FALL 2010 ENGINEERING DYNAMICS CORPORATION

Technical Newsletter

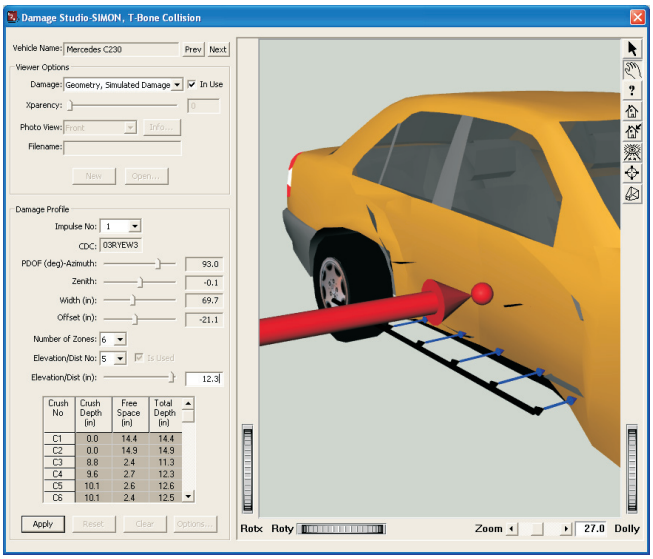
Available on-line in the EDC Library at www.edccorp.com

Version 8.1 - It's On The Way!

Version 8.1 of *HVE*, *HVE-2D* and the new *HVE-CSI* is currently undergoing final development and testing programs, with the expectation they will be released by the end of the year. This latest version offers users exciting new features, such as:

DamageStudio® - *DamageStudio* is a graphical analysis tool available in the *HVE* Playback Editor, that allows the user to visualize collision data, and to correlate collision damage with the kinetics (force magnitude and direction), delta-V, acceleration and other important collision parameters. *DamageStudio* is an option that replaces the Damage Profiles output report. *DamageStudio* was described in great detail in the Technical Session of the Summer 2010 newsletter.

Vehicle Dynamics Properties - Some *HVE* vehicle simulation models now calculate and display steady state vehicle handling properties in their Vehicle Data output reports. Please refer to the Technical Session of this newsletter for more information, as it focuses on these properties and how they are calculated.



DamageStudio, displaying results for a typical side impact. This example uses 6 crush zones and five crush elevations. Color-coded crush vectors displayed in the viewer show both the actual crush and free space. The large arrow and sphere are the computed PDOF and impulse center, respectively.

File Browsers - All file browsers in Version 8.1 now check the length of the names being used for case files, geometries (vehicle and environment) and images (textures). If the filename (including the extension) exceeds the limit of 30 characters, a message is displayed identifying that you must use a shorter name. This action corrects an issue that has resulted in corrupt case files for some users. Because *HVE* was not checking the length of the filename, the additional characters could over-write important case file data, resulting in an unreadable case file.

AutoSave - The AutoBackup function in the User Preferences dialog has been improved to provide a more robust backup of your case file. Up to 10 temporary backup files of your active case can be created and stored in the Temp folder of the *HVE* directory. These files are only used in the event of a program crash or to purposefully revert back to a recently saved version of the active case file. Your regular routine of using *Save* or *Save As* always creates a proper case file in your selected location, typically your supportFiles/case folder.

Accelerometers - In addition to local acceleration components, the Key Results Accelerometers output group now reports earth-fixed X, Y, Z coordinates and earth- and vehicle-fixed velocities.

Vehicle Dimensions Basis - The User Preferences dialog in *HVE* and *HVE-2D* now includes an option for setting the Vehicle Dimensions Basis to either Sprung Mass or Total Mass. *HVE* has always used Sprung Mass basis (a requirement for 3-D simulation). However, 2-D calculations use the location of the total mass CG. Total Mass basis is more commonly encountered, since most vehicle measurements reflect the vehicle total weight and do not separate sprung and unsprung masses.

And Much, Much, More - These are just a few of the enhancements that are available to users of Version 8.1. As more details become available, they will be posted on our website at www.edccorp.com. When visiting the site, also check out the *Library*, *Training* and *Support* sections for helpful resources.

Technical Session

This Technical Session provides an overview of the vehicle dynamics properties now presented by some *HVE* vehicle simulation models. The following steady state vehicle handling properties are now calculated and displayed in the Vehicle Data output report:

- Understeer Gradient
- Roll Gradient
- Roll Couple Distribution
- Steering Wheel Sensitivity
- Weight Distribution

These properties may be new to some users, so we'll explain what they mean and how they are calculated. Notice that they are called *steady state* handling properties. That means that these properties describe the handling of a vehicle driven under control and well below the limit threshold.

Understeer Gradient

Understeer Gradient, or simply Understeer, U (common units, deg/g) is perhaps the single most important descriptor of vehicle handling. Understeer describes how much steering (at the tire) is required in addition to the theoretical amount predicted by simple Ackermann steering. Ackermann steering is defined solely by the geometry of a turning vehicle, as shown in Figure 1.

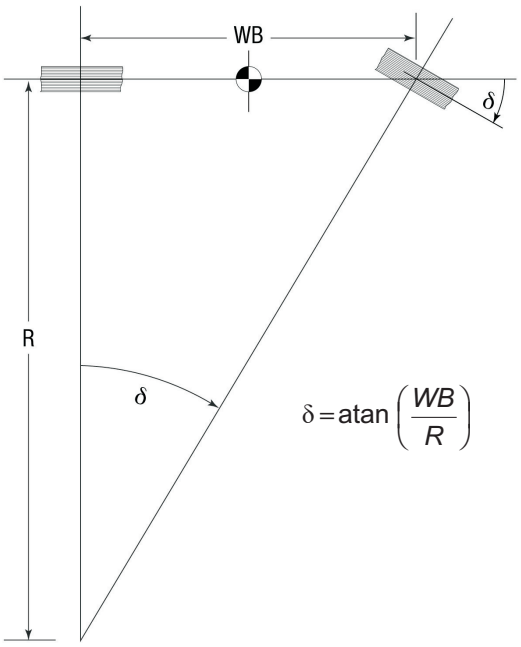


Figure 1 - Ackermann steer angle definition

For example, if a vehicle has a 10 ft. wheelbase and attempts to negotiate a 200 ft. radius turn, the amount of Ackermann steering at the tire is:

$$\delta = \text{atan}\left(\frac{WB}{R}\right) = \text{atan}\left(\frac{10}{200}\right) = 2.86 \text{ deg}$$

Note that this value is defined at the tire. If you want to know how much steering is required at the steering wheel, simply multiply the steer angle at the tire by the vehicle's steering gear ratio. For example, if the steering gear ratio is 18.0 (degrees at the steering wheel per degree at the tire), the required steering wheel angle is

$$\delta_{SW} = 2.86 \times 18.0 = 51.5 \text{ deg}$$

If, because of various vehicle loading, suspension, steering system and tire effects, the driver needs to steer more than 51.5 degrees at the steering wheel to negotiate the 200 ft radius turn, the vehicle has understeer. If, for the same reasons, the driver needs to steer less than 51.5 degrees at the steering wheel, the vehicle has oversteer. It's that simple. (By the way, oversteer is simply negative understeer.) If the required steer angle is exactly equal to the Ackermann steer angle, the vehicle has neutral steer.

So how is understeer calculated? Total understeer is the sum of several individual understeer components:

Weight Distribution and Tires, U_1 – This is by far the single most important handling predictor, a function of the tire loads and cornering stiffness at the front and rear tires:

$$U_1 = \frac{W_F}{C_{\alpha_F}} - \frac{W_R}{C_{\alpha_R}}$$

where

$W_{F,R}$ = load on the front and rear axles
$C_{\alpha F,R}$ = tire cornering stiffness for the front and rear tires (sum of right and left sides)
F,R = subscripts for front and rear axles

Inspection of the above equation for U_1 reveals some incredibly useful information. It shows that if front and rear cornering stiffness are equal, a vehicle will be understeer if the weight on the front axle is greater than the weight on the rear axle. It shows that as you add weight to the rear axle (e.g., put a large load in the trunk or the bed of a pickup) or reduce the cornering stiffness of a rear tire (e.g., reduce the inflation pressure), a vehicle normally having understeer handling characteristics can become oversteer! There are lots of variations on this theme.

Suspension and Tires, U_2 – A smaller but important contributor to understeer is caused by the suspension roll camber and tire stiffness:

$$U_2 = \left(\left(\frac{C_\gamma}{C_\alpha} \frac{d\gamma}{d\phi} \right)_F - \left(\frac{C_\gamma}{C_\alpha} \frac{d\gamma}{d\phi} \right)_R \right) \frac{d\phi}{da_y}$$

where

C_α = tire cornering stiffness for the front and rear tires (sum of right and left sides)

C_γ = tire camber stiffness for the front and rear tires (sum of right and left sides)

$\frac{d\gamma}{d\phi}$ = Camber change coefficient (a function of suspension design) for the front and rear suspensions (see below)

$\frac{d\phi}{da_y}$ = Roll Gradient (see below) for the front and rear suspensions

$\frac{d\gamma}{d\phi}$ Is a change in wheel camber due to vehicle body roll. It occurs in nearly all independent suspension, and has a value near unity (slightly + or -, depending on whether camber increases or decreases due to roll.

Suspension, U_3 – Roll steer in the suspension increases or decreases understeer, depending on suspension and steering linkage design:

$$U_3 = (\varepsilon_F + \varepsilon_R) \frac{d\phi}{da_y}$$

where

ε = Roll steer coefficient (due to suspension and steering linkage design)

There are four additional factors that typically play a lesser role and are not included in our calculation:

Suspension Compliance, U_4 – Compliance in suspension bushings increases or decreases understeer, again depending on suspension design.

Steering Compliance, U_5 – Compliance in the steering linkage increases understeer.

Tire Self-aligning Torque, U_6 – Self-aligning torque is small in today's radial tires. Inside and outside tires tend to offset each other.

Tire Rolling Resistance, U_7 – Rolling resistance also very small, but can become a factor for under-inflated tires.

The *HVE* Vehicle Model does not include suspension or steering compliance.

U_4 - U_7 are ignored in *HVE*'s Total Understeer calculation, thus:

$$U_T = U_1 + U_2 + U_3$$

Roll Gradient

Roll Gradient, $\frac{d\phi}{da_y}$, (common units, deg/g) is the vehicle roll angle per unit of lateral acceleration. In simple terms, it defines how much the vehicle rolls when turning. Roll Gradient is calculated as follows:

$$\frac{d\phi}{da_y} = \frac{W_S h_S + \left(W_U h_U \frac{d\gamma}{d\phi} \right)_F + \left(W_U h_U \frac{d\gamma}{d\phi} \right)_R}{K_{\phi_F} + K_{\phi_R} - W_S h_S - \left(W_U h_U \frac{d\gamma}{d\phi}^2 \right)_F - \left(W_U h_U \frac{d\gamma}{d\phi}^2 \right)_R}$$

where

W_S = Sprung weight

h_S = Distance from sprung mass CG to roll center axis, downward +

W_U = Unsprung weight for front and rear axles

h_U = Elevation of unsprung mass CG for the front and rear axles

K_ϕ = Roll stiffness for the front and rear suspensions

Roll Couple Distribution

Roll Couple Distribution (common units, %/100) is the fraction of the total vertical load shift to the outside tires of each axle during a steering maneuver. It is determined by the vehicle's suspension properties and weight distribution. It is calculated as follows:

$$RCD = \frac{TW_F}{TW_R} \left\{ \frac{\left(W_S z_S + W_U h_U \left(1 - \frac{d\gamma}{d\phi} \right) + K_\phi + W_U h_U \frac{d\gamma}{d\phi} \left(1 - \frac{d\gamma}{d\phi} \right) \right)_F \frac{d\phi}{da_y}}{\left(W_S z_S + W_U h_U \left(1 - \frac{d\gamma}{d\phi} \right) + K_\phi + W_U h_U \frac{d\gamma}{d\phi} \left(1 - \frac{d\gamma}{d\phi} \right) \right)_R \frac{d\phi}{da_y}} \right\}$$

where

TW = Track width for the front and rear axles

Roll Couple Distribution should be slightly greater than the fraction of total vehicle weight on the front axle. That's because during cornering, if the weight shift is greater on the front axle, the vehicle's understeer tendency will increase. This is desirable, since increasing oversteer under heavy cornering would potentially lead to a spin-out.

Roll Couple Distribution is a parameter that allows a 2-D simulation model (i.e., a model that does not directly include the effects of suspension rates and anti-sway bars) to approximate the effects of lateral load transfer during cornering. This approach, used by EDSMAC4, is referred to as quasi-static load transfer.

Steering Wheel Sensitivity

Steering Wheel Sensitivity (units, deg/g) is the amount steering wheel input required to produce a given lateral acceleration at a given speed (it is sometimes presented as the reciprocal and called Lateral Acceleration Gain, g/deg, but the concept is identical). Steering Wheel Sensitivity is calculated as follows:

$$SWS = \eta\left(\frac{WB \times g}{V^2} + U_T\right)$$

where

η = Steering gear ratio
V = Velocity
g = Gravity constant

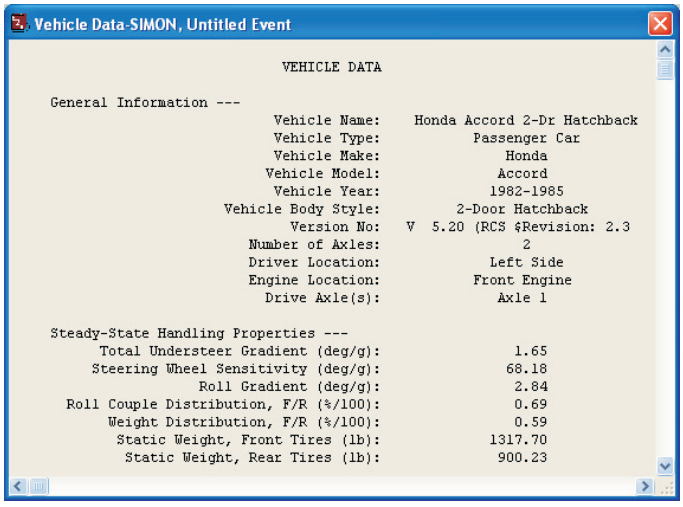


Figure 2 - *SIMON* Vehicle Data report with Steady-State Handling Properties section

The velocity used in the equation is arbitrary (*HVE* uses 60 mph). However, it is important to use the same velocity when comparing the Steering Wheel Sensitivity of different vehicles.

An Example

The handling descriptors described above are presented as part of the Vehicle Data output report for some physics programs, e.g., *SIMON* (see Figure 2).

The information in Figure 2 may be interpreted as follows:

- The vehicle, a 1984 Honda Accord 2-Dr Hatchback, has understeer characteristics during steady-state steering maneuvers (U_T has a positive value). The front tires will need to be steered 1.65 degrees more than the angle defined by Ackermann steering in order to perform a 1-g turn (of course, the vehicle cannot achieve that level of lateral acceleration, but the concept of understeer has nothing to do with what happens during a limit maneuver).
- The Steering Wheel Sensitivity tells us the driver must turn the steering wheel 68.18 degrees to perform a 1-g turn at 60 mph (same comment as above applies regarding limit maneuvers).
- The Roll Gradient tells us the vehicle roll angle will be 2.84 degrees during a 1-g steering maneuver (same comment as above).
- The Roll Couple Distribution tells us that while cornering, 69 percent of the lateral load shift is transferred to the outside front tire and 31 percent is transferred to the outside rear tire.
- The Weight Distribution tells us the static load on the front tires is 59 percent of the total vehicle weight; the static load on the rear tires is 41 percent of the total weight.
- The static load on the front tires is 1317.7 lb; the static load on the rear tires is 900.23 lb.

Want to learn more about how these and other vehicle dynamics properties affect vehicle handling and controllability?

Sign up now to attend the Theoretical & Applied Vehicle Dynamics workshops at the 2011 *HVE* Forum.

2011 *HVE* FORUM Sign Up Today!

The 2011 *HVE* Forum is the perfect opportunity to get trained on using the latest features and capabilities of *HVE*, *HVE-2D* and the newest member of the *HVE* family, *HVE-CSI*. The 2011 *HVE* Forum offers a wide selection of workshops designed for beginning, intermediate and advanced users, along with User's Groups, the *HVE* White Paper session and social hours at the end of each day. Highly anticipated workshops at this year's event include:

Advanced *HVE*

If you're looking to make the most of *HVE*'s newest tools and capabilities using a hands-on approach, this is the workshop for you. The Advanced *HVE* Workshop for 2011 focuses on *DamageStudio*. The following topics are covered:

- High-level Overview
- Description of CollisionData
- Description of *DamageStudio*
- *DamageStudio* Applications and Examples (Hands-on)

Introduction to *HVE-CSI*

This workshop series is designed for the new *HVE-CSI* user who wants to gain a basic understanding of how to use *HVE-CSI* to reconstruct vehicle crashes and loss-of-control scenarios with the *EDCRASH* and *EDSMAC* physics programs. The following topics are covered:

- Introduction to the *HVE-CSI* User Interface.
- Creating Vehicles
- Creating Environments
- Creating *EDCRASH* Events
- Creating *EDSMAC* Events
- Creating Outputs

Environment Modeling for the Professional Graphic Artist

This workshop is designed to give the professional graphic artist using 3D Studio Max the background required to properly build 3-D environment models for use in *HVE*. The course content will provide step-by-step instructions for the construction of custom environments that are easily imported into *HVE*.

3-D Humans: *GATB*

This workshop provides an overall understanding of how to use the *GATB* model to study occupants and pedestrians in car crashes. The following topics are covered:

- *HVE* Human Editor
- Human Parameters
- *GATB* - Graphical Articulated Total Body
- Examples - Occupants and Pedestrians

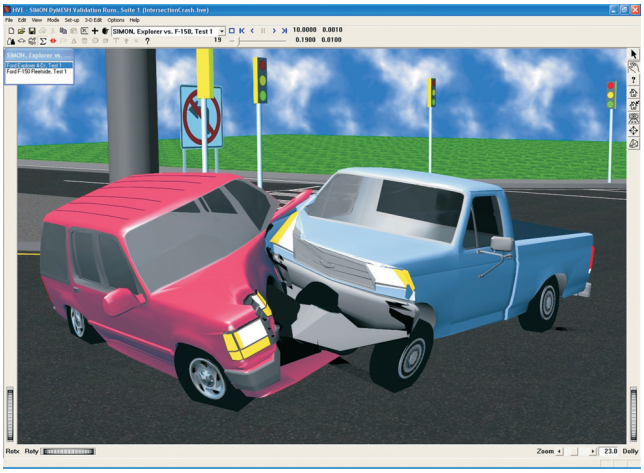
The 2011 *HVE* Forum Registration Booklet, containing the workshop schedule, descriptions, registration form and hotel information, is available to download from **www.edccorp.com/2011HVEForum**. If you have any questions about the events for the week or would like assistance with selecting your workshops, please contact EDC Customer Service at 503.644.4500.

The Hottest Add-ons and Upgrades of 2010

Thinking about additional capabilities for your system software or an upgrade to the next level? With the end of the year approaching, now is the perfect time to contact EDC for options to enhance your software. Here are the "hottest" add-ons and upgrades of 2010:

SIMON and *DyMESH*

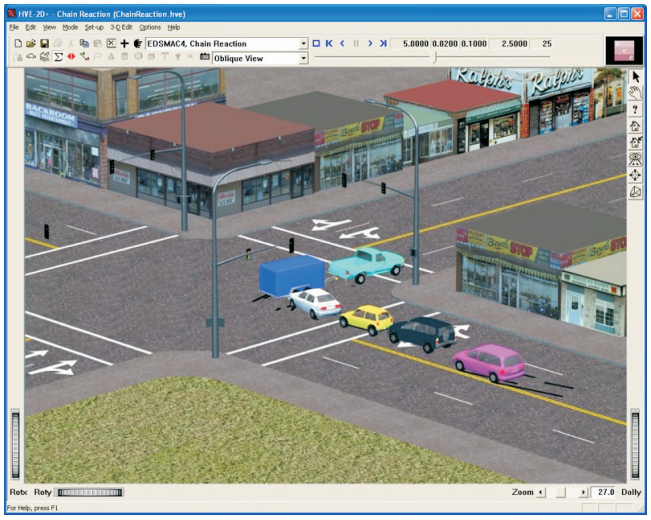
SIMON was specifically designed to take advantage of the rich feature set available in the *HVE* 3-D simulation environment, including the *HVE* Brake Designer, ABS Simulation Model, *HVE* Driver Model, Tire-Terrain Models, Tire Blow-out Model and the patented *DyMESH* 3-D Collision Model. *SIMON* has been validated against several well-instrumented vehicle handling studies, including combined steering and braking, severe irregular terrain traversal, rollover tests, staged crash tests and tire blow-out experiments.



This screenshot from HVE is of a SIMON simulation used to analyze an intersection collision between an SUV and a pickup. At every timestep, SIMON is calculating 3-D vehicle dynamics and the DyMESH 3-D collision model is calculating forces due to the interaction of the vehicles exteriors. The combined result is a true 3-D collision simulation.

HVE-2D+

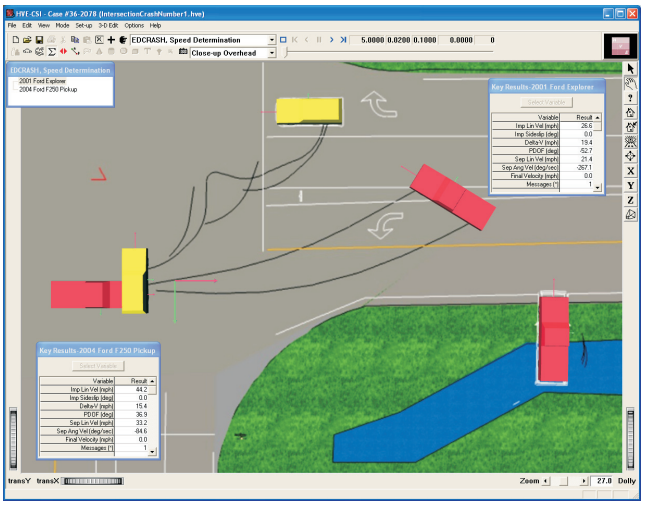
HVE-2D users now have the option to upgrade to *HVE-2D+*. This option converts the regular *HVE-2D* viewers to those used by *HVE*, allowing the user to position the camera anywhere and look everywhere in a 3-D world. This also allows *HVE-2D+* users to easily work with ground level views and target-following cameras, such as those used for displaying the driver's view of an impending crash.



The new 3-D viewers option of HVE-2D+ allows the camera to be easily positioned anywhere, such as providing an oblique view of the EDSMAC4 chain reaction collision simulation shown above.

HVE-CSI

HVE-CSI is now the first choice for law enforcement crash reconstructionists and long-time EDC software users upgrading from their trusted EDVAP DOS programs. *HVE-CSI* provides momentum- and damage-based reconstruction calculations, as well as time-based simulation calculations, to confirm vehicle speeds at loss of control and impact. *EDCRASH* and *EDSMAC*, the two reconstruction software tools included with *HVE-CSI*, have been extensively validated using actual crash tests. Results have been accepted in courts worldwide for over 25 years.



This screenshot is from a reconstruction in HVE-CSI using EDCRASH to calculate impact speeds and the delta-V of an intersection crash between an SUV and a pickup. The impact and final rest positions of the vehicles have been input.

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

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

Q. I am an HVE-2D user working with the Distance Tool to measure the distance between two vehicles in an EDSMAC4 simulation. When I select a point on one vehicle and then select a point on the other vehicle, I see the Distance Tool dialog reports a distance that includes a Z value and also a Zenith angle. If I look closer at the coordinates displayed for the two points, I see that there are non-zero values in the Z coordinates? Why is this occurring and what do I have to do to get an absolute horizontal distance between the points on the two vehicles?

A. No matter which system software you are using, the Distance Tool provides information between two selected points on the geometries of vehicles or the environment. Vehicles in *HVE-2D* and *HVE-CSI* have 3-dimensional shape to them, which are reflected in the coordinates of the points selected on each object. You may have selected the roof of one vehicle and the lower front fender of the other vehicle. There will be an elevation difference between the two selected points, which will be displayed in the results. If you want to see the absolute horizontal distance between any two points using the Distance Tool, simply edit the From/To Z coordinates for both points to be exactly the same. When you press *Apply*, you'll see that the Z distance and the zenith angle results are now shown as 0.0.

Q. At the end of my simulation run, I am seeing an unexpected rotation or sideways motion of my vehicle. The vehicles are at low velocities, almost at a stop, when this motion is displayed. I believe my inputs are correct for all the driver controls and other set-up options, so why am I getting this unexpected behavior at the end of my run?

A. If your simulation involves heavy vehicles or those with large numbers of tires, such as commercial truck configurations, it may be that the default integration timestep for the vehicle trajectory calculations may not be fine enough to limit the range of change in calculated tire forces at low velocities. The default setting for the Vehicle Trajectory Integration Timestep found in the Simulation Controls dialog is 0.0025 seconds. While this is suitable for a lot of simulations, the conditions in your specific simulation event are producing a calculated tire force at low velocities that is causing the vehicle to rotate or shift sideways unexpectedly. The easy solution to your situation is to simply adjust the Vehicle Trajectory Integration Timestep to be 0.001 seconds, which is the same as the default value for the Vehicle Collisions Integration Timestep. This simple change will reduce the potential for instability in the results of the calculation routine and your vehicles will behave as expected.

Q. I am looking to buy a new computer to run my HVE software. Any recommendations?

A. Based upon anecdotal reports from users, a wide variety of makes and models of desktop and laptop (notebook) computers are great platforms for running *HVE*. Our main advice is that we still recommend NVIDIA graphics chipsets over Intel Integrated or ATI chipsets. Users have reported the most stable operation of their *HVE* software when running on computers with NVIDIA graphics cards, especially the NVIDIA GeForce line. If you have a question about a specific make and model, please call EDC Technical Support for advice.

Q I recently installed my Version 8.00 software on my new computer running the Windows 7 operating system (I'm finally moving up from Windows XP). During the installation, I noticed that the default installation location is now C:\HVE, rather than C:\Program Files\HVE. I'm so used to installing all of my applications under the Program Files directory. Why has it changed for Windows 7?

A. Starting with the Windows Vista operating system and continuing on in Windows 7, the Program Files directory location has security settings that make it very difficult or impossible for applications like *HVE* to create and store necessary operating files within the installation tree. When you run *HVE*, you generate temporary files, case files and other supporting files directly within the *HVE* directory. If you had full Administrator privileges, then you may be able to override the security settings of the Program Files directory. However, your user created files may still wind up being placed into a virtual store under your logged in User directory. To keep your access to case files and your overall use of *HVE* simple, we have changed the default installation location to be just C:\HVE (or C:\HVE-2D or C:\HVE-CSI depending upon your system software).

Visit the Support section of www.edccorp.com for the latest Downloads and answers to F.A.Q.'s

EDC Training Courses

EDC Reconstruction & EDC Simulations

EDC offers excellent one-week courses on the use of the *EDCRASH* reconstruction program or the use of simulation programs, such as *EDSMAC*, *EDSMAC4*, *EDSVS* and *EDVTS*. The **EDC Reconstruction** and the **EDC Simulations** courses are designed to fully investigate the inner workings of the physics programs . Lectures are full of helpful hints gained from years of experience. During the course, students will use the physics programs to complete several workshops highlighting the capabilities of each program discussed in the course.

Both new and long-time users of *HVE* and *HVE-2D* agree that these courses are extremely beneficial and challenging. It's the fastest way to learn what you really need to know – how to effectively use the physics programs and get the right results. Note: These courses focus on the physics programs, not on the user interface. For courses on using *HVE*, *HVE-2D* or *HVE-CSI*, check out the *HVE* Forum.

Vehicle Dynamics

The **Theoretical & Applied Vehicle Dynamics** course extends the scope of a general vehicle dynamics discussion by including several direct applications using the *SIMON* vehicle dynamics simulation program within *HVE* and providing a solid theoretical background for such simulations. The course is focused towards engineers and safety researchers with an interest in an understanding of vehicle dynamics and automotive chassis systems development.

Engineering Dynamics Corporation
Training Course Schedule

EDC Simulations

Los Angeles, CA . . . . . January 24 - 28, 2011
Miami, FL . . . . . November 7 - 11, 2011

EDC Reconstruction

Los Angeles, CA . . . . . January 2012
Miami, FL . . . . . November 2012

Theoretical & Applied Vehicle Dynamics

Upon Request

2011 *HVE* FORUM

Scottsdale, AZ. . . . . February 21 - 25, 2011

HVE Forum

The ***HVE* Forum** offers workshops designed to help *HVE, HVE-2D* and *HVE-CSI* users improve their modeling and application skills. By participating in workshops, attendees learn new techniques and also how to use the latest advancements in the software. The *HVE* Forum is also a great opportunity to meet other users and expand your network of resources.

Course Registration

To register for a course, download a registration form from the Training page at edccorp.com or contact EDC Customer Service at 503.644.4500 or by email to training@edccorp.com. All courses are eligible for Continuing Education Units and ACTAR credits.

HVE Training Partners

HVE, *HVE-2D* and *HVE-CSI* users looking to improve their skills, but unable to attend one of EDC's regularly scheduled courses, can contact an *HVE* Training Partner for assistance. *HVE* Training Partners are experienced *HVE* and *HVE-2D* users who offer introductory and custom training courses on the use of *HVE*, *HVE-2D*, *HVE-CSI* and compatible physics programs.

HVE Discussion Groups

Websites hosted by experienced *HVE* Users offer information about using *HVE* as well as moderated online discussions with other users. Be sure to visit:

tech.groups.yahoo.com/group/HVErecon - Discussion group hosted by Roman Beck of Casteel, Beck & Associates.

DiscoverHVE.com - Online training and discussion group hosted by Wes Grimes of Collision Engineering Associates

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