Accelerating Regulatory Test Simulation with LS-DYNA through Process Guidance Technology

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ABSTRACT

With the strength in implementing best practices process guidance technology has proven dramatically reduced lead times in pre and post processing while meeting the increasing complexity imposed by ever changing safety regulations.

Using predefined template processes for regulatory tests, for example for Euro NCAP, ACEA, or FMVSS standards, process guidance technology allows users to be driven or guided by ready made test templates for the most common load cases with LS-DYNA and other crash and safety solvers. When integrated in the pre and post environment modelling and results preparation for load cases such as ECE-21, FMVSS 208, the bumper test, or pedestrian safety, analysis loops are reduced from days and hours down to minutes.

This presentation describes why and how process guidance technology is introduced, covering both the technological and organisational aspects and decision made as part of the implementations. With the example of pedestrian safety processes the benefits and issues of implementations are presented.

Introduction

Process Guidance Technology is introduced to dramatically increase productivity in crash, safety and noise, vibration, harshness (NVH) simulation. The technology was introduced in the US as part of the EASi Suite already in 1998. Since then, a large number of implementations have been completed, especially for crashworthiness and NVH simulation best practices. In Europe the rate of adoption has been slower than in Asia and the US. There are different reasons to this, rational or not, but it is clear the technology is proven and that there are changes in the European automotive industry which suggests the pace of adoption is to increase fast. Key change drivers are:

- An increasing rate of change in early phases
- An increasing number of variants of products
- An increasing rate of change in legislation
- A forced cost reduction in R&D in general
- Global sourcing and resource mobility

The first three are key change drivers motivated by the faster rate of adoption of a frontloading strategy. Japanese firms have been very successful in introducing this strategy through CAE, where simulation is actively used to cut lead times through early detection of design or process issues, enabling more decisions earlier in the development process. European organizations which build a competitive advantage on innovation, for example in safety, have been forced to increase the application of CAE with similar development strategies.

One key issue, especially for the automotive firms which develops car for the European market, is the increasing rate of change in an increasing number of legislations. Engineers are forced to pay more attention to changes in regulatory tests and the administration of models which follows on this – taking time from engineering analysis, instead of adding the value of engineering analysis. When the time for engineering analysis is reduced the technical risk of product development is of course increased. To respond to this, automotive firms have to look for new solutions which allow them to reduce time in model build-up and report generation. Process guidance technology is particularly well fitted for productivity increases in modeling for compliance with European standards.

Additionally, over the last two years cost cutting and modesty in investments have been, and are, in fashion in Europe. As mentioned above there is an increasing acceptance and need for simulation, but is also a fact that many development organizations have to face this with reduced resources. Now when the activity in development projects is increasing there are two common approaches to handle this - either perform routine work cheaper (outsource) or automate.

Therefore, process guidance technology is being adopted at a faster rate, and it is expected to continue in the years to come. The next section will exemplify how the technology is applied in a sub-process in our process suite for pedestrian safety simulation in accordance with Euro NCAP or ACEA.

Pedestrian Safety – An Example

Process Guidance Technology is taking a set of tasks in pre and post processing and binds them together to a defined process template, or best practice. The process can be fully or partially automatic, a choice which is determined by application, the specific organisation it is implemented in, or by the end user. The example used in this case is a sub-process in a set of processes which build models and generate reports related to the pedestrian safety simulation (in this case in accordance with Euro NCAP and ACEA).

The pedestrian regulation highlights issues common to most implementations. The basis for this process is the regulatory tests for pedestrian safety as defined by European or Japanese standards. In Europe the regulatory test set-up covers adult headform, child headform, and upper and lower leg impactors. The lower leg simulates a leg hit from the side, usually at the height of the bumper. The upper leg impactor simulates a follow on impact, often at the bonnet leading edge. Depending on the shape of the frontal structure the impactor speed mass and angle are varied. The child headform impacts the bonnet at six impact points, as defined by wrap-around distances in between 1 – 1,5 meters from the ground. The adult headform impacts the bonnet also at six impact points, but in this case in between 1,5 – 2,1 meters from the ground. The performance criteria for the headforms are Head Injury Criteria (HIC) which should not exceed the value 1000 at any point of the impact zone on the bonnet. The performance criteria for the leg impactor are defined as max values of knee bending angle, tibia acceleration, and shear displacement. The regulatory tests are implemented in different phases with differences in requirements over time, and differences in relation to different markets (Japanese or European).

The set up of the regulatory test in itself has a level of complexity which is obvious, but is manageable. But a key issue is that design changes in the frontal structure effects many different parts of the organisation – it is multidisciplinary, and that a solution has to handle perhaps conflicting load cases, styling and packaging issues. This requires a rapid turn-around, something which has asked for a simplification of models. This approach has proven to be successful in some cases, in other cases not.

Conventionally, the model to represent the above regulatory test is built using general purpose pre and post-processors, which is very labour intensive and requires from the engineers a high level of concentration during process execution to ensure that no error was made during model definition, analysis, post-processing and result interpretation. The engineers' attention and energy is spent more on executing the processes than in engineering the product. The engineers which build the model have to not only manage all the data but also need to ensure that every aspect of the process is per current corporate practice. The burden of procedure consistency, repeatability and accuracy lies entirely on the engineer. When a different person, a different group, or the same person at a different time performs the analysis, there is a real chance of obtaining different results. This is because conventional process execution does not lend itself well to standardization and repeatability.

Early attempts to deal with the modelling complexity used scripts and session files. Although this increased the level of process automation, they where seldom user-friendly, they where non-intuitive and had a very low level of integration in the CAD or CAE environments. Furthermore, when the second phase of the legislation was introduced, and later on the Japanese requirements, many realized that it was cumbersome to update all scripts, especially since the senior analyst who developed the scripts had moved to a different department. This motivated the introduction to a structured implementation of regulatory test simulation, process automation and productivity improvements.

Introducing Process Guidance for Pedestrian Safety

Introducing Process Guidance Technology for pedestrian safety is taking each task in the modelling and report generation in pre and post processing and binds them together to a defined process template. The first step is to capture the best practice from CAE users, corporate and legislative standards. This captured practice is then implemented in a set of templates of process and sub process tasks. Unlike a solution built with scripts and session files the process flow of the task sequence is provided to the CAE user with necessary execution control, for example to pause a process, bypass or undo a task, or step through a process manually or automatically. An example sub process is displayed in Figure 1.

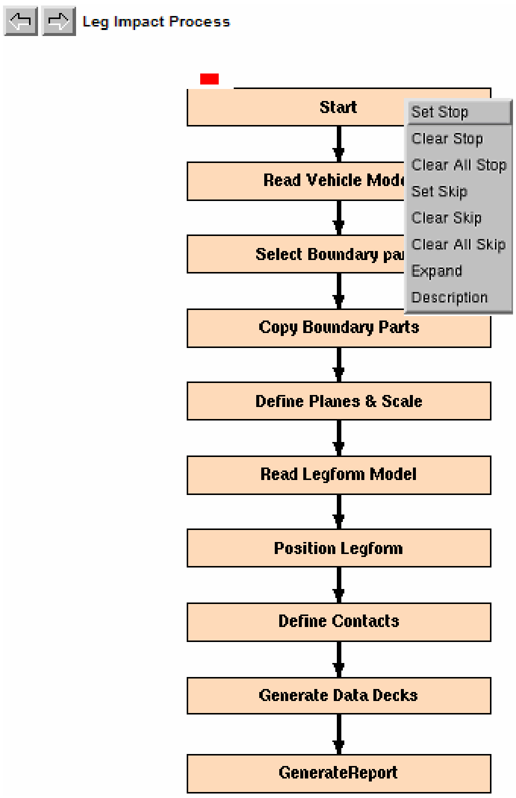

Fig. 1 The Leg Impact Sub Process

When the process is defined as a flowchart it is visible and accessible, also for engineers not directly involved in the CAE process, or engineers new to the pedestrian organisation/simulation. When the best practice is mapped it is also common to map models for simulation data management. Processes are connected to corporate defined or standardized data pools. When this pedestrian process is connected to the PDM system, a change in a design can trigger a re-mesh of the component and launch “part replace”. When the part is updated the process can be automatically rerun to reflect the design change.

The above flowchart, or process template, is built within the Process Builder. The Process Builder is a graphical interface dedicated to building and updating process flows (Figure 2 below). It has access to all modules in ESI Group’s Open Virtual Try-Out Space, (VTOS) the complete and open pre and post-processing environment for RADIOSS, LS-DYNA, PAM-CRASH, MADYMO and MSC.Nastran as well as already developed template processes and sub processes. The Process Builder contains a set of software modules and object libraries for various CAE tasks. Each task is represented by a process block. Each block is provided with a knowledge advisory that captures the expertise of experienced users. When building a process for LS-DYNA, EASi-CRASH DYNA (the part of the Open VTOS which is DYNA specific pre and post processing) is used for prototyping. All functionality of EASi-CRASH DYNA can be used to build a process, and the process in itself will later be used as a completely integrated process in the pre and post tool.

For a number of standard tests, for example for FMVSS 208, Euro NCAP, FMVSS 201, ECE-21, the bumper test, etc ready made templates are already available in EASi-CRASH DYNA, and sub processes of existing templates are reused where appropriate. Additional templates can be designed and implemented either by ESI Group or by the engineers in the development project.

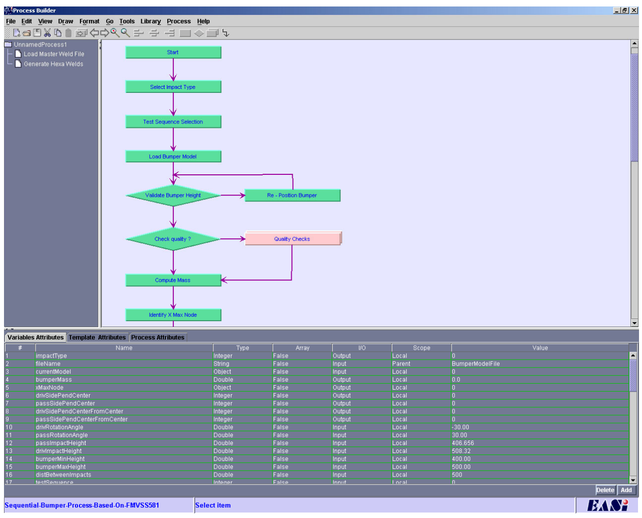

Figure 2: Building a Process Template in the Process Builder

Some of the most frequently requested process templates for LS-DYNA as of spring 2005 are:

- ECE-21, FMVSS 201
- FMVSS 201 Upper
- The bumper tests
- FMVSS 203
- Euro NCAP, US NCAP
- FMVSS 208
- FMVSS 214
- Pothole analysis
- Roof Crush Analysis
- Pedestrian Safety (Euro NCAP/ACEA)
    - Create impact zone areas
    - Frontal structure morphing
    - Head form positioning
    - Leg impactor positioning
    - Report generation

Executing the Process

A user friendly and intuitive interface is used to execute the process templates. The user selects out of the process template library which process to apply. The layout of the interface is explained in Figure 3 below.

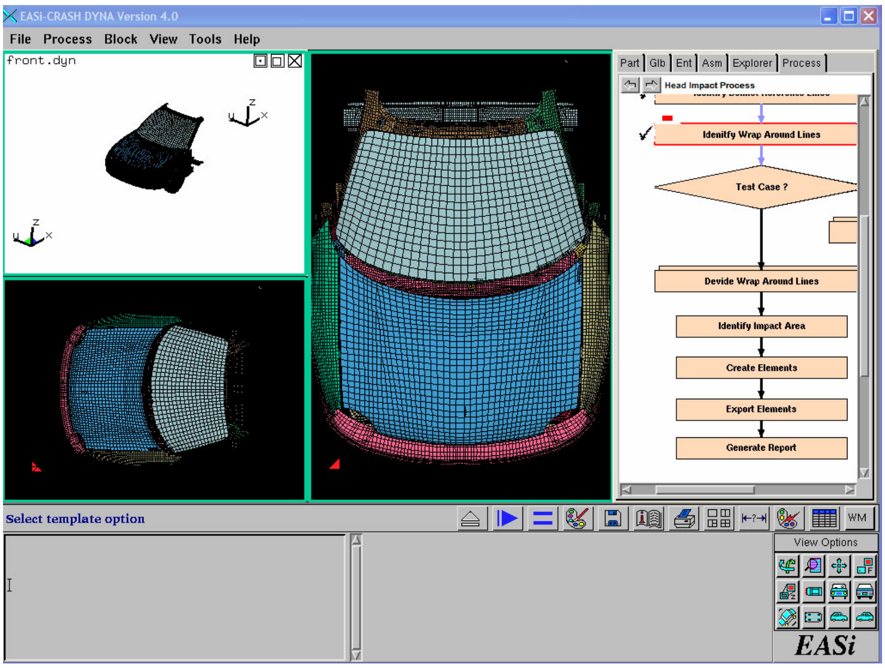

Figure 3 Impact Zone Area Creation in the Pedestrian Process

In the process executive view the user has access to:

- The process modelling and execution area
- The model area
- The audit trail
- The user interaction area

When the user selects the desired process template, in this case the process for the creation of the impact zones areas, its process flow template is displayed in the **process modelling and execution area**. The execution area has the capability to run the complete process automatically or step through or undo individual tasks. The user can choose to pause, bypass, step through the process, or run the complete or parts of the process in automatic mode.

The model is displayed in the **model area**. This is the area where users can input FE entities, screen select FE components, nodes, and elements, and this is where animations or reports will be displayed.

The audit information of each step is given in the **audit trail area** as the process is executed task by task. The trail may be exported as a log in the report, useful to a supervising engineer to verify that the process was executed properly. This area also provides the key note, intermediate computed results to the users with necessary comments and feedback.

The **user interaction area** will be activated whenever the user interaction is needed (text input, query response or option selection). In the example in Fig. 3 the user will for example be asked to confirm the selection of boundary components and wrap around lines. At any time during process execution, the user can request more information or guidance by picking the appropriate task block. A knowledge advisory capturing the corporate best practice with hints and suggestions is provided for each task block.

To generate reports standard functionality in EASi-CRASH DYNA is used to prototype the report layout. This report template is then introduced in the process.

To give the user guidance but complete freedom in the modelling with process guidance technology, the user can at any task in the process flow switch from the pedestrian process and the complete pre and post-processing capability of EASi-CRASH DYNA and back. A typical scenario is that the user builds a completely runnable model in EASi-CRASH DYNA, switches to the process to start model build-up according to ACEA, then switches back for a re-mesh, then switches back to the process to complete the impact zone creation. The integration is complete. The freedom which this integration enables introduces the high level of flexibility which is needed for a smooth implementation – removing the rigidity of process automation technology, something which has been a main concern hindering wide spread introduction in European organisations.

The Benefits of Process Guidance for Pedestrian Safety

The most direct advantage of introducing the presented solution is to radically shorten the modelling time per design iteration. This time reduction is often substantial, and the process technology for pedestrian safety has proven to speed up modelling 15-45 times, depending on the efficiency of a previous solution. But there are further direct advantages[1,2, 3]:

- the risk for engineer induced errors is reduced, increasing repeatability
- bookkeeping of modelling is streamlined
- the need for involving experts in standard tasks of model build up and results processing is reduced
- the effort needed for model administration is educed, freeing up engineering time to be spent on the real design and the real added value of engineering
- an intuitive user environment is provided, even for complex regulations, which is ideal for new users and non-specialists

On an enterprise level we see the following advantages:

- A best practice is established integrated directly in the pre and post environment of LS-DYNA – which means that it is really used. And an OEM can this way clearly define a best practices to be applied by its suppliers and sub-suppliers.
- Enterprise standardization for pedestrian safety modelling is established, in the CAE organisations located in different locations, perhaps in different European countries or on different continents.
- Resource mobility is improved. The process guide defines how the model is to be set-up and it introduces the control mechanism to follow it up.

Summary

Process Guidance Technology is introduced to dramatically increase productivity in crash and safety pre and post-processing with LS-DYNA. The interest for this technology is increasing rapidly, driven by the immediate need for productivity improvements in European CAE organisations. In this paper the suite of processes for model build-up and report generation for pedestrian safety have been used as examples. The complete integration of process guidance technology in the standard functionality of EASi-CRASH DYNA introduces a very high level of flexibility in the modelling even though a semi-automatic or fully automatic subprocess is used. The technology has proven substantial productivity gains, reducing the complete model build for pedestrian safety to minutes instead of hours or days.

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