

Technical Newsletter

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Version 9.1 and the 2013 HVE Forum

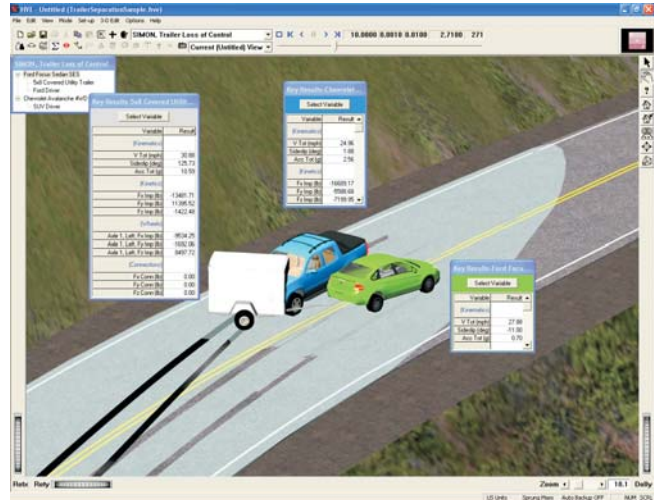


The robust features and functionality of Version 9.1 helped make the 2013 HVE Forum one of the best all-around training events to date for HVE, HVE-2D and HVE-CSI users. Whether being used in beginning, intermediate or advanced workshops, the software supported a rich learning experience that allowed attendees to focus on how to make best use of the tools available in their respective level of HVE software.

Also contributing to the success of the event was the participation by attendees in open discussions during workshops, the HVE White Paper session, Users Group Meetings and networking opportunities. And of course the great weather and the outstanding training venue located in the Gaslamp Quarter in San Diego should be factored in as well.

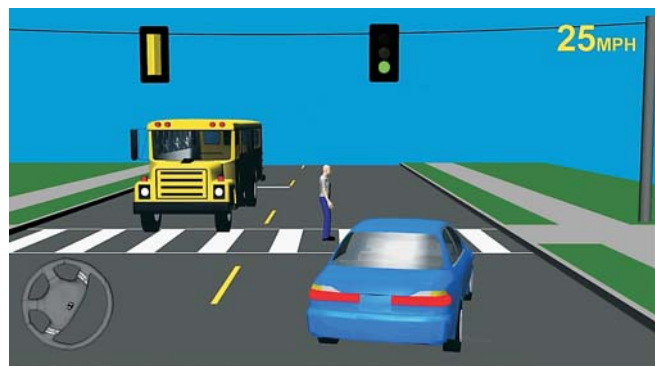
Workshops that worked extensively with the new capabilities in Version 9.1 included:

- Advanced HVE Workshops** - The Advanced HVE workshops used a combination of open discussions and hands-on examples to provide the ultimate exposure to HVE's powerful capabilities. The in-depth example involving the loss of control of an articulated vehicle due to hydroplaning conditions, which lead to the subsequent collision and trailer separation, exposed the attendees to the detailed use of the new SIMON trailer separation model, the DyMESH wheel impact model and also the Hydroplaning model. Additionally, the vehicles used in the example were selected from the Vehiclemetrics vehicle database, providing firsthand experience of the quality and usability of these vehicles in HVE simulations.



Screenshot from the Advanced HVE Workshop example showing the moment of impact between the front of SUV and the wheel of the trailer towed by the sedan. Note that the vehicles are currently traveling over a flooded roadway.

- Advanced Video Techniques** - This workshop presented the latest techniques to enhance simulation videos using new tools available in the Video Creator, along with tools available in other advanced video editing software.



Screenshot from the Advanced Video Techniques workshop demonstrating the visual display of the traffic signal light, and the current speed and steering wheel angle of the sedan.

Start planning now to attend the **2014 HVE Forum!** Watch for the exact date and location to be announced on the EDC website and in your weekly E-News.

Technical Session

This Technical Session discusses *HVE's* Damage Profiles dialog. This event editor dialog is used to assign a vehicle damage profile (the sheet metal and structural deformation resulting from a collision). The damage profile data are used by a reconstruction-type program (e.g., *EDCRASH*) in the calculation of delta-V.

The Damage Profiles dialog (see Figure 1) has three basic components:

- Input Data
- Numeric Results
- Damage Profile Viewer

These components are described below.

Input Data

The Damage Profile dialog complies with SAE Recommended Practice J-224, Collision Deformation Classification (CDC). As such, the damage profile is defined by the following parameters:

CDC – 7-character damage code used to define a default damage profile. This profile is usually edited by changing the following parameters.

PDOF – The principal direction of force, as defined by SAE J-224. The default PDOF is assigned as a clock direction in the first two characters of the CDC (above).

Damage Width – For damage measured horizontally (i.e., 2-dimensional damage), damage width is the scalar dimension from the start of damage to the end of damage, measured horizontally along the side or end of the vehicle.

Damage Offset – For damage measured horizontally (i.e., 2-dimensional damage), damage offset is the vector distance from the vehicle centerline (end damage) or CG (side damage) to the midpoint of the damage width. As a vector, if the damage midpoint is to the left of the centerline (end damage) or behind the CG (side damage), the sign of the damage offset is negative; otherwise, it is positive.

Crush Depth(s) – For damage measured horizontally (i.e., 2-dimensional damage), crush depth is the distance from the original vehicle outline to the damaged vehicle outline at multiple, equally spaced locations along the damage width. *HVE* allows the user to enter as few as two crush depths and as many as 10 crush depths.

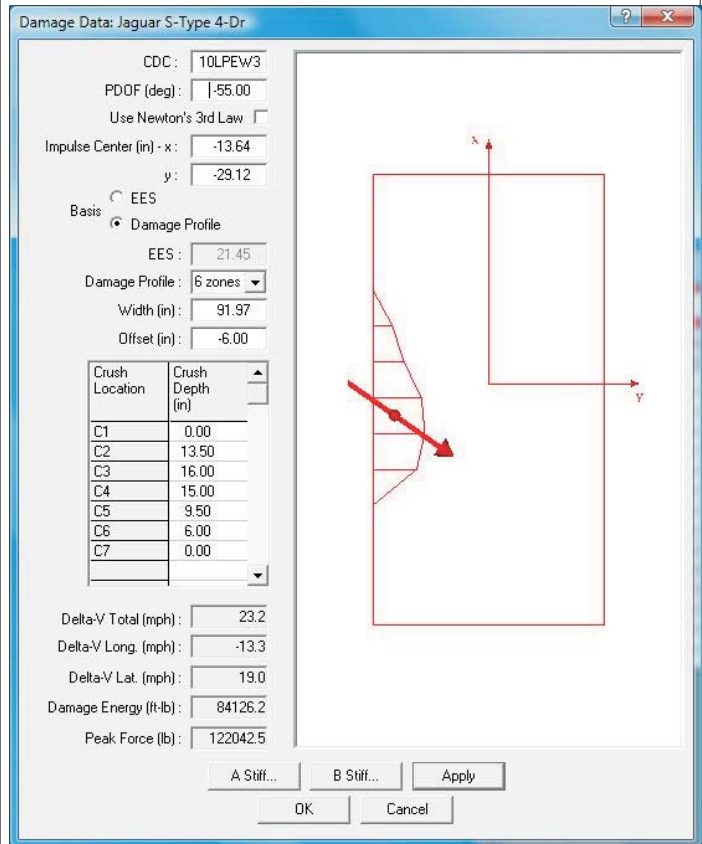


Figure 1 - *HVE* Damage Profiles dialog

Because the current implementation of the Damage Profile dialog is 2-dimensional, the elevation of crush is not assigned or used by the Damage Profiles dialog.

Numeric Results

Based on the user's input data, the Damage Profiles dialog calculates and displays the following numeric results:

Total Delta-V – The magnitude of the total velocity change during impact

Delta-Vx – The vehicle-fixed x (longitudinal) component of the total velocity change

Delta-Vy – The vehicle-fixed y (lateral) component of the total velocity change

Damage Energy – The energy lost during impact due to collision damage

Peak Force – The magnitude of the peak collision force during impact

The Damage Profiles dialog also calculates and displays the location of the center of impulse. It is initially defined by the centroid of the damage profile and is user-editable.

Damage Profile Viewer

The idealized (rectangular) vehicle outline is displayed with the current damage profile and PDOF.

Calculation Procedure

The damage analysis used by *EDCRASH* is actually embedded into the Damage Profiles dialog. When you enter the required data and press *Apply*, *HVE* is executing the same computations that *EDCRASH* performs. However, there is one important distinction: Whereas *EDCRASH* can calculate the delta-Vs for two vehicles or a vehicle striking a fixed or movable barrier, the Damage Profiles dialog always calculates the delta-V for a single vehicle striking a fixed barrier. Thus, the delta-V reported in the Damage Profiles dialog is the Energy Equivalent Speed.

NOTE: As an aside, this means that the Delta-V reported in the Damage Profile dialog will be the same as the Delta-V reported in an *EDCRASH* 2-vehicle event if (and only if) the 2 vehicles in the *EDCRASH* event have equal weights.

During a collision between two objects, the resulting motion obeys the laws of impulse and momentum. The vehicles share the impulse, *I*, thus

$$I = \int f dt = m_1 \Delta V_1 = m_2 \Delta V_2$$

The procedure for calculating the damage-based delta-V is based on the equation for calculating the impulse. In general

$$I = \sqrt{2(E_1 + E_2) \frac{m_1 m_2}{m_1 + m_2}}$$

This equation reveals that two quantities must be known for both colliding vehicles: damage energy, *E*, and vehicle mass, *m*.

Damage Energy

Damage energy is calculated by assuming the vehicle structure has a linear force-vs. displacement characteristic defined by an initial force constant, *A*, per unit of damage width and a linear deformation (spring) constant, *B*, per unit of damage width. Based on the measured vehicle crush, *C*, at any point along the damage

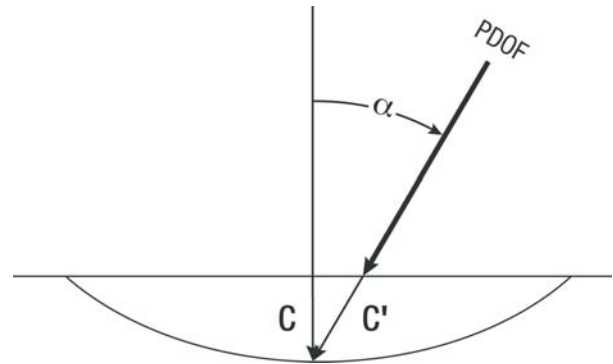


Figure 2 - Energy Magnification Factor

width, the force per unit of damage width acting on that point is

$$F = A + BC$$

and the damage energy per unit of damage width is

$$E = \int f dx = \int (A + BC) dx$$

The total damage energy is calculated by integrating the above energy across the entire damage width. This integration is performed using the trapezoidal rule, along with the user-entered crush depths which are equally spaced along the damage width.

Energy Magnification Factor

The crush depths are measured perpendicular to the surface of the rectangle defined by the vehicle overall dimensions. However, the direction of the impulse causing the damage might not be perpendicular to this surface. Thus, the crush forces acted along a direction different from the measured crush depth, as shown in Figure 2. Therefore, the effective crush depth, *C'*, is greater than the measured crush, *C*. Since damage energy is a function of the crush depth (actually, the crush depth squared), non-perpendicular crush results in greater damage energy than perpendicular crush. To account for this phenomenon, the damage energy is increased by the *energy magnification factor*, *EMF*

$$EMF = \left(\frac{C'}{C}\right)^2 = \left(\frac{C}{C \cos \alpha}\right)^2 = 1 + \tan^2 \alpha$$

Thus, the total damage energy for the impulse is

$$E' = E \times EMF$$

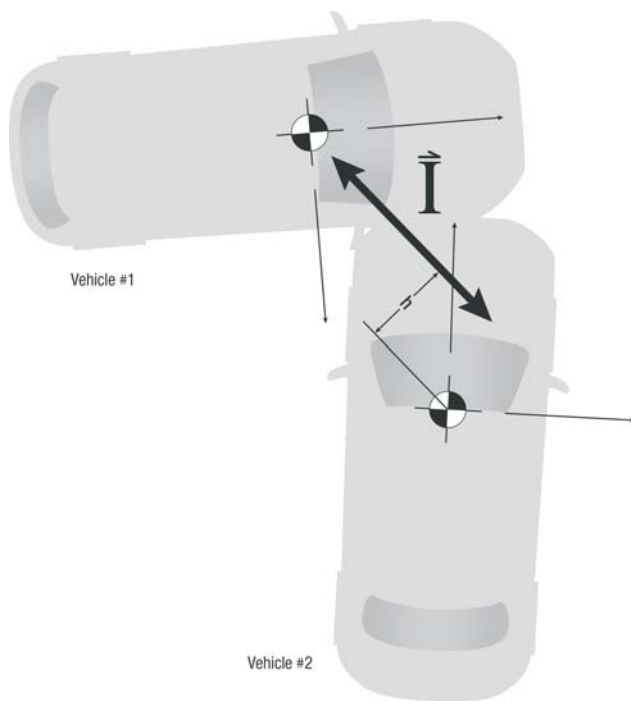


Figure 3 - Mass Reduction Factor

Note that the *Energy Magnification Factor* increases substantially as the angle between the PDOF and the surface normal increases beyond 45 degrees. In order to yield results that are consistent with experiment, the *Energy Magnification Factor* is limited to 2.0; increasing the PDOF beyond 45 degrees has no effect.

Vehicle Mass

Vehicle mass is simply the vehicle weight divided by the gravity constant.

Mass Reduction Factor

Figure 3 shows a typical collision between two vehicles. Note that the impulse for Vehicle 1 acts through its CG, while the impulse for vehicle 2 acts at a distance, *h*, from the CG. Under these conditions, it is obvious that vehicle 2 will rotate, while vehicle 1 will not. Because vehicle 2 rotates, some of the damage energy must be converted into rotational kinetic energy, meaning that the amount of damage energy producing the delta-V must be smaller. The calculation for delta-V must account for this fact. This is done using the *Mass Reduction Factor*, γ

$$\gamma = \frac{r_{gy}^2}{r_{gy}^2 + h^2}$$

where

r = radius of gyration

$$= \sqrt{\frac{I_z}{m}}$$

where *I_z* = yaw moment of inertia
m = mass

h = moment arm of the impulse; see Figure 3

Note that if the impulse acts directly through the CG, *h* is zero (see Figure 3, vehicle 1), and the *Mass Reduction Factor* is

$$\gamma = \frac{r_{gy}^2}{r_{gy}^2 + 0} = 1.0$$

Final Equation

The final equation for the impulse, which includes the *Energy Magnification Factor* and the *Mass Reduction Factor*, is

$$I = \sqrt{2(E'_1 + E'_2) \frac{m_1 \gamma_1 m_2 \gamma_2}{m_1 \gamma_1 + m_2 \gamma_2}}$$

and the delta-Vs are

$$\Delta V_1 = \frac{I}{m_1}$$

and

$$\Delta V_2 = \frac{I}{m_2}$$

The Technical Support desk at EDC sometimes fields questions from users who have programmed the damage calculations into a spreadsheet and are getting answers different from the results displayed in the Damage Profiles dialog. Typically, the *Energy Magnification Factor* and/or *Mass Reduction Factor* are found to be missing from their spreadsheet calculations.

Rate This Tech Session

Please go to www.edccorp.com/TechSessionRating to tell us if you liked this Technical Session and to suggest other topics you'd like to see in future technical sessions in the EDC Technical Newsletter. Thank you!

2013 HVE White Papers Now Available

The *HVE* White Paper Session at the 2013 *HVE* Forum provided users with excellent supporting information for the application of *HVE* simulation technologies. The following papers are now available to download from the *HVE* White Paper library on the EDC website:

WP-2013-1 - "Restitution in Frontal Impact Simulations Using the *EDSMAC4* and *SIMON/DyMESH* Collision Models" - Micky Marine, Joseph Cuadrado and Stephen Werner - Exponent Inc. -- Test and Engineering Center

Abstract: In this study, the restitution (i.e., structural recovery) models within the *EDSMAC4* and *SIMON* (via *DyMESH*) physics modules of the *HVE* program are examined. By way of background, the methodologies for handling structural recovery within these physics modules are reviewed. Results from simulation studies using these modules are presented. In these simulation studies, the effective coefficient of restitution values from a series of frontal vehicle-to-barrier impact simulations and a series of vehicle-to-vehicle collinear frontal impact simulations are determined from the program output and compared to results from publicly available full-scale vehicle crash tests. Studies were also conducted to evaluate simulation sensitivities vis-à-vis changes of the user-supplied parameters that directly control the respective structural recovery algorithms.

WP-2013-2 - "Analysis of Tire Rub Rail Interaction" - Dirk Smith, Ph.D., P.E. - Rimkus Consulting Group, Inc.

Abstract: On December 20, 2010, a Mine Safety and Health Administration (MSHA) inspector issued a citation at a mine site because the side railings on the drive-over scale were not mid-axle height of the largest piece of equipment to use the scale. The side railings were 5 inch diameter tubing with the top of the rail 10 inches high. *HVE SIMON* was used to model the interaction of a tractor-trailer and a straight truck with the side railing. Based on the speed of trucks on the scales, the method of operation on the scales, truck dynamics and driver control, the *HVE* analysis revealed that the height of the side rails on the subject scale was sufficient to give feedback to the driver and keep the truck on the scale. The MSHA judge agreed with this analysis and dismissed the citation.

WP-2013-3 - "Linear Error Analysis and *HVE*" - Scott B. Anderson, Ph.D. - Anderson-Lee Applied Science

Summary: Many non-linear dynamical systems will behave linearly with respect to small perturbations of their initial conditions. The usual goal for an *HVE* user is to determine the initial state given the final state. The example presented in this monograph is from an actual collision involving a semi and two cars and it clearly illustrates how linear error analysis can be applied to refine an *HVE* run.

WP-2013-4 - "A Method to Determine Non-Linear Crush for Use in *HVE*" (Oral Presentation Only) - Brian Gilbert, Ron Jadischke and Joe McCarthy - McCarthy Engineering/Vehiclemetrics

Summary: The potential advantages of using non-linear crush coefficients include the ability to better model vehicle structural changes and also improved accuracy of simulation results over a range of crush depths. The purpose of the present work is to develop a method to calculate the A, B, C and D stiffness coefficients utilized by the *DyMESH* 3-D collision model. The proposed methodologies are evaluated using crash test results from the NHTSA database for the 2002-2007 Jeep Liberty SUV in comparison with *SIMON/DyMESH* simulations.

WP-2013-5 - "Evaluation of *DyMESH* Wheel Impact in a Rollover Collision" - Eric Deyerl, P.E. and Mu-Hua Cheng - Dial Engineering & Louis Cheng, Ph.D. - Applied BioMechanics

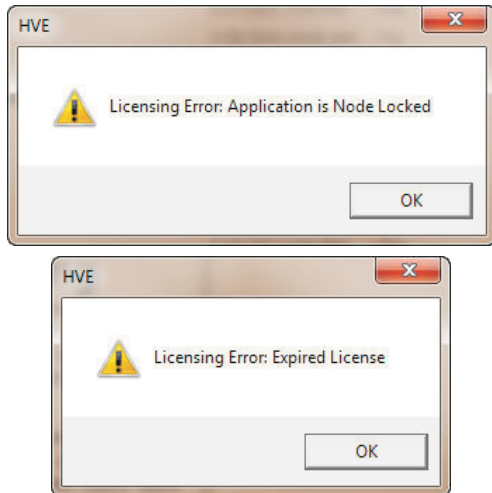
Summary: An evaluation of the performance of the wheel impact model within *SIMON/DyMESH* by simulating a rollover crash test involving significant interaction between the wheel of the bullet vehicle and the body of the target vehicle. The rollover crash test used in this evaluation was conducted by W. R. Haight at the 2012 ARC-CSI Crash Conference and involved a 2011 Jeep Grand Cherokee SUV that was induced to roll over by driving up and over a 1987 Bertone (Fiat) X1/9 sports car.

2014 HVE Forum HVE White Paper Session Call for Papers

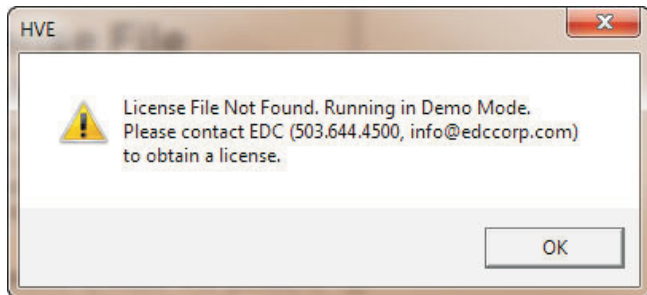
All users interested in presenting a technical paper in the "HVE White Paper" session at the 2014 *HVE* Forum are invited to submit an abstract for consideration. *HVE* White Paper topics include *HVE* Case Studies, any application of *HVE* showcasing its capabilities, and innovative tips and techniques using *HVE*. Abstracts are due by September 1, 2013.

Troubleshooting Licensing Issues

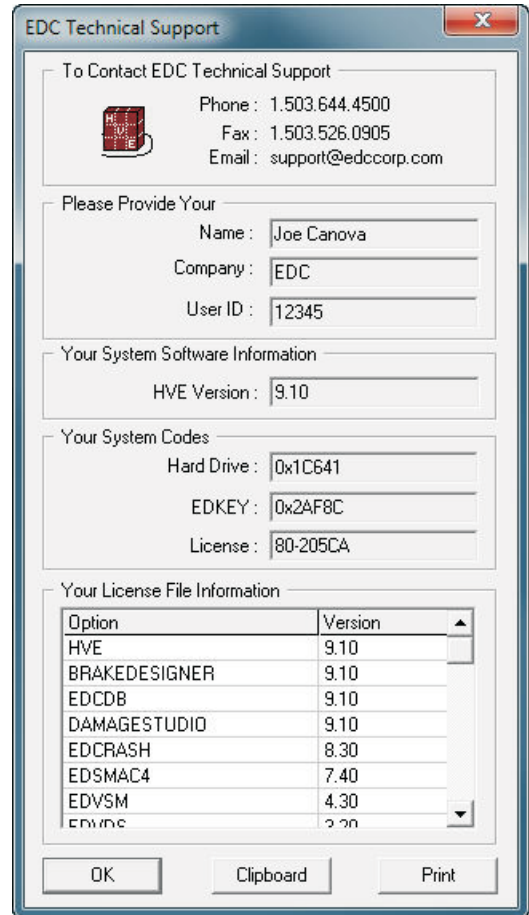
If the *HVE* License Manager detects an expired license or an incorrect value of system code compared to that encrypted in the license file, the user will see a message such as one of those shown below:



After OK is selected, *HVE* will not exit but will continue to start up in Demo Mode, as identified by the message shown below:

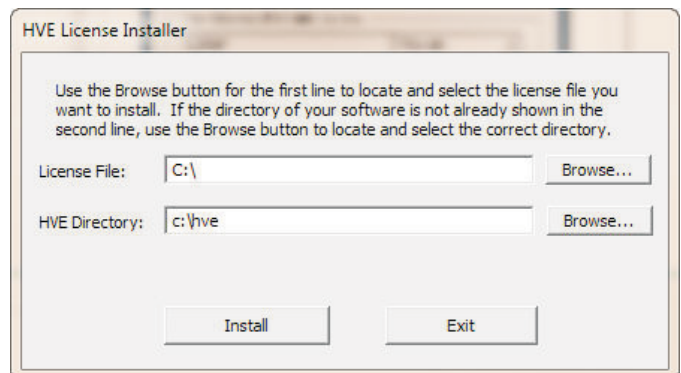


While running in Demo Mode offers limited functionality, you can access a great troubleshooting tool, found by selecting *Help, Tech Support*. The Technical Support dialog shown at the top of the next column displays your User Information, the version number for the system software and the system codes for the computer's Hard Drive, *EDKEY* (if plugged in) and License File. The *Your License File Information* table displays program options and their respective version numbers for the currently installed license file. The buttons at the very bottom allow you to Print for your own records or to easily copy this information to the system clipboard for pasting into an email to send to EDC Technical Support if you require additional assistance with resolving a licensing issue.



Once the system codes and the version information are clearly visible, you can quickly identify if your license problem is due to version or system code mis-match. The most frequently identified situation is that the user simply forgot to plug the *EDKEY* back into the USB port before starting the software.

If your license file is incorrect and you need to install a replacement that you received from EDC, try using the *Install License File* utility program shown below. This program can be found by selecting *Start, All Programs, HVE, Install License File* on your Windows Desktop.



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. After crashing while attempting to save a vehicle to the User Database in Version 9.10, I restarted HVE but the program window does not appear on my Desktop or in the Windows Task Bar. What do I do?

A. HVE Version 9.10 has a bug related to the User.DB. We are working on a patch that will be released in early May. Until the patch becomes available, users should not save a vehicle to User.DB. This problem also prevents HVE from restarting properly.

To correct the situation, please follow these steps:

1. Launch the Task Manager (Press ctrl + alt + delete and then select to Start Task Manager).
2. Click on the Processes tab and then locate hve.exe in the list.
3. Left-click to select the hve.exe process, then right-click to display the menu.
4. Select "End Process" on the menu to terminate the hve.exe process.
5. Close the Task Manager.
6. Open your file browser and go to the HVE/supportFiles/db folder location.
7. Locate and delete the user.db file. Note that it is only 1kb in size.
8. Close your file browser.
9. Start HVE and get back to work.

Q. I recorded a simulation movie using the Video Creator, but when I play the movie in Windows Media Player, it is actually the movie I previously recorded before the one I just made. It seems that the steps I am following are making movies that are one step behind what I think they are. What am I doing wrong?

A. It sounds like you are trying to name the movie file using the Save As function in the Video Setup dialog, before you actually record the movie. The important detail to remember is that the Video Creator only creates a single file named default.avi located in the supportFiles/images/movies folder. When you route the display of the Video Creator to the Destination of Default Video File and start recording, it will erase/replace an existing default.avi with the one using the current output. Only after you have recorded the movie can you then go back to the Video Setup button

and use the Save As functionality to make a copy of default.avi movie file you just created using a file name that is more descriptive of the contents of the movie.

Q. In my simulation, the truck-trailer jack-knifes and the trailer comes into contact with the truck. I have tried setting the Max Articulation Angle of the truck fifth wheel to a value that is representative of the point where the two bodies would make contact, but that simply terminates the event rather than holding the vehicles at that relative position for the remainder of the event. Is there any way to model this?

A. SIMON and EDSMAC4 do not model the "pinch force" that occurs between a tow vehicle and trailer during a jackknife. The Maximum Articulation Angle setting is a termination condition that is triggered during a severe jackknife. Its purpose is to prevent the simulation from continuing beyond its valid range of conditions. In that sense, the setting is performing exactly as intended. The ability to "hold" an articulation angle either specified by the user or determined by contact detection between the truck and trailer bodies is not available.

Is it possible that the trailer separated from the tow vehicle in your scenario? If so, you should use the new trailer separation model that is available in HVE V9.10 (SIMON events only). Once the trailer separates from the tow vehicle, they are recognized as two independent vehicles and are able to collide with each other or with other vehicles (or the environment).

Q. I am trying to simulate a vehicle rolling backwards at a low speed and then accelerating in reverse, such as the situation of backing out of a driveway into the street. I'm using EDSMAC4 and finding that when I apply any throttle inputs, the vehicle accelerates forward and not in reverse. Is there a way to do this in EDSMAC or EDSMAC4?

A. In those physics programs, you can apply an initial velocity with a sideslip angle of 180 degrees to start the event with vehicle moving backwards, but you cannot accelerate the vehicle in reverse. To simulate that behavior, you will need to use the drivetrain model available in SIMON and shift the vehicle into reverse gear and apply throttle pedal force in order to accelerate in reverse.

**Visit the Support section of
www.edccorp.com for answers in
the Knowledge Base and also
the latest Downloads**

EDC Training Courses

EDC Reconstruction & Simulations

EDC offers excellent one-week courses on the use of the *EDCRASH* reconstruction program and the *EDSMAC*, *EDSMAC4*, *EDSVS* and *EDVTS* simulation programs. 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.

All 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.*

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.

Engineering Dynamics Corporation Training Course Schedule

EDC Simulations

Los Angeles, CA January 2015
Miami, FL November 11 - 15, 2013

EDC Reconstruction

Los Angeles, CA January 20 - 24, 2014
Miami, FL November 2014

Theoretical & Applied Vehicle Dynamics

Upon Request

2014 HVE FORUM

Southeastern USA . . February or March 2014

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.

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:

AccidentReconOnline.com - Online training courses and also the DiscoverHVE video tutorials and discussion group hosted by Wes Grimes of Collision Engineering Associates.

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