

## **JSD - Introduction of Integrated Seat Design System for LS-DYNA<sup>®</sup>**

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### **Abstract**

*Recently vehicle modelling is becoming more detailed and complex. Automotive companies are more and more directly evaluating dummy injury criteria in crash analysis. To evaluate injury criteria, a more detailed seat model is needed, because injury criteria are highly depending on seat structure and restraint system. In addition to the above, many types of LS-DYNA analysis are carried out during one seat design process (e.g. frontal impact, side impact, whiplash, and so on). Because these analyses use different dummy models, different loading conditions and sometimes different dummy/seat positions, the engineer needs to understand all regulations and make a big effort to prepare the input data. To reduce this effort in the demand for more detailed seat models, an integrated seat design system named JSD has been developed.*

*In this paper, an introduction of JSD is presented and some advanced features demonstrated. JSD consists of three different systems and a GUI. The first is a database management system, which manages master models of dummy, seat, BIW and so on. The database manages not only keyword filenames but also additional information for automatic assembling. Thanks to the database management system, the user needs no effort to find suitable master models on their server and miss-communication between engineers in the case of multiple seat analyses is reduced. The second system is automatic assembling, whose main features are:*

- Automatic model assembling*
- Automatic setting for typical crash regulation and assessment.*
- Automatic positioning for dummy and seat*
- Simulation based h-point measurement*
- Simulation based pre seat deformation*

*The final system is for seat modeling. This system has tools dedicated to seat structure modeling. Although only a few tools will be built in ver1.0, we are planning to add several tools for seat cover fitting, material parameter identification and THUMS positioning in the next version.*

## Introduction

Vehicle modelling is becoming more detailed and complex in crash simulation. Thanks to the refinement of vehicle models automotive companies can now directly evaluate dummy injury criteria using crash analysis. To do this more detailed seat models are needed, because injury is often highly dependent on seat structure and restraint system. In addition to the above, many types of LS-DYNA analysis are performed on a seat during its design process (e.g. frontal impact, side impact, whiplash, and so on). Because these analyses use different dummy models, different load conditions and sometimes different dummy/seat positions, the engineer must understand many regulations and make a big effort to prepare all the input data. In some cases, accuracy and stability improvements made to commonly used models are only stored on local disks rather than the data server, so these improved models are not efficiently shared. Some companies are trying to centrally manage dummy models and common models (e.g. transmission, engine, steering column, etc.) for crash simulation to avoid the miss-communication mentioned above. To meet these demands, JSOL has decided to develop a seat design system named JSD (JSOL Seat Designer).

## System Concept

The main objective of JSD is to provide high accuracy results of seat related simulations for all engineers without special effort and knowledge. This means that the engineer who has no information about crash regulations can run sled simulation and have high accuracy results for JNCAP, Euro-NCAP, US-NCAP, etc. To achieve this objective we need a framework that can cover following requirements:

- Easy setting and user-friendly GUI
- Management system for models
- Include information for seat design related regulation and assessment
- Easy to improve models for high accuracy results
- ID free system

Primer, developed by Arup, is one of most powerful pre-processors for LS-DYNA. Primer has several features for automotive application like dummy/seat positioning, seatbelt fitting and seat foam deformation with and without using simulation. However operation of these special features is not easy for the entry-level user because of the need to understand these features and set several parameters to get proper results. To efficiently use these features the user requires a new graphical interface as few input parameters as possible. We developed JSD as a seat design system in Primer to meet this requirement.

JSD consists of four systems as below:

- Graphical user interface
- Database management system for models and related information
- Automatic assembly system
- Seat modeling system

In the first version (ver. 1.0) we focused on making the framework for an automatic sled model assembling system, and as yet the seat modeling system has only a few features. We are planning to implement several seat modeling features to improve simulation accuracy in the next version. In the next section several useful features in ver1.0 are introduced.

## Graphical user interface

### *Project management panel*

Project management panel is the main panel for JSD. The user can manage all analysis cases for one seat in this panel. Fig.1 shows the project management panel for one sample project. All analysis cases are categorized by regulation and test condition. By right-clicking on each analysis case, the user can copy, rename and delete the case via a pop-up menu. When the user copies the case into a different regulation or test condition (e.g. from JCAP-Full Frontal to EuroNCAP-MDB), the regulation related settings like dummy model are automatically updated and the other settings still are kept unchanged. This is an easy way to duplicate analysis cases over different regulations. Users also can execute the automatic assembling system and run LS-DYNA from this menu.

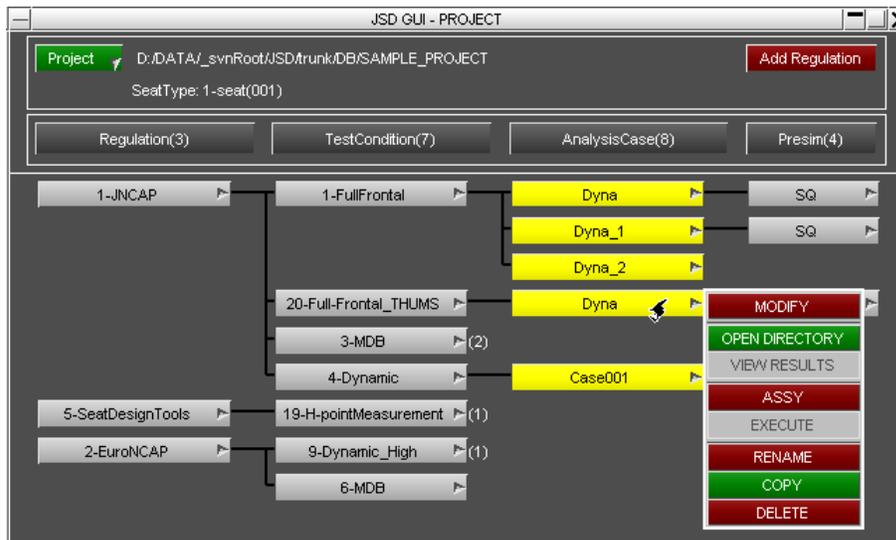
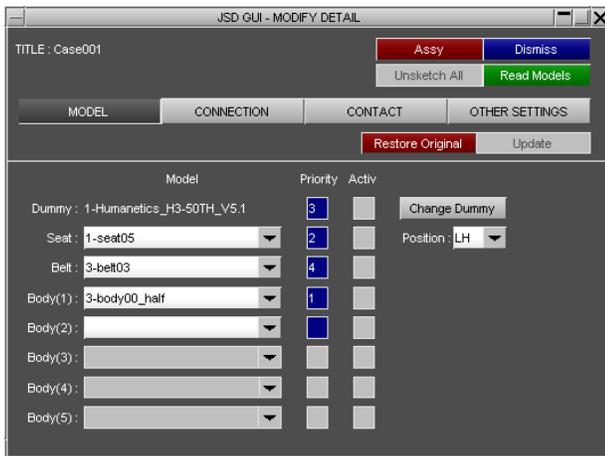


Figure 1 Project management panel.

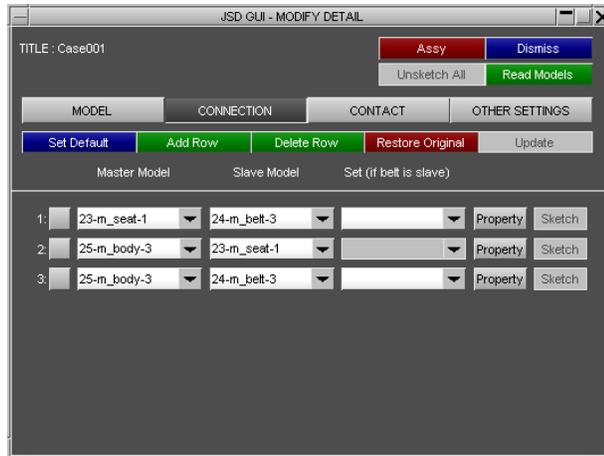
### *Analysis case setting panel*

In the “Analysis Case” setting panel the user sets up all necessary information to make the input deck for one analysis case. This panel has four tabs named “MODEL”, “CONNECTION”, “CONTACT” and “OTHER SETTINGS” as shown in fig.2. In the “MODEL” tab, the user selects models for their analysis case. The dummy model is preset based on test condition of the regulation in the project management panel. Seat, seatbelt, and vehicle body models can be selected from the model database. In the “CONNECTION” tab, nodes have been defined for

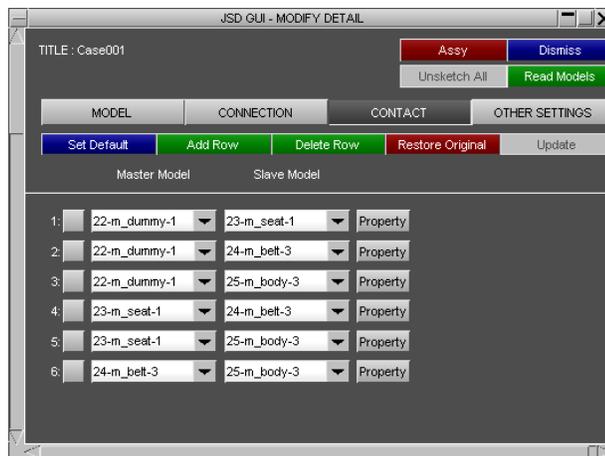
positioning and connection by Nodal Rigid Body (NRB). The user selects pairs of master and slave models for positioning at first. To reduce operation time, automatic selection can be used. The next step is selection of pairs of nodes that are associated with each model for positioning and connection. The node association is set up when user registers the model to database (see section on Database management). In the “CONTACT” tab, pairs of master and slave models are selected for contact definition. Models in the database already have \*PART\_SET definitions defined for contact so user does not need to create/select \*PART\_SET in this tab. In the “OTHER SETTINGS” tab, the user turns on/off the seat positioning, dummy positioning, seat foam deformation and seatbelt refitting. For seat positioning and dummy positioning, seat position can be selected from 9 pairs of horizontal (front, center and rear) and vertical (low, middle and high) position and seat back angle and torso angle can also be set as a numerical value. When the user activates the LS-DYNA seating simulation, if the simulation result does not exist the input deck for seating simulation is generated in the assembling process.



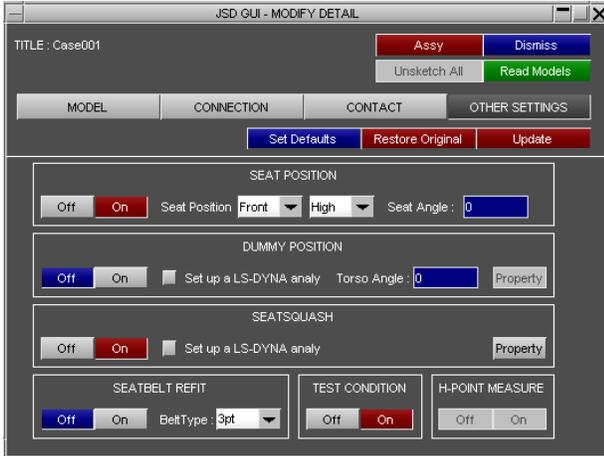
a) MODEL tab



b) CONNECTION tab



c) CONTACT tab



d) OTHER SETTINGS tab

Figure 2 Analysis case setting panel.

## Database management features

### *Managing information for automatic model assembling*

As mentioned in the previous section, not only models but other additional information is needed for automatic assembling model, like SET PART ID for contact, NODE ID for positioning/ connection, dummy facing direction in model coordinates and so on. To manage this information outside the input deck, JSD contains an object-relational database management system. The path of the model files and additional information for JSD are in this database but the model files are not in the database. Thus the user can separately manage the database and key files for registered models using this system. This database system can be run on network server or local computer. This means that user can build environment flexibly like fig.3.

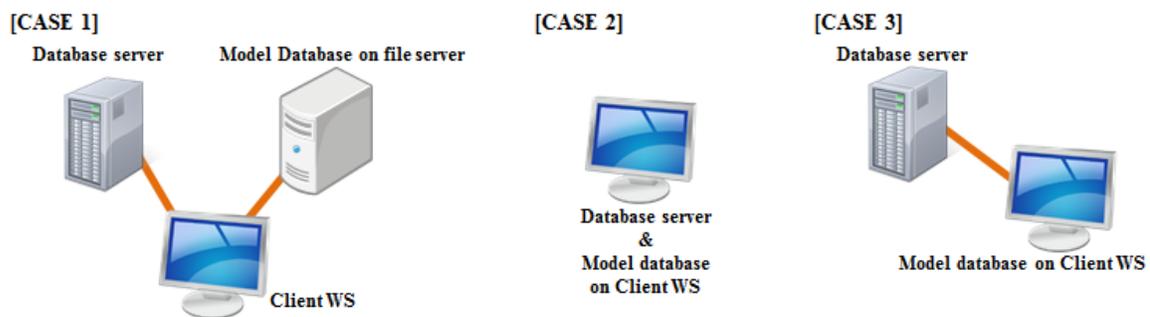
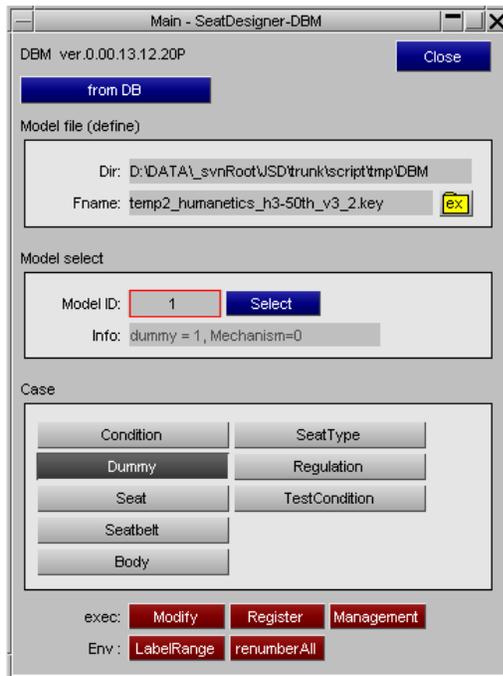


Figure 3 Construction examples for database.

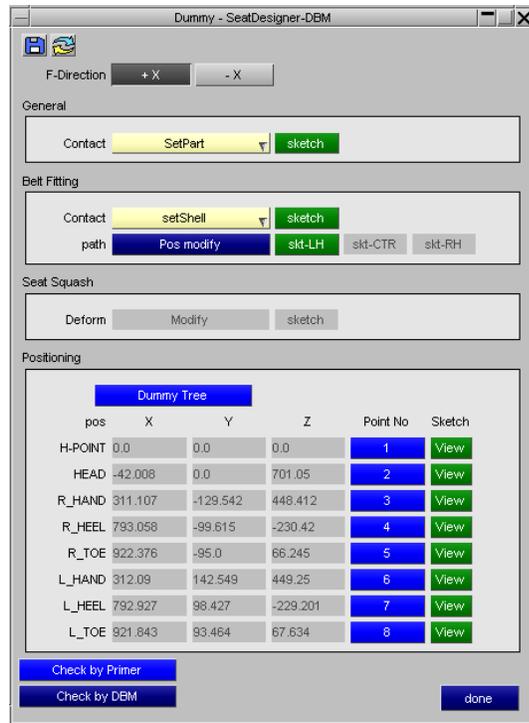
### *Access to database*

JSD provides an original interface named DBM panel to access the database. To avoid error from lack of necessary information during automatic assembly process, the DBM panel is the only way to access the database using JSD. From the DBM panel the user can read, delete, rename and register models for/to the database. Before model registration, the user needs to add special keyword definitions to the model and information to the database for automatic assembly via the DBM panel. Registered models are categorized and stored in the database according to their purpose. Because each category requires different information and additional keyword definitions, DBM has a different modification panel for each category (see fig.4). In the case of the dummy category, the following information and definitions are required:

- Facing direction in global coordinates
- Part set for contact with others
- Seatbelt path and
- Tree-file definition for positioning



a) Main DBM panel



b) modification panel for dummy

Figure 4 DBM panel and modification panel for dummy category.

## Automatic assembly features

### *Automatic dummy and seat positioning*

To perform dummy and seat positioning, the user only has to activate positioning buttons of seat back angle and seat cushion position for the seat, and torso angle for the dummy. Based on the information in the database, JSD automatically identifies where positions of hands, heels and toes should be in the assembled model. Fig.5 shows example of positioning with same dummy and different vehicle body (BIW) model. As shown in fig.5, the dummy's feet are on the pedals in both cases, however the dummy's hands are located on the steering wheel in fig.5a and kept at the initial position in fig.5b. This is because the BIW model in fig.5a has target points on steering wheel for hands but the BIW in fig. 5b has no target points for hands. If the refitting button is activated, after dummy and seat positioning the seatbelt is refit to the new position. Fig.6 shows several refitting results. Fig.6a shows seat belt refitting of a loose seat belt that occurred after seat positioning. Fig 6b shows refitting in the case of a penetrating seat belt that occurred after dummy positioning.

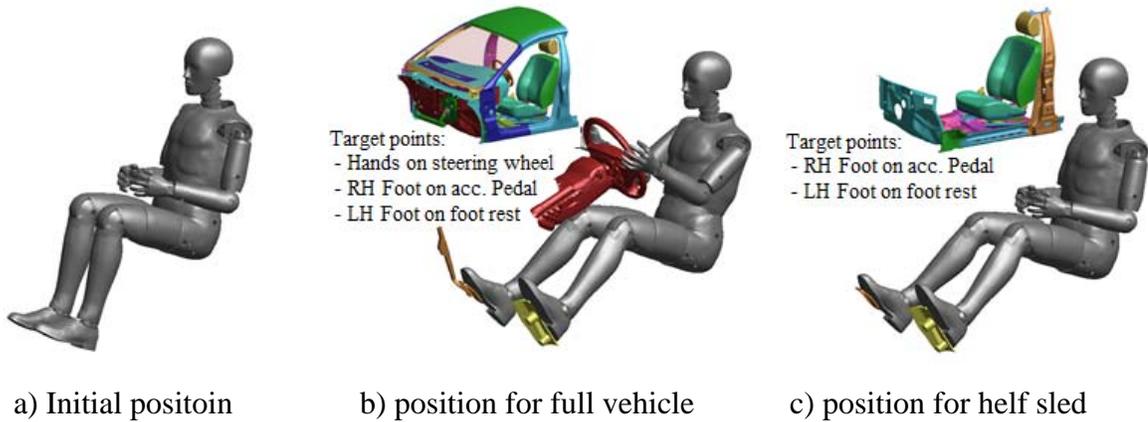


Figure 5 Dummy positioning with different BIW model

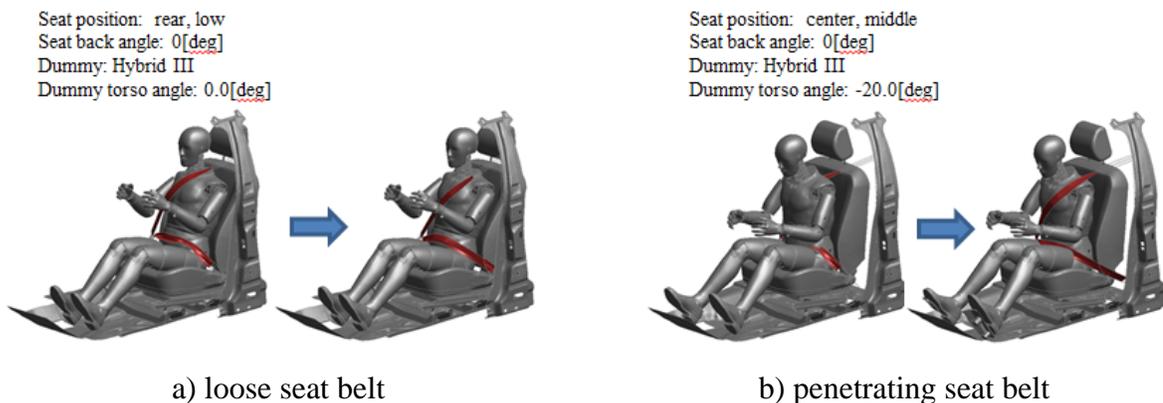


Figure 6 Seatbelt refitting results for different seat/dummy position

### *Seating simulation and import seating simulation results*

JSD provides two types of seating simulation method. The first we call a kinematic based method. “Kinematic” means to calculate the deformed geometry of seat foam without stress calculation. In this method, coordinates of internal nodes of seat foam are interpolated from surface nodes positions which are prescribed by contact between dummy surface and seat foam. Thus some internal node coordinates may not be realistic. The second is an LS-DYNA based method. Here the deformed geometry is the result of a seating simulation with LS-DYNA and material properties in seat model are fully considered. In the first version of JSD the dummy model is made rigid for the seating simulation. After the seating simulation the deformed geometry is registered in the database and can be imported during the automatic assembly process. Thus the user does not re-execute the seating simulation if it has already been done before. JSD uses “\*INITIAL\_FOAM\_REFERENCE\_GEOMETRY” to set initial stresses of seat foam in the sled simulation. Some examples of imported seat deformation are shown in fig.7. In these examples the seating simulations have been done in advance so user can select either seat deformation without any calculation.

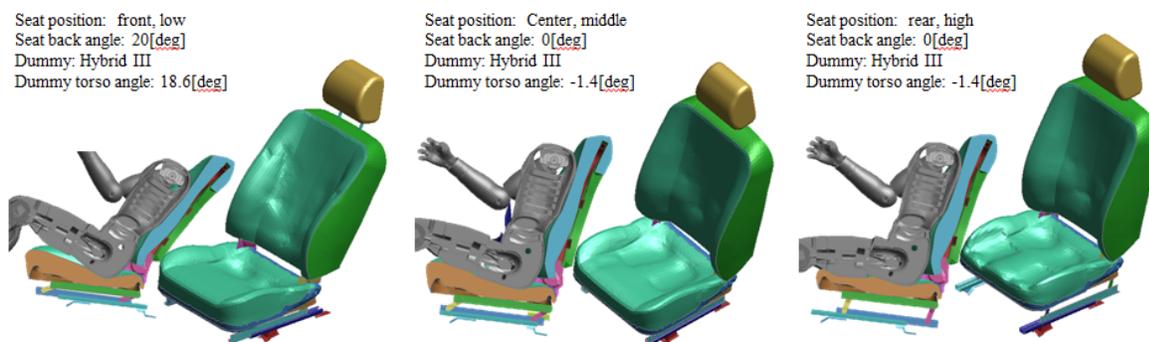


Figure 7 Imported seat foam geometries for several seat/dummy positions

### *Simulation base H-Point measurement*

The H-point is an important piece of information to run a seat related simulation. In general the H-point position is measured by experiment and cannot be determined without the real full seat structure. To evaluate the H-point position without real a seat structure, JSD has simulation based H-point measurement feature and uses the Arup H-point manikin FE model. To run simulation based H-point measurement, the user adds new case as “H-point measurement simulation” and selects a suitable regulation in project management panel. Supported regulations in the current version are SAE, ECE and Japanese safety standard. The H-point measurement steps in these safety standards are as below:

1. Put the manikin on seat
2. Adjust position of leg and foot
3. Move manikin forward to remove penetration with seat
4. Apply load on T-bar
5. Put weight on torso, buttock, thigh and leg
6. Apply load on back angle bar

7. Measure the coordinate of H-point

In JSD, steps 1 to 3 are done automatically as a pre-process and then an LS-DYNA input deck for steps 4 to 6 is generated. After the LS-DYNA calculation, JSD reports the H-point coordinate from the result.

### **Next version**

In the first version we focused on reduction of workload when assembling models for sled simulation. Our goal of JSD is reduction of workload when modeling seat related simulation and providing an environment for high accuracy results without any know-how about seat related simulation. Thus we are continuing to develop JSD to extend the application for general seat structure evaluation in LS-DYNA. Now we are doing R&D and implementing the following features for the next version:

- Seat modeling tool
- Material identification tool
- Support new regulation
- Support child seat

### **Conclusion**

In this paper we show the JSD concept and some useful features for seat simulation in LS-DYNA. JSD is not a simple preprocessor but an integrated system to assemble models efficiently and avoid time loss coming from miss-communication between each engineer. In addition, JSD is designed based on over 20 years' experience in automotive crash simulation. By using JSD, all users can obtain our know-how for automotive crash simulation without any effort and spending time. We hope that JSD helps engineers who need seat related simulation to have useful simulation result in LS-DYNA.