

# Technical Newsletter

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## 2007 HVE Forum - Rollin' Rollin' Rollin'

Come on down to the 2007 HVE Forum and tune up your skills to "keep those simulations rollin'!" The 2007 HVE Forum offers workshops of interest to every user of HVE and HVE-2D. For example, you might choose to study the background, theory and application for your physics programs. Or you might choose to learn how to build a vehicle from scratch, build a 3-dimensional scene using survey data, run test simulations to adjust vehicle parameters and then work through real-world cases using a variety of analytical approaches and

techniques. At the 2007 HVE Forum, you'll choose from a large selection of workshops, the HVE White Paper session, User's Groups and interactive social hours for everyone.

### Hotel

Located on the famous River Walk in beautiful downtown San Antonio, the Hilton Palacio del Rio hotel is surrounded by Texas culture and attractions, including the Alamo, just two blocks away. This hotel provides an ideal setting for the 2007 HVE Forum, within walking distance of a selection of restaurants, shopping and other activities.

Special hotel room rates of \$169 + tax per night have been arranged for your stay at the Hilton Palacio del Rio during the 2007 HVE Forum. In order to receive this special room rate, reserve your room directly with the hotel by contacting their Reservations Desk at 210-222-1400 and indicating the Group Code 'HVE'.

### Registration Deadlines

Early registration discounts are only available until December 30, 2006. Workshops and hotel rooms are on a first-come, first-served basis so be sure to register early to ensure you get the choices you want. Last year the Advanced HVE workshops were FULL!

Workshop schedules, descriptions and registration forms are available to download from the 2007 HVE Forum pages at [www.edccorp.com](http://www.edccorp.com). Take a moment right now to visit our website or call EDC Customer Service to register for the 2007 HVE Forum today! See you in San Antonio!

Mark these dates on your calendar . . .

**2007 HVE FORUM**  
**FEBRUARY 26 - MARCH 2, 2007**  
**SAN ANTONIO, TEXAS**

**Rollin' Rollin' Rollin'**  
**HVE Forum**  
 2007 Workshops

Advanced HVE Case Studies Using EDSCMAC4, SIMON and DyMESH  
 Using EDCRASH, EDSCMAC, EDSCMAC4, EDSVS and EDVTS in HVE-2D  
 Creating and Enhancing Environments Using the 3-D Editor  
 DyMESH 3-D Collision Model Overview and Applications  
 Multi-Occupant Human Impact Simulation Using GATB  
 Importing Scene Drawings as Environment Models  
 Tractor-Trailer and Commercial Vehicle Simulation  
 Advanced Multi-vehicle Simulation Using SIMON  
 Importing 3-D Environments from Total Stations  
 Theoretical and Applied Vehicle Dynamics  
 Simulating Curbs, Potholes and Soft Soils  
 Multi-Vehicle Collisions Using EDSCMAC4  
 Building Vehicles for HVE and HVE-2D  
 Simulating Blow-outs and Rollovers  
 Details of the HVE Vehicle Model  
 HVE and HVE-2D User's Groups  
 Advanced HVE-2D Case Studies  
 Powerful Tips and Techniques  
 Recording Simulation Movies  
 Brake System Simulation  
 HVE White Paper Session  
 ABS Simulation  
 Animation

February 26 to  
 March 2, 2007  
 Hilton Palacio del Rio  
 San Antonio, Texas

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# Technical Session

This Technical Session addresses pole impacts using *EDSMAC4*.

A “pole” is a rigid, immovable barrier. The thing that distinguishes a pole from any other immovable barrier is its small size: a pole is typically only 10 to 15 inches in diameter. Barriers in general present problems for the *EDSMAC* collision algorithm, and the small size only makes matters worse. Having said that, there are still many pole impacts that can be simulated.

## Algorithm Issues

For a successful pole impact result, it is very helpful and important to understand how the collision algorithm in *EDSMAC* works. Rather than provide the details here, the reader should refer to SAE Paper No. 880069, “An Overview of the Way *EDSMAC* Computes Delta-V,” and SAE Paper No. “An Overview of the *EDSMAC4* Collision Simulation Model.” The first paper provides a detailed backgrounder for the collision algorithm; the second describes the extensions to the basic *EDSMAC* collision algorithm that are incorporated into *EDSMAC4*. We recommend that you become familiar with those two papers before continuing with this article.

The most important observation regarding the collision algorithm is that it is “deformation-driven.” By that we mean that the algorithm starts by determining the current overlap between colliding vehicles, then calculating the *Rho* vector compression (crush depth) that results in an equal force between the two vehicles. Looking at the equation for calculating this force, we have for *EDSMAC*

$$F = k_v \delta$$

and for *EDSMAC4*

$$F = A + B\delta$$

where

$F$  = force

$k_v$  = *EDSMAC* stiffness coefficient

$A, B$  = *EDSMAC4* stiffness coefficients

$\delta$  = *Rho* vector compression (crush depth)

A typical road vehicle has a deformable exterior, i.e.,  $k_v \sim 100 \text{ lb/in}^2$  (*EDSMAC*), and  $A \sim 300 \text{ lb/in}$  and  $B \sim 100 \text{ lb/in}^2$  (*EDSMAC4*). On the other hand, a rigid barrier

has an almost infinite stiffness, perhaps four orders of magnitude larger (on the range of, say,  $10^6 \text{ lb/in}^2$ ). Applying this fact to either of the above force calculations reveals a serious problem: The overlap is adjusted by a discrete amount (see *EDSMAC/EDSMAC4* Calculation Options dialog, *Rho* Vector Adjustment Increment, *DelRho*). The default value for *DelRho* is 0.20 inches. Using this default value, the change in the force,  $\Delta F$ , for each incremental adjustment in *Rho* vector length will be

Typical Road Vehicle:

$$\Delta F = 0.20 \times 100 = 20 \text{ lb}$$

Barrier:

$$\Delta F = 0.20 \times 10^6 = 200,000 \text{ lb.}$$

Thus, for a rigid barrier the incremental adjustment for a single *Rho* vector is larger than the entire collision force on a typical vehicle! Clearly, any displacement of a “rigid” surface cannot be accommodated by this algorithm.

So, how do we proceed? We do so by conceding that a small amount of surface deformation must be tolerated, and then by making the data adjustments necessary to allow the algorithm to work.

Since a rigid surface cannot be tolerated, we first must choose stiffness coefficients that provide a nearly rigid surface while also allowing just enough surface (*Rho* vector) deflection. Experience has shown that a  $k_v$  of  $500 - 1000 \text{ lb/in}^2$  (*EDSMAC*) and  $A$  and  $B$  equal to  $1000 \text{ lb/in}$  and  $\text{lb/in}^2$ , respectively, (*EDSMAC4*) are sufficient.

A second adjustment we need to make is to reduce *DelRho* from its default value, 0.20 in, to a much smaller value, 0.01 in. This change improves the resolution of the collision algorithm by reducing the incremental difference in force,  $\Delta F$  (see above). After these changes to the stiffness coefficients and *DelRho*, the new value of  $\Delta F$  for the barrier is

$$\Delta F = 0.01 \times 1000 = 10 \text{ lb.}$$

Compared to the original value, 200,000 lb, the improvement in resolution is significant.

The above modifications would be sufficient for most rigid barrier impacts, such as bridge abutments or buildings. But for pole impacts, we need to make one more important adjustment. We need to change the *Rho* Vector Spacing, *DelPsi*, from its default value of 2 degrees to 1 degree. The reason for this change is apparent in Figure 1. Because of the (small) size of the pole, very few *Rho* vectors on the impacting vehicle are

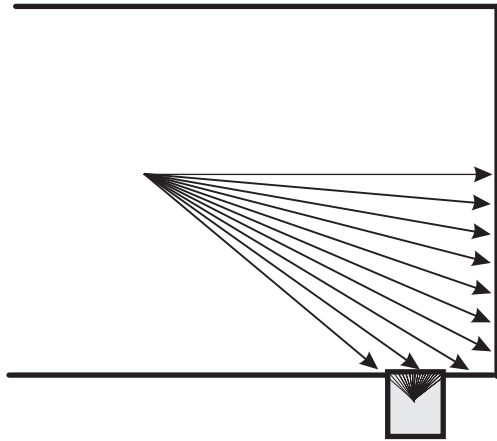


Figure 1 - Rho Vector Spacing, *DelPsi*. Note there is only a single *Rho* vector on the vehicle that is in contact with the pole when the default spacing, 2 degrees, is used, while the pole has 20 *Rho* vectors in contact with the vehicle. By reducing *DelPsi* to 1 degree, we double the number of *Rho* vectors, thus improving the result.

engaged by the pole. We can essentially double the number of *Rho* vectors by decreasing *DelPsi* to 1 degree. Further reduction of *DelPsi* might seem like a good idea, but such a change runs the risk of exceeding the internal data storage capabilities of the collision algorithm.

*EDSMAC* and *EDSMAC4* use three different integration timesteps: *dtTraj* is used during the normal trajectory phase, *dtColl* is used during the collision phase, and *dtSep* is used during the first 100 timesteps following the collision phase. The default values are 0.02, 0.001 and 0.01 seconds for *dtTraj*, *dtColl* and *dtSep*, respectively.

Consider what might occur during the collision phase if *dtTraj* is too large: Figure 2 (A) shows the vehicle approaching a pole barrier at 50 mph (73.3 ft/sec). Note that the front of the vehicle is close to, but not touching, the pole. If *dtTraj* is 0.02 sec., the vehicle will move 73.3 ft/sec x 0.02 sec = 1.467 feet during the next timestep. At that point, the vehicle vs. pole configuration will be as shown in Figure 2 (B). Because of the overlap, the collision algorithm will be activated, but will terminate immediately with a fatal error (too many collision vectors) because the entire pole is engulfed by the vehicle. This problem is easily solved by reducing *dtTraj* and *dtSep* to 0.001 sec. After making this modification,

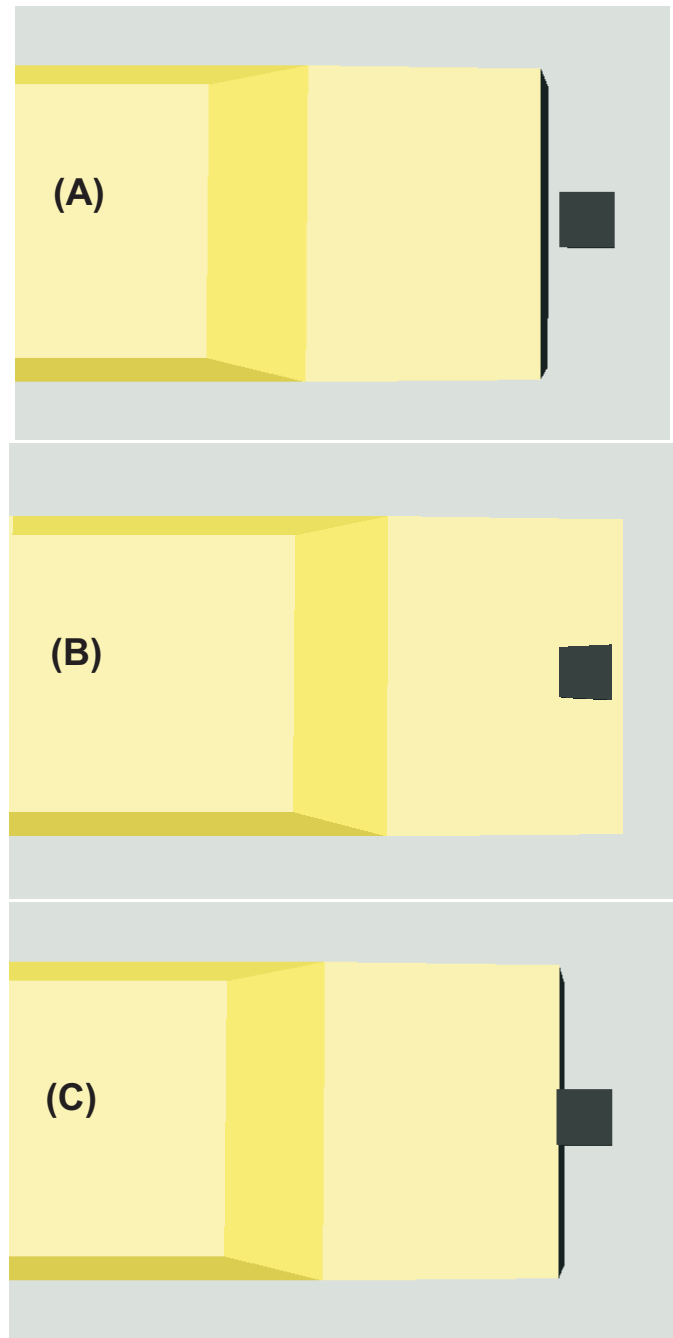
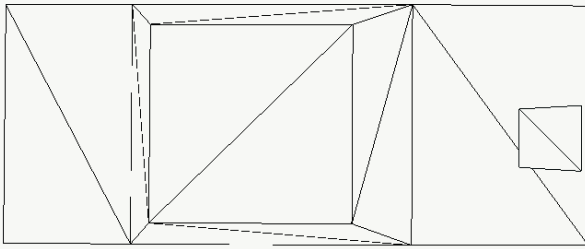
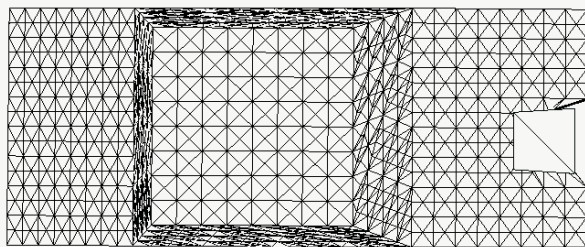


Figure 2 - Effect of integration timestep on configuration at impact. In (A), the vehicle is one timestep from initial contact. In (B), after one timestep, the vehicle has moved forward 1.46 feet. Not only has the vehicle contacted the pole, it has completely engulfed the pole. This will result in a collision phase error. By reducing the *dtTraj* and *dtSep* timesteps to 0.001 sec., the configuration at impact is as shown in (C), and the collision phase is initiated successfully.



(A)



(B)

Figure 3 - A Generic Vehicle without tessellation is shown in (A). Note there are no vertices in contact with the pole, thus, there can be no deformation visualized. After tessellating at 7.5 inches (B), there are numerous vertices in contact with the pole, and the deformation is visualized.

the vehicle moves only 0.073 feet during a single timestep, and the configuration at the start of the collision will be as shown in Figure 2 (C).

**Tessellation**

The damage profile in *EDSMAC* and *EDSMAC4* is defined by the endpoints of all the compressed *Rho* vectors. *HVE* displays the damage profile by moving back each vehicle body vertex to match the compression of the *Rho* vectors. Thus, if there is no body vertex in the vicinity of a group of damaged *Rho* vectors, there will be no apparent damage. A gross example of this condition is shown in Figure 3 (A), involving an impact between a Generic Class 3 Passenger Car and a pole. Note the pole is completely engulfed by the car - for a reason completely different from the situation shown in Figure 2 (B). In this case, there are no body vertices in the vicinity of the pole (this is easily seen in Figure 3 (A), which shows the vehicle in

wireframe), so there is no way to draw the damage. However, the dynamics of the vehicle are calculated correctly; the problem is limited to the issue of displaying the damage profile.

The solution to this problem is to tessellate the vehicle. Tessellation adds vertices to existing body geometry. After tessellating the vehicle to a 7.5 inch maximum side length, the damage is properly visualized, as shown in Figure 3 (B). (Smaller poles require more tessellation.) Again, it is very important to note that the vehicle dynamics are exactly the same as before tessellating.

**Other Issues**

*EDSMAC4* tests to see if an event involves a barrier collision. If so, the vehicle's *A* and *B* stiffnesses are set to 1000 lb/in and 1000 lb/in<sup>2</sup>, respectively, and *DelRho* is set to 0.01 inches. The user is still responsible for adjustments to *DelPsi* and the integration timesteps.

*EDSMAC* and *EDSMAC4* were designed to simulate vehicle collisions, i.e., objects having a shape (as viewed looking down from above) that is basically rectangular. Although the dimensions can be reduced and be made to reflect a square shape, it is not possible to create a round-shaped object (and, of course, a pole is a round-shaped object). This probably has a small effect on the results. A validation study of pole impacts is underway.

During an impact between a vehicle and a pole, the pole sometimes breaks off. This phenomenon is not possible to simulate directly using *EDSMAC* or *EDSMAC4*.

While simulating a high-speed vehicle vs. pole impact, the *Rho* vectors on the pole will be compressed (remember, the pole cannot be perfectly rigid in an *EDSMAC/EDSMAC4* simulation). Because of the pole's (small) size, it is possible to compress one or more *Rho* vectors beyond the center (more correctly, the CG) of the pole. The collision algorithm cannot handle this condition - for vehicles or poles. This places a practical limit on impact speed for pole impacts.

**Summary of Procedures**

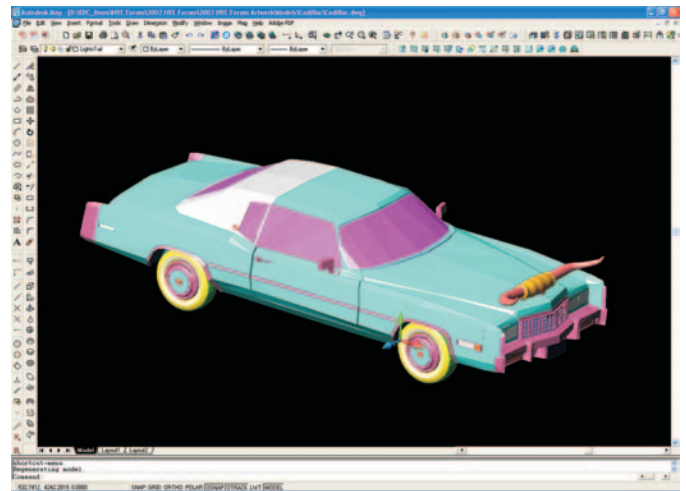
1. Add vehicle(s) and fixed barrier(s)
2. Optionally, add an environment
3. Add an *EDSMAC4* event, choosing the barrier(s) first in the list of event vehicles
4. Change the Trajectory and Separation Integration timesteps to 0.001 seconds
5. Change the Rho Vector Spacing to 1.0 degree
6. Tessellate all vehicles to 5 to 10 inches

# Techniques For Converting Vehicle Geometry Files

Preparing vehicle geometry files from external sources for use in *HVE* may be very straightforward or it may take several techniques to achieve the required result. Ideally you would download the file in the format for your preferred CAD program, quickly make modifications and then scale, orient and export a VRML or DXF format model ready to use in *HVE*. However, this is not always the case. Here is a simple overview of several techniques using the geometry file of the Cadillac featured in the 2007 *HVE* Forum poster artwork.

A vehicle geometry was located on the Turbo Squid website. The file was downloaded in both .3ds (3D Studio) and .lwo (Lightwave) formats in case one file provided different advantages over the other. The files were imported into Rhinoceros and evaluated for their object layout and layers and attributes settings. It turned out that the .lwo format was better structured than the .3ds file, so the .lwo format file was actually used as the starting point. After a few edits, the file was exported to DXF format and then imported into AutoCAD for further editing. (We could have continued in Rhino, but we chose to use AutoCAD for other reasons.)

We wanted to turn the coupe into a convertible so the polyface meshes for the top region were exploded to



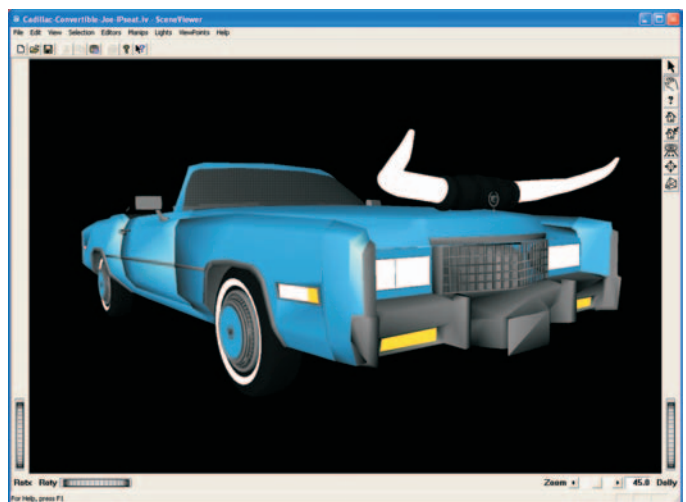
*Cadillac model shown in AutoCAD before the top and other areas were removed to produce a convertible version of the vehicle.*

allow “chopping” off the top of the vehicle. Once the regions were removed, the body of the vehicle was easily converted back to polyface meshes by exporting the exterior layer using 3DS OUT and then reinserting it as a .3ds object back into the AutoCAD workspace (Can you tell we didn’t use ACAD 2007 for this work?).

After a few more edits and some rearrangement of the layers, the final model was exported as a R14 DXF file. Then using the DXF translator in the *HVE* Environment Editor, the model was converted to .iv (SGI Open Inventor) format. (See Spring 2004 Newsletter for more details about this process.) We then began working with the temp.iv file to assign material attributes typical of a vehicle geometry file supplied with *HVE*.



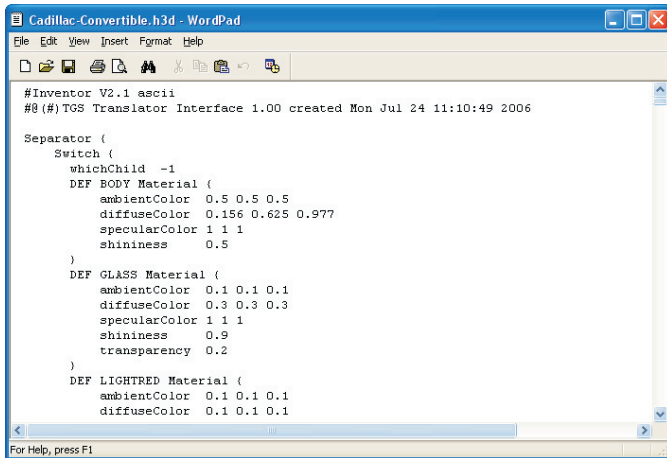
*Cadillac model ready to purchase and download in multiple formats from the Turbo Squid website.*



*Cadillac model shown in SceneViewer during the process of editing the .iv file for USE material statements.*

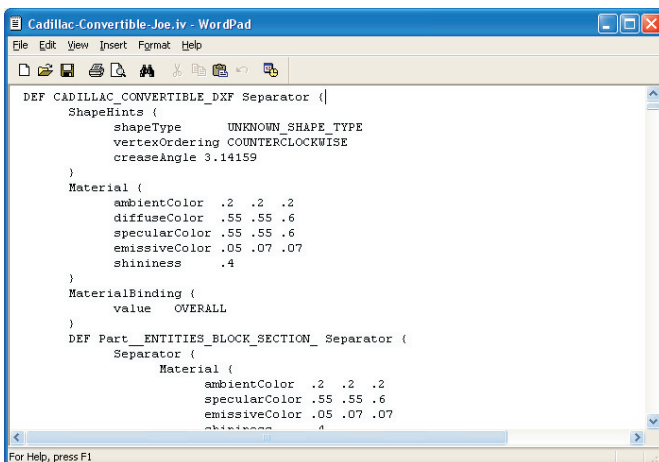


The next step was to add material DEF statements at the top of the text of the .iv file. The material definitions are normally used to properly display trim, headlights, turn signals, undercarriage and the body of the vehicle. Objects using the BODY material will appear transparent in the Vehicle Editor and the color may be actively changed within HVE simply by clicking on the CG and selecting the Color option.

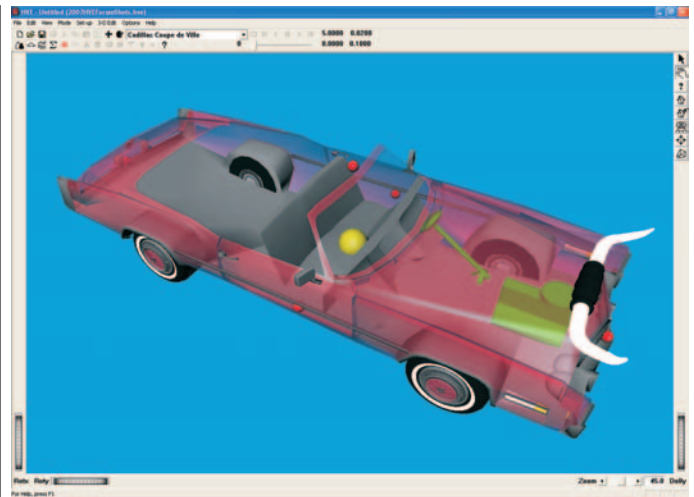


Vehicle .iv format file displayed in Wordpad showing the Material DEF section added to top of file.

The next step was to replace the individual material definition for each entity with a call using one of the materials defined at the top of the file. The Material sections for each entity contained in the file were replaced with the appropriate USE statements. To easily identify which entity should be using which material, an iterative process of editing the text and viewing the model in SceneViewer was employed.



Vehicle .iv format file displayed in Wordpad showing the original Material section of an entity before replacement with a USE material statement.



Cadillac model shown in the Vehicle Editor in HVE. The model has been placed on the appropriate Generic Passenger Car. Note the body of the vehicle is transparent. The color may be changed by clicking on the CG and using the Color option.

Once the proper materials were assigned to the model and everything looked good in SceneViewer, a Transform section was added to the text of the file. This Transform section allowed for quick positioning of the geometry on the CG of a generic vehicle in the HVE Vehicle Editor. The appropriate Generic Passenger Car was edited for the proper dimensions and wheel locations. Then the geometry file was imported onto the vehicle. Rather than returning to the original CAD model and trying to relocate the origin and then go through the material assignment steps again, we simply adjusted the position of the geometry relative to the CG by adjusting the translation, rotation and scale of the geometry. This is a quick iterative process by editing and saving the text file, then importing it onto the vehicle in the Vehicle Editor. In this case, the final values for the Transform statement were:

```

Separator {
  Transform {
    translation 17 2.75 24
    rotation 1 -1 0 3.14159
    scaleFactor .0285 .0285 .0285
  }
}
    
```

As you can see, preparing a vehicle geometry for use in HVE may take more time than you expect. This was a very brief overview of the steps and didn't thoroughly explain every detail of the process. If you would like to know more about this process or other methods for editing vehicles for use in HVE, make plans to attend the 2007 HVE Forum. This method as well as several others will be discussed in the workshop for "Building Vehicles for HVE and HVE-2D".

## HVE and HVE-2D F.A.Q.

This section contains answers to frequently asked questions submitted to our Technical Support staff by HVE and HVE-2D users.

*Q. I am trying to increase the length of the bed of the Dodge Ram pickup in the Vehicle Editor. I have increased the CG to Back distance and I see the red sphere move, but the geometry didn't stretch to match the new location. Why?*

A. The geometry doesn't change shape because it is an actual digital model of the Dodge Ram pickup that is displayed. You cannot edit an actual geometry file within the Vehicle Editor, you can only do that externally in a CAD program. But when you change the dimensions of a generic vehicle in the Vehicle Editor, HVE will update the basic displayed shape of the generic vehicle to reflect the new dimensions.

*Q. I am working in a casefile that has multiple events with various run time lengths (i.e. they are not all 5 seconds runs). They are all executed so the results are available to view in Playback. When I am using the Playback Window to display and record a specific Traj Sim for one of my short run time events, I am finding that the controller on the toolbar shows that I am running for much longer than the time of the short event. When I record the AVI file, I see that the vehicles move as expected for the length of the Traj Sim, but then the frame continues to record to the AVI file until some later time. After a closer examination, I see that the length of time that my AVI is recorded is exactly the time of the longest event in my case file, even though it is not displayed as a Traj Sim in Playback. Why? How can I work around this situation?*

A. In the current Version, the Playback Window is using the length of the longest executed run in the Event Editor. In your situation you are trying to record the results from a shorter event. The solution is to go back to the Event Editor and reset all events that are longer than the event that you want to record. Then when you display the short Traj Sim in the Playback Window, it will only be recorded for the length of time of the actual event.

*Q. I'm trying to simulate a sedan crashing into a pole using SIMON/DyMESH. I'm finding that the pole initially interacts with the front of the vehicle, but then appears to continue to pass through the vehicle. Why?*

A. The most likely cause of this problem is that the vehicle and/or barrier are not sufficiently tessellated.

DyMESH will only calculate a contact force for vertices that are in contact with the other surface. You can confirm the presence of required vertices by using the Render Options dialog and changing the Render Method to Wireframe.

Poles represent additional problems for DyMESH. For this reason, we are currently recommending EDSMAC4, not SIMON/DyMESH, for simulating pole impacts. (Although some pole impact simulations appear to work properly, unexpected behaviors can occur and we are currently investigating these issues.)

## DyMESH User Notes

When using DyMESH, you're doing 3-D collision simulation. This is technically a very difficult task, so don't expect it to be easy. Here are a few important points to keep in mind:

- DyMESH is not going to work on every crash.
- Computer horsepower means everything to DyMESH. On a fast PC (3GHz, P4), a typical run takes from 1.5 minutes to 15 minutes, depending on the length of the collision phase. Collisions with sustained contact all the way to rest may take as long as an hour.
- Induced damage is not included. No damage will be displayed unless one or more vertices on one vehicle were actually in contact with the other vehicle.
- Generic Vehicles' meshes need to be tessellated before using in DyMESH events.
- In the current version of DyMESH, only meshes of vehicles are recognized for collisions. The environment model mesh is not recognized for vehicle body vs terrain interaction. However, the user may simulate a rollover by placing a geometry file that is representative of a portion of the terrain onto a vehicle positioned such that another vehicle will roll over it.
- In the current version of DyMESH, collisions between more than two vehicles at the same time (such as a vehicle pushing another vehicle under a trailer) may not be properly handled. Although some simulations appear to work properly, unexpected behaviors may appear in others. This issue will be resolved in a later version of DyMESH.
- In the current version of DyMESH, collisions involving narrow objects such as poles may not be properly handled. Although some pole impact simulations appear to work properly, unexpected behaviors may appear in others. This issue will be resolved in a later version of DyMESH.

# EDC Training Courses

## EDC Reconstruction & EDC Simulations

EDC offers an excellent training course on the use of the EDC reconstruction program, *EDCRASH*. Both new and long-time users of *EDCRASH* agree that the *EDC Reconstruction* course is extremely beneficial and challenging.

EDC also offers an excellent training course on the use of EDC simulation programs, such as *EDSMAC*, *EDSMAC4*, *EDSVS* and *EDVTS*. The *EDC Simulations* course offers the fastest way to learn what you really need to know – how to efficiently use the program and get the right results.

These one-week courses are designed to fully investigate the program's inner workings. Lectures are full of helpful hints gained from years of experience. During the course, students will use the programs (e.g. *EDCRASH*, *EDSMAC4*) in either the *HVE* or *HVE-2D* simulation environment to complete several workshops highlighting the capabilities of the programs.

## HVE Forum

The *HVE* Forum is an excellent opportunity for *HVE* and *HVE-2D* users to jump to a new level of ability. By participating in workshops, attendees brush up on their present skills, learn new techniques, and learn how to use the latest advancements in the software. The *HVE* Forum also presents a great opportunity to meet other users and expand your network of resources.

### Engineering Dynamics Corporation Training Course Schedule

#### EDC Simulations

Los Angeles, CA . . . . . January 15 - 19, 2007

Miami, FL . . . . . November 12 - 16, 2007

#### EDC Reconstruction

Los Angeles, CA . . . . . January 2008

Miami, FL . . . . . November 6 -10, 2006

#### Theoretical & Applied Vehicle Dynamics

TBD . . . . . Fall 2006

#### 2007 HVE FORUM

San Antonio, TX . . . . . Feb 26 - March 2, 2007

## Vehicle Dynamics

Theoretical and Applied Vehicle Dynamics extends the theory of the basic SAE course and includes direct applications using several vehicle simulation programs (e.g. *SIMON*, *EDVSM*) within the *HVE* simulation environment, as well as a solid theoretical background for such simulations. The course is focused towards vehicle design engineers and safety researchers with an interest in a greater understanding of vehicle dynamics and automotive chassis systems development.

## Hands-on Training

Intensive hands-on training on how to use your *HVE* or *HVE-2D* system software, physics programs and databases is available. Contact EDC Customer Service for more information about bringing this two-day on-site course to your office.

## Course Registration

You may register for a course by contacting EDC Customer Service at 503.644.4500, or by email to [training@edccorp.com](mailto:training@edccorp.com). You can also visit the Training pages on our website and download a course registration form. All courses are eligible for Continuing Education Units and ACTAR credits. See you at our next course!

## Related Training Courses

Northwestern University Center for Public Safety (NUCPS) is no longer actively scheduling the COMPTAR and MATAR courses which used *EDCRASH* and *EDSMAC*. The material previously covered in these courses is covered in the EDC Reconstruction and EDC Simulations courses. If you are interested in hosting one of these courses at your location, please contact EDC Customer Service at 503.644.4500.

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