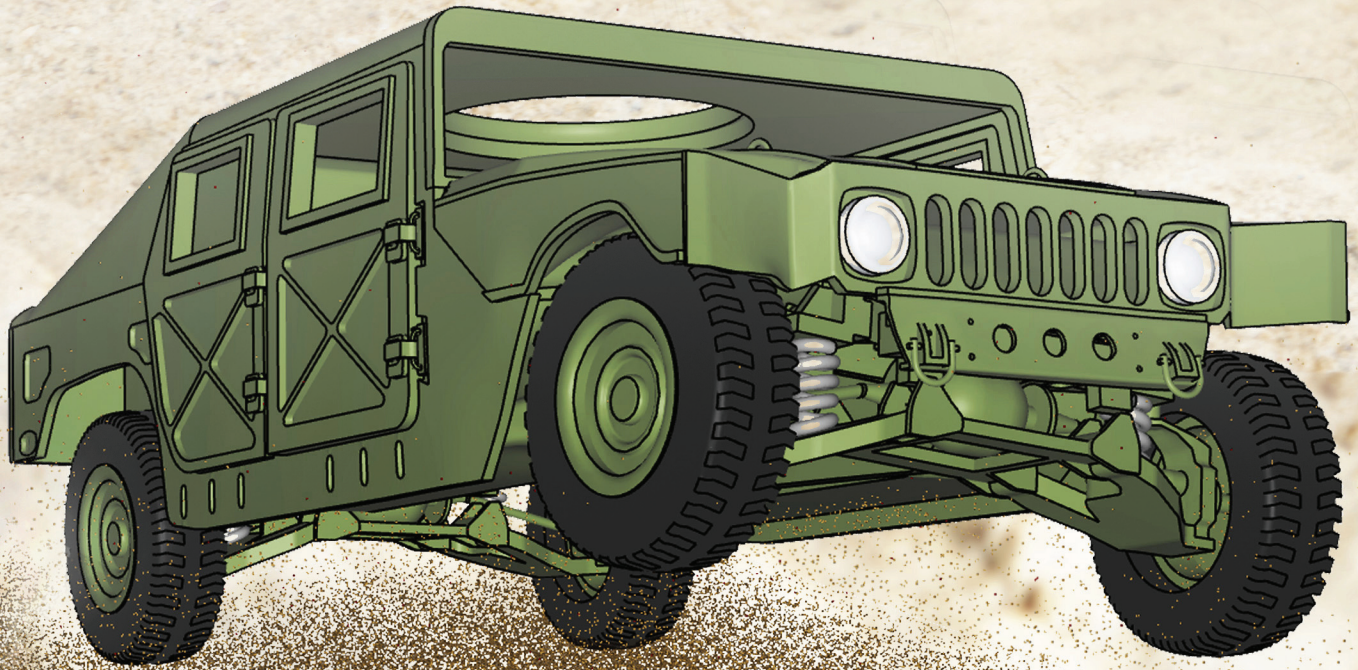
the Certa Sim SOLUTION™

Featuring:
Modeling of a
HUMVEE
Subjected to
Mine Blast Loading
in a Difficult Terrain



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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

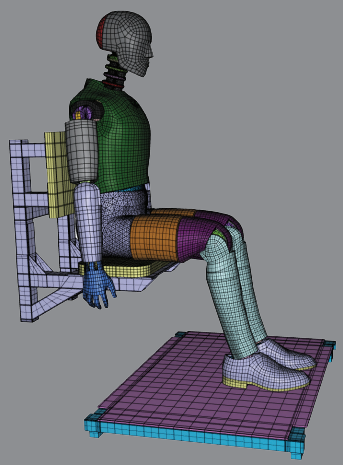
CertaSIM, LLC Sponsor's Mine Blast Tests to Calibrate the IMPETUS Afea Hybrid III 50 Percentile ATD Model for Mine Blast Impact.

CertaSIM, LLC believes all Finite Element software should be validated with experiments for different applications. This is why a large experimental project for deformation of extruded aluminum profiles was funded by CertaSIM and carried out at University of Windsor, see the Q4 2015 issue of the CertaSIM Solution.

A new R&D project was started that concentrates on calibration of the IMPETUS Afea Hybrid III ATD Model for mine blast impact. The building and calibration of the model was done by IMPETUS AB Sweden according to automotive industry crash standards.

"*We know there is a need for testing the dummy in a real blast environment, to obtain loading for such an event. It does not make sense to use a dummy calibrated for automotive crash tests in a simulation of a mine blast application. Especially if one is seeking a realistic and accurate response. This is why we have chosen to spend a significant amount of our R&D Funds this year on blast tests. Even as a software provider we have a responsibility to be involved in experimental work! I really look forward to visiting GDLS's test site to view the tests.*" said Dr. M. R. Jensen, CTO, CertaSIM, LLC.

A handful of explosive tests will be performed in July at the General Dynamics Land Systems Test Facility in Edgefield, South Carolina. In the next issue of the CertaSIM Solution, the test results will be discussed. Currently, the finite element ATD model has been properly seated in the test fixture and the sensors placed to correspond to the physical ATD test setup.



2016 NDIA GROUND VEHICLE SYSTEMS ENGINEERING and TECHNOLOGY SYMPOSIUM (GVSETS) August 2-4, 2016 - Novi, Michigan

CertaSIM, LLC will again attend the TARDEC conference on ground vehicles (GVSETS 2016). Dr. Morten Rikard Jensen will present work co-authored with Senior Technical Specialist Jim Rasico and Chief Engineer Craig Newman both from Navistar Defense. The paper is entitled "MODELING FRAGMENTATION OF A 155MM ARTILLERY SHELL IED IN A BURIED MINE BLAST EVENT". The paper investigates how to model detonation and fragmentation of a buried M795 artillery shell packed in soil and the resulting impact of the TARDEC Generic Hull model including a seated Hybrid III 50 percentile ATD dummy. The first step in the investigation was to model an explosively driven fragmentation of a cylinder to gain experience with the fragmentation process and assess the sensitivity of the relevant parameters. The next step was to model the M795 artillery shell filled with HE. Next bury the shell in soil, run a simulation and finally add the hull and dummy models to capture the impact to the structures. The paper demonstrates the complexity of this scenario and pushes simulation technology to a new level.

The presentation is scheduled to be at 2:30pm August 4th and we hope to see you there or at some of the other conference functions.

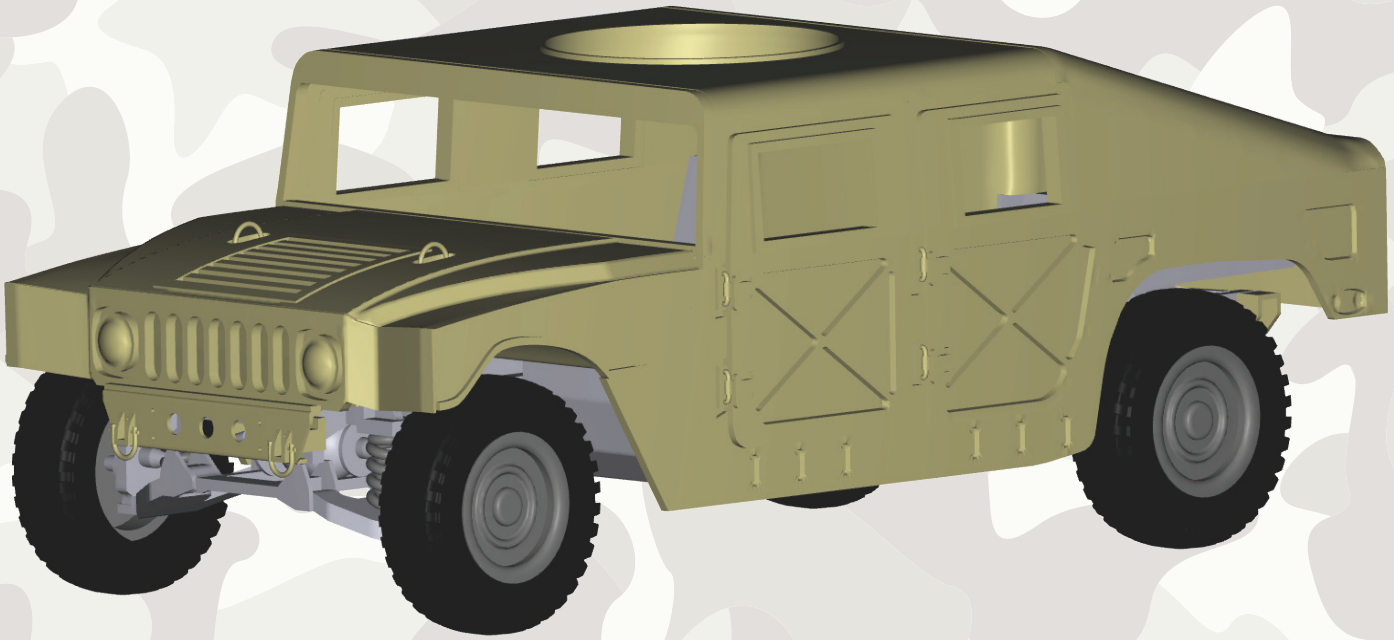
New Brochures

If you have not already received our new brochures, please contact us! Two brochures have just been released. One that covers the general features in the IMPETUS Afea Solver® and one that highlights the benefit of using IMPETUS for modeling mine blast events.

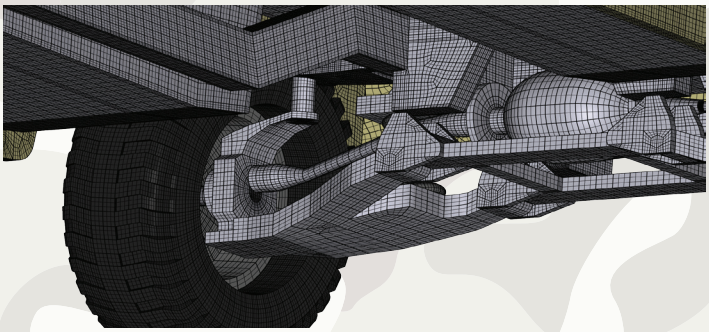
Modeling a HUMVEE Subjected to Mine Blast Loading in a Difficult Terrain

Throughout the years CertaSIM's staff have modeled hundreds of buried mine blast events, some have been customer models and others have been used to showcase various features or to obtain knowledge in a research project. The TARDEC Generic Hull model has been used for some of the research projects with great success, see [1]. This model is a hull model which represents a real structure. The next logical step is to simulate a realistic vehicle, so we have developed a new model.

The structure chosen was a HUMVEE [2] where the model and mesh were developed from publicly available CAD files.



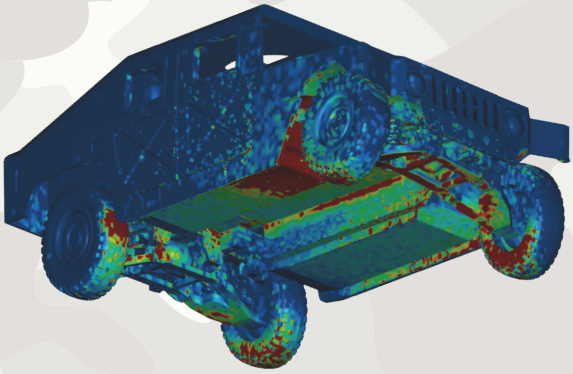
It was modeled with enough detail, such as wheel suspension and door hinges, etc. to represent the real vehicle. Special attention was focused on the underbody of the vehicle to make sure that the belly is detailed enough to represent the realistic shape.



The structural model has around 100,000 elements of which, 75,000 are cubic hex elements. The first scenario considered was a mine blast event where the terrain was not level and the vehicle was in a tilted position. It has a "wave formed" upper part instead of the traditional box shape. Modeling a complex shaped soil bed is not a problem with the IMPETUS Afea Solver® since any geometry chosen is automatically filled at RUNTIME. For the soil bed shown here a geometry was created to include in the model as a part and the *GEOMETRY_PART command simply generates a geometry based on this part definition making it very easy for the user. Future plans are to vary the shape of the soil surface and compare the blast impulse on the vehicle. An additional option is to see the effect that embedded rocks placed in the soil bed have on the blast impulse.

The charge used in this simulation was a cylindrical 1:3 8 kg C4 mine, placed under the front driver wheel. The soil bed is large so 8,000,000 particles were used to model the terrain. The termination time was set for 80 msec in order to observe the tilting of the vehicle due to the blast loading.

Both the HE and the soil bed are modeled with the IMPETUS Discrete Particle Method (DPM). This is done by using the *PBLAST command. The results look reasonable and the wheels are properly connected to the suspension so they do rotate.



There were no problems in running the simulation, even for the large deformation of the vehicle.

The next step is to compare the blast impulse on the structure with results from a vehicle placed on a flat soil bed.

The structure is currently used in several R & D projects at CertaSIM and customers can obtain the model by contacting support@certasim.com.

References:

[1] M. R. Jensen and Wilford Smith, "Discrete Particle Method is a Predictive Tool for Simulation of Mine Blast - A Parameter Study of the Process and Approach", 2015 NDIA Ground Vehicle Systems Engineering and Technology Symposium, MSTV, August 4-6, 2015, Novi, Michigan.

[2] Pat Ware, "AM General HUMVEE - 1985 onwards (all military variants) - Enthusiasts Manual", Haynes Publishing, 2014, ISBN 978-0-85733-374-2.

Acknowledgement:

The initial HUMVEE model development was done by MDG Solution, Inc. under contract with CertaSIM, LLC.

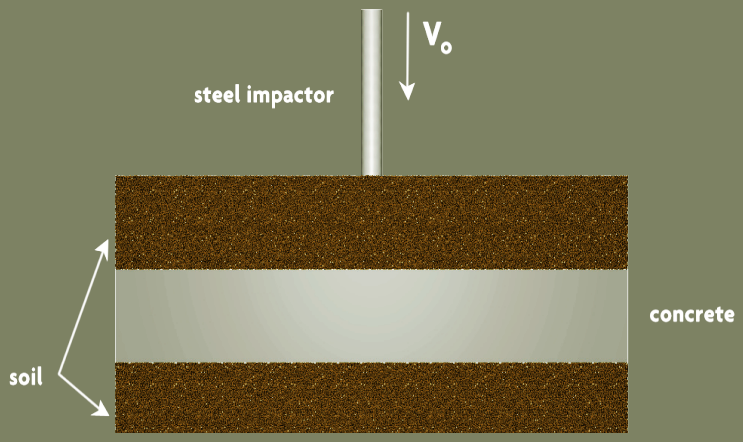
2016 BMES / FDA Conference

CertaSIM, LLC attended the 2016 BMES/FDA conference: “Frontiers in Medical Devices Confenrece - Innovations in Modeling and Simulation”. The conference was in Washington, DC, May 23-25, 2016. CertaSIM, LLC was an exhibitor as well as attending the conference itself.

A booth was shared with csimsoft, the developer of Trelis and Bolt meshing software. Videos were played at the booth showing both meshing tools and simulations with the IMPETUS Afea Solver®. CertaSIM was represented by Dr. Wayne Mindle and Dr. Morten Rikard Jensen and csimsoft was represented by Mr. Paul Ressler. It was a great synergy to be able to show both parts of a finite element model development, the pre-processing and the simulation itself. It also gave both companies a chance to share their connections as customers from both companies viewed the booth. We had great feedback from our colleagues in the medical device industry and fortunately many could see the benefit of applying IMPETUS in their applications where accuracy is definitely the key concern for this industry. The conference was the perfect venue to introduce IMPETUS to the medical device industry. One of the videos that we presented was a radial compression of a stent. The mesh for the model was created with Trelis. The video can be found at: **http://files.certasim.com/download/file/tech-info/videos/RadialStentCompression.mp4**

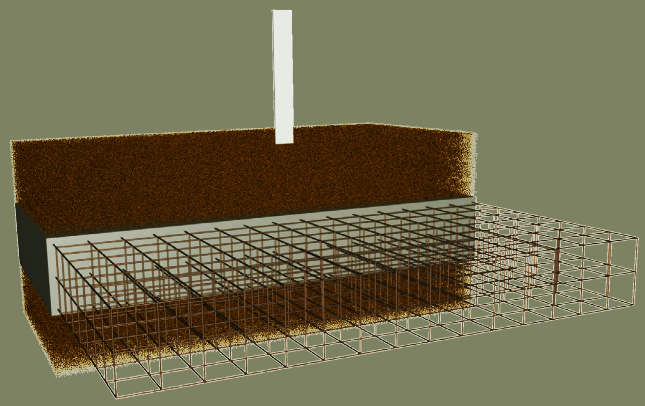
Modeling Warhead Penetration

CertaSIM's R&D department has investigated the impact of buried structures as a result of

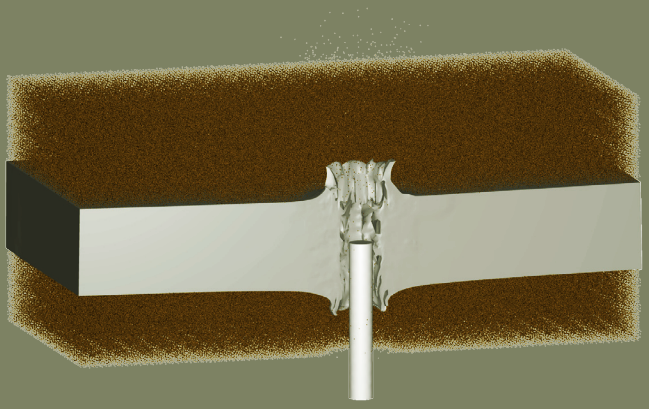


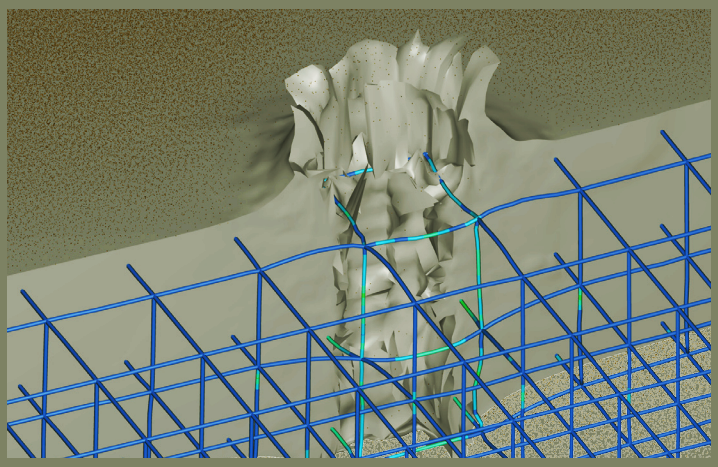
a customer's request. Specifically, the interest has been in warhead penetration of a concrete structure buried in soil. As a first step, an initial velocity driven cylinder penetrating soil which impacted a concrete slab was modeled. The penetrator had a diameter of 6.5in and weight of 400lbs. Two cases were considered, a rigid penetrator and a deformable one. The concrete slab was two feet thick and covered with two feet of soil. The soil was defined under the slab as well and rebar was also included in the concrete.

The penetrator was modeled with cubic elements and the concrete slab was a combination of linear and cubic elements which took advantage of the IMPETUS solver capabilities to easily and effectively mix element order to minimize computation time. The rigid penetrator was modeled using *MAT_RIGID where the deformable structure used a Johnson-Cook constitutive material model, *MAT_JC with properties from [1]. The concrete was specified as Holmquist-Johnson-Cook material with *MAT_HJC_CONCRETE. Rebar was modeled as elastic-plastic material with a Cockcroft-Latham failure, this is specified with *MAT_REBAR. It is easy to generate rebar elements with the *COMPONENT_REBAR. One simply defines the dimensions and location of the rebar cage and the diameter is defined in *PART. The soil is modeled with the Discrete Particle Method using the *PSOIL command. A total of 35,000 fully integrated linear hexahedron elements and 2,160 fully integrated cubic hexahedron elements were used along with 3,000,000 particles for the soil. The default dry soil option was used. Termination time was set at 5ms and the initial velocity of the penetrator at 2000 ft/sec.

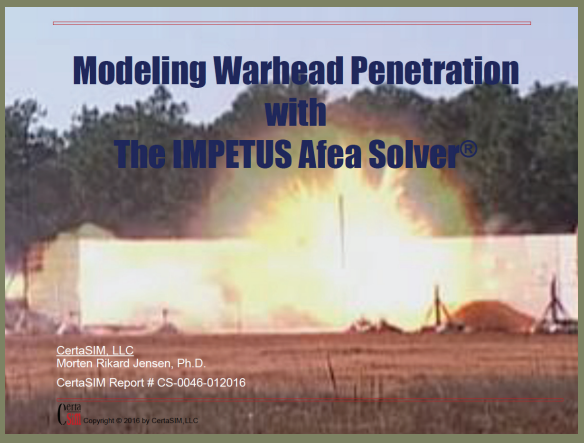


The model ran to successful termination with the penetrator digging into the soil, impacting the concrete and deforming the rebar. The thickness and strength was not enough to stop the penetrator which went through the concrete and continued into the soil below. If additional travel of the penetrator is of interest the soil domain needs to be extended as well as the termination time. No large difference was observed between the velocity profiles for the deformable and rigid penetrators, nor was there a large influence by including the rebar. However, it is believed that if the penetrator had impacted the rebar directly then there would be a definite difference. We plan to develop a model where the penetrator does impact the rebar and to develop a model where the soil domain is increased so the velocity profile for larger penetration in the soil can be analyzed.





The results for this study are documented in [2] and are available for CertaSIM customers by contacting sales@certasim.com. Accuracy of the solution can only be verified with experimental data and unfortunately publicly available data is hard to find so we leave that to our customers. New models are currently being developed where moving and deforming High Explosives are included. In this case the penetrator is not a solid cylinder but a geometry part filled with a HE that penetrates the soil and concrete and at some point in time detonates. This would include fragmentation of the artillery shell which is modeled with the IMPETUS "Node Splitting" Algorithm.



[1] G. T. Gray III, S. R. Chen, W. Wright, M. F. Lopez, "Constitutive Equations for Annealed Metals Under Compression at High Strain Rates and High Temperatures", Los Alamos Report, LA-12669-MS, 1994.

[2] M. R. Jensen, "Modeling Warhead Penetration with the IMPETUS Afea Solver®", CertaSIM report #CS-0046-012016.

Karl Merkley, Ph.D. - Director of Research and Development, csimsoft.

Karl Merkley, Ph.D. has more than 28 years experience in CAE software development. He received a Ph.D. in Mechanical Engineering in 2002 from Brigham Young University with an emphasis in engineering software development. He worked at The Aerospace Corporation, MSC Software, Aspen Research Corporation, and Edgix where he developed sophisticated cross-platform engineering applications. In 2001 he joined the development team and is csimsoft's Director of Research and Development. He specializes in Finite Element Mesh generation, Finite Element Analysis, scientific visualization, tolerance analysis, engineering software development. He co-founded Computational Simulation Software, LLC (csimsoft).

csimsoft develops Trelis and Bolt, which are very accurate and easy to use pre-processor working with hexahedron elements. CertaSIM, LLC believes that accurate geometry and accurate elements leads to accurate results. Some areas where accuracy is very important is the Biomedical field and CertaSIM has chosen to work closely together with csimsoft since they are world leaders in accurate hex meshing. We asked Dr. Merkley to discuss their Next Generation mesher, Bolt.

"Over twenty years ago, I co-authored a paper comparing hexahedral vs. tetrahedral elements for elastic and elasto-plastic analyses [1]. The summary points of that paper are still valid. 1) 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. 2) Linear tetrahedral elements (TET4) are not appropriate for solving elasticity problems. 3) Quadratic tetrahedral elements (TET10) give very good results for both linear and non-linear elasticity problems. 4) Linear hexahedral elements (HEX8) give results that are as good as quadratic tetrahedral elements with fewer degrees of freedom. Experience since that paper was published has also shown that hexahedral elements give better results for a range of non-linear problems.

Let's consider point 4 for a moment. Consider a simple cube that is 100mm on a side. Now create a linear hexahedral mesh in that brick. This gives 9261 nodes or 27783 degrees of freedom. Now, meshing that same cube with quadratic tetrahedral elements you end up with 105335 nodes or 316005 degrees of freedom. While machines and algorithms are faster, the hexahedral mesh creates a problem that is 11 times smaller and faster to solve. This becomes especially critical for non-linear solutions involving multiple time steps.

The biggest drawback to using hexahedral elements is the time that it takes to generate a high quality hex mesh. In production environments, we don't have a week to create a quality model. Hence, we rely on rapidly created tetrahedral meshes. Too often, the only time we create really accurate analyses is after some kind of catastrophic failure. Then management finds time and resources to resolve the problem.

But, what if it were possible to create an accurate, well formed hexahedral mesh in just a few minutes? What if one of the leading government labs in the country tested that mesh and was finding it to give excellent results on some of the hardest kinds of problems?

Bolt can provide all hexahedral meshes for a wide variety of problems. The core is a traditional grid overlay technique. The overlay grid is then modified using pillowing and sheet insertion techniques to give well formed elements at the surface and reasonable transitions from surface to the overlay grid. The algorithm is highly parallel and reproducible. Node and element numbering of the mesh is consistent even when run on a different number of processes.

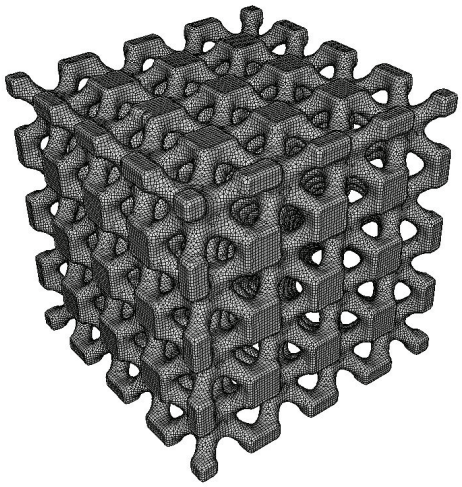
Bolt is designed to provide a high quality all-hexahedral mesh, with minimal user interaction. It provides a very good mesh for some kinds of physics and some kinds of analyses. As we continue researching and developing this capability, we believe that we will be able to provide a mesh that is appropriate for a wide range of analyses."

[1] Benzley, S.E., E. Perry, K. Merkley, B. Clark, and G. Sjaardama. "A comparison of all hexagonal and all tetrahedral finite element meshes for elastic and elasto-plastic analysis." In Proceedings, 4th International Meshing Roundtable, vol. 17, pp. 179-191. Sandia National Laboratories Albuquerque, NM, 1995.

csimsoft bolt - the Next Generation Mesher

csimsoft recently released Bolt, a new automatic hexahedron meshing tool that produces high quality meshes. Anyone that has tried to mesh a complicated geometry knows how difficult it is to create a good hexahedron mesh. Bolt solves this problem with new technology that makes the job easier, in fact with many structures just the push of a button. Bolt can mesh irregularly shaped topology found in the Bio-medical industry, Metal Forming applications, Microstructures, etc. Key features of the software are:

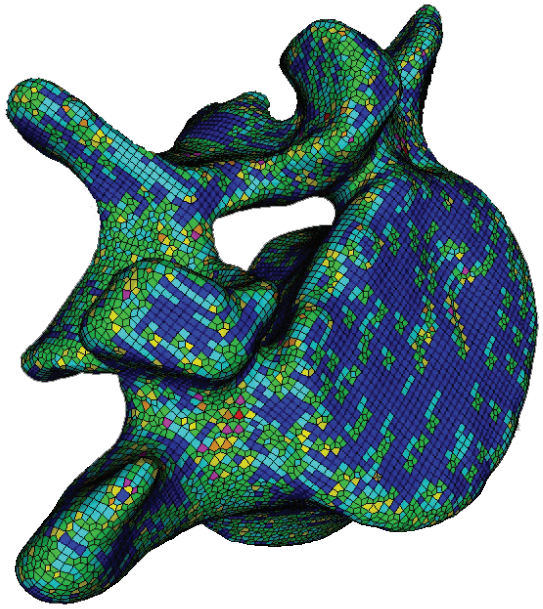
- No more cutting up of models.
- Tolerant of dirty geometry.
- Massively Parallel Processing.



Bolt supports the geometric format for the IMPETUS command file so a mesh can be exported and used directly in IMPETUS. We suggest you try it for yourself and request a Trial Version of Bolt.

An overview of Bolt can be found here:

http://www.csimsoft.com/boltoverview.jsp



FAST HEX MESHING AT THE PUSH OF A BUTTON