Recent advancements in LS-DYNA® pre-processing for crash simulation

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Abstract

The increasingly demanding and complex requirements in Crash Analysis, call for continuous and innovative software development. BETA CAE Systems in an effort to meet and exceed the requirements of the industry is introducing new cutting edge technologies, in the pre-processing area with ANSA. This paper presents these new technologies.

As CAE comes to maturity the challenges and requirements for the CAE preprocessing software also evolve. Preprocessing should not be a manual job anymore. Automated processes and data handling is crucial for solving complex real world problems.

In the area of Crash and Safety analysis we can find many such examples. FMVSS 201 226, and EURO NCAP pedestrian testing protocols demand highly specialized tools that can perform complex positioning operations that until now could only be done manually. With the introduction of the newer ANSA versions, all these operations can be performed, by the software, in a totally automated way.

Automating such procedures leads to the next step. This is performing robustness and sensitivity analyses to gain confidence of the analysis results and deeper understanding of the designs and models.

The advanced scripting environment along with the pre and post processing facilities provided by our products has been used to demonstrate such a use.

Introduction

ANSA has a long history of innovative tools for the manipulation and management of complex crash models. The sophistication of such tool has been steadily increasing making their use easier, robust and most importantly totally automatic. This is extremely important for tools that simulated complex positioning operations, such as dummy positioning or impactor positioning for the FMVSS 201U protocol.

The goal of all these analyses is to predict system performance. Especially in the case of safety simulations there is a lot of uncertainty on results. The questions that arise are:
- Is the lab going to run the test with the same parameters?
- How sensitive is the model to small input changes?

The answer and the trend are to perform a Robustness Analysis. Having the ability to automate such operations make it possible.

Dummy and Seat Handling

Dummy handling has long been very powerful within ANSA. All commonly used dummies from major dummy manufacturers are supported (ie Humanetics, LSTC, Dynamore etc) and validated with each release.

Apart from the usual dummy controls, dummies can be part of more complex mechanisms in combination with automotive seat models.

Seat models can be getting full kinematic properties either by automatic extraction from the LS-DYNA deck or by external files.

Figure 1. Combined dummy seat model

Both dummies and seats are treated by an internal HHT-I3 implicit multi model solver and thus can be positioned in any predefined position.

All these processes can be predescribed in script files and batch applied in multi load cases.

Pedestrian Safety Tool

The pedestrian safety tool has been further developed to support and be current with all popular protocols.
Protocols supported include:

- EuroNCAP,
- EuroNCAP Grid
- EU Phase 1
- EU Phase 2
- JNCAP
- TRIAS 63

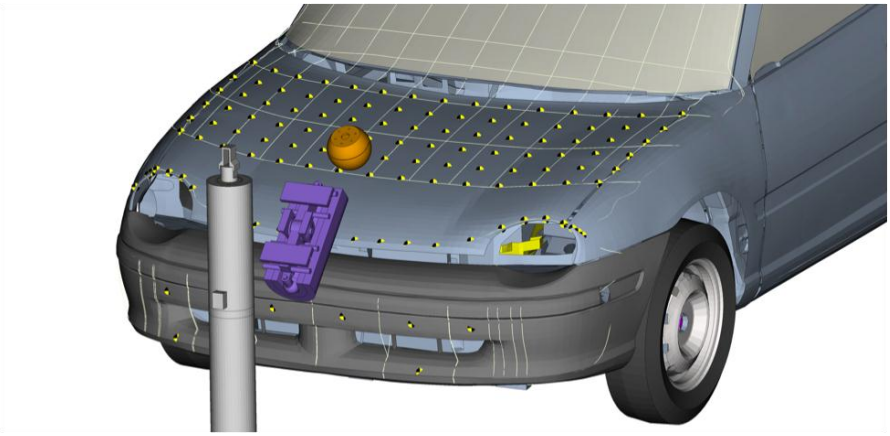

Figure 2. Pedestrian Safety protocols

The whole process can be fully automated. Major points are:

- Automatic creation of curves defining areas per regulations and protocols
- Ability to modify reference line calculations
- Target points creation per configurable resolution
- Target point Entity that keeps all the target information
- Identification of worst points based on underlying hard parts
- Position with a contact based algorithm.
- Mass positioning output – Output transformation matrices

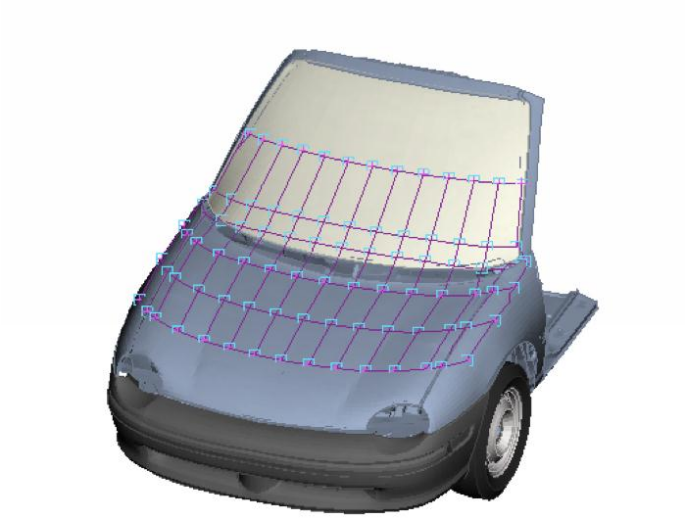

Figure 3. Automatic creation of areas

FMVSS 201U, FMVSS 226

FMVSS 201U has a very complex positioning protocol, which makes the whole process very difficult to automate. Nevertheless latest ANSA versions have been able to position the headform even at the most difficult target points, which are usually on the side rails and upper roof, without any user intervention. The algorithm itself uses an optimizing methodology to achieve the best results.

Other important points include

- Automatic creation of target points per the regulation
- Contact based algorithms closely replicating the regulation movements
- Visibility Enhancements – Cutting planes
- Mass positioning output – Output transformation matrices

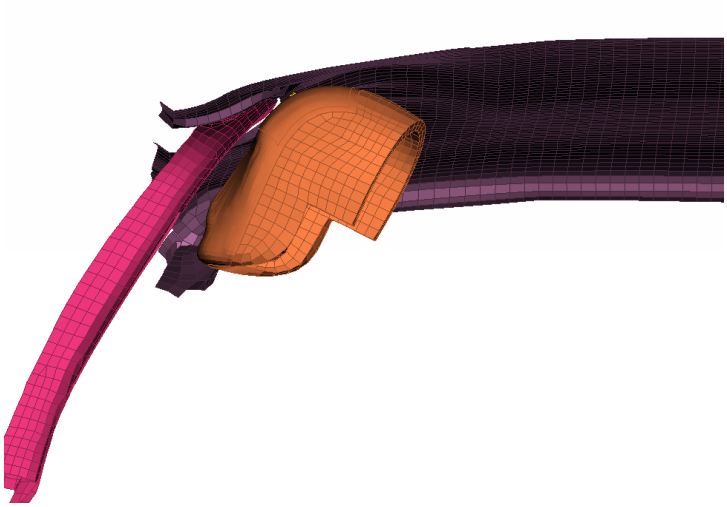

Figure 4. FMVSS 201 Fully automatic positioning on difficult positions

FMVSS 226 ejection mitigation tool follows the same philosophy calculating automatically the targets and performing multi positioning and outputting ready to solve files.

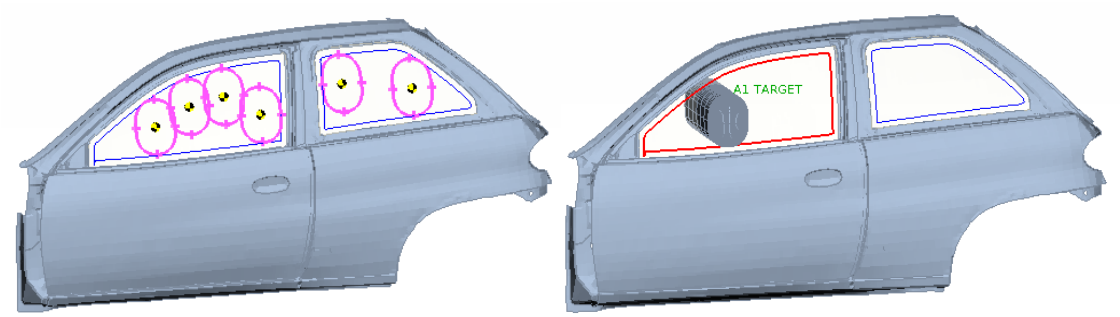

Figure 5. Ejection Mitigation tool

Performing Robustness Analysis

Having developed all functionality needed for the automatic creation of load cases of safety and crash analyses as demonstrated, we can then perform robustness and sensitivity analysis.

Since scripts can drive all processes in ANSA, the robustness analysis process can be driven by an optimizer as well.

Moreover one can use the powerful scripting capabilities of ANSA to drive such a process and perform the required steps.

Demonstrating these capabilities we have developed such a tool and applied it successfully in the case of FMVSS 201U problem.

A Monte Carlo simulation is performed creating all the required load cases automatically, then the jobs are submitted to the solver. Meta post processes the results and a report is automatically generated.

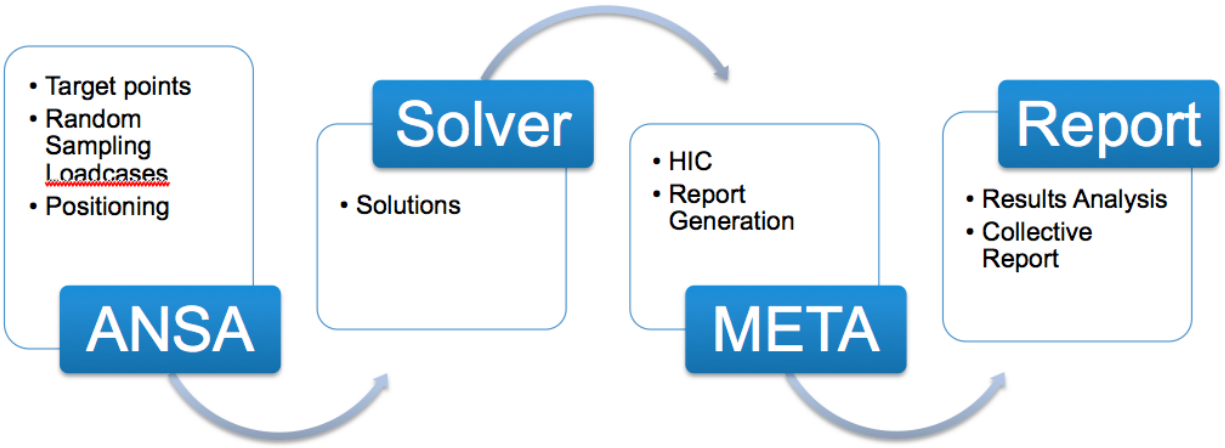

Figure 6. Automated Robustness Analysis process

In the case of the FMVSS201U protocol the stochastic parameters are the spatial offsets from the target point (X and Y in the local coordinate system) as well as the two angles defining the shooting directions (horizontal and vertical).

The response to be studied is the HIC value.

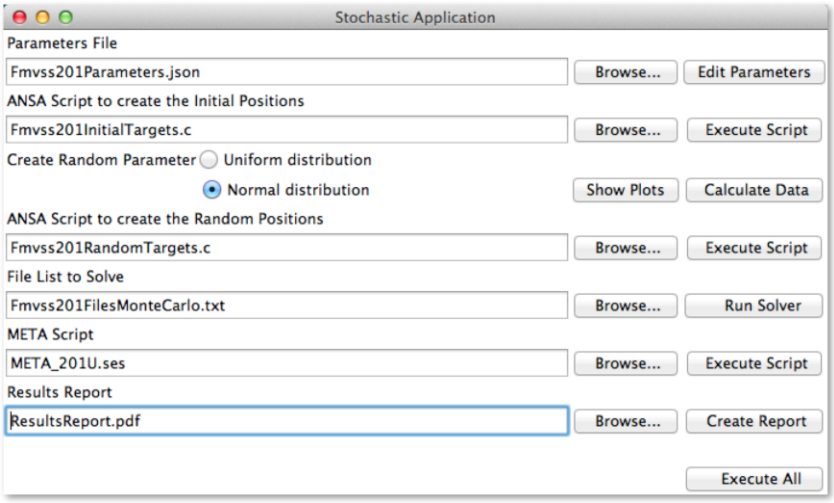

Figure 7. Robustness Analysis tool dashboard

The objective was not only to perform the specified analysis but also to develop a software module that would be very easy to use and equally easy to extend with more sophisticated algorithms.

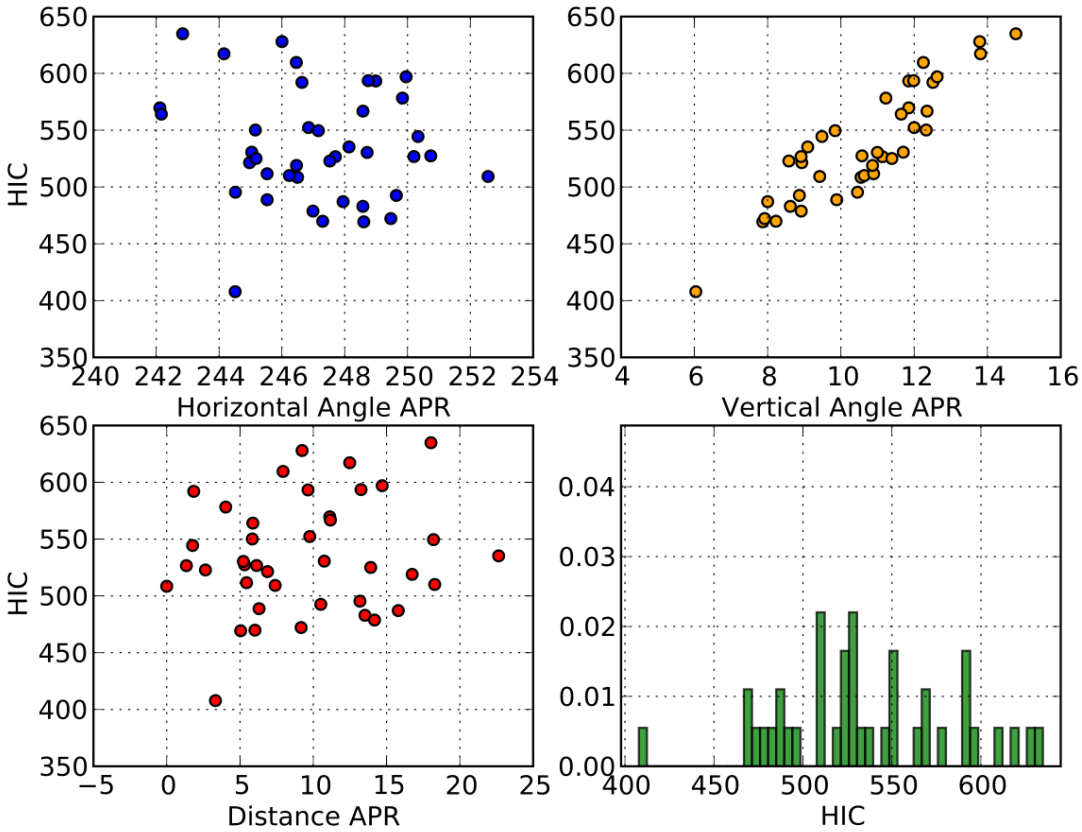

Figure 8. Results from the report created

The report that is automatically created contains graphs of the response versus the parameters for the various load cases while "quick" analysis quality factors like the Coefficient of Variation are produced. Thus the engineer at the end of this process gets a complete review that will help him evaluate the performance of his model.

Coefficient of Variation (Sample Std Deviation/Standard mean)

$$CV = \frac{\sigma}{\mu}$$

Test	Number of Tests	min HIC	max HIC	mean HIC	CV(%)
APR	40	407.81	634.84	534.74	9.18
AP2	40	631.94	728.42	676.34	3.19
AP3	40	166.54	785.64	711.52	13.25
OPR	40	483.59	574.39	541.1	4.00

UR	40	513.53	707.05	569.03	6.42
BPR	40	462.25	739.94	648.75	9.28
BP2	40	532.02	754.00	679.77	7.43
BP3	40	207.78	411.97	342.36	14.52
BP4	40	271.08	483.41	339.67	12.65

Conclusions

It has been demonstrated that the use of the latest ANSA tools in the field of crash and safety together with the advanced scripting/automating facilities that the program provides make possible the creation of repeatable, automated, processes from load case setup to report generation.

References

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