

# Technical Newsletter

## Version 5.10 - Coming Summer 2005

*HVE* and *HVE-2D* Version 5.10 will be available this summer. In-house testing is underway and field testing will begin this Spring. This highly anticipated release will provide numerous enhancements, improvements and new capabilities to users.

### Highlights of Version 5.10

- Additional Tire Model options for *SIMON*, including the Radial Spring, Soft Soil and Sidewall Impact models. (Refer to the Technical Session of the Winter 2005 EDC Technical Newsletter or *HVE* White Paper WP-2005-6 for more detailed information. Both of these publications are available to download directly from the Library section of the EDC website.)

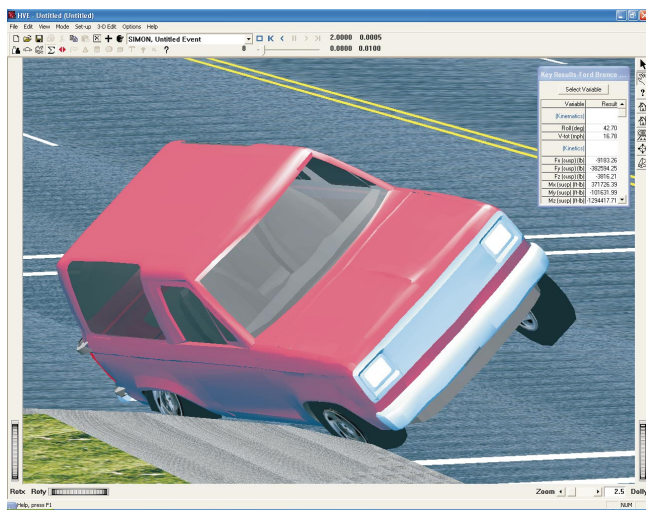


Figure 1 - Screenshot from a *SIMON* simulation showing a curb-tripped rollover scenario utilizing the new Sidewall Impact Tire Model option. Note the suspension deflection at the right rear tire as the vehicle begins to roll due to the contact between the right front tire sidewall and the curb.

- Enhanced Steer Axis Geometry - The wheels may be steered about an axis defined by user-entered caster and inclination angles. Steering offset (also called *scrub radius*) is also modeled. These changes enable the simulation of the self-steering and brake- or throttle-induced steering moments that can exist in all modern vehicles.

- Direct support for Hyper-Thread Technology and Dual Processors - Users will not have to disable Hyper-Threading or *Set Affinity* of *hve.exe* to a single processor in order to create or run events.
- Event Status is now displayed in the Report Information dialog in the Playback Editor - When adding reports in Playback, the user will clearly see that an event has output tracks available if the word "Executed" is displayed in the dialog's Event Status field. If the event does not have output tracks available, then the field will display "Not Executed (No Reports Available)."
- Updated Inertias Dialog - The Inertial Data dialog found in the Vehicle Editor now displays the Total Yaw Inertia and the Sprung Mass Yaw Inertia for the vehicle. This will help both *HVE* and *HVE-2D* users easily confirm that they are using the desired values in their reconstruction or simulation events.
- Additional enhancements for reducing run-times when using *DyMESH*, such as checks for water tight meshes, vertex welding, and selection of mesh object groups to include in the calculations.

### New Vehicles Added To The Database

The following vehicles have been added to the *EDVDB* vehicle database for Version 5.10:

Vehicle	Year Range
Dodge Durango SLT	1998 - 2003
Isuzu VehiCross	1999 - 2001
Jeep Wrangler	1997 - 2004
Suzuki Vitara	2002 - 2004
Chrysler Cirrus	1995 - 2001
Dodge Intrepid SE	1998 - 2004
Ford Escort LX Wagon	1991 - 1996
Jaguar S-Type	2000 - 2004
Lincoln Town Car	1994 - 1997
Mercedes C230 Sedan	1994 - 2000
Dodge Ram 2500 4x4 Pickup	2002 - 2004

# Technical Session

This Technical Session deals with tire-road friction. It may seem like a simple concept – and it is. But *HVE* provides many options, each providing an important capability. We will also discuss how driver braking and throttle tables enter the picture.

## Fundamental Equation

The fundamental equation that determines the tire-road friction for any tire at any time on any surface is as follows:

$$\mu_{effective} = \mu_{tire} \times n \times f$$

where

- $\mu_{effective}$  = effective tire-road friction coefficient at the current time on the current surface
- $\mu_{tire}$  = tire-road friction coefficient from the Tire dialog (Vehicle Editor)
- $n$  = *In-use Factor* from the Tire Friction Data dialog (Vehicle Editor)
- $f$  = terrain friction multiplier for the current surface (Environment Editor)

A couple of things are worth mentioning before moving on. For 2-D users, the value of  $\mu_{tire}$  used in the above equation is fairly straight-forward. It is the value of  $\mu_{peak}$  and/or  $\mu_{slide}$  that is displayed directly in the Tire Dialog (see Figure 2). The one complicating factor is that 2-D users can assign a friction speed-dependence (again, refer to Figure 2). The value of  $\mu_{tire}$  as a function of speed is:

$$\mu_{tire} = \mu_{0_{tire}} \times (10 + d \times v_{tire})$$

where

- $\mu_{0_{tire}}$  = value of  $\mu_{peak}$  and/or  $\mu_{slide}$  displayed in the Tire dialog
- $d$  = speed dependence  $\left(\frac{1}{in / sec}\right)$
- $v_{tire}$  = tire's current total linear velocity (in/sec)

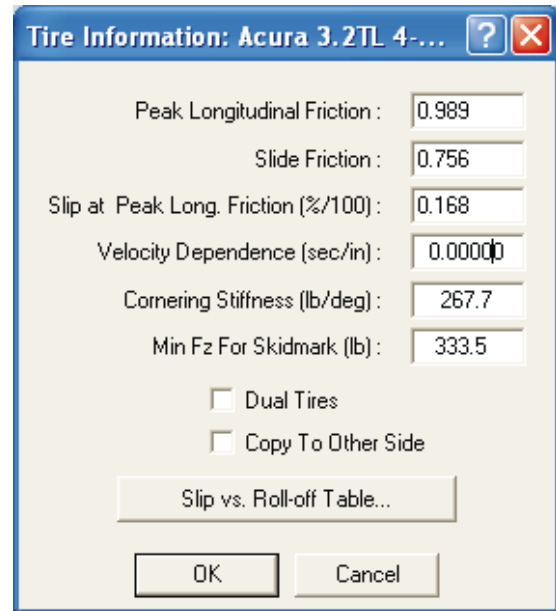


Figure 2 - HVE -2D Tire Data dialog

Table 1 - Friction parameter usage for each physics model

	$\mu_{peak}$	$\mu_{slide}$	$d$
EDCRASH		✓	
EDSMAC		✓	✓
EDSMAC4		✓	✓
EDSVS	✓	✓	
EDVTS	✓	✓	
EDVSM	✓	✓	✓*
EDVDS	✓	✓	
SIMON	✓	✓	✓*

\*Velocity dependence is not assigned explicitly, but is calculated if friction data are provided at multiple speeds.

Table 1 shows which friction parameters are used by each physics program. In addition, there is no *In-use Factor* for 2-D users. Also, in the above equation for 2-D users the *In-use Factor* is always 1.0, and is not user-editable.

For 3-D users, the value of  $\mu_{tire}$  that is used at any particular time is complicated by the fact that 3-D tire-road friction properties are load and speed dependent. Therefore, the Friction Data dialog (see Figure 3) displays  $\mu_{peak}$  and  $\mu_{slide}$  for up to three loads and three speeds. When executing a 3-D physics

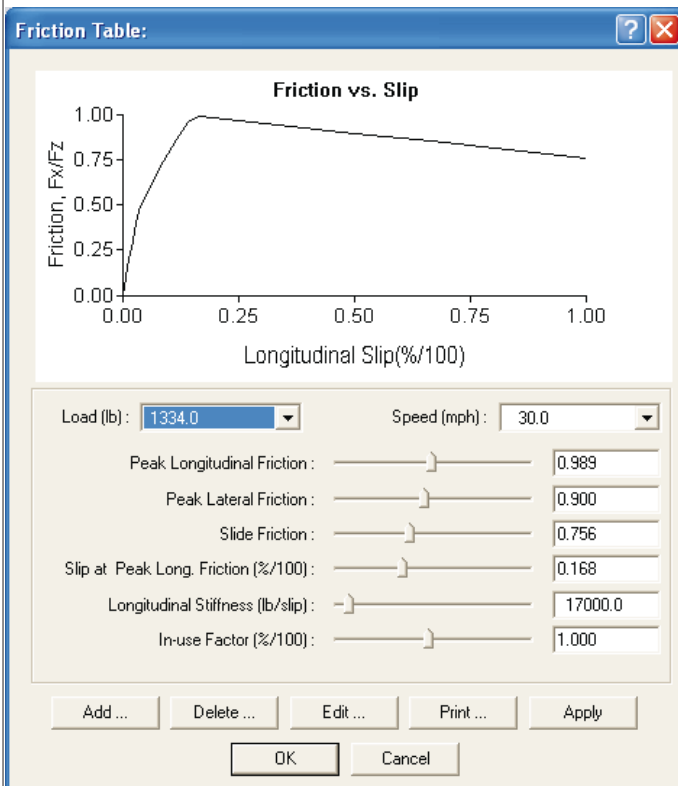


Figure 3 - HVE Tire Friction Data dialog

model (e.g., SIMON or EDVSM), that program will interpolate using up to 3 loads and 3 speeds (depending on the number of loads and speeds found in the tire data), and calculate the friction parameters according to the current vertical tire load and speed.

3-D users executing a 2-D physics model (e.g., EDSMAC4 or EDSVS) must also remember that the 2-D models do not have load- or speed-dependent tire properties. When these models are executed, they will use the friction data associated with the middle load and middle speed. There is no need for an explicitly defined speed-dependence parameter for 3-D tire data because speed-dependence is calculated during execution using interpolation (described in the previous paragraph). If you're not sure which friction value is actually used, simply check the Vehicle Data output report. The friction values are displayed for each tire.

### Assigning a Terrain Friction Multiplier

Terrain friction multipliers (sometimes called *friction zones*) are a useful way to simulate the effects of traveling over multiple surfaces having different friction characteristics. A common example would be an interstate freeway with concrete travel lanes, asphalt shoulders, gravel immediately adjacent to the shoulder,

and a grass median. Each of these surfaces has a different tire-terrain friction characteristic. Because the tire data assigned in the Vehicle Editor were determined using a flat bed tire test machine, we need to assign friction multipliers that achieve the desired values of  $\mu_{peak}$  and  $\mu_{slide}$  for each surface.

For example, let's assume we have the following data from a flat-bed tire test at rated load and speed:

$$\mu_{peak} = 1.02$$

$$\mu_{slide} = 0.76$$

Now, let's say we would like to achieve the following slide friction properties during a simulation:

- Concrete Travel Lanes:  $\mu_{slide} = 0.75$
- Asphalt Shoulder:  $\mu_{slide} = 0.70$
- Gravel:  $\mu_{slide} = 0.55$
- Grass Median:  $\mu_{slide} = 0.50$

The required friction multipliers are calculated as follows:

Concrete Travel Lanes:

$$f_{concrete} = \frac{\mu_{slide, req'd}}{\mu_{slide, test}} = \frac{0.75}{0.76} = 0.987$$

Asphalt Shoulder:

$$f_{concrete} = \frac{\mu_{slide, req'd}}{\mu_{slide, test}} = \frac{0.70}{0.76} = 0.921$$

Gravel:

$$f_{concrete} = \frac{\mu_{slide, req'd}}{\mu_{slide, test}} = \frac{0.55}{0.76} = 0.724$$

Grass Median:

$$f_{concrete} = \frac{\mu_{slide, req'd}}{\mu_{slide, test}} = \frac{0.50}{0.76} = 0.658$$

These values are entered by launching the 3-D Editor, selecting the desired surface and editing the Friction Factor in the Object Attributes dialog. Figure 4 illustrates this editing process for the asphalt shoulder.

Note that the same friction multiplier is applied to both  $\mu_{peak}$  and  $\mu_{slide}$ . For 3-D users, the friction multiplier is also applied for each load and each speed. In most cases, the multiplier for  $\mu_{peak}$  and  $\mu_{slide}$  for all loads and

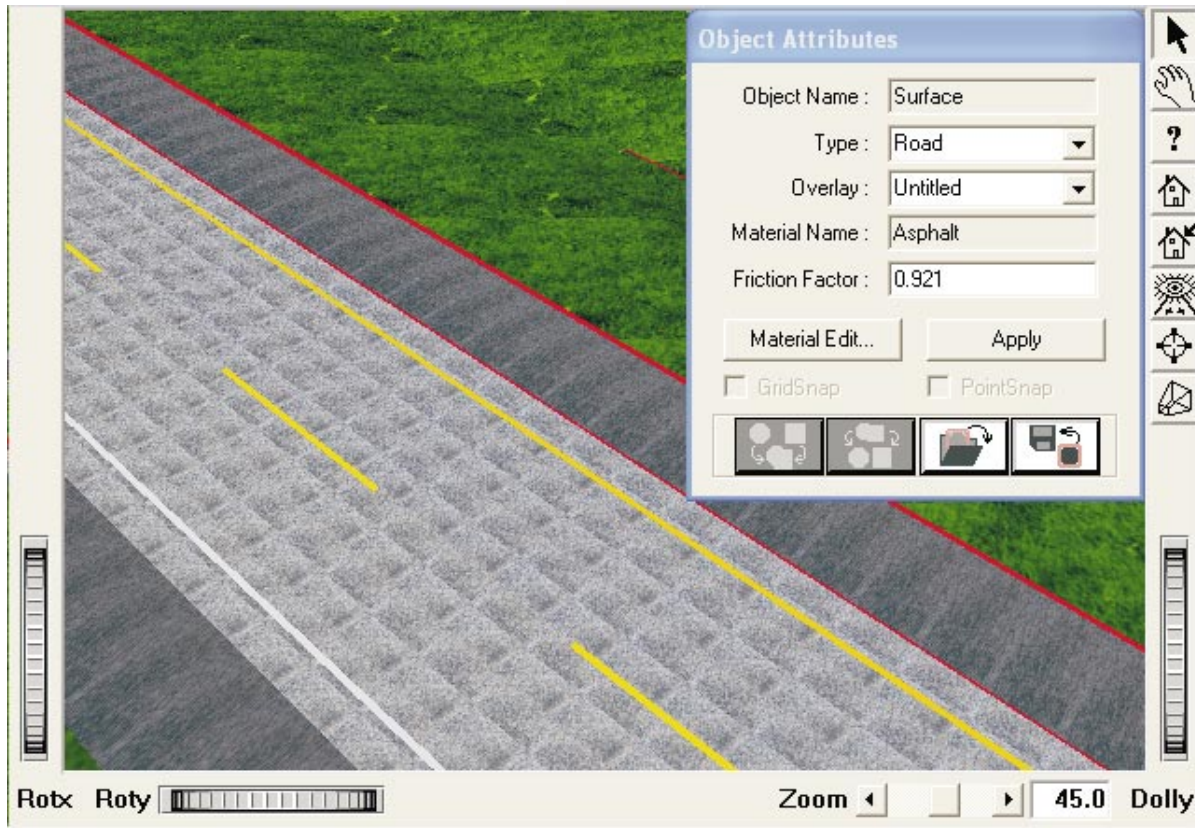


Figure 4 - Assigning a friction factor (multiplier) to the asphalt shoulder

speeds is not identical for all surfaces, but practically speaking, it will be very close. Nevertheless, it should be noted that using a single friction multiplier is an approximation that results in a significant simplification and convenience (the alternative would be to enter individual multipliers for both  $\mu_{peak}$  and  $\mu_{slide}$  at each load and speed).

During the simulation, the current friction multiplier for each tire may be displayed in the Key Results window (Event Editor) or Variable Output report (Playback Editor).

### Achieving A Desired Deceleration Rate

The user often wants a vehicle to decelerate at a user-controlled rate. The method used to achieve that goal differs according to the type of brake table the user has selected.

**Percent Available Friction** - For braking at each of the four wheels, the entries are

$$\%_{Wheel 1} + \%_{Wheel 2} + \%_{Wheel 3} + \%_{Wheel 4} = \frac{4a}{\mu_{tire}}$$

where

$$\%_{wheel n} = \text{user-entered lock-up at wheel } n \left( \frac{\%}{100} \right)$$

$$a = \text{desired deceleration rate (g)}$$

Typically the user-entered wheel lock-ups are the same for each wheel. Note that this method will not produce a constant deceleration if the vehicle travels across surfaces having different friction multipliers because  $\mu_{tire}$  varies for each surface. The deceleration will also vary if the tire has velocity-dependent friction properties.

**Wheel Force** - For braking at each of the four wheels, the entries are

$$F_{Wheel 1} + F_{Wheel 2} + F_{Wheel 3} + F_{Wheel 4} = W \times a$$

where

$$F_{wheel n} = \text{user-entered brake force at wheel } n \text{ (lb)}$$

$$W = \text{Total vehicle weight (lb)}$$



**Pedal Force** - The method used for determining the required brake pedal force entry is quite different from the other methods. It is, however, quite simple:

Step 1 - Create a *SIMON*, *EDVSM* or *EDVDS* event.

Step 2 - Set up the event by placing the vehicle at any position (the earth-fixed origin works fine) and assign an initial velocity of 50 mph.

Step 3 - Create a Brake Pedal Force table as shown in Table 2, below.

*Table 2 - Brake Pedal Force inputs for determining deceleration rate as a function of brake pedal force.*

Time (sec)	Pedal Force (lb)
0.0	0.0
5.0	100.0

Step 4 - Select the following output variables in the Key Results window: Kinematics Output Group, Fwd Acc and Driver Output Group, Brake Pedal.

Step 5 - Execute the event. The Key Results window will display the brake pedal force and associated vehicle deceleration (you may want to graph this relationship).

Note that, if the *Show Skidmarks* option is used, you can also find the brake pedal force required to produce a skidmark.

### Achieving A Desired Acceleration Rate

The method used to accelerate the vehicle at a desired rate is basically the same as for decelerating it. However, you will use Throttle Tables instead of Brake Tables. Note also that most vehicles are not AWD (all wheel drive), so the Percent Available Friction and Wheel Force tables will have fewer entries.

**A compilation of Technical Sessions, F.A.Q.'s and Tips & Techniques sections from previous newsletters is available:**

**EDC Library Publication 1080 - US\$ 45.00**

## Newsletters Now Available In EDC Website Library

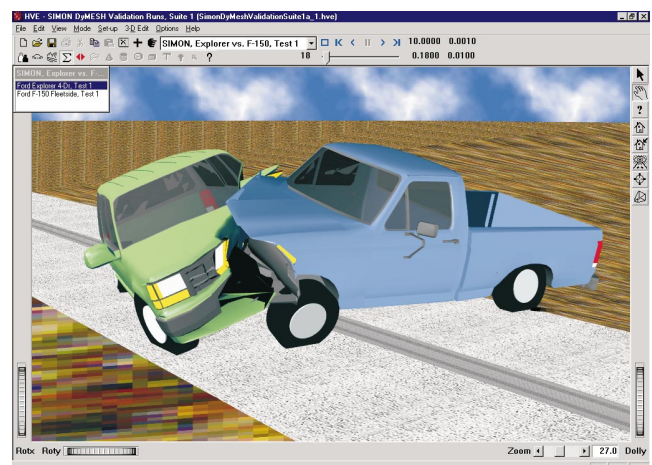
EDC Technical Newsletters dating back to Summer 2000 are now available in the new EDC Technical Newsletters section of the EDC website Library. These newsletters are an excellent resource to learn more about *HVE* and *HVE-2D*. Important highlights from each issue are listed to help you choose which newsletter to download. To access the newsletters, go to [www.edccorp.com](http://www.edccorp.com), then follow the link to the Library and then the link to the Technical Newsletters.

## Preview *HVE* Version 5.10 at the 2005 SAE Congress

Be sure to stop by Booth 435 at the 2005 SAE World Congress Exhibition and preview the new capabilities available in *HVE* Version 5.10. The new Tire-Terrain Models available in *SIMON* that were announced in our Winter 2005 newsletter and also on Page 90 of the March 2005 issue of *Automotive Engineering International* will be on display. We'll see you there!

## *DyMESH* - A 'SAE Top Product of 2004'

*DyMESH* was selected by readers of SAE's *Automotive Engineering International* magazine as one of the highest-rated product offerings of 2004. The Top Products Of The Year section of the December 2004 issue of *Automotive Engineering International* featured a brief description of *DyMESH* along with a screenshot from a collision simulation. If you would like to learn more about *DyMESH*, please contact EDC Sales.



## 2005 HVE FORUM RECAP

The 2005 HVE Forum offered the best workshops and information ever at a HVE Forum. The new Advanced HVE workshops covered many topics, including “Techniques for setting vehicle stiffness parameters when using *DyMESH*”, “Comparing an *EDSMAC4* simulation to a *SIMON/DyMESH* simulation of the same crash”, “Using *EDGEN* to study the vehicle motion during a median barrier crash”, “Understanding why it is so important to properly model the stiffness parameters on a vehicle during a collision where significant rotation occurs”, “Using *Path Follower* to model a vehicle traveling around a curve”, “Using *Path Follower* to determine controllability of a vehicle with a blowout”, “Placing a payload and moving the vehicle CG to duplicate axle weights on a tractor/trailer”, and “Using *SIMON* to model tractor/trailer skid testing” during the 6-part series. This series was highly rated and received reviews such as “The best workshops I have attended in nine years” and “Excellent, practical hands-on work showing things to watch out for and also demonstrating the full modeling capabilities of HVE”.

In fact, all of the 2005 HVE Forum activities (workshops, HVE White Paper Session, User’s Group Meetings, etc.) received excellent reviews and comments. If you missed it, you really missed out!

### HVE White Paper Session

This year’s HVE White Papers covered topics of interest ranging from the surface friction values to the hydroplaning of tires on wet pavement conditions to the validation of the HVE Brake Designer for heavy trucks under various loading and pavement conditions. The following White Papers are now available to download directly from the Library section of the EDC website:

WP-2005-1 “HVE Data Inputs Based on Testing for a Wet Pavement Accident Involving an Intercity Bus and an SUV”

WP-2005-2 “Heavy Truck Brake Designer Validation Testing”

WP-2005-3 “SIMON and EDVDS Validation Study: Steady State and Transient Handling”

WP-2005-4 “Simulation of a Side Impact and Vehicle Rollover Using EDVSM and EDSMAC4 within HVE”

WP-2005-5 “Investigating the Sensitivity of Vehicle Response to Inter-Vehicle Friction Values for Broadside Collisions utilizing HVE (EDSMAC4 Algorithm)”

WP-2005-6 “Simulation of Tire Interaction with Curbs and Irregular Terrain”

### User’s Group Meetings

Here are the results, ranked in order of importance (including tie votes), of the Wish Lists developed in the HVE and HVE-2D User’s Group Meetings:

#### HVE Users’ Top 10 Wish List

1. Continue with 2004 Top 10 Wish List Suggestions
1. Jump to specific time in Playback/Event window
2. Accept “Paste” inputs into tables
3. Key Results displayed in Playback Window
4. Data input sheet for required vehicle inputs
5. Trajectory Simulation with Storage Option
6. Calculate *DyMESH* stiffnesses
7. Grid displayed in Damage Profile
7. Standardized default Camera Views
7. Automatic “Save As” after event execution and then also allow for a revision number to be entered
8. *EDSMAC4* simulated crush “measurements” included in Output Reports.

#### HVE-2D Users’ Top 10 Wish List

1. Colored skidmarks by vehicle or tire position
2. Single step advance control in Playback and Event Editor, and also a slow motion speed control slider.
3. Create *EDSMAC* event from *EDCRASH* results
4. Open All, or Open Selected Output Reports for selected events. Similar to Add New Event dialog. (Full list pane, instead of drop down menu.)
4. Reference to Friction Zone use and the Friction Factors to be included in Playback reports
4. Visible timer in Playback Window (shows in video)
7. Prevent loss of focus when cursor is moved outside of the active dialog.
7. Ability to specify scale in Damage Profiles. And/or have visible scalable grid aligned with vehicle.
7. Resizable viewport windows in 3-D Editor
7. Traced tire and/or CG path regardless of Slip or Fz

### 2006 HVE Forum - Phoenix, Arizona

The 2006 HVE Forum will be held in late February or early March 2006 in Phoenix, Arizona. The final venue and exact dates have not been finalized, but as soon as they are they will be posted on the EDC website. Next year’s workshops are already under development, and we plan on updating and expanding the Advanced HVE workshops, as well as introducing Advanced HVE-2D workshops. See you in Phoenix in 2006!

## 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 display my Key Results windows, but I can't see them anywhere. I have used them before in my events, but they are not appearing this time. I have toggled Show Key Results on and off and back on again, but they still do not appear. I am using a notebook computer and I often connect to my projector or the flat panel monitor on my desktop. What do I do?*

**A:** It's quite possible that your active desktop area on your notebook computer is less than your usual setting. Some high-resolution screens, such as WUXGA formats (1920 x 1200) are the default setting for a notebook computer, but when connected to a projector or a flat panel monitor, it may be automatically resized to match the native resolution of the display device. Your key result windows are probably being displayed, but are outside of the active display area of the current display. Try disconnecting from the projector or flat panel and ensure that your notebook display is set to its native resolution. You will see the key results windows appear and you can move them to a better location.

*Q: I would like to simulate a tractor-trailer jack-knife scenario and then have the jack-knifed vehicle continue sliding down the road and into a collision with other vehicles. Is this possible?*

**A:** No, because events using connected vehicles have a termination condition established by the articulation angle that is set in the Connections dialog for the vehicle in the Vehicle Editor. If during the simulation this articulation angle is reached, the event will terminate. At the present time, there is not a simulation model that recognizes the contact between the trailer and the tow vehicle, allowing the vehicles to contact and then slide along in the direction of travel.

*Q: I am getting the following message from an EDCRASH event: "WARNING: The direction of angular velocity change from SCENE DATA for vehicle 1 is not compatible with moment arm of principal force from user-entered PDOF. Review damage data if results are questionable. Most likely, this requires either a change in the rotation direction or the PDOF." I think my Impact and Rest positions are correct, but how can I easily check this?*

**A:** Look at the position data in your Accident History report. When positioning vehicles in EDCRASH, the

rest positions need to be entered with the proper heading angle indicating the direction of rotation in the event. A vehicle with a heading angle of 90° is not the same as a vehicle with a heading angle of -270°, even though they look the same. One has been rotated clockwise and the other counterclockwise.

## Who Wants To Be A HVE Jillionaire?

Each year during the Monday Night Social Hour at the HVE Forum, attendees randomly selected from the audience have the chance to test their HVE knowledge in the "Who Wants to Be A HVE Jillionaire" game. Contestants that answer all seven multiple-choice questions correctly can win up to \$500, good towards EDC products or services. Here's a sampling of Jillionaire questions at the 2005 HVE Forum:

*Q: You are executing a SIMON collision simulation using DyMESH. The Accident History report shows the vehicles never separated and the Delta-Vs are almost equal to the impact speed. What happened?*

**A:** The total acceleration remained above 1 g at some point after impact, so SIMON thinks the collision phase isn't over yet.

*Q: You are running an EDSMAC4 collision simulation with a passenger car hitting the side of a large truck. You notice the delta-Vs are not inversely proportional to the masses. What's wrong?*

**A:** Nothing. The result is due to the large tire forces.

*Q: You are executing a SIMON/DyMESH collision simulation between a passenger car and a default J-850 Fixed Barrier, and the vehicle is passing through the barrier. The problem might be:*

**A:** The barrier needs to be tessellated using the Vehicle Mesh dialog.

Are you up to the challenge? Attend the 2006 HVE Forum for your chance to become a HVE Jillionaire.

## F.A.Q.'s on EDC Website

The EDC website provides a special section dedicated to Technical Support, including answers to F.A.Q.'s from this and previous Newsletters. We encourage you to visit our website to search for answers to your questions before contacting Technical Support for assistance. Go to [www.edccorp.com](http://www.edccorp.com) and then follow the link to Support and then to F.A.Q.'s page. You can also find links to newsletters, examples and tutorials.



# 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 2007  
Miami, FL . . . . . November 7 - 11, 2005

#### EDC Reconstruction

Los Angeles, CA . . . . . January 2006  
Miami, FL . . . . . November 2006

#### Theoretical & Applied Vehicle Dynamics

TBA. . . . . Fall 2005

#### 2006 HVE FORUM

Phoenix, AZ. . . . . March 2006

## 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 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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EDVAP, EDCRASH, EDSMAC, EDSMAC4, EDCAD, EDSVS, EDVTS, EDHIS, EDVSM, EDVDS, EDGEN, EDVDB, HVE, HVE-2D, HVE Brake Designer and GetSurfaceInfo() are trademarks of Engineering Dynamics Corporation. All Rights Reserved.

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