Audi and ESI have been working together for many years on safety simulation in order to efficiently support the development of occupant safety standards in all territories where Audi sells cars. Recently, they have tackled the simulation of Out of Position (OoP) situations, in order to pass the FMVSS* 208 regulation. These simulations help Audi evaluate, early in the development cycle for new vehicles, the physical phenomena of the airbag deployment behavior, and thereby optimize the folding pattern and reduce the number of tests.

**THE BENEFITS**

- Reduce airbag development cost and time by decreasing the number of physical tests performed
- Optimize the development process by improving procedure and interactions between departments
- Shorten airbag model construction time
- Improve airbag model quality and robustness

**Improving child safety**

OoP testing on the passenger side consists of conducting several tests with dummies representing 3 and 6 year old children. To evaluate the injury criteria, engineers must define and test whether a child seated in the car front passenger side would be injured upon airbag deployment. For each child dummy, Audi tested two positions with the OoP simulation. First, with the dummy standing in front of the dashboard; second with the dummy seated in front of the dashboard. In both cases, the airbag hits the child during its deployment, hence the airbag folding sequence has to be carefully designed in order to avoid injuries during deployment.

**Performing airbag folding and deployment with simulation**

Audi developed an integrated CAE method applied to the OoP simulation featuring passenger airbags. Working closely together throughout this project, Audi and ESI shared methodologies during workshops and common working groups. Audi engineers first used Sim-Folder, ESI’s airbag folding tool, to efficiently support the development of occupant safety standards.

Depending on the airbag, Audi engineers obtained the following results:

- The curtain airbag (base model) took one or two days to set up, and an additional modification added another half day;
- The driver airbag took from one to three days to set up, then a modification in the model could be run overnight;

* FMVSS: Federal Motorway Vehicle Safety Standards

**“Four or five years ago, I had high discrepancies between physical testing and my simulation results. Nowadays, I am in a very good range: I can do specific simulations in order to validate my models and then really make decisions on how to design the airbags. ESI’s Sim-Folder helps Audi design accurate airbag folding pattern in good timing.”**

Dr. Erich Blümcke, Vehicle Safety Simulation Engineer, AUDI AG
The passenger airbag being the most difficult, Audi engineers are currently working on it with ESI. Indeed, it currently takes two weeks to set up, which is very competitive with respect to physical tests. The main objective is to complete the full OoP simulation in less than two days, which is a very competitive calculation time relative to physical tests.

Sim-Folder helps speed up the different design phases where occupant restraint systems are concerned. For instance, it enables the development of the airbag simulation in an early development phase, which improves the entire process, and strengthens common interests.

Mastering the folding simulation process

Audi engineers perform the complete airbag process in simulation, including folding, assembly and deployment with the Finite Point Method (FPM).

By coupling these several complementary tools, Audi performs the complete airbag simulation process.

Before using simulation for the folding process, estimate how much the numerous parameters would influence the test results. With simulation, engineers can track the detailed influence of one or several parameters and perform experiments accordingly. Thus, combining both simulation and experimental testing, they are able to assess the quality and robustness of their airbags, as well as predict parameters that will impact the dummy loads.

Replacing physical airbag prototypes with an end-to-end virtual prototype brings competitive advantages. Not only are Audi engineers able to save time by making quick decisions on the airbag design but they also reduce cost by decreasing the number of tests performed. The entire airbag development process is improved.

Acknowledging the benefits of these new assessments in airbag folding and deployment, Audi has recommended this integrated CAE method be included in the safety technical requirements of all new car projects. At Audi, Sim-Folder plays a key role in that virtual process.

Audi continues to develop projects with Sim-Folder on the side airbag and the knee airbag.

To find out more about ESI’s Sim-Folder safety application for virtual airbag prototyping, please visit: www.esi-group.com/sim-folder