

New Technologies for Side Impact Model Set up

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1 Abstract

During the development and design process of a vehicle, Occupant protection in side impact studies has become a standard analysis. One of the most important issues that analysts face in side impact is the adjustment of the passenger's seat and the dummy in the proper position for the laboratory tests. This makes the application of numerical simulations inevitable. Simultaneously, as new legal tests and regulations are continuously introduced, the amount of relative loadcases has increased dramatically. In order to set up standardized processes that will minimize the complexity and lead time of the numerous side impact CAE simulations, automated and efficient tools are continuously developed by CAE software providers.

The positioning of the seat and the dummy is also a demanding process in CAE simulations. From the import of the model in the pre-processor to the output of the file for the solver, a lot of complicated steps in a strict hierarchy have to be followed. BETA CAE Systems has implemented some special tools in the ANSA pre-processor to, import a dummy, position it on the seat, de-penetrate it from the seat, restrain it using seatbelts and then produce automatically all the corresponding adjustments for the dummy – seat system as far as all relevant regulations and legal tests are concerned.

These efficient tools mentioned above offer to the analyst the ability to set up an automated and robust procedure for the dummy – seat demanding CAE system that fulfills all the needed steps for a side impact analysis, with the minimum human interaction and time consumption.

2 Introduction

One of the most important issues during the production of a vehicle is the safety it offers to its passengers during a crash. In particular, the occupant protection against Side Impact is considered as one of the standards that a vehicle should meet. One of the most crucial parts of the Side Impact analysis during a laboratory test is how the dummy and the passenger seat will be adjusted. As a result, numerous legal tests and regulations are being introduced raising the necessity of CAE simulations. The need of robust processes with high level of automation is huge, in order to bring in success such a complicated project as the dummy – seat positioning is. BETA CAE Systems has developed some special tools, in ANSA pre – processor, that deal with the dummy – seat system and offer a complete solution that covers all the alternatives for the set up of a Side Impact analysis. The ANSA Seat Positioning tool will adjust the seat according to all the available Side Impact Regulations. An automated tool will input the dummy and position it on the seat achieving simultaneously its depenetration. Finally, this tool will create all the corresponding keyword files and output them to be solved by LS-DYNA.

3 Seat Adjustment in Side Impact

The passenger's seat adjustment is one of the most complicated processes, not only during laboratory tests but also during a simulation. Focusing on a simulation and specifically on the work that is needed for the production of a specific loadcase, the members of a seat kinematic mechanism have to undergo a lot of different movements for the final position. Considering that the seat has to be set for all the different regulations, a lot of effort must be given by the analyst to realize all the corresponding scenarios for a complete side impact numerical analysis.

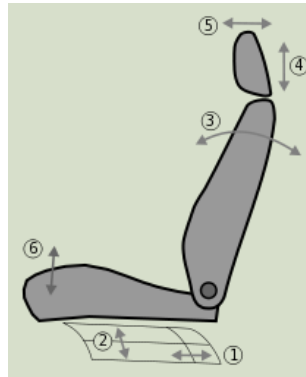


Fig.1: Seat Adjustments for Side Impact Tests

3.1 ANSA Seat Positioning tool

Considering the seat as the basis of the Side Impact simulation test, the first task that an engineer faces is the positioning of the seat according to all the regulations. The kinematic mechanism of the seat has to be moved according to specific (regulation) or sometimes custom rules. Moreover, these mandatory steps, follow a strict order. The need of a wizard like functionality which simultaneously offers the ability to automate those steps is substantial. ANSA has implemented a special tool that moves the seat kinematic mechanism according to each step of all Side Impact regulations and in the end, produces and saves the final position that the seat must have.

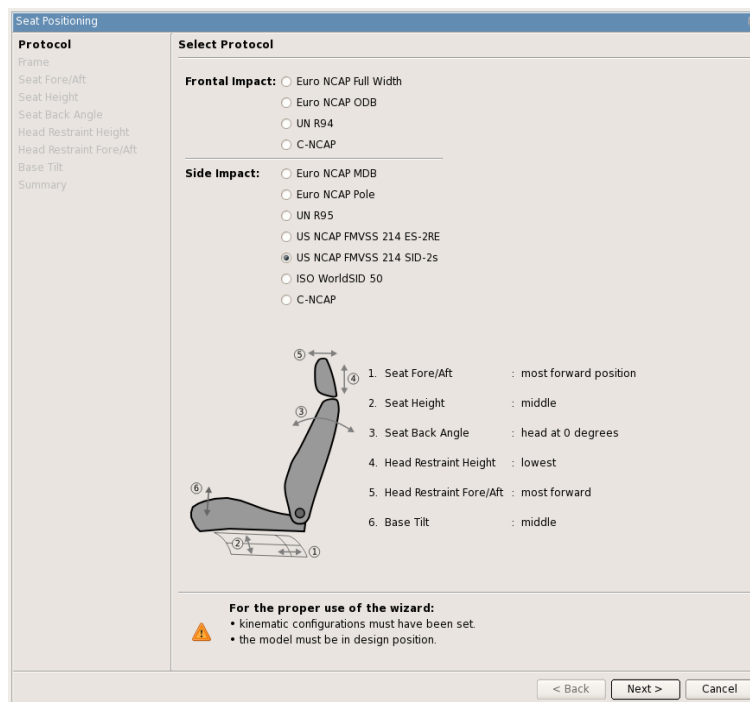


Fig.2: ANSA Seat Positioning tool

Once the user passes all the steps of one regulation and the final position of the seat is to be confirmed, the corresponding python script code is produced. This editable snippet of code can be used to automate these regulation steps, not only for the current seat in future use, but also for a completely different seat. This offers the advantage to avoid passing from each step for a second time. It is also worth mentioning that the specific tool works not only for Side but also for Front Impact regulations. This means that everything described in the current document can be applied on Frontal Crash analysis as well.

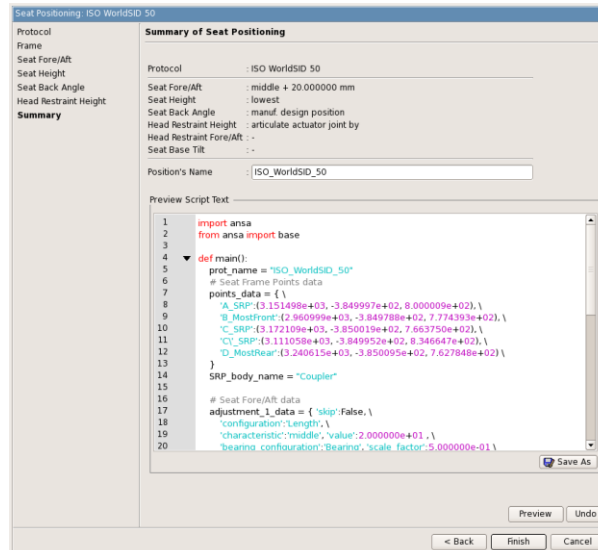


Fig.3: Python code produced for ISO_WorldSID_50

3.2 Sensitivity analysis

According to the different regulations and the corresponding final positions there is a relative number of Seating Reference Points which will be associated with the H-POINT of the dummy. Considering the procedure of positioning a dummy on a seat during a laboratory test, there is always a deviation in the calculation of the Seating Reference Point. This leads the analysts to apply sensitivity analysis in order to cover all those different scenarios of dummy positioning on the seat. The tool mentioned above pass through each step of the regulation and enables the analyst to tune the parameters for the corresponding movement according to ones need. Taking into account that in the final step a python script code is produced, the user can edit this script and set a desired range of values at each and every parameter that may affect the final position in terms of applying a sensitivity analysis.

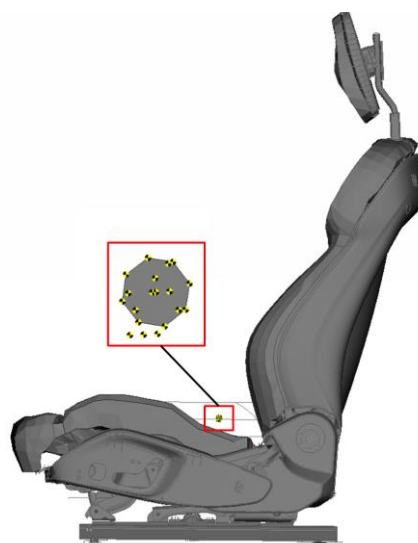


Fig.4: Seating Reference Points for Sensitivity Analysis calculated in ANSA

3.3 Seat Saved Positions

The result of running the Seat Positioning tool of ANSA is a list of saved positions, that correspond to the final position for each regulation and some user defined ones (sensitivity analysis). This means that from the design position of the seat one can move at any time to the desired position. These saved positions are being kept during the process set up with the use of ANSA Comments. An LS-DYNA file with ANSA Comments will be saved containing all those saved positions, for the massive loadcase production in a later step.

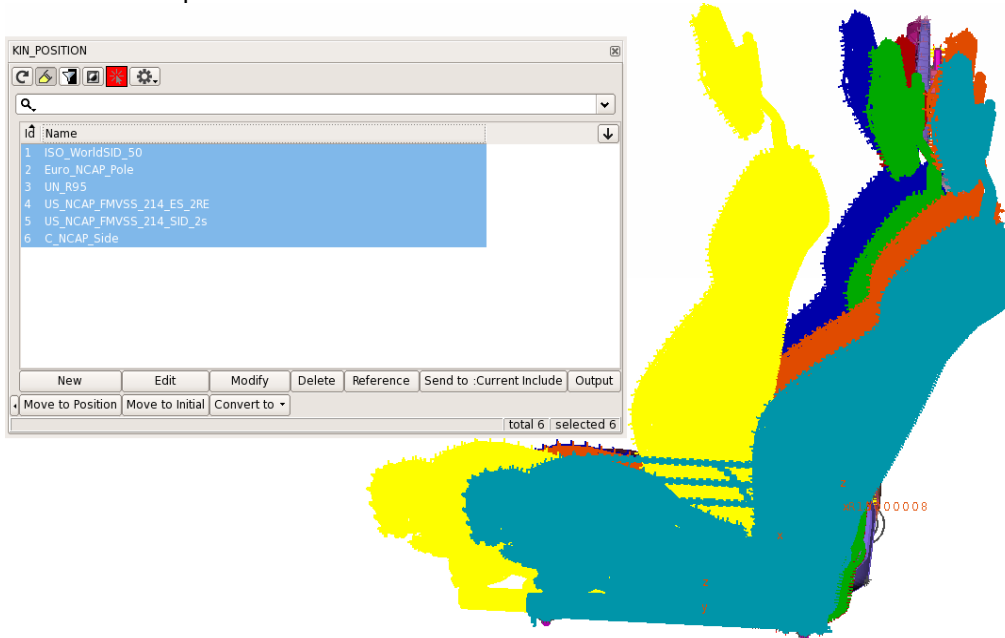


Fig.5: Saved seat Positions in ANSA for Side Impact Regulation

4 Dummy Handling

The next step of the process is the positioning of the dummy. The dummy has to be translated to the Seating Reference Point for each regulation. Apart from this translation there is the need of several movements of its limbs so as to avoid any penetrations with the seat structure. An advanced tool in ANSA, enables the user, not only to move a dummy to a specific position, but also using the "Contact" algorithm, to apply constrained movements on its limbs averting any possible intersections between seat and dummy.

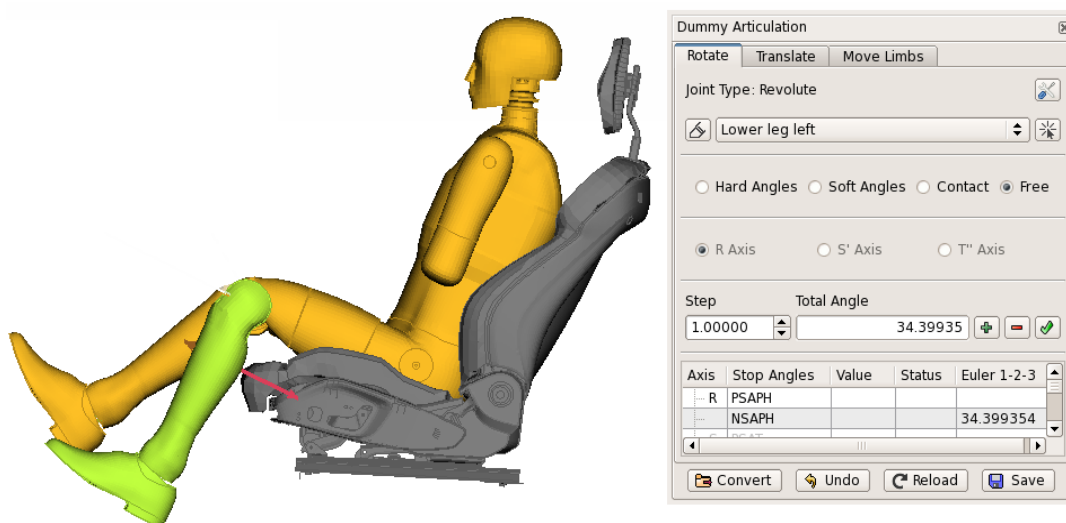


Fig.6: Movement of the Lower leg left avoiding penetration with the seat

4.1 Dummy Saved Positions

After applying all the needed movements to the dummy and its limbs, the next step is to save this position as the final position for each seat position, either according to a regulation or a user defined one. As a result, there will be a list of dummy saved positions. These positions will be saved in a LS-DYNA file with ANSA Comments that will be used in the final step of the process for the massive loadcase creation.

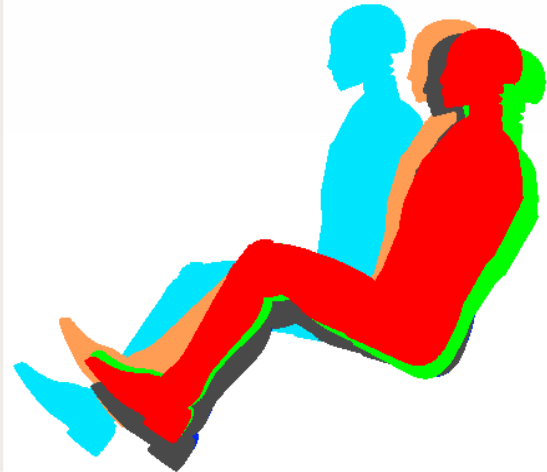
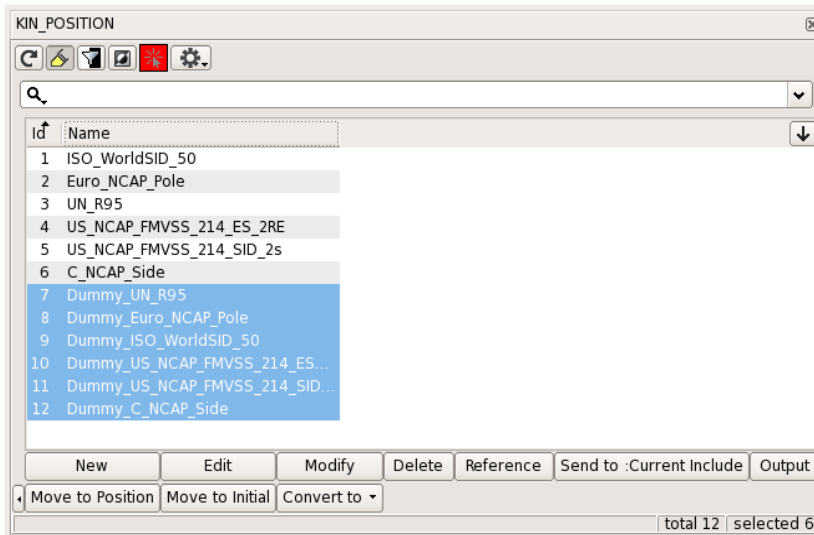


Fig.7: Saved Dummy Positions in ANSA for Side Impact Regulations

5 Seat De penetration

The whole process moves one step further with the deformation of the seat, which leads to its de penetration from the dummy. The penetration between dummy and seat is needed mostly in the area of cushion and backrest. In ANSA, 3 SETs of entities are needed for each case of de penetration. One with the entities of the dummy that penetrate the seat, one with the corresponding entities of the seat and finally one for the seat entities that will be the fixed ones (undeformed) during the deformation.

These SETs will be output in a separate LS-DYNA file. This file will be used for de penetrating the dummy from the seat for all saved positions.

6 Restraining with Seatbelts

The seatbelt creation is the last step of the process before the final LS-DYNA file output. In ANSA there is a special tool for creating the desired seatbelt. The tool offers the ability to modify real-time the shape of the belt by "drag and drop" functionality. Furthermore, through its interface one can build automatically the corresponding LS-DYNA *KEYWORDS (sliprings, retractors, pretensioners) for a proper run later on, in the solver.

A huge advantage that this tool offers is that the created ANSA seatbelt entity can be reapplied massively on all different positions of the same dummy – seat system for all the regulations and user defined ones (sensitivity analysis). The seatbelt entity is created once and with the functionality of ANSA Comments is maintained as ANSA entity and can be reapplied at any time during the process. As a result, a LS-DYNA file with ANSA comments, is created to be used as template for the seatbelt massive application on all different loadcases.

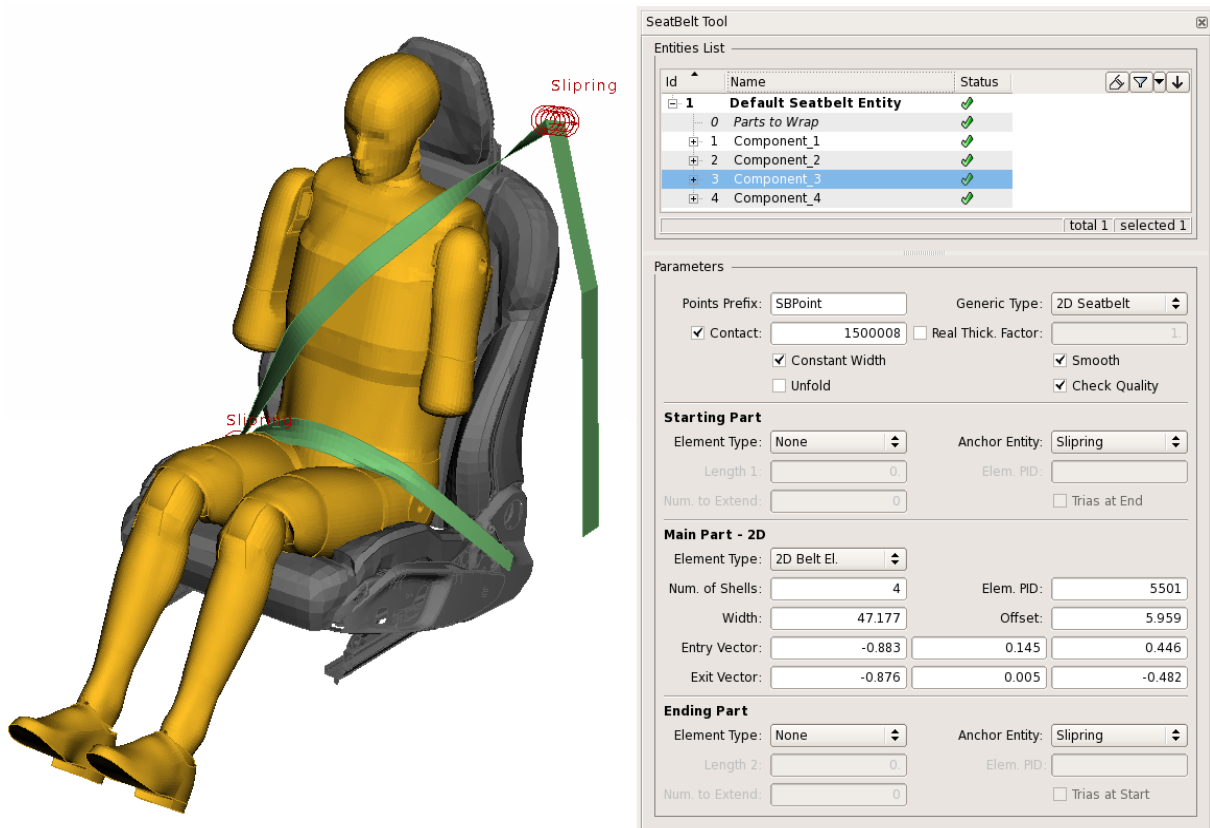


Fig.8: Seatbelt creation in ANSA

7 Automated massive Loadcase generation

The last step of the Side Impact analysis set up is the generation of the different loadcases, according to the number of different regulations one is about to study. Taking into account what have been mentioned already, the basis for a massive loadcase generation has been set. The files that consist the master structure for the creation all the different scenarios are the seat, dummy, depenetration and seatbelt ones, all in their initial position.

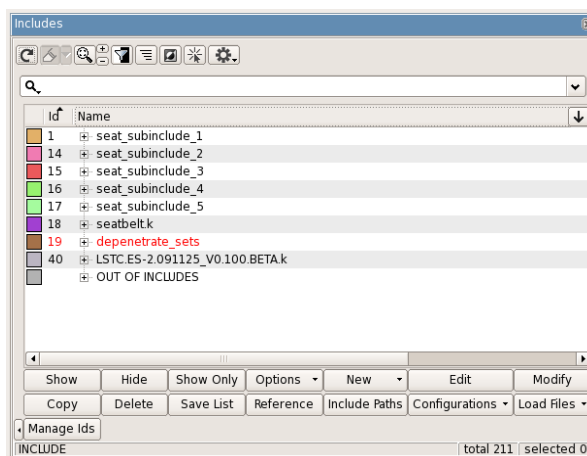


Fig.9: Basic Include structure (design position) in ANSA

This basic structure, in combination with the files that contain the saved positions of the seat and the dummy according to all different cases (regulations and sensitivity analysis), will give the final LS-

DYNA file for each loadcase. ANSA offers an advanced special tool which under a simple interface combines all the needed files for the loadcase generation. This ANSA loadcase generator tool, offers the ability to produce a LS-DYNA seat depenetration (deformation) loadcase as well.

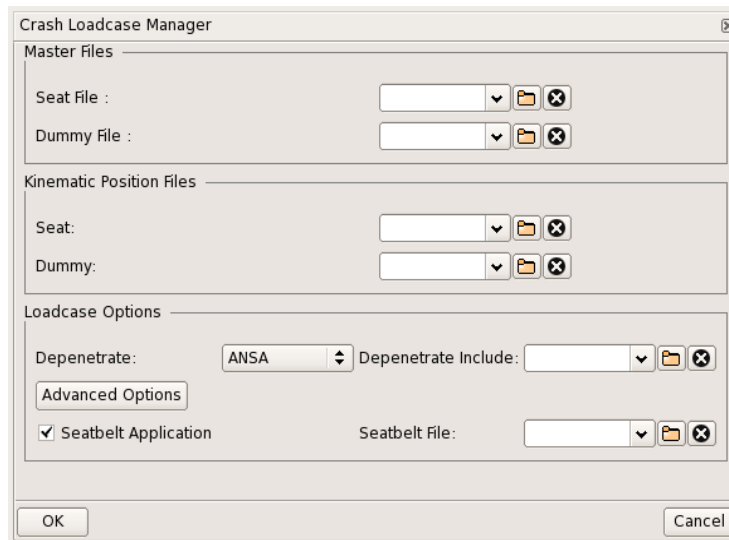


Fig.10: Loadcase Manager tool of ANSA for massive Crash loadcase generation

7.1 LS-DYNA keyword files

The saved positions for the seat and the dummy depenetrated for each position are saved in LS-DYNA files using the keyword *NODE_TRANSFORM. Depending on the selection of *NODE_TRANSFORM file, in combination with the basic structure of seat – dummy and the updated seatbelt, the main final file for the loadcase of each regulation is created. The setting up of the final loadcase file is created by ANSA Includes Manager tool which works in the background of Crash loadcase Manager.

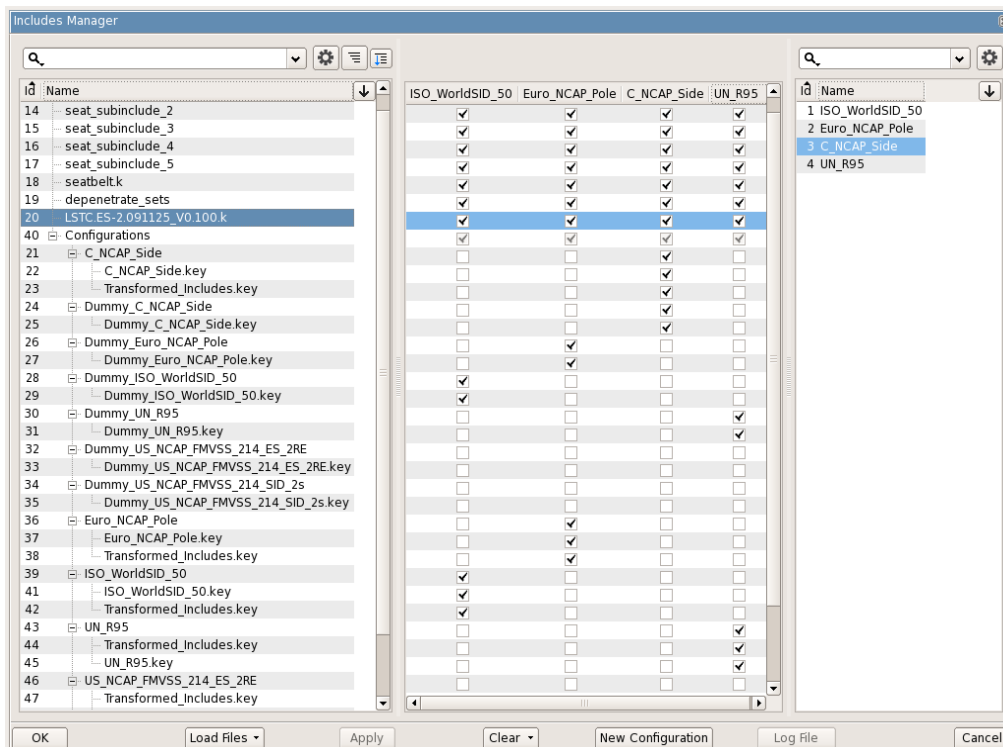


Fig.11: Files selection for the loadcase generation in ANSA

```
$ output from :
$
$ /user/output/files/Seat_front_side.ansa
$
$
$
$
*INCLUDE
../seat_subinclude_1
*INCLUDE
../seat_subinclude_2
*INCLUDE
../seat_subinclude_3
*INCLUDE
../seat_subinclude_4
*INCLUDE
../seat_subinclude_5
*INCLUDE
../seatbelt.k
*INCLUDE
../depenetrate_sets
*INCLUDE
../LSTC_ES-2.091125_V0.100.BETA.k
*INCLUDE
../Configurations/C_NCAP_Side/C_NCAP_Side.key
*INCLUDE
../Configurations/C_NCAP_Side/Transformed_Includes.key
*INCLUDE
../Configurations/Dummy_C_NCAP_Side/Dummy_C_NCAP_Side.key
*END
```

Fig.12: Final file for C_NCAP Regulation created by ANSA Crash Loadcase Manager

8 Summary

A CAE process has been presented for setting up massively Side Impact loadcases in LSDYNA for all available regulations. The analyst, taking advantage of the ANSA functionality in combination with its extended scripting tools, has the ability to set up flexibly different Side Impact scenarios that otherwise would need huge effort due to their complexity.

The seat adjustment according to all available regulations has been automated, requiring the minimum human interaction. Simultaneously, sensitivity analysis for numerous different Seating Reference Points of the dummy can be applied in order to study the deviation of the real dummy position on the seat. Dummy positioning on the seat, its depenetration from it and the seatbelt restraining are done massively for all different seat positions. Finally, the set up of the final loadcases for all the desired Side Impact scenarios, either regulated or not, are being created in a massive way decreasing in its minimum the lead time of a CAE simulation.

What is need to be mentioned finally is that all this process is applicable to Frontal Impact simulation tests as well.

9 Literature

- [1] ANSA version 15.1.x User's Guide, BETA CAE Systems SA, June 2014
- [2] Halquist, J.o., LS-DYNA Keyword Users Manula Version R7.x, Livermore Software Technology Corporation, Livermore 2014
- [3] carhs, SAFETY COMPANION 2015, 2014