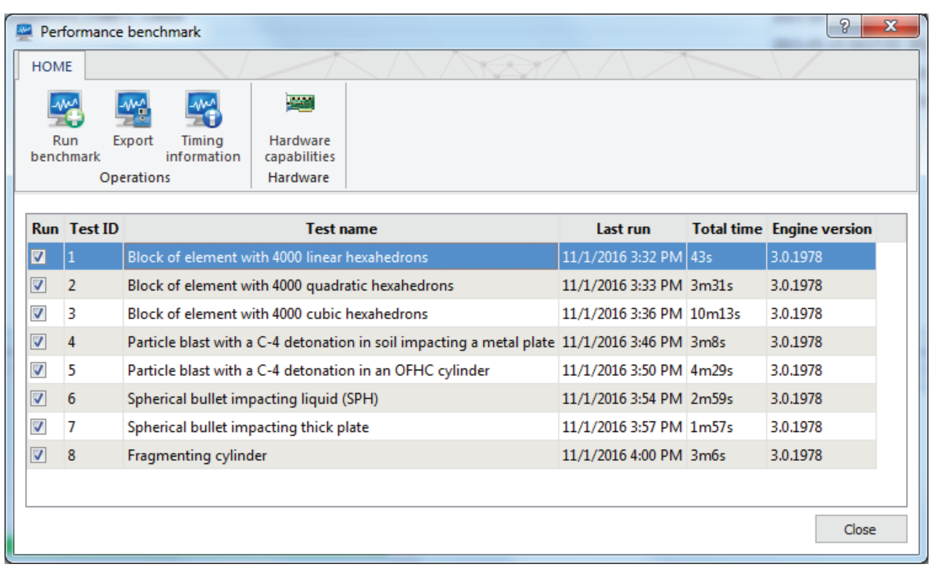
Click the button and a dialog box appears showing the various test cases that can be run.



Run	Test ID	Test name	Last run	Total time	Engine version
☑	1	Block of element with 4000 linear hexahedrons	Never		
☑	2	Block of element with 4000 quadratic hexahedrons	Never		
☑	3	Block of element with 4000 cubic hexahedrons	Never		
☑	4	Particle blast with a C-4 detonation in soil impacting a metal plate	Never		
☑	5	Particle blast with a C-4 detonation in an OFHC cylinder	Never		
☑	6	Spherical bullet impacting liquid (SPH)	Never		
☑	7	Spherical bullet impacting thick plate	Never		
☑	8	Fragmenting cylinder	Never		

After the runs are completed the timing is displayed and also exported. 

The format is an ASCII file with the extension .json. The specific timing information for each Benchmark job can be found with the timing icon. 



Run	Test ID	Test name	Last run	Total time	Engine version
☑	1	Block of element with 4000 linear hexahedrons	11/1/2016 3:32 PM	43s	3.0.1978
☑	2	Block of element with 4000 quadratic hexahedrons	11/1/2016 3:33 PM	3m31s	3.0.1978
☑	3	Block of element with 4000 cubic hexahedrons	11/1/2016 3:36 PM	10m13s	3.0.1978
☑	4	Particle blast with a C-4 detonation in soil impacting a metal plate	11/1/2016 3:46 PM	3m8s	3.0.1978
☑	5	Particle blast with a C-4 detonation in an OFHC cylinder	11/1/2016 3:50 PM	4m29s	3.0.1978
☑	6	Spherical bullet impacting liquid (SPH)	11/1/2016 3:54 PM	2m59s	3.0.1978
☑	7	Spherical bullet impacting thick plate	11/1/2016 3:57 PM	1m57s	3.0.1978
☑	8	Fragmenting cylinder	11/1/2016 4:00 PM	3m6s	3.0.1978