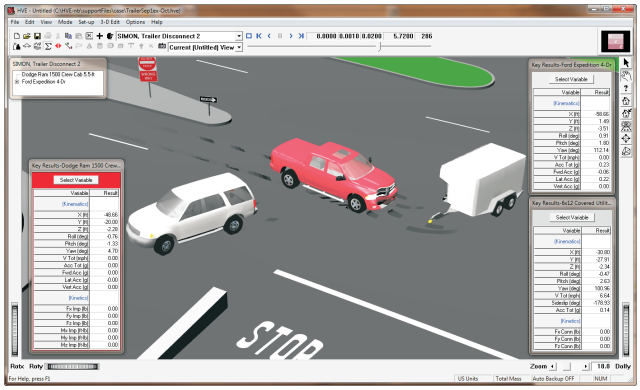
FALL 2012 ENGINEERING DYNAMICS CORPORATION

Technical Newsletter

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

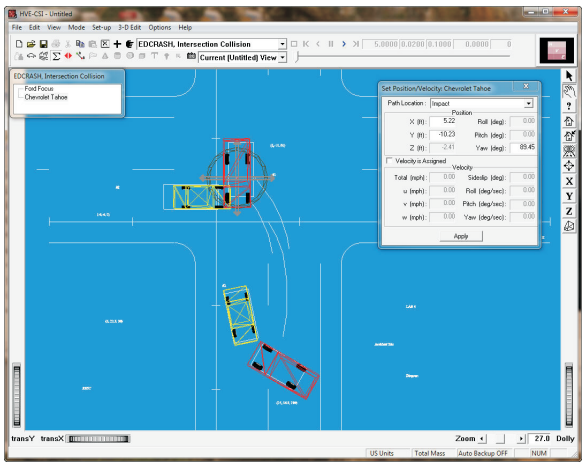
Version 9.10 - Now Available!

After months of extensive development and testing, Version 9.10 was released December 18, 2012. New features eagerly awaited by users include:

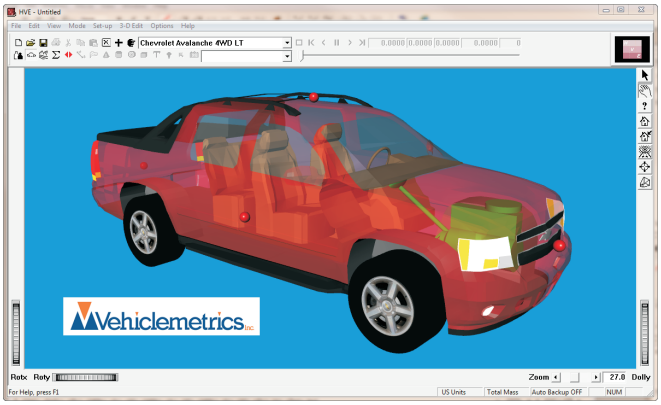


- ***SIMON* Trailer Separation -** Simulation of trailer disconnection resulting from mechanical failure or collision forces/moments is possible. The robust handling of the individual vehicles post-separation allows for detailed study of free-rolling trajectory, roll-over and collision with other objects.

- **Key Results In Video Creator -** The Video Creator viewer includes a Key Results window that displays time-domain results which are recorded directly in your simulation movie. The available Key Results include all the standard outputs (e.g., time, positions, velocities, accelerations, forces...).



- **DXF Support in *HVE-CSI* -** Users can choose between Aerial Photo or Terrain as environment models used in *HVE-CSI*. If Terrain is selected, an AutoCAD DXF format line drawing or 2-D surfaced model can be imported directly into the Environment Editor. This capability allows for quick placement of vehicles over scene evidence in *EDCRASH* reconstructions by switching to wireframe mode.



- **Third Party Vehicle Database License Manager -** License management of vehicles selected from a third party database provider, such as those available from Vehiclemetrics, is supported.

More information about these and other enhancements can be found online at www.edccorp.com/Version910.

Technical Session

Vehicles towing trailers can encounter conditions, such as a crash or rollover event, that cause extremely high forces and moments at the vehicle-trailer connection. When high enough, these forces and moments can result in the trailer separating from the tow vehicle. *HVE* Version 9.10 includes a new inter-vehicle connection model that allows articulated vehicles to become separated and, thus, move independently. This Technical Session provides the technical background and a brief tutorial for the new trailer separation model.

The fundamental basis for the trailer separation model comes from *SIMON*'s vehicle dynamics model, which has six equations of motion (X,Y,Z,Φ,Θ,Ψ) for each vehicle. Articulated vehicles (i.e., a tractor towing one or more trailers, or a passenger car towing a utility trailer) remain connected by a "constraint force" acting at the connection point between vehicles. This design is in contrast to some vehicle dynamics models that use an alternative approach wherein a trailer has only (Φ,Θ,Ψ) articulation degrees of freedom; X,Y,Z motion is not independent for a trailer, but is constrained by the tow vehicle's X,Y,Z motion.

While both of these design approaches work perfectly well for a set of articulated vehicles, the latter approach, lacking independent X,Y,Z equations for each vehicle, cannot be used when the vehicles become disconnected. This is where the "constraint force" approach shines: If you wish to model a trailer that has separated from its tow vehicle, simply remove the constraint force. The vehicles, having sufficient degrees of freedom to move independently, will do just that.

The new trailer separation model in *HVE* is really quite simple. It works as follows:

- The user sets a maximum allowable force and moment at each tow vehicle connection.
- During execution, the vehicle dynamics model (i.e., *SIMON*) calculates the inter-vehicle connection forces and moments (as it always has).
- If either the total force or moment at the connection exceeds the maximum allowable value set by the user, *SIMON* sets a flag indicating the connection has failed. From that point on, the constraint force and moment are set to zero and the vehicles, as a result, move independently.

Note that this model may be applied to a vehicle towing a single trailer or a vehicle train with any number of trailers. Connection failure may occur on trailer dolly connections as well. The model is very powerful because it is very simple.

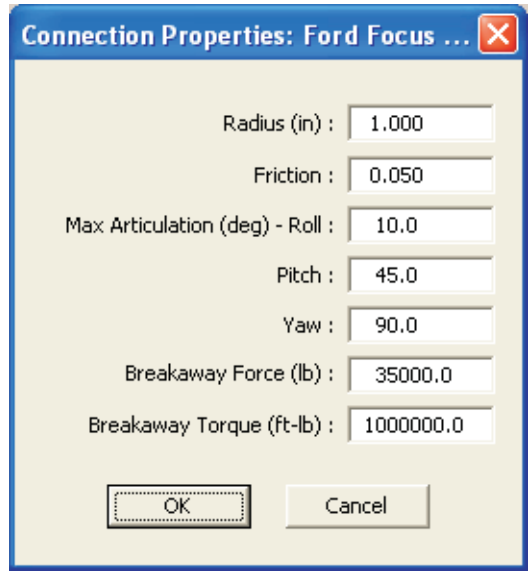


Figure 1 - Connection Properties dialog showing the new Breakaway Force and Breakaway Moment fields.

Details

HVE allows the user to model three different connection types:

- Ball/Hitch
- Pintle Hook/Eye
- Fifth Wheel/King Pin

These connection types behave slightly differently. All types will resist large forces in the x-y plane. However, a fifth wheel connection will virtually never fail under a compressive (downward) force; it will only fail in tension. The model takes that into account. A fifth wheel connection also transmits a roll moment, as well as a small frictional yaw moment as well. Thus, for practical reasons, only an excessive roll moment will produce a separation. However, the general failure mechanism will be tension or compression, not torsion.

After separation, the front of a typical utility-type trailer or semi-trailer will be unsupported, causing it to fall until it contacts the terrain. Because an unsupported trailer falls and interacts with the terrain, the motion is clearly 3-dimensional. This precludes simulating trailer separation in a 2-D physics model, such as *EDSMAC4*.

This contact is well modeled by *SIMON*/*DyMESH*. To simulate this contact requires using *DyMESH*'s Include Environment option. When modeled in this manner, the post-separation simulation (including rollover) of all trailer types is rigorous.

Implementation

To implement the trailer separation model, the only obvious addition to *HVE* is that the Vehicle Editor's Inter-vehicle Connections dialog has a new "Properties" section that allows the user to set the Breakaway Force and Breakaway Moment, as shown in Figure 1. The only change to *SIMON* was to compare at each simulation timestep the current inter-vehicle connection forces and moments with the breakaway force and moment, and to set a flag when the breakaway force and/or moment is exceeded. Once exceeded, the constraint force and moment are set to zero for the remainder of the simulation.

An Example

To illustrate the use of the new trailer separation model, we will use an event involving a vehicle towing a utility trailer that gets hit by an oncoming vehicle. The collision force separates the trailer, causing it to roll down an embankment. We will describe how to assign the breakaway forces and how to efficiently use the *DyMESH* Include Environment option. Let's begin.

We have created a case file with all the vehicles, environment and our sample event. Our sample case file uses vehicles from the Vehiclemetrics database*: a 2011 Ford Focus 4-Dr Sedan (tow vehicle), and a 2010 Chevrolet Avalanche LT (oncoming vehicle). A 5 x 8 Covered Utility Trailer was pulled from the EDC database. The case file includes an environment, a downhill 2-lane road with a cut bank on one side of the road and a downhill embankment on the other. Finally, the case file includes the *SIMON* simulation of the event.

When we execute the event, no trailer separation occurs. This is a result of the default values for Breakaway Force and Moment, which are set to extremely high values to prevent separation. To assign values for Breakaway Force that result in a connection failure, perform the following steps:

- Display your Key Results windows.
- In the 5 x 8 Utility Trailer's Key Results window, click on Select. The Variable Selection dialog is displayed.
- Choose the Connections output group, and select F_x, F_y and F_z to display the connection force in the Key Results window.

*The Vehiclemetrics database is an *HVE*-compatible vehicle database available from Vehiclemetrics, Inc. For information, call 855-966-3357 or go to www.VehicleMetrics.com.

- Replay the event, paying close attention to the connection forces during the collision. In our example, the peak force components are F_x = 23,303 lb_f, F_y = -26,172 lb_f, F_z = 1831 lb_f.
- Calculate the peak total force:

$$F_{Total} = \sqrt{F_x^2 + F_y^2 + F_z^2}$$

$$= 35{,}091 \text{ lb}$$

Setting the Breakaway Force below this value will result in trailer separation.

- Go to the Vehicle Editor.
- Choose the Ford Focus (i.e., the tow vehicle) as the current vehicle.
- Click on the CG icon and choose Connections. The Connections dialog is displayed.
- Click Properties. The Connection Properties are displayed, including the Breakaway Force and Moment.
- Change the Breakaway Force from its default value to a value slightly less than the peak force (determined above), say 35,000 lb_f.
- Press *OK* to close the Properties dialog, then press *OK* again to close the Connection dialog.

NOTE: There is no need to edit the Breakaway Torque. As described earlier, separation will occur if either the connection force or moment exceeds the breakaway value.

- Return to the Event Editor.
- Choose Options, *DyMESH*, to display the *DyMESH* options dialog.
- Click the Include Environment checkbox.

Using the Include Environment option will cause *DyMESH* to simulate the interaction between the trailer and the terrain after separation. We waited until now to include the environment because including the environment in the *DyMESH* calculations increases the amount of work for *DyMESH*, thus increasing the calculation time.

- Reset and re-execute the event.

Watch the sequence as the collision occurs and the trailer separates from the tow vehicle, rolling off the road and down the embankment. Also note the connection force in the Key Results window as it increases quickly during impact, then drops to zero when separation occurs.

Discussion

One might think testing of the connection strength would be important for setting the breakaway force/moment. However, from a reconstruction standpoint, that approach is completely unworkable.

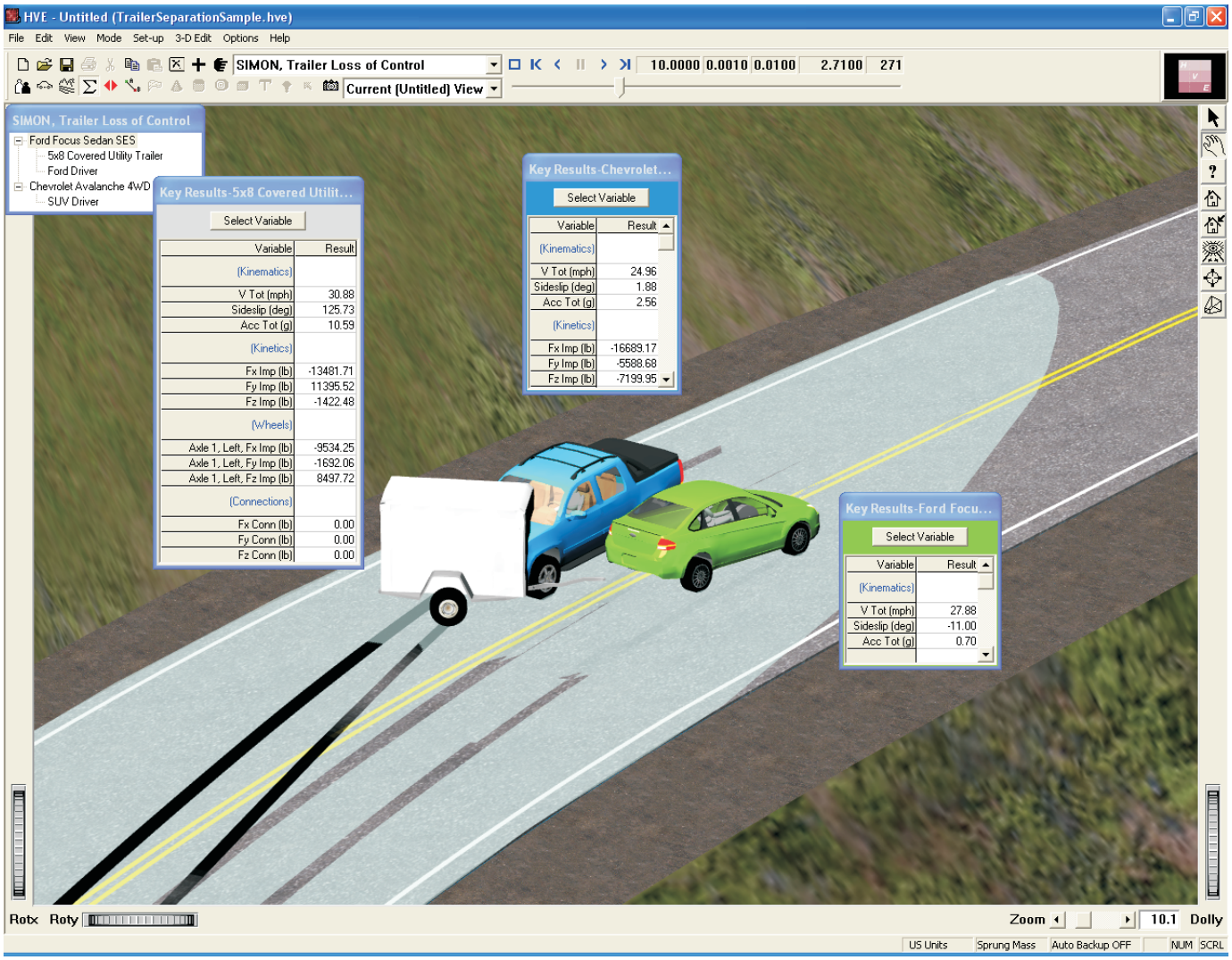


Figure 2 - *SIMON* event illustrating a trailer separation occurring as a result of impact.

First, it would generally be cost-prohibitive. Second, the required test set-up would be unknown because the exact direction of forces and moments during the actual event is unknown. And finally, any variation between the test set-up and the actual event (the perfect test does not exist) would render the test results useless. The only reasonable approach for setting the breakaway force/moment is to assign them a priori, that is, to use a breakaway force and/or moment that results in the observed vehicle behavior.

Summary

In summary, using the new trailer separation model is very easy:

- Execute the simulation, noting the magnitude of the trailer connection forces.
- Interrupt the simulation at the desired point of separation and observe the current connection force.
- Set the tow vehicle connection breakaway force slightly below the observed connection force.
- Use the Include Environment *DyMESH* option.
- Re-execute the event.

The ability to simulate trailer separation is a powerful and useful extension to *HVE*.

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!

Adding Key Results to Your Simulation Movies

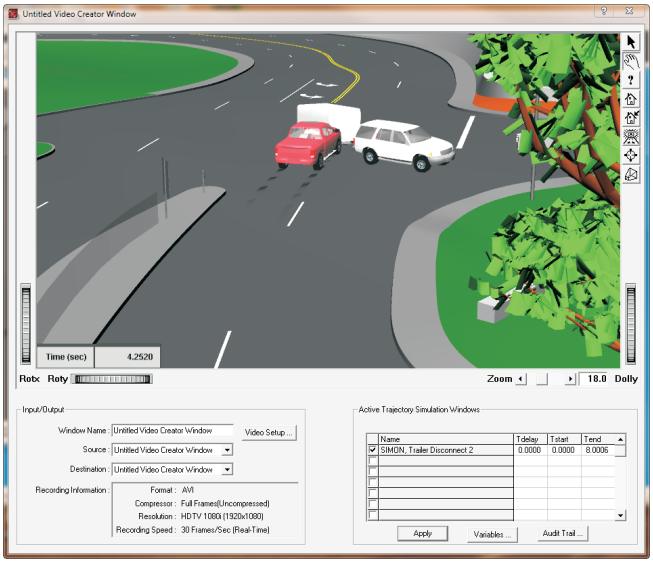
In Version 9.10, an enhancement to the Video Creator allows you to display and record Key Results directly in your simulation movies. The process of selecting and displaying the variables is identical to that used in the Event Editor and for the Variable Output report.

In the Playback Editor, first select *Options* and verify that *Show Key Results* is checked. Next, add the *Traj Sim* for the event. Then select *File*, *Video Creator* to open the Video Creator window, as shown below.

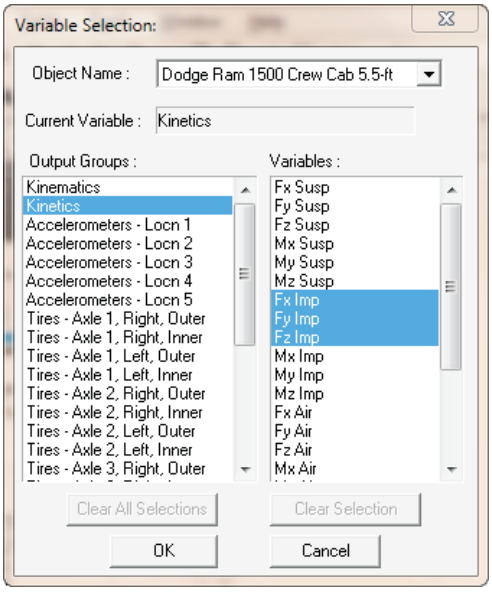
Just below the Active Trajectory Simulations table in the Video Creator, click the *Variables* button to display the Variable Selection dialog. Select the desired human or vehicle from the dropdown list and then select all of the variables that you want to display on the screen. Close the dialog and the current simulation time and your selected values will appear in the semi-transparent table in the lower left corner of the viewer.

To move the Key Results table to another location in the viewer, use the buttons on the right hand side of the viewer to change from Manipulate to Pick mode (if necessary). Then, left-click on the Key Results table and drag it to a new location.

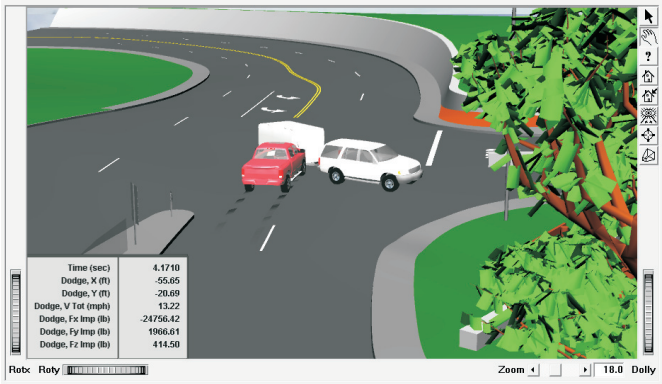
Users have been eagerly awaiting this enhancement, especially those that have used external video editing programs to overlay results in their movies. It's now integrated directly in the Video Creator, so try it out!



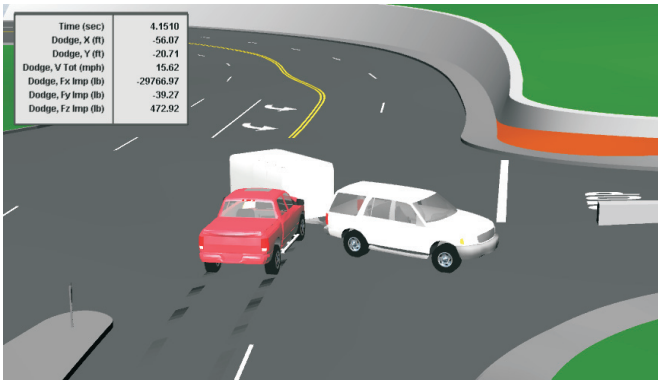
Video Creator with the initial variable display table in the lower left corner of the viewer displaying the current time.



Key Results Variable Selection dialog in the Video Creator used to select and display the important variables that support the visualized motions in your simulation movie.



Close-up of Video Creator viewer showing the Key Results table in the default lower left corner and also the right-hand side buttons to change from Manipulate to Pick mode.



Screenshot from the simulation movie showing the Key Results table has been moved to the upper left corner of the viewer.

2013 *HVE* Forum

March 11 - 15, 2013
Westin Gaslamp Quarter
San Diego, California

The 2013 *HVE* Forum is where you will learn how to use the latest features and capabilities of *HVE*, *HVE-2D* and *HVE-CSI*. An excellent selection of workshops is available, designed for beginning, intermediate and advanced users. In addition, the Forum has User's Group meetings, the *HVE* White Paper Session and interactive networking social hours at the end of each day. Another great benefit is pre-approval for 20 - 35 ACTAR credits depending upon your workshop selections for the week.

A schedule of events, detailed workshop information, registration forms and a custom link to make your room reservations at a special rate directly with the Westin Gaslamp Quarter hotel are available on the EDC website at www.edccorp.com/2013HVEForum.

Since the Early Registration schedule was posted, a workshop series designed for new users and a specialty workshop for more experienced users have been added to the schedule for the 2013 *HVE* Forum:

Simulation Fundamentals

This workshop series is designed for the new user who wants a basic understanding of how simulation programs can help them investigate vehicle crashes and loss-of-control scenarios. Through a combination of lectures and hands-on computer labs, the student will learn how *HVE*-compatible simulation programs model vehicle behavior using physics to predict vehicle trajectories based upon user entered vehicle and environmental factors, initial conditions and driver inputs. *EDSMAC4* will be used extensively in these workshops.

Topics to be covered include:

- Anatomy of a Simulation
- Inputs
- Outputs
- Tire Model
- Tire Force Calculations
- Friction Circle
- Vehicle Connections
- Collision Model
- Driver Controls

Advanced Video Techniques

This workshop is for the user who is already familiar with creating simulation movies in *HVE* and wants to learn advanced techniques to enhance their *HVE* videos. Extended uses for *EDGEN* beyond vehicle kinematics will also be demonstrated.

The following material is covered:

- Extracting frames from *HVE* videos
- Adding text and graphics to frames
- Adding timers, speedometers, or distance markers to *HVE* videos
- Using *EDGEN* to create illustrative icons
- Merging graphics or videos using blue screens
- Adding title slides to videos

Note: A portion of this workshop uses Adobe Premier to illustrate enhancement concepts that must be performed using other video editing software tools in conjunction with *HVE* outputs.

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. Why does the Peak Acceleration value on the Damage Data report from my EDSMAC4 event not match the values shown in the time based Variable Output report?

A. When you ran the *EDSMAC4* event, did you notice a message at the end of the run that said "Warning: The output interval is rather large for a collision simulation. Important collision pulse data may be missing."? This message is designed to help you remember to reduce the Output Time Interval for collision simulations from the default value of 0.1 sec to a value of 0.02 sec or smaller (ideally 0.001 sec) if you want to correctly view time-domain reports in Playback such as Variable Output and *DamageStudio*.

Alpha-numeric output reports, such as the Damage Data report, are created when the event is executed, and are based directly on the current integration timestep. Time-domain reports, such as Variable Output, are based on the current Output Time Interval setting, which is normally larger than the integration timestep. Thus, the peak acceleration (and other dynamic variables) may be “filtered out” by the (coarser) Output Time Interval.

Q. I am not seeing any response of the vehicle to a modified friction factor of a section of the road in my terrain model. I am carefully watching the output variable for Mu (surf) and it isn't showing that the tire sees the changed friction factor. Why might this be happening?

A. One of the most common answers to this question is that your terrain model has the surface normal of that section of roadway pointing away from the tire. In the 3D Editor workshop at the *HVE* Forum, one of the topics covered explains how the *GetSurfaceInfo* routine determines the current terrain model attributes below each tire to use in the calculations, and the tire needs to see the surface normal of a polygon pointing directly back at the tire. If the normal is pointing away from the tire, it will not see any attributes of that surface.

Q. I am trying to open a recent casefile that I was just working on, but I am now getting a message that says the file is unreadable. What can I do?

A. If the file is unreadable, an error occurred during the most recent file save. If you have AutoBackup turned on, you may be able to go into the Temp folder inside the *HVE* folder and locate a recently saved version of that case. Only the last 10 or so backup files are saved in this folder, so if it has been a long time since you last worked on the file it may not available. Version 9.10 contains a more robust case file saving routine that helps to prevent case file corruption issues.

Q. I want to have a human driver in both vehicles in a SIMON simulation. However, when I try to create the event by selecting each vehicle and its human driver and press the OK button on the Event Information dialog, I get an error message. What am I doing wrong?

A. This is a bug, but there is a workaround. At this time, a *SIMON* event needs to have each human assigned to a different vehicle location. When you add humans in the Human Editor, one of the selection options is *Location*. If you select a different location for each human, you will be able to create the event as expected. When you position the human in the vehicle within the event, it can be located anywhere within the vehicle, no matter what the Location was in the Human Editor. Remember that a human in *SIMON* is treated simply as a payload. There are no forces, accelerations, or mechanics calculated for the human, so its motion is not simulated. You would need to use an occupant simulation program such as GATB for that type of work.

Q. How can I easily display the upper left and lower right coordinates of the Aerial Photo used as the environment model in my EDSMAC4 event?

A. The Environment Data report in the Playback Editor now displays the Aerial Photo surface coordinates.

Q. I'm trying to determine the effects of changes in vehicle stiffness coefficients in a SIMON/DyMESH event by going back to the Vehicle Editor and changing the values for A & B in the Stiffness dialog, but I'm not seeing the changed values reported in the Vehicle Data report. What might I be doing wrong?

A. In *HVE*, the new Vehicle Exterior Stiffness dialog has a Type selection for 2-D or 3-D. When 2-D is selected, only the classic A and B values are available to edit. When 3-D is selected, the coefficients for a full quadratic stiffness behavior are available. In *HVE*, it is important to remember that *EDSMAC4* uses values from the 2-D setting, while *SIMON/DyMESH* uses values from the 3-D setting.

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 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.*

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 14 - 18, 2013
Miami, FL . . . . . November 11 - 15, 2013

EDC Reconstruction

Los Angeles, CA . . . . . January 2014
Miami, FL . . . . . November 2014

Theoretical & Applied Vehicle Dynamics

Upon Request

2013 *HVE* FORUM

San Diego, CA . . . . . March 11 - 15, 2013

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:

Yahoo - tech.groups.yahoo.com/group/HVErecon - Discussion group hosted by Beck Forensics, Inc.

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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