Development of a New Software Architecture for LS-DYNA® Applications

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Abstract

Engineers and researchers are able to carry out complex, multi-physics simulations using LS-DYNA®. The scope of these simulations may include multiple solvers and multiple steps. The variety of simulations available in LS-DYNA® require a complete FE modeling software that allows for creation of all types of elements, materials, contacts and properties.

While this complete coverage of all entities is critical, the ability to provide users a unique subset of the complete toolset, to address a specific simulation area, such as fluid-structure interaction or vehicle crash simulations.

Inventium is a software architecture that provides both a complete coverage of all LS-DYNA® entities, but is configurable both by software architects and the user, to provide a set of streamlined tools to carry out a specific simulation task.

Examples of customized menu systems and application tools will be presented for drop test, fluid structure interaction and vehicle crashworthiness simulations will be presented.

Introduction

Specialized user interfaces for specific engineering applications provide many benefits to engineers engaged in simulation activity. Among these benefits are: quick set up of models, simplified user interfaces, automation of repetitive processes and knowledge capture.

As described in a previous paper by the author [1], the ability of a software architecture to meet the needs of customized or vertical applications was defined. The architecture must:

- Have a complete function set
- Configurable User Interface
- Ability to capture processes
- Interaction with external databases and software tools
- Open access to functions, scripting access

In addition, the development of such an architecture must provide a means to move forward und update the support for solvers as those solvers make changes and additions.

These basic capabilities provide the needed infrastructure to identify and create interfaces for specific types of simulation. This paper will discuss the development of 3 interfaces for unique and varied analysis types; Fluid-Structure Interaction modeling, Drop/Shock and Vibration modeling and Vehicle Crashworthiness and Occupant Safety modeling. These types of simulation are varied in both their types of products on which they are applied and the industries that make use of these simulations- but they all share a common theme; they are all performed using LS-DYNA®.

ETA's Inventium® product architecture meets these requirements by providing complete coverage and support of all LS-DYNA® entities. It also was designed to have a flexible, configurable user interface. Inventium also meets the needs of users who need to interact with external databases and use scripting to drive modeling tasks.

Vertical Application Toolsets

Vertical Applications can be defined as a specific type of simulation or a class of simulations that are product focused, and follow a type of analysis i.e. vibration, stress, deflection. Vertical Applications are also usually linked with an industry, such as automotive or electronics.

Users of LS-DYNA® may be found in many industries, and the range of uses is continually growing, as the capabilities within LS-DYNA® continue to expand. To create a vertical application interface in Inventium each of these above considerations must be studied and finally, the vertical application must have a commercial impact on the product design and development process.

Inventium development has identified three vertical applications for development which meet these requirements: Fluid-Structure Interaction, Drop/Shock and Vibration and Vehicle Safety.

Complete Function Set Support

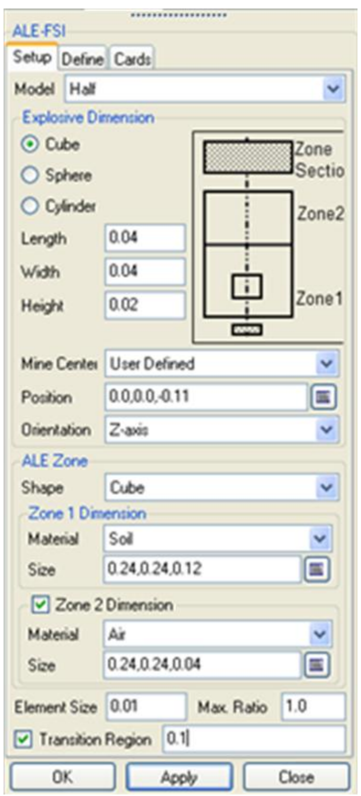
Inventium's PreSys® module is a complete pre and post processing software for LS-DYNA®. This product supports all of the simulation types available in LS-DYNA®, The interface with LS-DYNA allows the user to create all keyword, either through a task panel style user interface or through an image of the specific keyword with all of the available data fields definable.

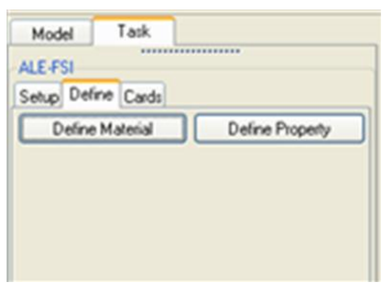
This complete coverage enables the creation of subsets of the modeling tools to support vertical application development.

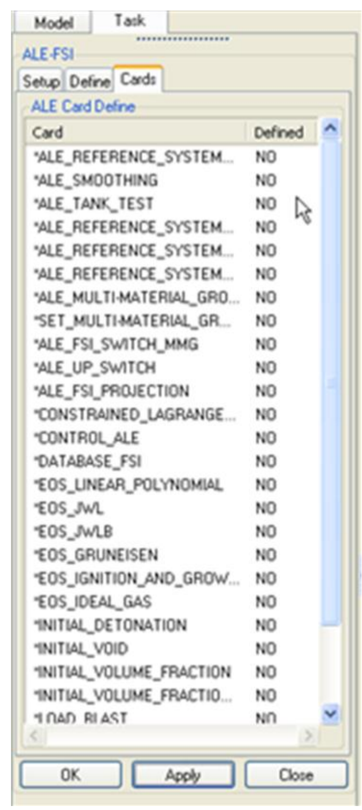
Fluid-Structure Interaction (FSI)

FSI modeling makes use of the ALE simulation capabilities of LS-DYNA®. This type of simulation may also make use of various materials, as well as structural models and fluid models which must be linked together to make the simulation perform properly.

Users who need to create these types of simulations make use of a limited number of material models and contact types. They also need to create solid meshes in large blocks, or to fill a volume. Each of these unique requirements provides an opportunity to create a subset of the complete features of the Inventium PreSys® software.

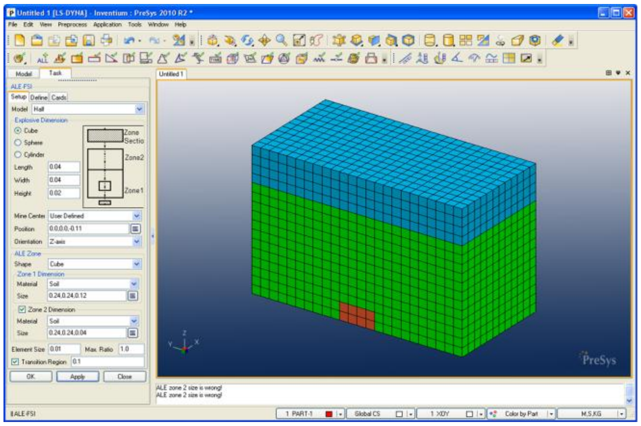


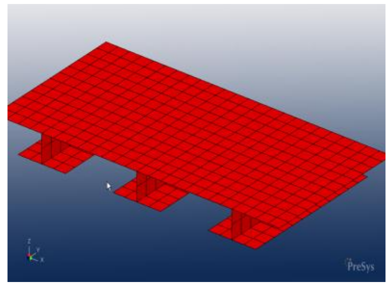


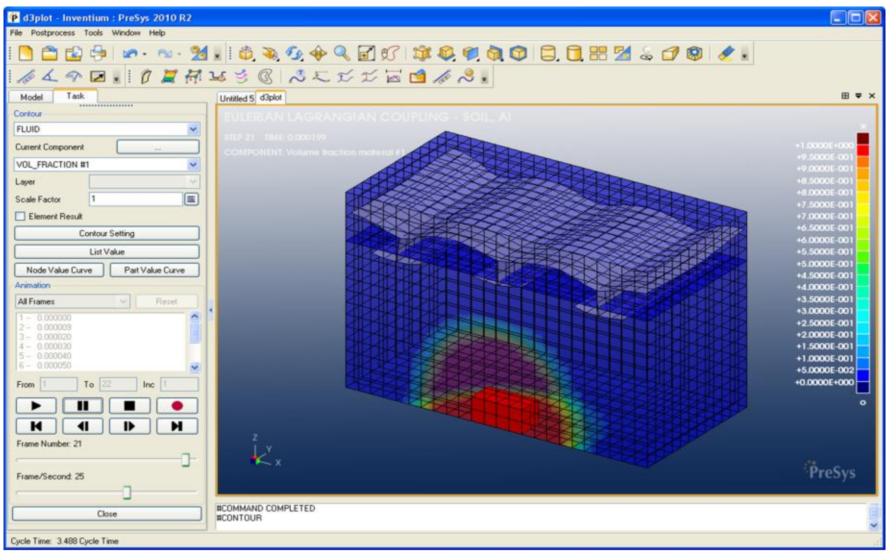


The creation of the vertical application for FSI focuses on blast simulations, using an ALE approach. The tasks identified in this modeling process were identified as ALE zone meshing, Blast Source Modeling, Material Definition, Structural Model Coupling, and Control Card Definition. Each of these major tasks can be further refined, to provide automated tools to consider standardized configurations such as standard blast source shapes, ALE zone shapes, and typical materials.

The implementation of this in the software product is shown in the following Figures.





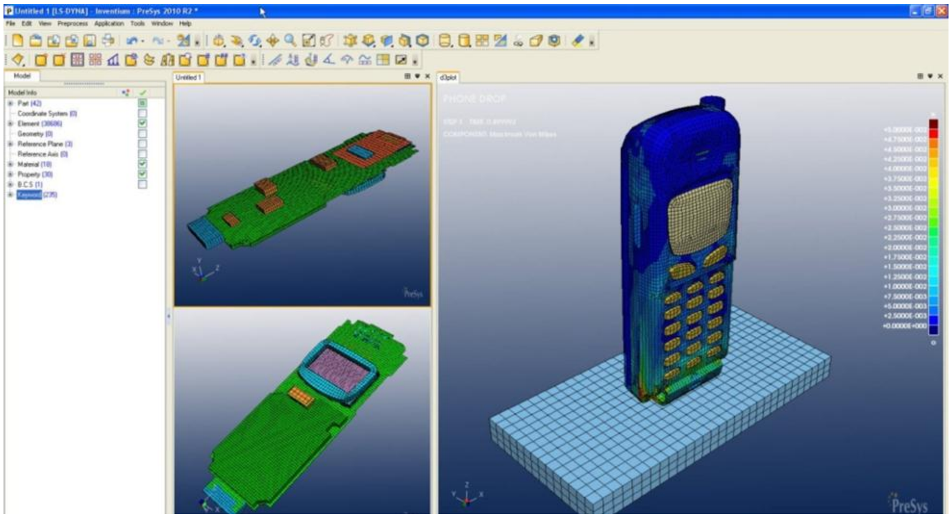


The user interface has a step-by-step process which was developed based on user input and follows the overall process that is required to successfully complete a simulation model.

Through this implementation, users can quickly set up the mesh, select the materials and material models from a drop down list, and define various standard shapes of the blast source and ALE mesh zones. This ultimately provides a toolset that is easier to use by less experienced users, and reduces the searching for the required control cards, coupling and materials amongst the many possible keywords in the PreSys user interface. This delivers on the final requirement, that is, it provides a commercial impact by reducing training requirements and improving productivity.

Drop/Shock/Vibration Simulation

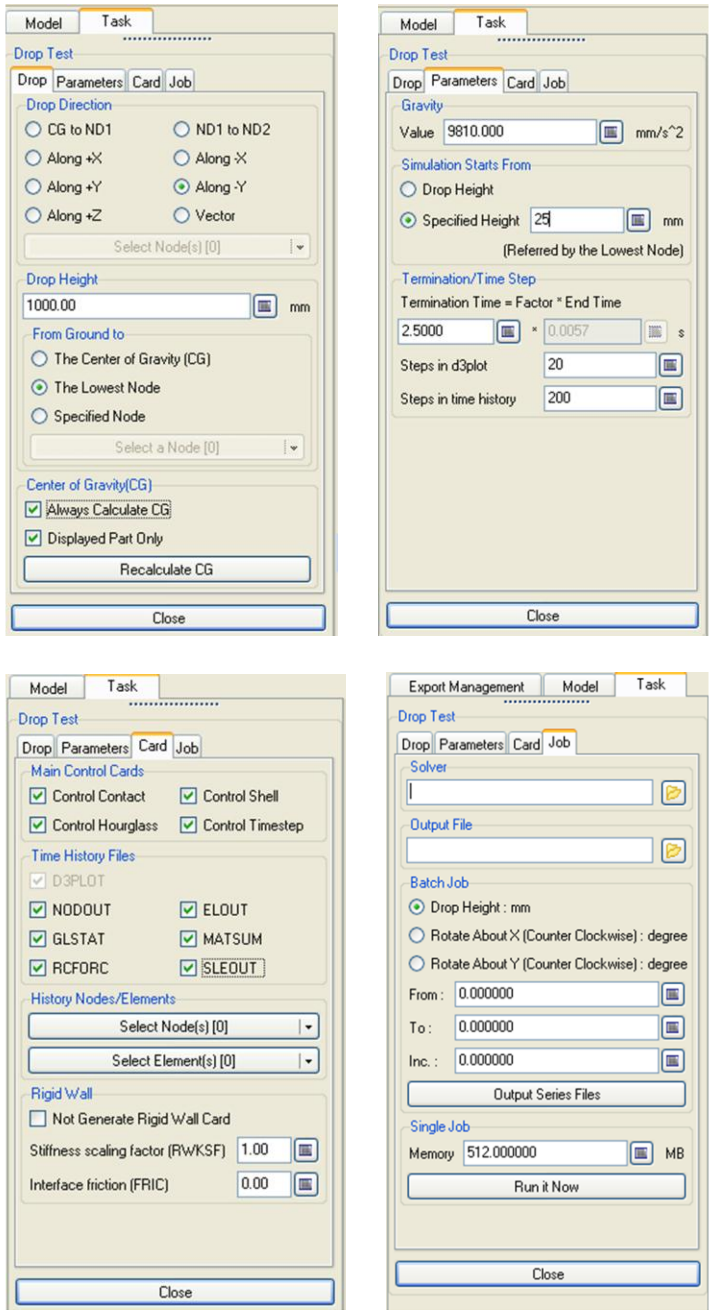
Drop testing makes use of the transient nonlinear dynamic capabilities of LS-DYNA®. Drop tests are based on the process identified through the physical testing procedures used for the evaluation of consumer products such as electronics, appliances and toys, as well as the packaging that these products are contained within during their shipment to the end user.



Drop Tests have a limited number of variables that can be defined; drop height and drop specimen orientation. While the number of variables are limited, the range of these variables in a product evaluation may result in the creation of many models which must be evaluated. Engineers who perform drop test simulations may not be experienced in the dynamic nonlinear finite element simulation practice, but still require this capability to properly evaluate their designs. By providing a vertical application toolset that automates the creation of the initial velocity definitions, the model drop orientation, node sets and control card definitions brings the use of LS-DYNA® within the reach of less experienced engineers.

Since the typical drop test may be carried out for many different drop orientations and drop heights, the automation of creating multiple models provides a useful tool for quickly and efficiently creating these model variations.

The implementation of these tools is shown in the following images.



Vehicle Safety Analysis

The areas of automotive crash and occupant safety make extensive use of LS-DYNA® for many simulations. These scope of these simulations is driven by the physical testing that is performed on the vehicles for both development of the vehicle and subsystems and the certification testing of the vehicle by governmental agencies and consumer groups.

Testing procedures for vehicle safety are consistent throughout the automotive industry, as a means for subjective assessment of a vehicle’s safety performance. Groups such as National

Highway Transportation Safety Administration (NHTSA) and Global New Car Assessment Program (NCAP) define and monitor the testing of vehicles.

This type of specific testing requirements lends itself well to the creation of a vertical application. The tests are carried out in a well-defined manner, using a specified set of boundary conditions and use a prescribed set of loading devices. There are a set of variables that must be defined, and, finally, there may be many different simulations, due to the number of tests specified, therefore, the commercial impact of a vertical application tool may be quite large in both the time spent preparing these analyses and the value of the results with respect to the development of the vehicle or subsystem performance.

The implementation of the Safety vertical application toolset in Inventium is quite broad. It applies to full vehicle test simulations as well as occupant safety and related subsystem performance. Tools have been developed to allow the user to import and position a finite element dummy model, define a seat belt system on that dummy and consider the deformation of the seat cushion foam beneath the dummy. Each of these tasks requires a degree of skill and understanding that can be captured within a vertical application toolset.

By defining libraries of dummy models and allowing the user to import 3rd party dummy models, the vertical application toolset helps the user by learning the hierarchy of the model such that movements of models parts can affect the ‘downstream’ components, such as the relationship between the upper leg, lower leg and foot.

Defining a seat belt element can be a laborious task. Not only must the user define a seat belt element and property, but they must also define a path along the dummy outer surface and create anchors, slip rings and retractors. Using a vertical application toolset for such a modeling activity allows the users to create these entities quickly, efficiently and without the detailed knowledge of how to define a path of the seat belt elements.

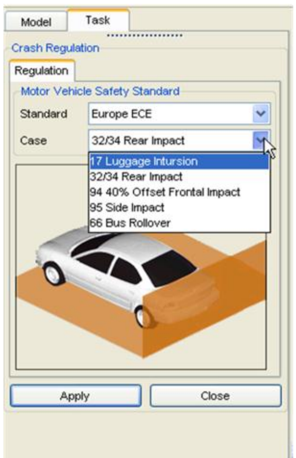
In order to define the mesh distortion due to the dummy sitting on the seat cushion, the vertical application simply identifies the interference and then morphs the mesh, achieving a geometry that matches that found in the physical test. The user would require several surfacing tools and mesh generation steps to achieve the results of the vertical application tools.

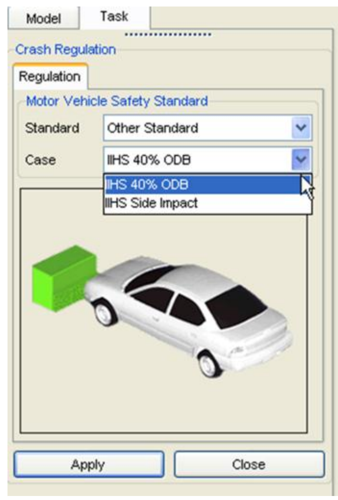
The full vehicle test simulation can also be impacted by the use of a vertical application toolset. Full vehicle tests prescribe the impact device (rigid wall, deformable wall, moving barrier, etc.) and the speed and attitude of the vehicle. These parameters can be easily controlled through a user interface that allows the user to select and position an impact device from a library, or import and position a device from a 3rd party. The user can also define the velocity of the device and any outputs that may be required. In the case of standardized outputs, the vertical application toolset can automatically define these output requests a priori, but allow the user to modify these parameters.

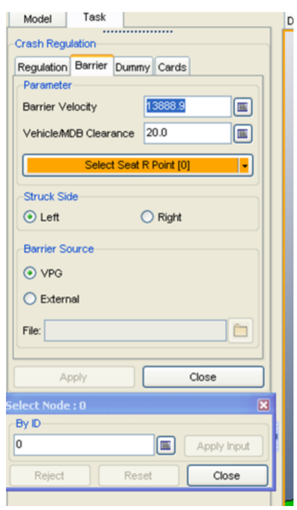
The Inventium Safety® vertical application is organized in a manner that guides the user through the process of defining the necessary parameters to define the setup of the FMVSS, ECE, JNCAP and Insurance Institute (IIHS) tests. The users select the impact device from an internal library or import and position a device from a 3rd party library.

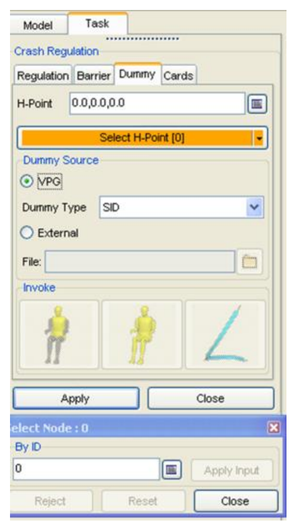
After the user positions the impact device, they have the ability to import and position a dummy model and add seat belt models. Standard outputs are collected for the dummy model(s) and the impact device, according to the test specifications.

The user interface for an example showing the various safety tests is shown in the following Figures.









Additional Vertical Application Toolsets

The opportunity for additional vertical application toolsets is as varied as the jobs that engineers perform. In many ways each of the simulation types available within LS-DYNA® may benefit from its own specific set of modeling tools. As an example, acoustics, and other frequency domain analyses often use different types of input data than that used in other LS-DYNA® simulation types. This can cause productivity problems in both the previously trained LS-DYNA® engineer, or the user of another simulation software which was developed for that specific purpose. Switching simulation types or software products can be aided by a specific set of tools that guide the user through the steps needed to successfully define the parameters needed for that specific type of simulation.

As engineers find additional uses of advanced simulation software such as LS-DYNA®, they will continue to seek out and benefit from the development of vertical application toolsets like those enabled by the Inventium product architecture.

References

1. "A Next Generation Software Platform for LS-DYNA Modeling and Configurable Vertical Application Development" By H. Ouyang, Tim Palmer, Q. He, Engineering Technology Associates, Inc. Proceedings of the 7th European LS-DYNA Conference, Salzburg Austria, 2009.