Increasing CAE Productivity - Airbag Model Verification using Visual-Environment

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1 Abstract

Technological advancement, customer expectations and globalization have increased the need for higher productivity in any industry. In general, productivity is a measure of performance or output. There are various proven methods/techniques to increase and improve productivity. One such proven method is through adoption of Automation, the technology by which a process or procedure is performed with minimum human assistance and interaction.

In this paper we would like to showcase the automation approach for verifying airbag models using the capabilities of ESI's Visual-Environment. As airbags are considered as one of the most important and integral parts of occupant safety during a crash, it is imperative to model it accurately and realistically. Once modeled, it is essential to check for its efficiency and effective deployment, so that it can be calibrated and certified to emulate the actual behavior when the impact occurs.

2 Trends and Challenges in Automotive CAE Safety Simulations

Automotive industry is in the process of embracing two major changes, the shift towards electric cars and the introduction of autonomous driving. Autonomous driving poses new challenges in the field of occupant protection. To name a few, the restraint systems which were part of Passive Safety should now participate in Active Safety Modules and Systems. The location, shape and size of the airbags impose a new challenge as the seating positions of occupants need not follow the conventional rules of facing forward and adherence to new safety regulations which are yet to be defined. Over the years the design of airbags as well as their protection scope evolved from Frontal and Side Airbags which are common in today's vehicles, to some new innovations: Inflatable Safety Belt, Front-Center Airbag, Panoramic Sunroof Airbag, Seat Cushion Airbag, External Hood Airbag, Motorcycle Airbag, Motorcyclist Vest Airbag, Bicycle Helmet Airbag. [1]

As of today, there is no specific design that has been defined for the airbags in autonomous cars. Many restraint suppliers are collaborating with OEM's to come up with proof of concepts to evaluate their airbag designs. At this stage a lot time is invested in the research and development of the airbags and also for certification. Many of the mundane and tedious manual work can be automated not only to speed up the process, but also enabling delivery of results with a higher efficiency rate, being more reliable and consistent and thereby improve overall productivity and/or performance.

Fig.1: Future Seating Scenario

3 Automation Requirement to Improve Airbag Model Quality at iSi

Airbag modelling mandates the need to fulfill specific requirements focused on addressing the model quality issues. The most basic checks, to achieve targeted standards and eliminate any occurring quality issues, are:

ID-Range compliance:
Every OEM has a specified ID-Range for certain airbag types and seat-positions. Especially in simulations with numerous airbag models it is important, that the IDs of the airbag model comply with the specified range.

Standardized / Reserved Sets adherence:
Every OEM has standardized/reserved sets, that have to be in every final airbag model, therefore they can be added to the model automatically. E.g. a Part-Set including all parts of the airbag model.

Keyword occurrence:
It is important to check, that certain keywords appear in the model. In some cases, it is also important that certain keywords do not appear in the model.

Mesh quality checks:
The mesh quality is checked to assure that the required Time Step can be met and the required mesh criteria of the OEM are satisfied.

Intersection checks:
For a realistic deployment it is mandatory, that the airbag has no internal intersections and no intersections to the surrounding components.

Time Step / Mass Scaling compliance:
To retain the mass, added by the mass scaling option during the simulation, to an acceptable level, it is important to meet a certain initial time step, mostly specified by the OEM.

iSi performs also more sophisticated checks with the presented tool. These checks can vary, depending on the type of the airbag and the purpose of the model release. However, these checks will not be part of this paper.

Many of these checks are performed manually by the engineers to achieve and ensure high quality modelling, which at times becomes time consuming and tedious. By automating the whole process of airbag verification, manual effort can be minimized, while at the same time ensuring the quality is not compromised due to human errors. The introduced automatic checking program, derived from best practices, generates a structured overview with a summary of all checks. It also generates an output for the engineer to evaluate the model quality faster and more efficiently.

4 Solution-oriented Approach for Process Automation

ESI's Visual-Environment is designed to offer end-user many ways to create and customize their own tasks which helps to capitalize, share and deploy their organizational best practices. An integrated software development toolkit allows to customize and extend this open architecture through process templates and macros. The capability for process automation and customization in Visual-Environment enables engineers to automate repetitive and cumbersome CAE tasks.

This open CAE Platform supports an extendable compute model across various physics and solvers. It is a complete solution for creating, automating and standardizing any regulatory CAE procedure and capture corporate best practices. This helps to simplify complex processes to improve efficiency, shorten time per design iteration and decrease user expertise requirement to prepare high-quality models.

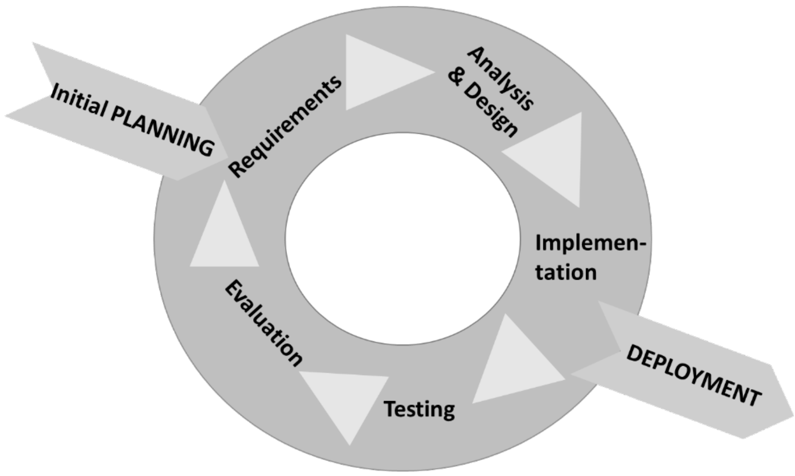

Fig.2: Iterative cycles of development

4.1 Implementation and Modus Operandi

For automated checking, a python script is attached to a user defined toolbar in Visual-Environment. The user is prompted to select a "csv" file, containing all the criteria needed to verify the model. Once the input is supplied, the checks are sequentially executed, and the report is written out in "csv" file format. This file can be read by the user and evaluated very quickly.

This automation model setup is like any other process developed in Visual-Environment. All the checks are placed in different process blocks for sequential execution; one after another in automated way once user has started the process. Users have the option to interactively decide whether to conduct or to skip any process block (check).

5 Automation of “Airbag Model Setup Checks”

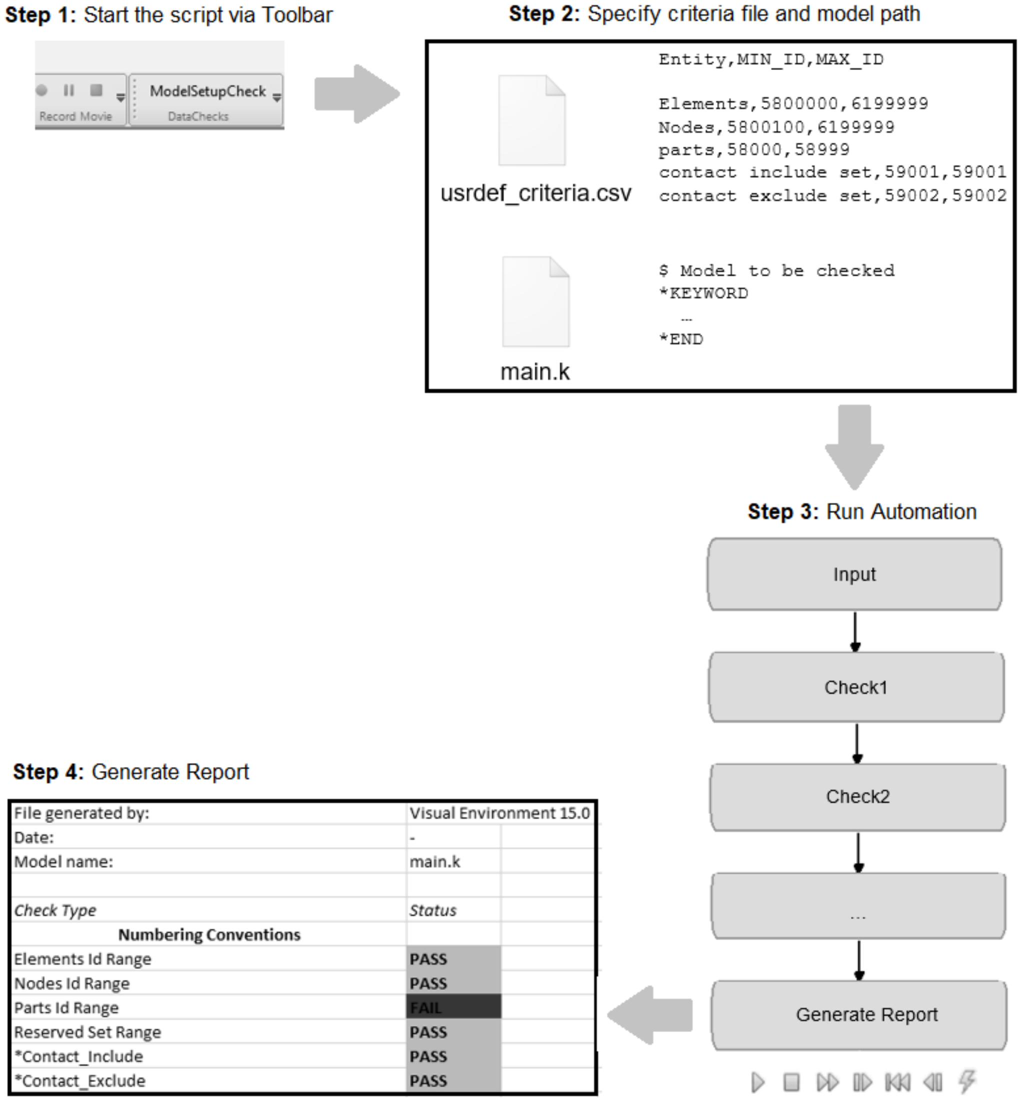

Fig.3: Process Flow Chart

6 Realization of Automation Benefits at iSi

- **Standardization of model checking**: As the criteria for the checks are predefined in the input file, all models undergo the same set of checks and this ensures a consistent level of model quality.

- **Identification of user errors**: Checks defined in the input criteria are sequentially performed without any user interaction. This eliminates the possibility of certain checks being skipped or performed incorrectly by the user.

- **Saving time**: Automatic checking reduces the time and effort of model checking and increases productivity. The user has more time to focus on other tasks.

- **Simple evaluation**: The output report consists of a summary with all checks and their results (Pass/Fail), which can be evaluated for a quick overview of the model quality.

7 Other Use Cases of CAE Automation

Automation can be adopted for the below mentioned use cases as well:

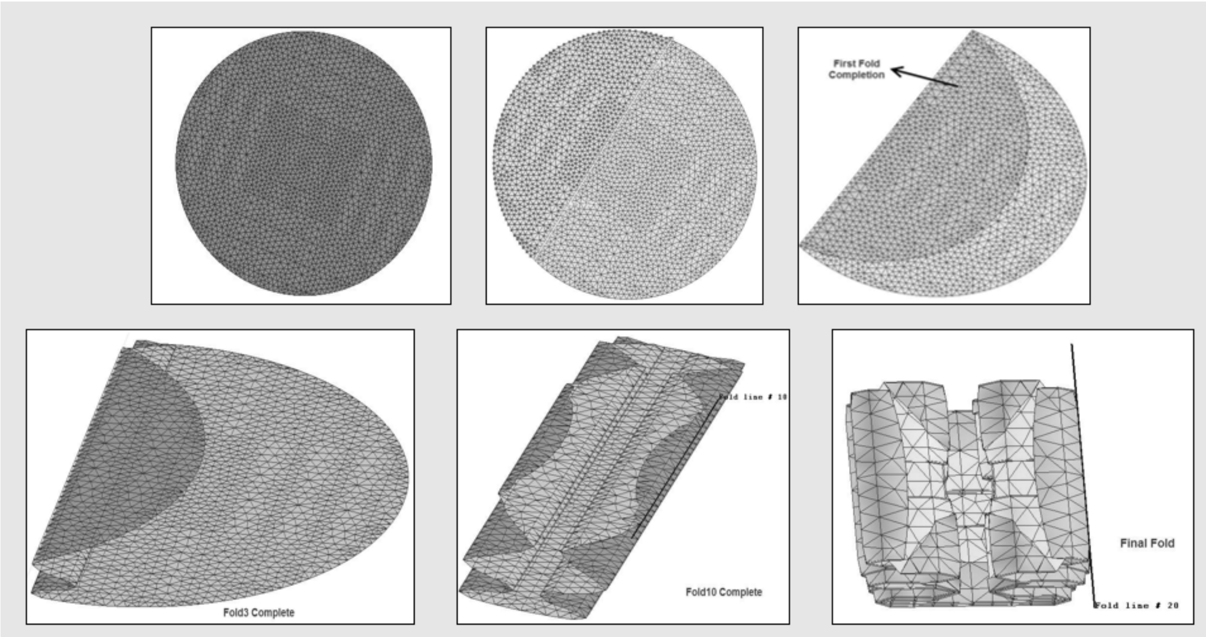

Fig.4: Automated Airbag Folding

- Meshing the CAD file to generate high fidelity FE Airbag models, including the tethers at appropriate locations, chambers created for sequenced inflation, element normals aligned as per contact requirements.
- Folding the Airbag using airbag folding tools in an automated manner for various fold sequences like Star Fold, Tuck Fold, Roll Fold, Zig-zag Fold, Wave Fold etc. The entire procedure of inflator insertion, folding the airbag, Housing and Relaxation can be fully automated.

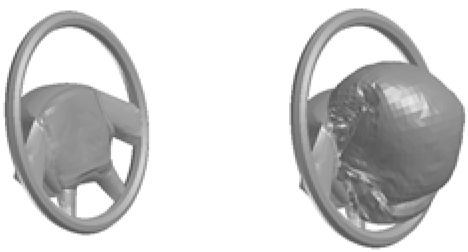

Fig.5: Driver Airbag Deployment

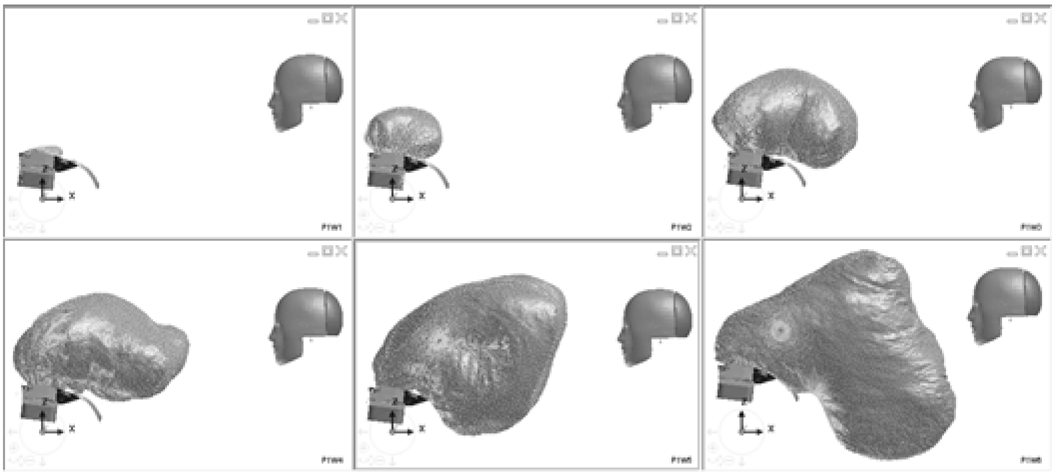

Fig.6: Passenger Airbag Deployment

- Airbag tank test setup and report generation can be fully automated.
- Furtheron, specialized studies like Airbag Energy Dissipation analysis can also be modelled and feasibility reports can be generated. For example, when the airbag is being deployed, beyond the basic energy abosorbtion from the dummy impact, the inflation should also consider the energy required to tear open the airbag covers, resistance for full deployment from the windshield, resistance from the occupant if the occupant is already out of position.

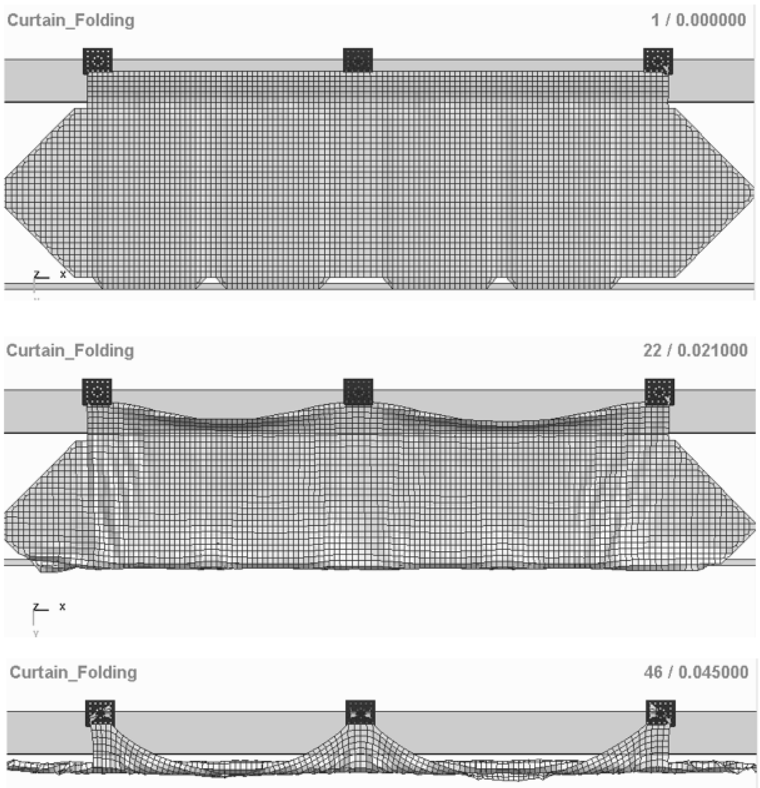

Fig.7: Curtain Airbag Folding and Positioning (part 1)

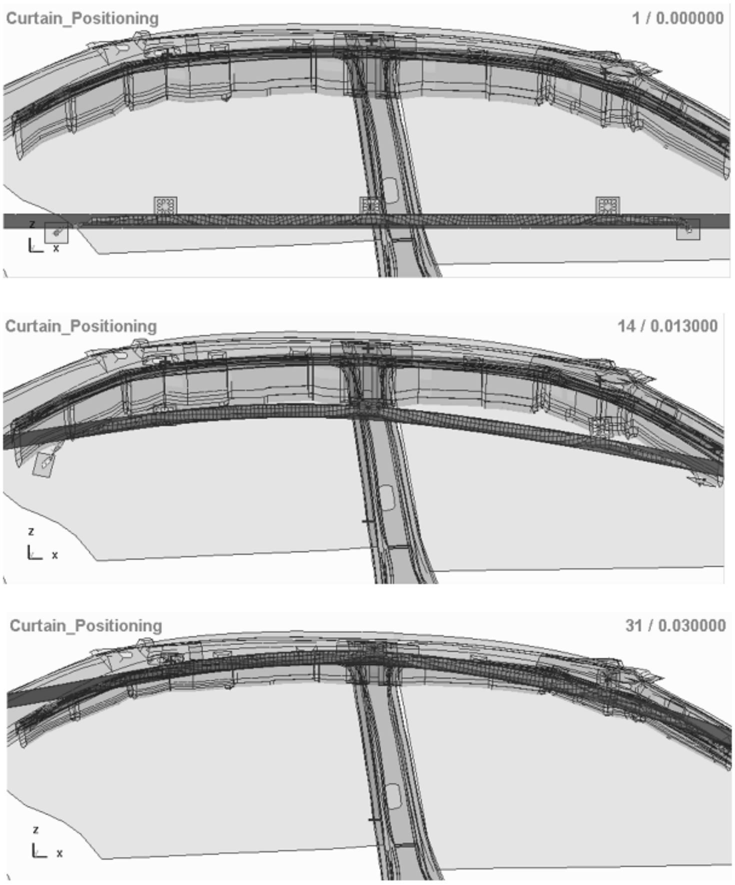

Fig.8: Curtain Airbag Folding and Positioning (part 2)

- Efficiently setup models for regulatory compliance like FMVSS 226 (Ejection Mitigation Analysis) in Rollover cases and designing suitable Curtain Airbags. Other analysis viz; Linear **I**mpactor validation of Side Curtain Airbag using CPM method**; D**eployment kinematic study on Driver Airbag**,** Passenger Airbag, Side Airbag, Knee Airbag and Curtain Airbag.

8 Conclusions

Automation has established itself as a primordial technique to further propel every OEM and its Tier-1 and Tier-2 suppliers to the high productivity zone. It is an efficient way to:

- Propagate best practices
- Remove person dependency and ensure consistency
- Reduce/remove duplicate efforts
- Empower descision makers
- Eventually avoid costly recalls by significantly reducing efforts to ensure all tests are qualifying, during design iteration phases by effective usage of automation

9 References

[1] https://www.iihs.org/iihs/topics/t/airbags/qanda