

Handling of large LS-Dyna Full Vehicle Crash Models with TECOSIM-advanced inhouse process Tools

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Abstract:

Based on several years of CAE experience TECOSIM has developed an advanced inhouse CAE process. Each TECOSIM tool was developed on the basis of TECOSIM internal projects as well as several projects carried out successfully at customers' site. All tools used in this process are able to run as stand-alone solutions, but the combination of them provides a very effective CAE process, thus reducing the entire vehicle development cost. The TECOSIM modular principle makes one of the differences to other compact CAE process tools. TECOSIM's process is very flexible because each module can be run separately and it could be also added to almost any existing process.

Keywords:

Design processes, development processes, concept development, crash analysis, software integration, optimisation.

1 Introduction

Today's global economic crisis is pressuring car manufacturers to redefine their vehicle development strategies to make the development process less costly. One of the strategies we can observe today is that OEMs worldwide are reducing their vehicle production, are reducing future vehicle development programs or trying to optimise the existing development process.

This paper shows how an effective CAE process could look like. Before we start to explain the TECOSIM process, the following questions should be answered:

What is an include?

Vehicles are normally built using an integral body. All hang-on parts (closures, axles, bumper systems, etc.) are normally bolted to the body in white structure. In our CAE process, all these hang-on systems (including the BIW itself) are defined as includes.

- Bumper systems
- Power train
- Seats
- Doors
- BIW
- etc.

Why do we use such include systems?

Using includes provides a lot of advantages:

- The ability to work in parallel while building up the completed FE model
- Smaller FE models are normally easier to understand than bigger ones
- Finding and fixing an existing error is less complex in a small system than in a completed FE model
- The possibility to exchange hang-on parts between projects and departments (saving time and development cost)

In order to use includes it is necessary to follow some rules regarding the ranges of nodes, elements, part IDs etc. for avoiding doubling between all includes. All the different rules which need to be followed are well defined in the TECOSIM process and will be checked several times while building up each include and the entire FE model as well. Therefore a very high model and result quality can be guaranteed.

What is a load case?

Load cases are the crash test configurations depending on the legal, consumer and inhouse requirements of each carmaker. These requirements depend strongly on the market where the vehicle will be introduced (US, Europe, China, Japan, Australia, etc.).

Being up to date with all the different crash test configurations and requirements around the world is a big challenge, but some requirements are the same or at least very similar in different markets. Taking advantage of this knowledge, CAE development costs could be saved. This also depends of course on the vehicle type, curb weight, vehicle configuration, etc.

2 CAE Process Chain Overview

TECOSIM's process chain normally starts by using CAD geometries (figure 1). After preparing these geometries by using CAD input, our advanced batch meshing tool TEC|ODM™ is started for meshing parts. As soon as these FE meshes are available, we start to build up the different includes using TEC|PROM™. Of course, it is possible too, to input mesh from other preprocessors, but only if the required mesh quality is guaranteed. To be able to build up all the includes we need some further information e.g. regarding connection, material and thickness for each part. All this information will be provided from our CAE input.

After finishing the includes with TEC|PROM™ Include setup they will always be checked by using TEC|CHECK. If an error is found, the include will be repaired and checked again before being stored in our include data base TEC|IDA Include DB. Using these includes in combination with the load case information from CAE Input, the TEC|PROM™ load case setup can be started.

Once the load case has been set up it will be checked using TEC|CHECK. If an error is found, the faulty include will be repaired with TEC|PROM™ using the same process steps as before. Only if the complete LS-DYNA deck is able to run without any error, it will be allowed to continue to our database system TEC|IDA Run DB.

After having passed the LS-DYNA solver it is also necessary to check each result such as untied interfaces, global energies responses, etc. If at this stage an error is found, the includes will be repaired using TEC|PROM™ again and this process loop will be followed until achieving the required result quality.

After having obtained the results we can start with TEC|PROM™ results documentation. Together, the results and the documentation will be stored in our TEC|IDA result DB.

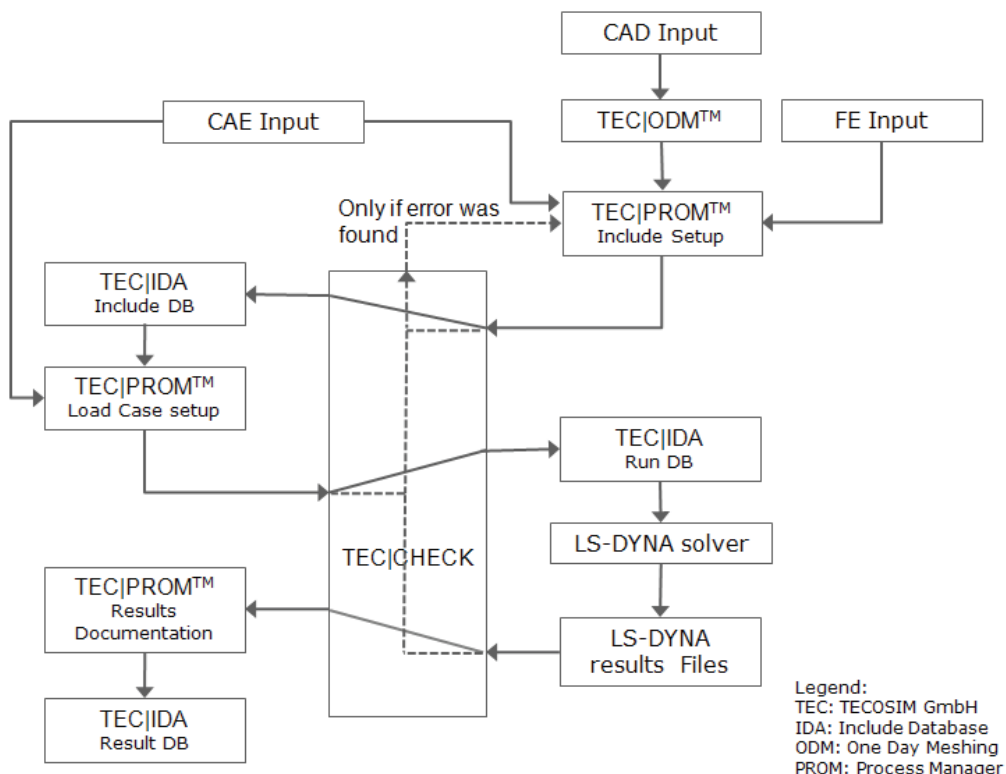


Figure 1: CAE Process Chain Overview

3 TECOSIM CAE tools

To make it easier to understand the TECOSIM CAE Process Chain it is necessary to explain each TECOSIM CAE module separately. Below, due to space restrictions, only the main functions but no details are going to be explained.

3.1 CAD Input

Any CAD format can be used in the TECOSIM CAE Process. We can extract the middle surface position and the part thickness out of a solid surface. Some of our customers only use an outer or inner surface (not solid part). Here, the middle surface position can be extracted by using the TECOSIM tools.

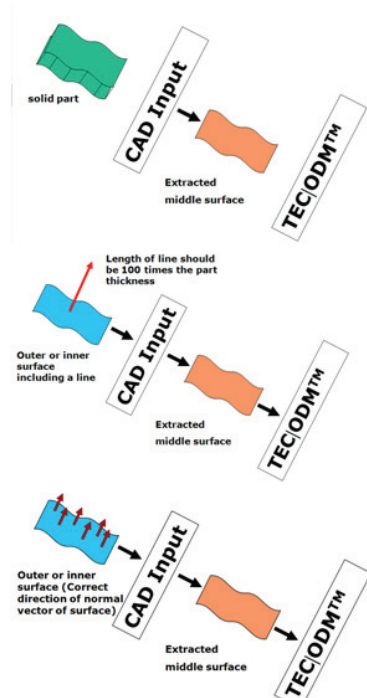


Figure 2: Geometries input possibilities

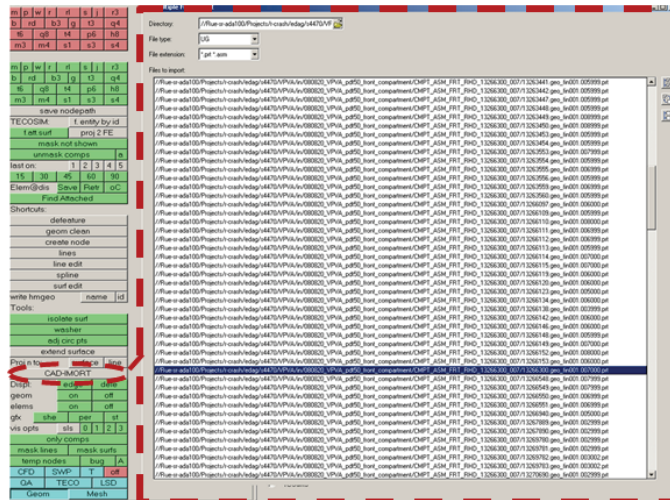


Figure 3: CAD Input GUI

3.2 TEC|ODM™

TEC|ODM™ One Day Meshing is an advanced easy-to-use meshing tool which can be started both in batch or cut and paste mode. More than 100 high level algorithms are working inside of TEC|ODM™. The major kernel is programmed in C++ (21 MB code). All this expertise leads to a minimum of necessary input variables. All common CAD geometry formats (CATIA, IGES, VDA, STEP, etc.) can be read.

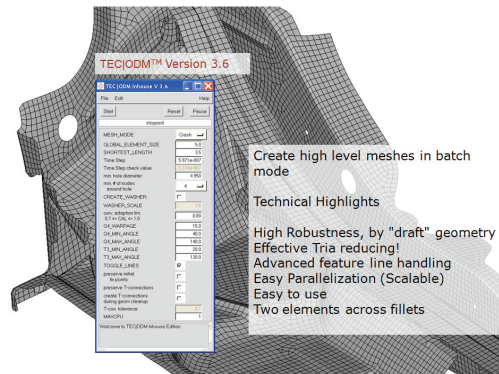


Figure 4: TEC|ODM™ GUI Version 3.6

3.3 FE Input

In order to save time and development costs, sometimes FE meshes or even completed includes, defined as carryover from other projects or even from other suppliers (e.g. Bumper systems, seats etc.), need to be inputted. In this case TECOSIM always checks these includes, thus being able to guarantee the quality of the modeled parts and the final results.

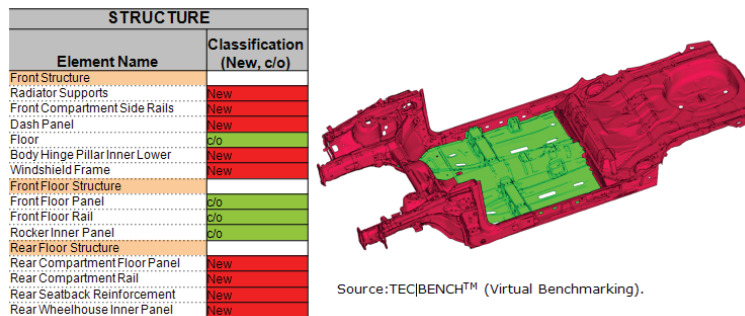


Figure 5: New and carryover parts example

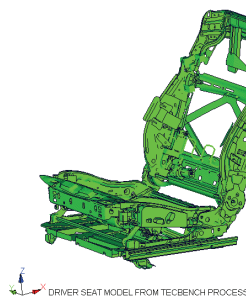


Figure 6: Seat structure as carryover include

3.4 TEC|PROM™

TEC|PROM™ Process Manager is a one-button solution to create complete FE inputs. It enables junior CAE engineers to create trouble free FE inputs and load cases. TEC|PROM™ manages different functionalities:

- Include setup
- Load case setup
- Results documentation

The include setup tool is used to build up all different FE includes. The load case setup is needed to build up different load cases, because each load case needs its specific includes (different power train configuration, seat position, dummy type, barrier type, etc.)

Each load case features its specific structure and dummy targets. Here TEC|PROM™ is a big help for documenting results, including the comparison between physical tests and FE results, too.

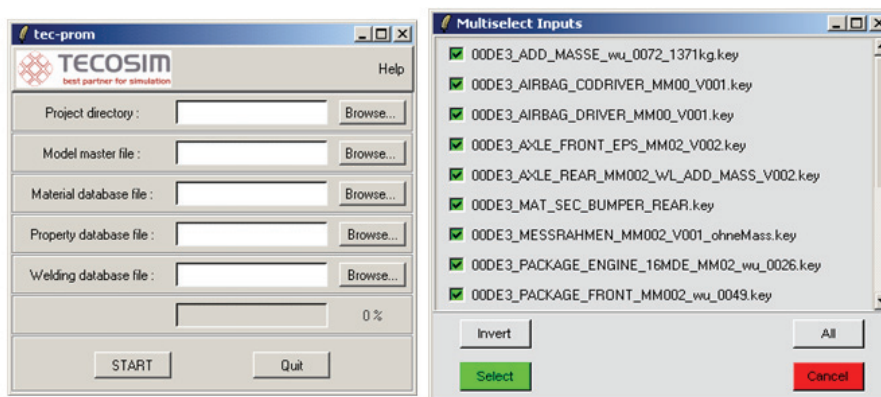


Figure 7: TEC|PROM™

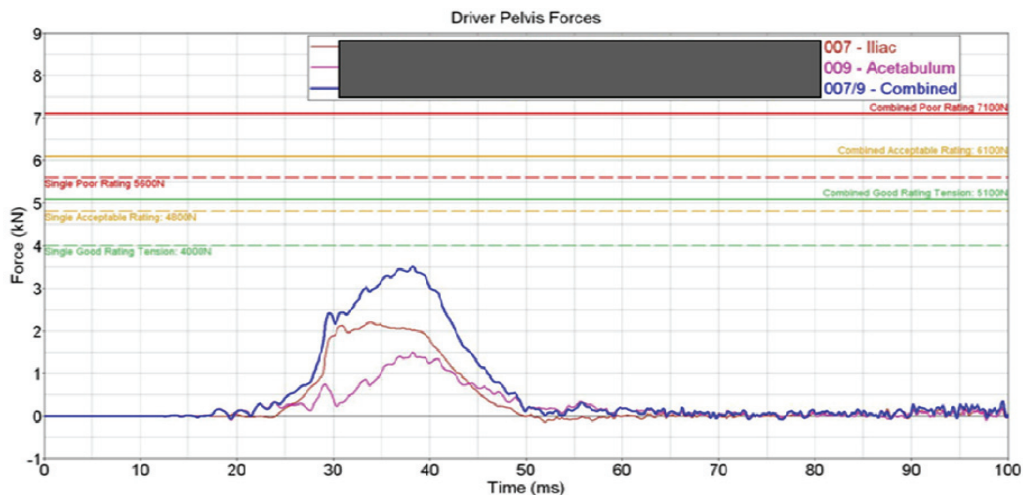


Figure 8: Example Driver pelvis force Side IIHS targets

3.5 TEC|CHECK

TEC|CHECK plays a decisive role in our CAE process. With TEC|CHECK each include (joints formulation, mesh penetrations, etc.) can be checked before sending it to the include database. At this stage, this check is both, helpful and necessary: it is always easier and faster to find and solve errors in a small and manageable include than in the complete FE model. This check gives us the guarantee that each include is LS-DYNA compatible.

Furthermore, the complete LS-DYNA deck files have to pass the TEC|CHECK tool before LS-DYNA calculations can be started, detecting any incompatibility between all includes necessary for the load case.

LS-DYNA results have to pass the TEC|CHECK tool too, before starting the results documentation. For example, this check helps us to find untied interfaces, smallest time step, mass less nodes, etc., providing a high level results guarantee.

For these checks no LS-DYNA licenses are needed. Therefore almost every LS-DYNA license is used to run the FE simulations, 24 hours a day.

```
C:\cae\UTIL\dyn2hma.exe
DYN2HMA_EXE Keyword-Input-Translator      U_2.2  TECOSIM 06.02.2008
License expires in 275 days!
Date: D:\-crash\lope\LS-Dyna_Conf_Salzburg\EXAMPLE_DOOR_FRONT\EXAMPLE_DOOR_FRONT
OK!

*INCLUDE File: EXAMPLE_DOOR_FRONT_LH.key found!
*INCLUDE File: MATERIALS.key found!
*INCLUDE File: SECTIONS.key found!

Working on *INCLUDE File: EXAMPLE_DOOR_FRONT_LH.key.....
Working on *INCLUDE File: MATERIALS.key
Working on *INCLUDE File: SECTIONS.key
Check nodes and set pointer
Allocate memory for constraint check
Check constrains!
Check free nodes!
Check initial velocity!
Check simple 2D quality!
6 Collector(s) with mat id 999999999 found! ==> Creating "con_rigid_bodies_new"!

2 Error(s) 41 Warning(s)

Writing nodes
Writing materials
Writing properties
Writing components
Writing loadcollectors
Writing curves
Writing groups

2 Error(s) detected!!!!!!!!!!!!!!
See file "D:\-crash\lope\LS-Dyna_Conf_Salzburg\EXAMPLE_DOOR_FRONT\EXAMPLE_DOOR_FRONT.INFO" (look for "Error").

Press any key to continue..._
```

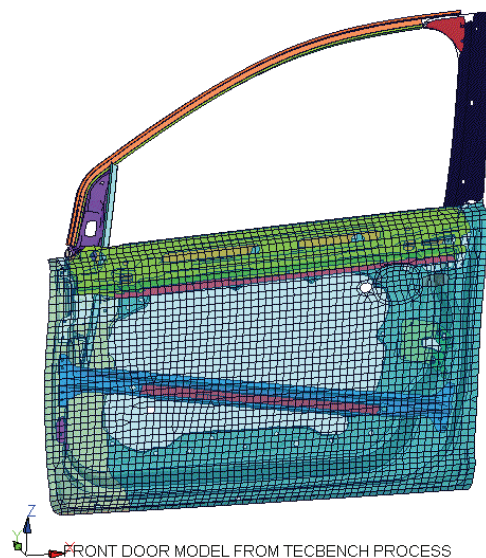


Figure 9: TEC|CHECK

3.6 CAE Input

As CAE input we need two different types of information: Input setup information and load case specification.

For the include setup we need information such as:

- Connection information (spot welds, weld line, rivets and bolts, etc.)
- Material information for each part
- etc

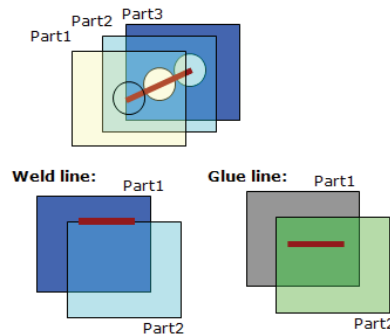


Figure 10: Connetion example

For building a load case the following information is necessary:

- Power train configuration
- Vehicle stand height
- Curb weight
- Weight distribution of test vehicle
- etc.

US	TEST	TEST Comment	Barrier	Velocity	ENGINE	Test-weight [Kg]	
FRONT	Frontalaufprall NCAP	US NCAP	0°	56 km/h	[Barriers and engine icons]	[Weight scale]	
	Frontalaufprall IIHS ODB	Frontalaufprall IIHS ODB	0°	64 km/h			
	FMVSS 208	2 x 50% H III ungegurtet	(+) 30°	40 km/h			
			(-) 30°				
		2 x 50% H III ungegurtet 2 x 5% H III ungegurtet 2 x 50% H III gegurtet 2 x 5% H III gegurtet	0°	56 km/h			
			2 x 5% H III gegurtet	ODB 40% offset			40 km/h
SIDE	FMVSS 214	Seitenaufprall FMVSS 214, Barriere	27°	54 km/h			
		Seitenaufprall FMVSS 214, Pfahl	75°	32 km/h			
	LINCAP	Seitenaufprall LINCAP	27°	61 km/h			
	SIDE IIHS	Seitenaufprall IIHS Barriere	90°	50 km/h			

Figure 11: load case information example

3.7 TEC|IDA

TEC|IDA Include Database is where we store all the necessary includes, the LS-DYNA input for the calculation, the results and the documentation. Using TEC|IDA it is easy to find the different include revisions and their update details. The load case summaries including the load case history and the different calculation variants are very helpful too, for providing CAE engineers and CAE project managers with a compact overview of the current project status.

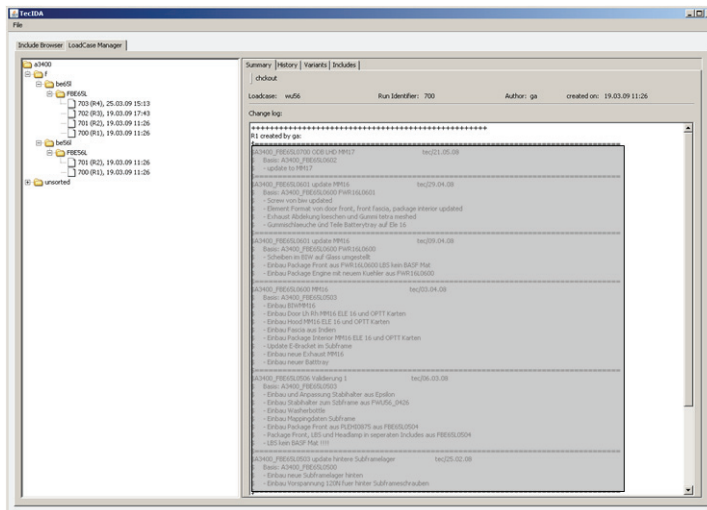
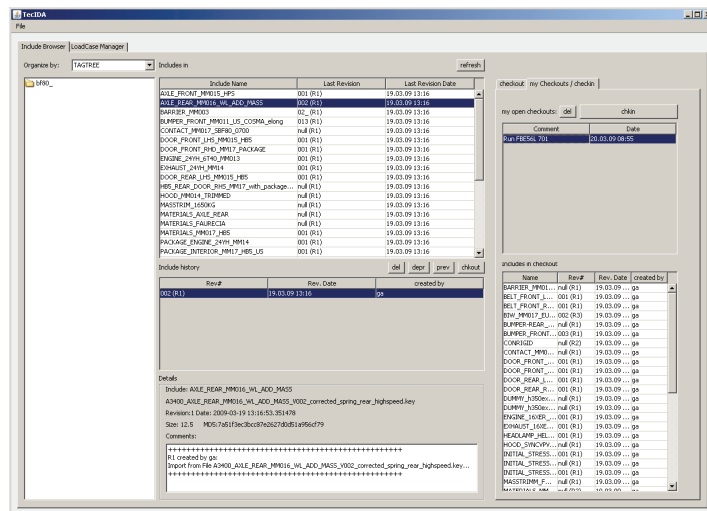


Figure 12: TEC|IDA GUI

4 Conclusion

This paper has pointed out that TECOSIM CAE process is an efficient overall process helping us to reduce time and CAE development costs.

Explaining the main functions of TECOSIM CAE tools it was shown that our CAE tools can be run as stand-alone solutions and can as well be integrated into any existing CAE process.

Due to the TECOSIM process flexibility and our experiences in complete vehicle development for all markets (US, Canada, Europe, China, Japan, etc.) we are able to provide our customers with a smooth and efficient tailor-made solution, reducing the total vehicle development time and cost.