

# VPG/Safety Tutorial

**Process Guidance for  
Vehicle Impact and Safety Analysis  
Model Creation**

Release Date: July, 2004

**ETA- Engineering Technology Associates, Inc.**  
**1133 E. Maple, Suite 200**  
**Troy, MI 48083**

Phone: (248) 729-3010  
Fax: (248) 729-3020  
Support e-mail: support@eta.com

This material is a compilation of data and figures from many sources.

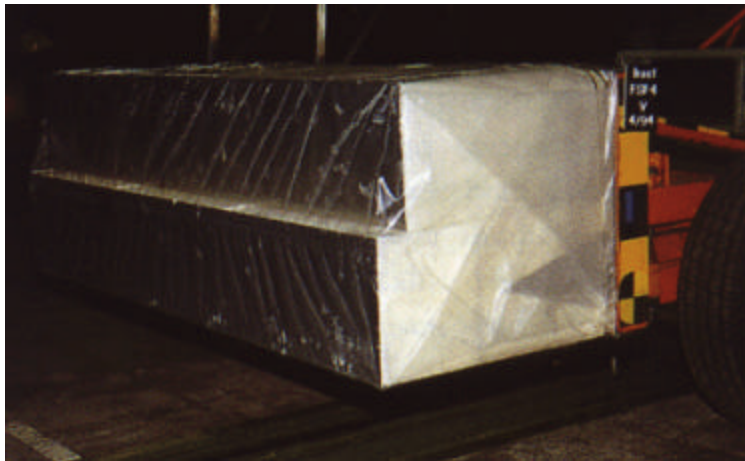
Engineering Technology Associates, Inc. assumes no liability or responsibility to any person or company for direct or indirect damages resulting from the use of any information contained herein.

Engineering Technology Associates, Inc., ETA, the ETA logo, and eta/VPG are the registered trademarks of Engineering Technology Associates, Inc. All other trademarks or names are the property of their respective owners.

Copyright 1998-2004 Engineering Technology Associates, Inc. All rights reserved.



Mobile Side Impact Barrier



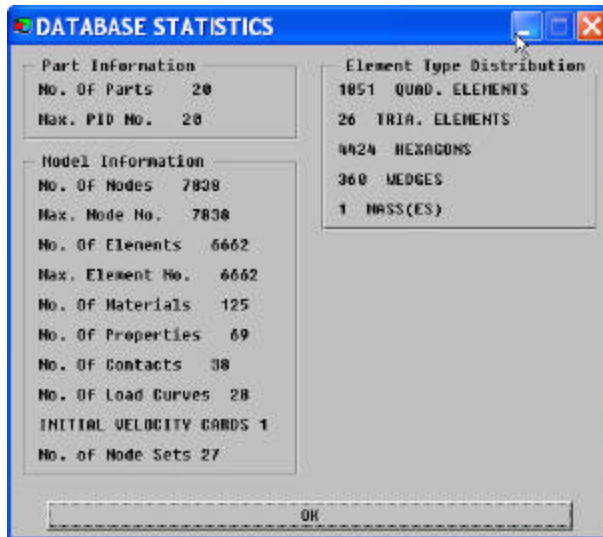
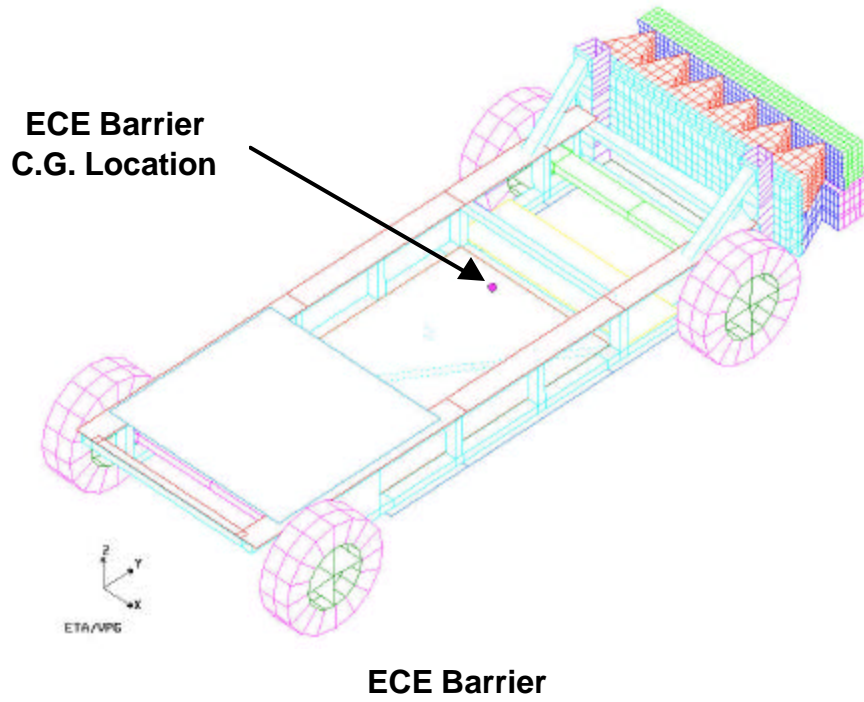
Side Impact Test

### **Introduction: ECE 95 (Euro Dynamic Side Impact)**

The ECE directive specifies that the barrier used in this standard is to be manufactured from aluminum honeycomb or equivalent elements. In full-scale side impact testing, a 950kg Mobile Deformable Barrier (MDB) is used to represent the front of the oncoming vehicle in-motion. The barrier must fulfill geometrical requirements and must conform to energy absorption limits when activated at a velocity of 50 km/h.

This regulation applies to the lateral collision behavior of the structure of the passenger compartment. Both M and N categories of vehicles where the R point of the lowest seat is not more than 700mm from ground level when the unloaded mass of the vehicle increased by a mass of 100kg (that is the mass of the side impact dummy and its instrumentation).

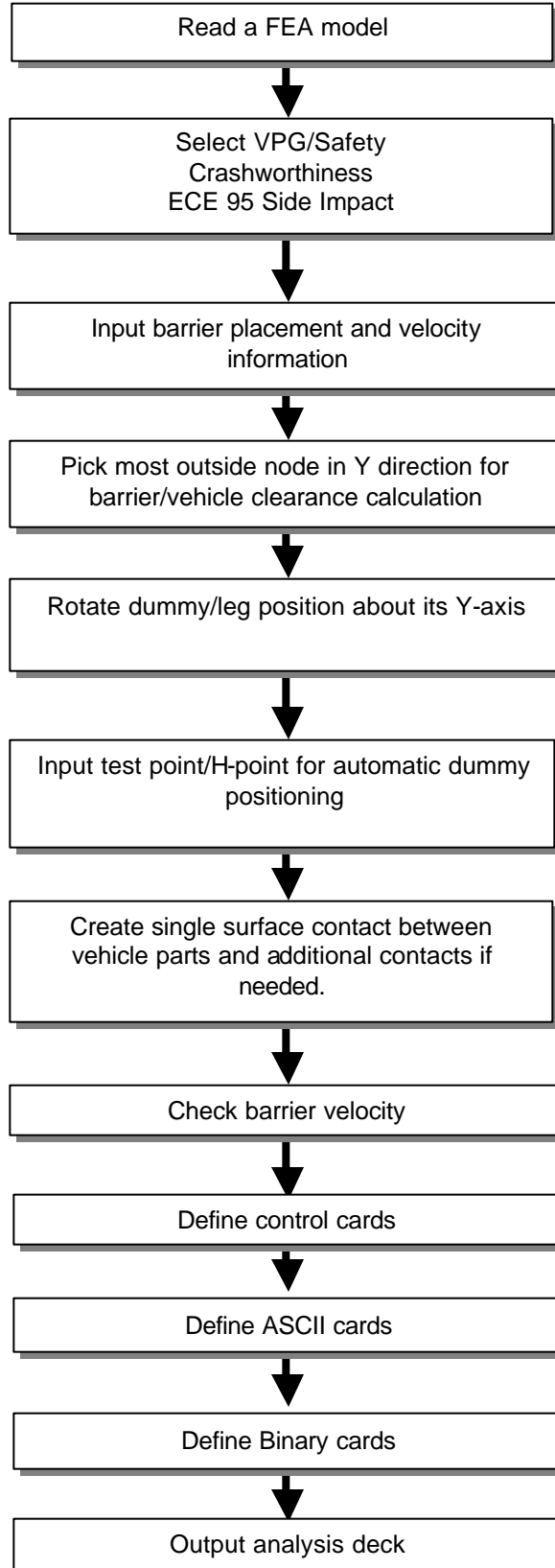
**Crash Tools**



---

**Procedure Flowchart**

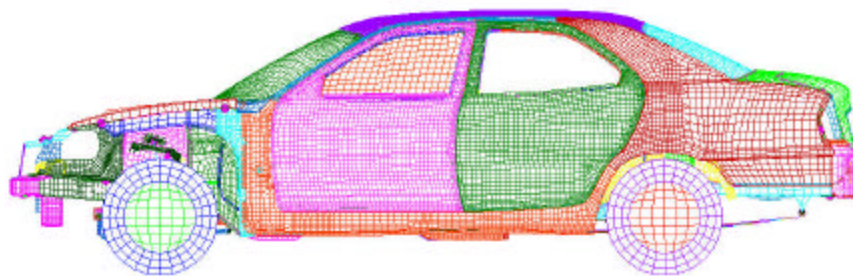
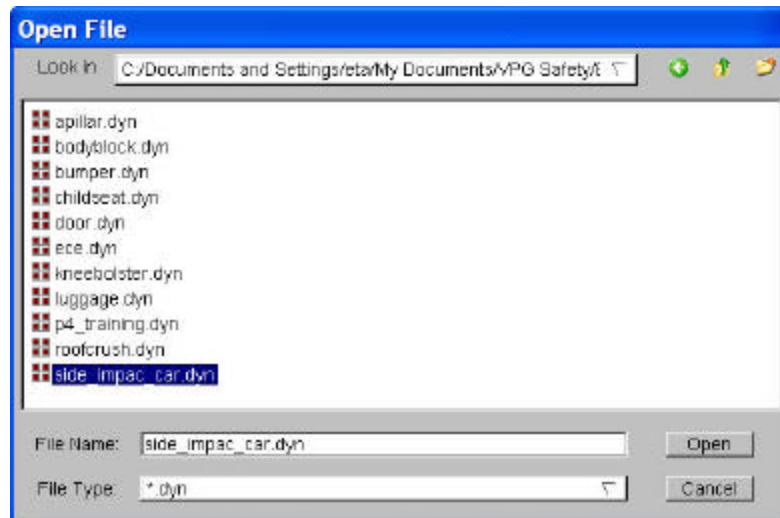
---



## ECE95 Dynamic Side Impact Analysis Step-by-Step Tutorial

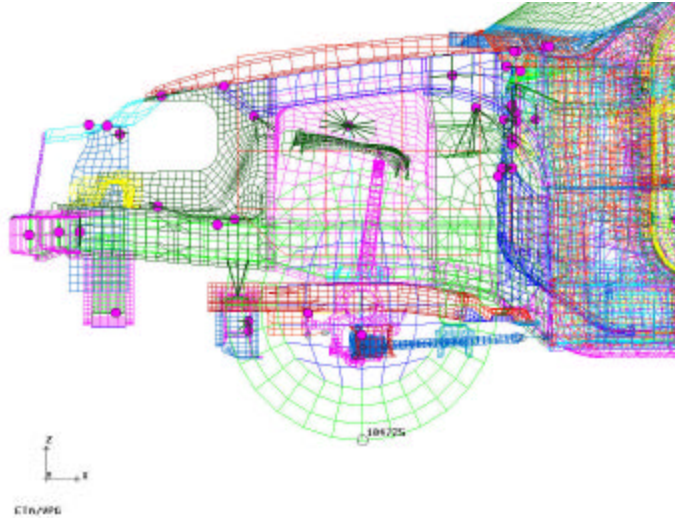
### Step-by-Step Procedure

1. First read in a validated car FEM model.
  - a. Select **FILE/READ DYNA** from Main Menu.
  - b. Select *side\_impac\_car.dyn* from the file name list and select OK.



- c. Press F1 back to Main Menu.

2. Import the ECE 95 Moving Deformable Barrier (MDB) and dummies.
  - a. Zoom in the front wheel. Select **UTIL/IDENTIFY NODE**, and select a node from the lowest position to get the minimum Z-coordinate of the vehicle.



The coordinates of the selected node displays in VPG Dialog Window,

NODE 104725 X= 2.1530 Y= 853.7250 Z= -258.7460

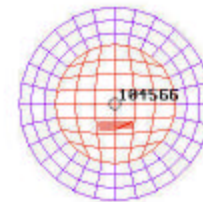
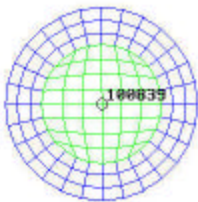
This gives the Z-coordinate of the vehicle ground as -258.7

- b. Fit the view by selecting **FILL** from View Options menu. Turn off all the parts except those belonging to the tires. Select two nodes at the center of the front and rear tires respectively.

NODE 100839 X= 0.00 Y= -778.0000 Z= 65.0000

NODE 104566 X= 2820.00 Y= -778.0000 Z= 65.0000

- c. Calculate the difference between the x coordinates of the two nodes to get the vehicle wheelbase. In this case it is 2820 mm. The vehicle wheelbase center is half of the above value (1410mm).



- d. Select **SAFETY\CRASHWORTHINESS\ECE95 EURO SIDE IMPACT** from **MAIN MENU**. VPG prompts "ENTER ECE95 SIDE IMPACT INFORMATION" and a window appears.

ECE SIDE IMPACT DATA	
ITEMS	DATA
VEHICLE/BARRIER Y CLEARANCE (m)	2.000000E+001
BARRIER VELOCITY (mm/s)	1.388889E+004
X OF VEHICLE WHEELBASE CENTER	1.41000000E+003
Z OF VEHICLE GROUND (mm)	-260

Cancel OK

Enter **X OF VEHICLE WHEELBASE CENTER** as 1410 mm which can be obtained from x-coordinates of the 2 nodes at the center of the front and rear tires.

We obtained the Z value of the vehicle ground as -258.7 earlier. Enter -260 mm **for Z OF VEHICLE GROUND** to avoid initial contact penetration.

Use default values for the other parameters.

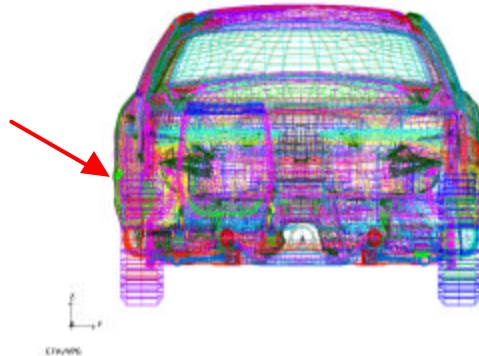
Select **OK** to proceed.

- VPG prompts for the crash target for MDB.

**>PICK A NODE TO CALCULATE BARRIER/VEHICLE CLEARANCE**

You can either select a node on the car or specify a position by entering x-, y- and z-coordinates for the crash target.

Set the model to rear view, and select a node from the left most position. The y-coordinate of this node acts as the contact clearance calculation base.



- VPG prompts whether using the default Side Impact Dummy (ETA SID):

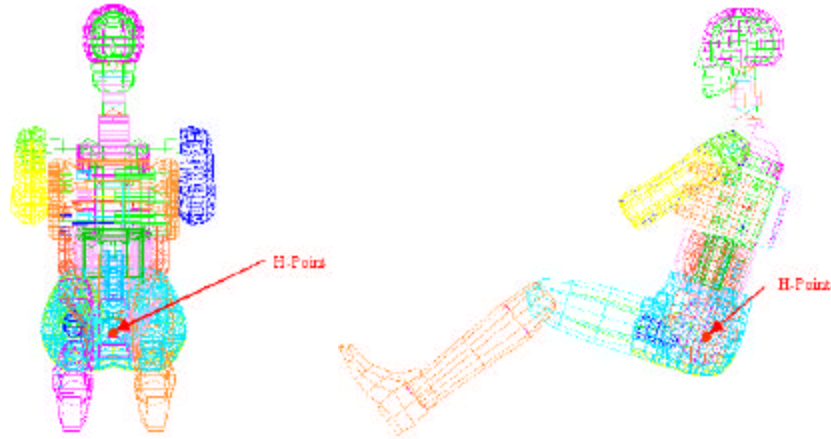
**>USE DEFAULT DUMMY? (Y/N)**

Select **YES**.

- VPG prompts for the location of the dummy.

**>PICK TEST POINT/H-POINT FOR ECE95 DUMMY**

H-POINT is a reference point on the dummy for the user to locate it.



Select KEY IN X, Y, Z from the CONTROL KEYS.

**>KEY IN XYZ FOR ECE95 DUMMY TEST POINT/H-POINT**  
**. 1408, -370, 277**

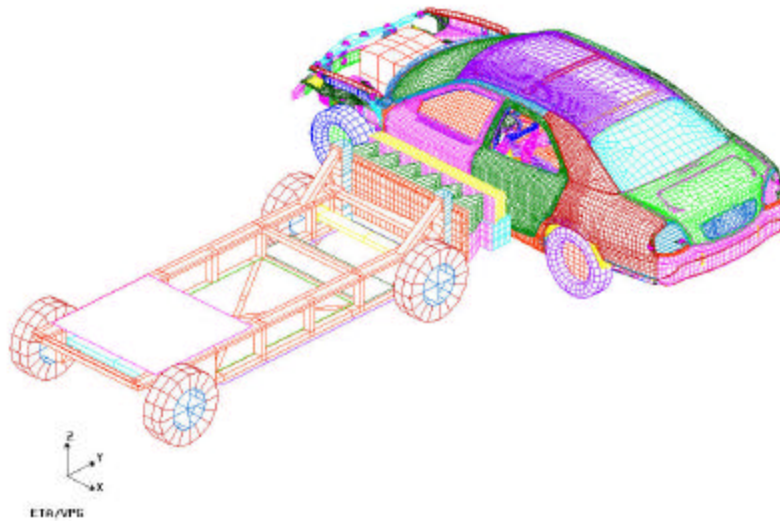
A ROTATION menu appears in the VPG Menu Window. The user can rotate the dummy or leg to adjust their position.



The default rotation angle increment is 1 degree. You can select CHANGE ANGLE to change it. Here we use the default position.

Select EXIT.

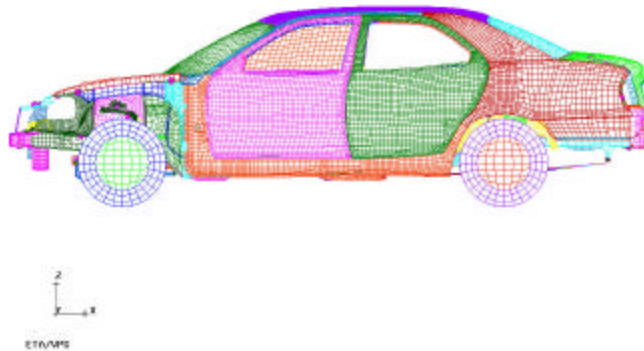
- The MDB and DUMMY are imported from the library and put on the location you have specified.



7. Define a part set for all vehicle parts.

Select **PARTON/OFF\PART SETS ON/OFF**, turn off part set 506 and 509 (ECE MDB PART SET and ECE DUMMY PART SET). Select **EXIT** back to the Main Menu.





Select **PRE/SET MENU/PART/CREATE** from the Main Menu.  
>**ENTER NEW PART SET NUMBER (1) OR E TO EXIT**

Enter 1 in VPG Dialog Window as the part set number to be created.

Select **DISPLAYED PARTS** from the part list window to select all the parts displayed on the screen.

>**OK TO SELECT ALL DISPLAYED PARTS? (Y/N)**

Select **YES** to response the prompt.

8. Modify the contact between the MDB and the vehicle structure.

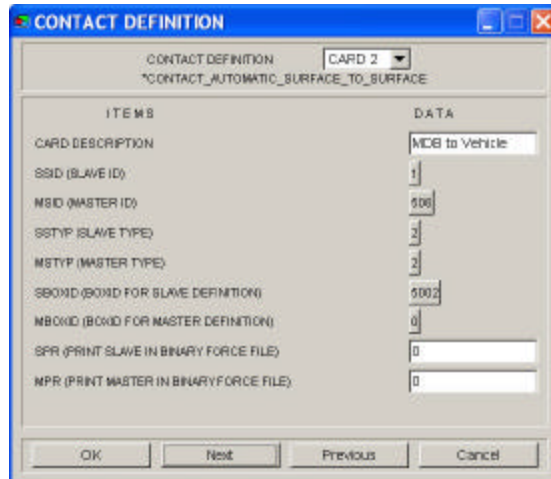
Select **CONTACT INTERFACE/MODIFY** from PRE menu. A contact card list pops up. Select the first contact from the list.

The **CONTACT DEFINITION CARD** appears.

Click **NEXT** to the second card and select the button following **SSTYP** and select **2-PART SET**.

Click the button following **SSID**, select 2-SELECT and select Part Set 1 from the part set list.

Click the button following **SBOXID** and select 5002 from the box list.



9. Modify Contact between ECE dummy and the vehicle.

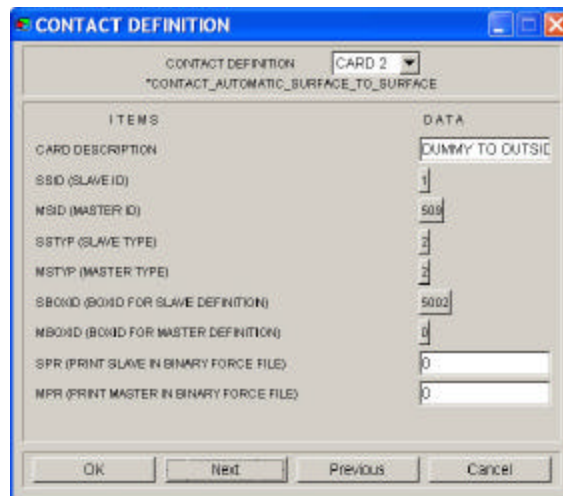
Select **CONTACT INTERFACE/MODIFY** from PRE menu. A contact card list pops up. Select the last contact (DUMMY TO OUTSIDE) from the list.

The **CONTACT DEFINITION CARD** appears.

Click **NEXT** to the second card and select the button following **SSTYP** and select 2-PART SET.

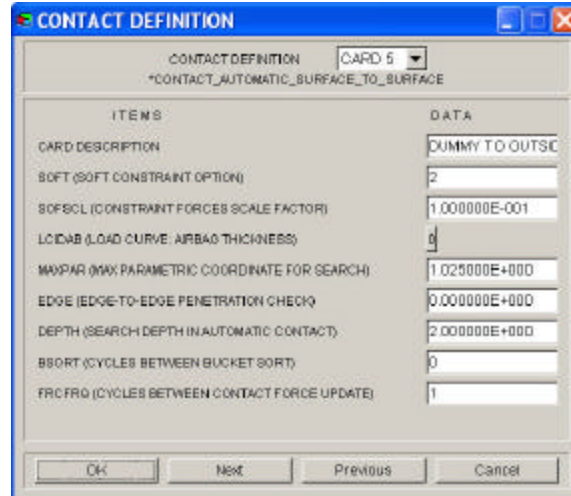
Click the button following SSID, select **2-SELECT** and select Part Set 1 from the part set list.

Click the button following **SBOXID** and select 5002 from the box list.



Enter the following parameters in card 5:

SOFT (SOFT CONSTRAINT OPTION): 2



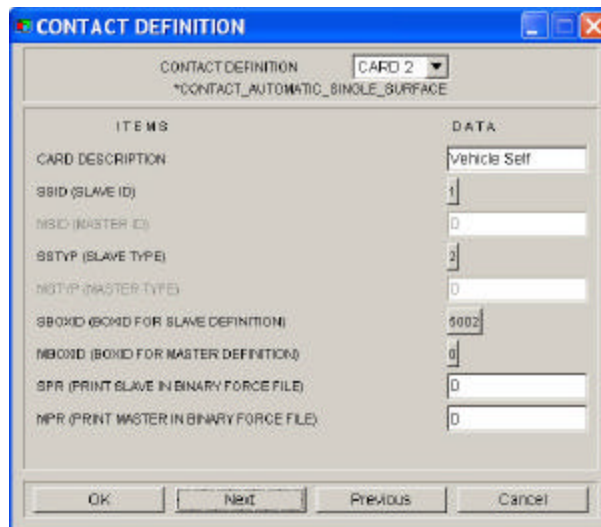
Select OK to accept the definition.

10. Create the Vehicle automatic single surface contact:

Select **SAFETYMODELING TOOL\CONTACT\CREATE\3 DIMENSIONAL**. A contact card list pops up. Select 13 –**AUTOMATIC SINGLE SURFACE** from the list.

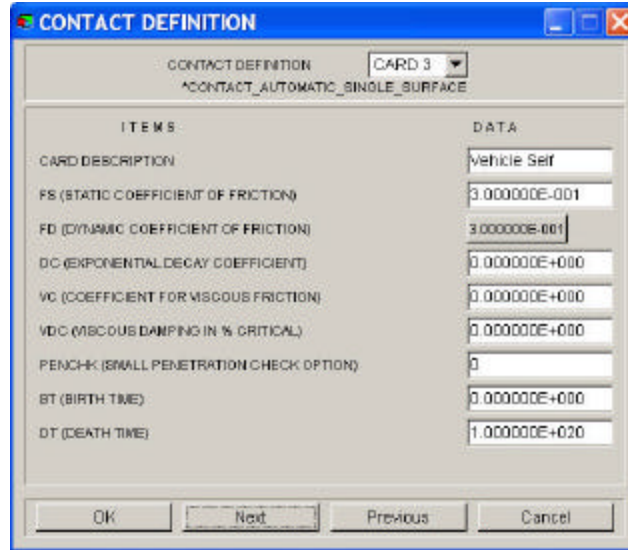
Click the button following **SSID**, select 2-SELECT and select Part Set 1 from the part set list.

Click the button following **MBOXID**, click on SELECT button and select Box 5002 from the box card id list.



Click to Card 3 and enter the following parameters:

FS (STATIC COEFFICIENT OF FRICTION):           0.3  
 FD (DYNAMIC COEFFICIENT OF FRICTION):       0.3



Select **OK** to accept the definition

#### 11. Define analysis control cards.

Select **CONTROL CARDS/ DEFINE** from MODELING TOOLS. The Control Card Definition window appears as follows:



Define the following control cards:

ITEMS	DATA
CARD DESCRIPTION	
SLFAC (SLIDING INTERFACE S.F.)	1.000000E-001
RWPNAL (RIGIDWALL PENALTY S.F.)	1.000000E+000
ISLCHK (INITIAL PENETRATION CHECK)	2
SHLTHK (SHELL THICKNESS CONTACT OPT.)	0
PENOPT (PENALTY STIFFNESS OPTION)	1
THKCHG (SHELL THICKNESS CHANGE)	1
ORIE (AUTOMATIC SEGMENT ORIENTATION)	1
ENMASS (TREATMENT OF ERODED NODE'S MASS)	0

**CONTROL\_CONTACT:**

This control card prescribes penalty factors, penetration factors, and contact options for the analysis.

Use these default values for this analysis.

ITEMS	DATA
CARD DESCRIPTION	
NRCCYK (ITERATIONS BETWEEN CONVERGENCE)	250
DRTOL (CONVERGENCE TOLERANCE)	1.000000E-003
DRFCR (DYNAMIC RELAXATION FACTOR)	9.950000E-001
DRTERM (OPTIONAL TERMINATION TIME)	0.000000E+000
TSSFDR (COMPUTED TIME STEP SCALE FACTOR)	9.000000E-001
RELAL (DYNAMIC RELAXATION OPTION)	0
EDTTL (CONVERGENCE TOLERANCE)	4.000000E-002
DRFLG (DYNAMIC RELAXATION FLAG)	0

**CONTROL\_DYNAMIC\_RELAXATION:**

This control card provides the necessary parameters for dynamic relaxation. This control card is important for stress initialization

Use the default values shown for this control card.

ITEMS	DATA
CARD DESCRIPTION	
HGEN (HOURLASS ENERGY CALC.)	1
RAEN (STONEWALL ENERGY DISSIPATION OPT.)	2
SLNTE (SLIDING INTERFACE ENERGY DISSIP.)	1
RYLEN (DAMPING ENERGY DISSIPATION)	1

**CONTROL\_ENERGY:**

This card controls the energy dissipation option in the analysis.

Use the default parameters shown for this control card.

CONTROL CARD DEFINITION **CARD 1**  
\*CONTROL\_OUTPUT

ITEMS	DATA
CARD DESCRIPTION	
NPOPT (INPUT PHASE PRINT SUPPRESSION)	0
NEECH0 (INPUT PHASE ECHO SUPPRESSION)	0
NREFUP (BEAM REFERENCE NODE UPDATE)	0
WCCOP (AVERAGED ACCELERATIONS)	0
ORFIS (INTERFACE FILE OUTPUT INTERVAL)	0.000000E+000
IPRINT (INITIAL TIME STEP PRINT OPT.)	0
KEFIT (PROBLEM STATUS OUTPUT OPT.)	100
FLUSH (NUMBER OF TIME STEPS INTERVAL FOR I)	5000

OK Next Previous Cancel

**CONTROL\_OUTPUT:**

This control card defines the printing options for the model nodal and element data.

The default parameters shown should be used in this analysis.

CONTROL CARD DEFINITION **CARD 1**  
\*CONTROL\_SHELL

ITEMS	DATA
CARD DESCRIPTION	
WRPANS (SHELL WARPAGE ANGLE [degrees])	1.700000E+002
TRIST (TRIANGULAR SHELL SORTING)	2
IRNXX (HUGHES-LIU SHELL NORMAL UPDATE)	-1
ISTUPD (SHELL THICKNESS CHANGE OPTION)	0
THEORY (SHELL THEORY)	2
BMC (MAPPING STIFFNESS BELYTSCHKO-TSAY)	2
WTER (PLANE STRESS PLASTICITY OPT.)	1
PROJ (PROJECTION METHOD)	0

OK Next Previous Cancel

**CONTROL\_SHELL:**

This control card defines options for computing shell response. This defines the shell warping parameters, default shell theory and shell stiffness options.

For this analysis, the default parameters shown will be used.

CONTROL CARD DEFINITION **CARD 1**  
\*CONTROL\_TERMINATION

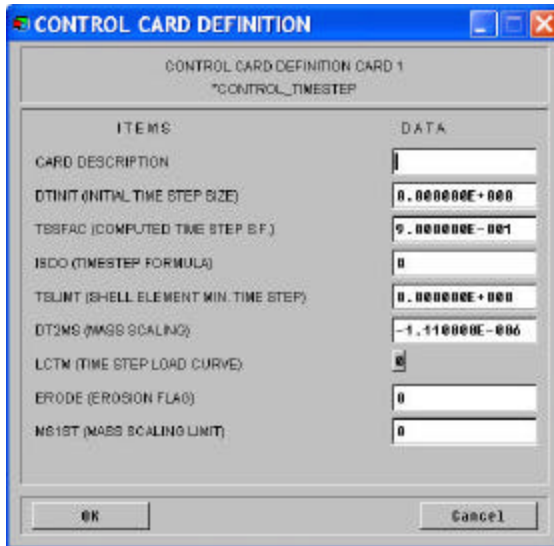
ITEMS	DATA
CARD DESCRIPTION	
ENDTIM (TERMINATION TIME)	0.000000E-002
ENDCYC (TERMINATION CYCLE)	0
DTMIN (INITIAL TIME STEP S.F.)	5.000000E-002
ENDENG (PERCENT ENERGY CHANGE)	0.000000E+000
ENDMAS (PERCENT MASS CHANGE)	0.000000E+000

OK Cancel

**CONTROL\_TERMINATION:**

This control card defines the analysis run time and job termination parameters.

For this analysis we will set the termination time to 0.09 seconds. All other parameters will be left as default values.



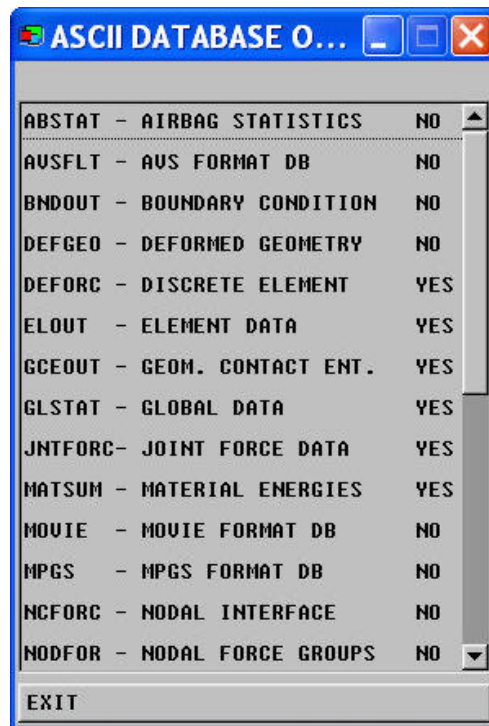
### CONTROL\_TIMESTEP:

This control card allows the user to define time step options, as well as mass scaling for the model.

In this model we will allow mass scaling to control the time step by setting DT2MS to - 1.11E-06. All other parameters are left as default values.

## 12. Define ASCII Cards.

Select **D.B. ASCII/ DEFINE** from **MODELING TOOLS**. The ASCII Database Definition window appears as follows:



Define the following Database ASCII cards:

The screenshot shows a dialog box titled "DB\_ASCII DEFINITION" with a subtitle "DB\_ASCII DEFINITION CARD 1" and "DATABASE\_DEFORC". It contains a table with two columns: "ITEMS" and "DATA".

ITEMS	DATA
CARD DESCRIPTION	
DT (TIME INTERVAL OF OUTPUT)	2.500000E-004

At the bottom of the dialog are "OK" and "Cancel" buttons.

**DATABASE\_DEFORC:**

This control card creates a file called DEFORC that contains discrete element data. This data is output for x-y curve plotting.

DT refers to the time interval between outputs.

The screenshot shows a dialog box titled "DB\_ASCII DEFINITION" with a subtitle "DB\_ASCII DEFINITION CARD 1" and "DATABASE\_ELOUT". It contains a table with two columns: "ITEMS" and "DATA".

ITEMS	DATA
CARD DESCRIPTION	
DT (TIME INTERVAL OF OUTPUT)	2.500000E-004

At the bottom of the dialog are "OK" and "Cancel" buttons.

**DATABASE\_ELOUT:**

This control card creates a file called ELOUT that contains element data from the element sets defined in the model. This data is output for x-y curve plotting.

DT refers to the time interval between outputs.

The screenshot shows a dialog box titled "DB\_ASCII DEFINITION" with a subtitle "DB\_ASCII DEFINITION CARD 1" and "DATABASE\_GLSTAT". It contains a table with two columns: "ITEMS" and "DATA".

ITEMS	DATA
CARD DESCRIPTION	
DT (TIME INTERVAL OF OUTPUT)	2.500000E-004

At the bottom of the dialog are "OK" and "Cancel" buttons.

**DATABASE\_GLSTAT:**

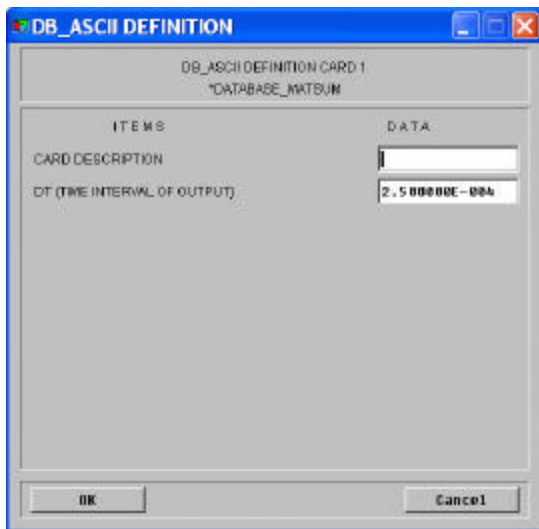
This control card creates a file called GLSTAT that contains all model global data. This data is output for x-y curve plotting.

DT refers to the time interval between outputs.

**DATABASE\_JNTFORC:**

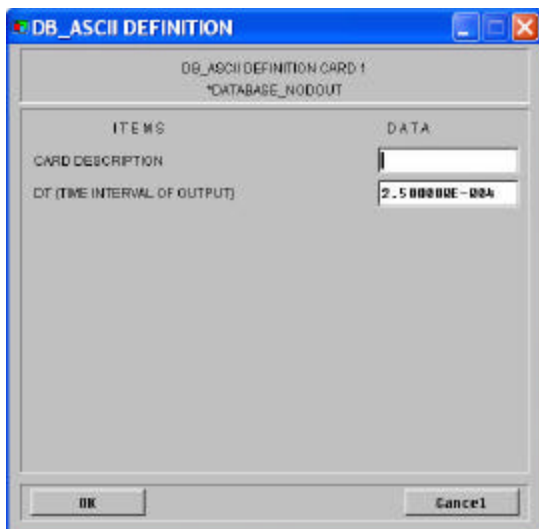
This control card creates a file called JNTFORC that contains all model joint force data. This data is output for x-y curve plotting.

DT refers to the time interval between outputs.

**DATABASE\_MATSUM:**

This control card creates a file called MATSUM that contains all material energy data. This data is output for x-y curve plotting

DT refers to the time interval between outputs.

**DATABASE\_NODOUT:**

This control card creates a file called NODOUT that contains all nodal group data (node sets), including force, displacement, velocity and acceleration. This data is output for x-y curve plotting

DT refers to the time interval between outputs.

ITEMS	DATA
CARD DESCRIPTION	
DT (TIME INTERVAL OF OUTPUT)	2.500000E-004

**DATABASE\_RCFORC:**

This control card creates a file called RCFORC that contains all contact interface data. This data is output for x-y curve plotting

DT refers to the time interval between outputs.

ITEMS	DATA
CARD DESCRIPTION	
DT (TIME INTERVAL OF OUTPUT)	2.500000E-004

**DATABASE\_RWFORC:**

This control card creates a file called RWFORC that contains all the rigid wall forces output for x-y curve plotting

DT refers to the time interval between outputs.

ITEMS	DATA
CARD DESCRIPTION	
DT (TIME INTERVAL OF OUTPUT)	2.500000E-004

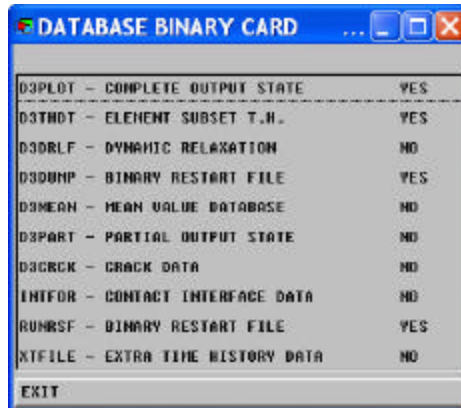
**DATABASE\_SLEOUT:**

This control card creates a file called SLEOUT that contains all sliding interface energy data. This data is output for x-y curve plotting

DT refers to the time interval between outputs.

### 13. Define Binary Cards.

Select **D.B. BINARY/ DEFINE** from MODELING TOOLS.



Define the following Database Binary Cards:



#### **DATABASE\_BINARY\_D3PLOT:**

This control card creates complete output states for the 3 dimensional data of the model (deformations, stresses, etc.)

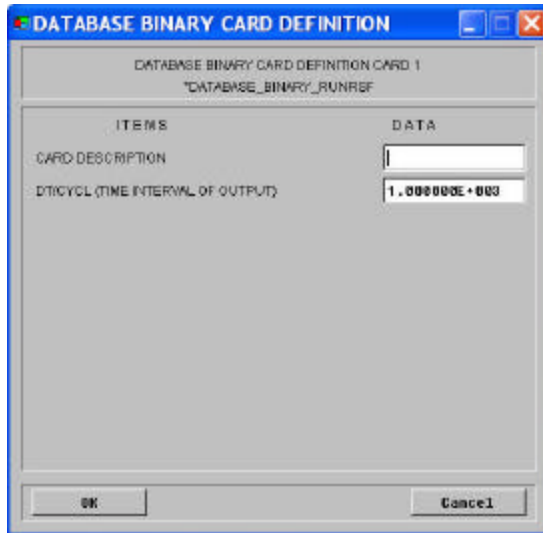
DT refers to the time interval between outputs.



#### **DATABASE\_BINARY\_D3DUMP:**

This control card creates a “family” of binary output restart files called D3DUMP01, D3DUMP02, etc. These files can be used to restart the analysis. A new D3DUMP file will be created after each interval.

DT refers to the time interval between outputs.

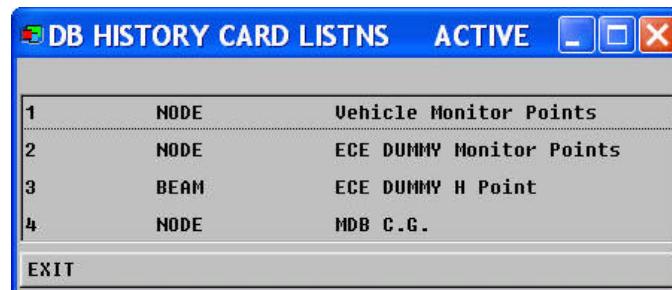
**DATABASE\_BINARY\_RUNRSF:**

This control card creates a binary output restart file called RUNRSF, this file can be used to restart the analysis if interrupted. It will be overwritten after each interval.

DT refers to the time interval between outputs.

## 14. Define Database History Cards.

Select **D.B. HISTORY/DEFINE** from **MODELING TOOLS**. The Database History Card Definition Window appears as follows:



In ECE95 Dynamic Side Impact Analysis, the following locations have been defined in time-history node output for correlation and post-processing:

- ECE Dummy upper, middle, and lower ribs, pelvic, head C.G. point.
- ECE Dummy H Point.
- MDB C.G. Point.

**SUBMITTING THE SIMULATION FOR ANALYSIS**

Use the VPG interface to directly submit the simulation for analysis.

**INTERPRETING THE RESULTS**

VPG/Safety automatically creates the following Database ASCII output cards to facilitate the post processing:

- Dummy HPC value: A seatbelt accelerometer is positioned in the C.G. location of dummy head to measure the nodal displacement, velocity, and acceleration values and these values are outputted to "nodout" file.

- b. Thorax Performance Criterion: Three spring elements are positioned at the dummy's rib area to measure the Rib Deflection values and this value is outputted to "deforc" file.
- c. Pelvis Performance Criterion: A beam element is positioned at the pelvis area to measure the pubic symphysis force and this value is outputted to "elout" file.
- d. Abdomen Performance Criterion: Three contacts (Contact Name: *Rear Abdomen Load Cell*, *Middle Abdomen Load Cell*, and *Front Abdomen Load Cell*) in the abdomen area are used to measure the abdominal force and these values are outputted to "rcforc" file.

Users should follow ECE 95 guidelines to interpret these results.

## **CONCLUSION**

The user should now be able to perform this procedure for vehicle evaluation according to ECE 95 standards.