EOC Technical Newsletter

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HVE & *HVE-2D* Version 5.10 - Now Available

After completing an extensive field testing process and a final evaluation by attendees to the 2006 *HVE* Forum, *HVE* and *HVE-2D* Version 5.10 were released on March 3, 2006. All users with current Update/Technical Support policies were shipped their updates before the end of March.

The update package included a CD (containing the Version 5.10 update software and user's license file), a new set of User's and Physics manuals, and also a detailed set of Release Notes identifying the new features, enhancements, and bug-fixes implemented in the software since Version 5.00.

A few of the important changes noted in the Release Notes are:

* Additional Tire Model options are now available in *SIMON*, including the Radial Spring, Soft Soil and Sidewall Impact models.
* Event Status is now displayed in the Report Information dialog in the Playback Editor.
* An off-screen renderer is now used for the recording of AVI simulation movies from the Playback Window.
* The Vehicle Editor in *HVE-2D* now includes additional parameters in the Tire Information dialog and also an Truck Air Brake Data dialog to support new applications.
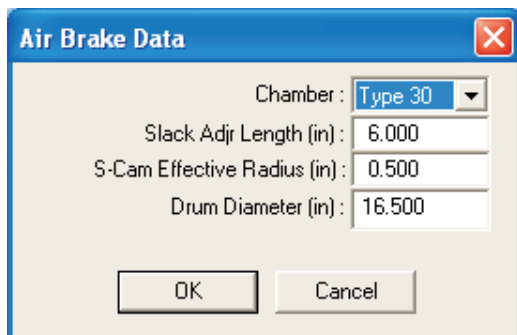
The Air Brake Data dialog is available for Heavy Trucks displayed in the Vehicle Editor in *HVE-2D*. The data fields provide for selecting the appropriate s-cam brake assembly fitted to that wheel location on the vehicle.

* The Inertias dialog now includes a new user-selectable option that updates rotational inertia when weight is changed.
* The Get Surface Info option has been moved from the Calculation Options dialog into its own dialog available under the main menu Options selection.
* *EDVDB* Vehicle Database - 75 vehicles, ranging from passenger cars to heavy trucks and trailers (such as the 1993-1996 Dodge Colt, the 1999-2004 Freightliner Columbia and the 2001 Wabash Flatbed Trailer) were added to the *EDVDB* vehicle database. Additionally, one light truck tire, three passenger car tires, and four heavy truck tires were also added to the database.

Users are strongly encouraged to review the entire set of Release Notes to be aware of all changes to their software. There have been several changes that may affect results of cases from previous versions.
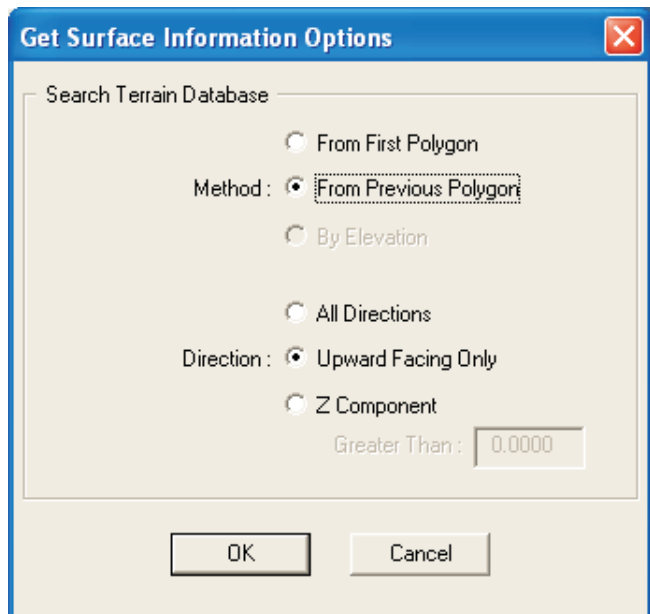
The new Get Surface Information Options dialog contains the Get Surface Info option and a new Search Direction option when looking for polygon surface normals that allows the simulation of more general vehicle motion in *HVE*, such as when using *SIMON* to simulate a "loop-de-loop".

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Technical Session

Most of you have been using simulation (e.g., *EDSMAC4*, *SIMON*, *EDVTS*…) for several years, yet to many the inner workings remain somewhat mysterious. This Technical Session describes the inner workings of a simulation. We call this the *Anatomy of a Simulation*.

But first, let's talk about the inputs and outputs for a typical vehicle simulation.

Inputs

The typical simulation input parameters are:

Vehicle Data – Dimensions and inertias, tire-road friction, stiffness coefficients (for collision simulations) and possibly other parameters, depending on the complexity of the model (e.g., suspension, steering and braking system and drivetrain data may be used by 3-D simulations).

Environment Data – A physical model of the road surface. This may be as simple as a flat, horizontal plane or a complex, 3-dimensional terrain with varying friction.

Event Data – Initial position and velocity (minimum requirement for all vehicle simulations), driver steering, braking and throttle tables, and possibly other parameters, again depending on the complexity of the simulation model.

Simulation Controls – Time intervals for calculations and for outputting simulation results.

Outputs

The typical simulation output results are:

  ➢ Kinematics (path position, velocity, acceleration)
  ➢ Kinetics (summation of forces, moments acting on vehicle)
  ➢ Tire (forces at each tire contact patch)

Simulations operate in the time domain. That simply means that the above output results are calculated and output at regular, user-defined output intervals as the vehicle moves along its path from its initial position to its final/rest position. This fact makes simulations ideal for visualizing a vehicle's motion during an accident sequence. Simulation provides the benefit of being able to pick any point along the vehicle's path and state the forces that caused it to be there (as opposed to animation, wherein a vehicle's position is at the sole discretion of the animator).

Anatomy of a Simulation

All simulation models, whether you're simulating a vehicle, a human or a tropical storm, include four basic components. These components are:

  ➢ Control Routine
  ➢ Numerical Integration Routine
  ➢ Physical Model
  ➢ Derivatives Routine

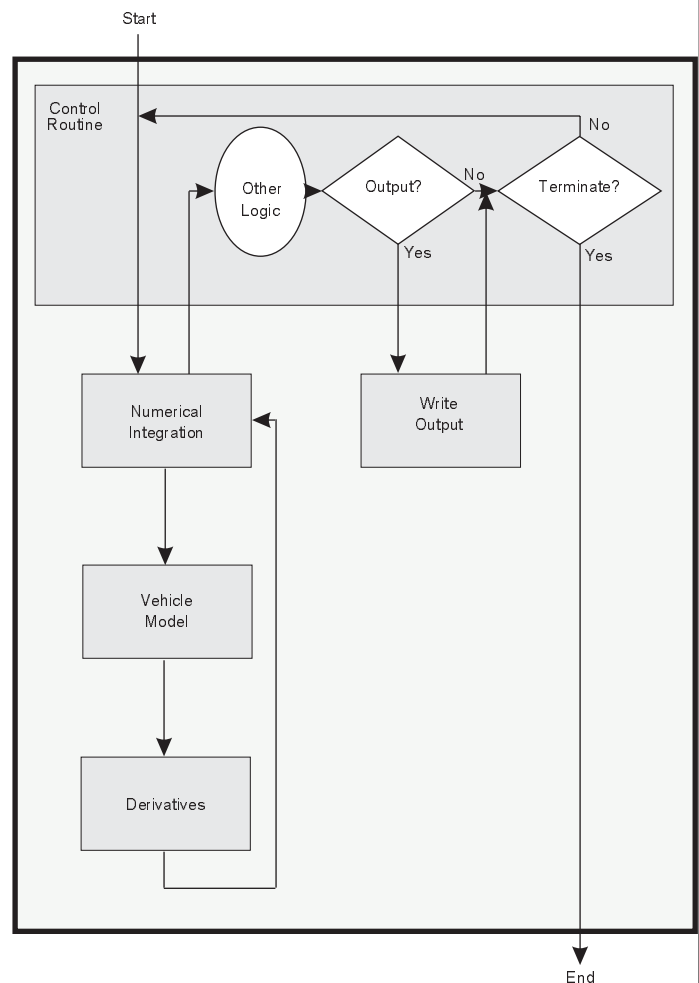These four basic components are shown in Figure 1.

Figure 1 - Anatomy of a Simulation

Control Routine

As its name implies, the control routine controls the flow of execution, making logical decisions, such as when it is time to output the current results and when to terminate the run. But the most important task of the control routine is simply to pass program control to the numerical integration routine.

Numerical Integration Routine

We mentioned that simulations operate in the time domain. Given the current simulation time, *t,* numerical integration calculates the vehicle position and velocity after a small time interval, Δt. In simple terms, the position at time $t + \Delta t$ is:

$$S(t_0 + \Delta t) = S_{t_0} + v\Delta t$$

and the velocity at time t + Δt is

$$V(t_0 + \Delta t) = V_{t_0} + a\Delta t$$

where

S = position (typically *X, Y* and Ψ for a 2-D simulation)

V = velocity (typically u (forward), v (lateral) and $\dot{\Psi}$ (angular) for a 2-D simulation)

a = acceleration (typically $\dot{u}$ (forward), $\dot{v}$ (lateral) and $\ddot{\Psi}$ (angular) for a 2-D simulation)

t = current simulation time

Δt =calculation time interval (typically 0.02 seconds for a 2-D simulation)

Actually, anyone who has studied numerical integration knows it's not quite that simple. But it is useful to know that, regardless of how sophisticated or complex the numerical integration routine may be, the process boils down to the process described by the above equations.

We provided the initial position, *S*, and the initial velocity, *V,* as part of our inputs (see Event Data, above). We provided the time interval, Δt, as well (see Simulation Controls, above). But where does the acceleration, *a*, come from? For that, we next require a vehicle model.

Vehicle Model

The vehicle model (see Figure 2) is defined by the vehicle's wheelbase and track width (actually, the wheel locations relative to the vehicle CG) and its weight, W, and yaw rotational inertia, I_z. If the simulation includes a collision, exterior dimensions and stiffness are also required.

The vehicle model also includes a tire model that calculates the forces acting at each tire. Although tire models can be quite complex, those used by 2-D simulations are relatively simple and require tire data (cornering and friction properties), tire slip angle and vertical tire load. Slip angle and vertical load must be calculated for the current timestep. The outputs from the tire model are the *Fx* and *Fy* forces currently produced at each tire.
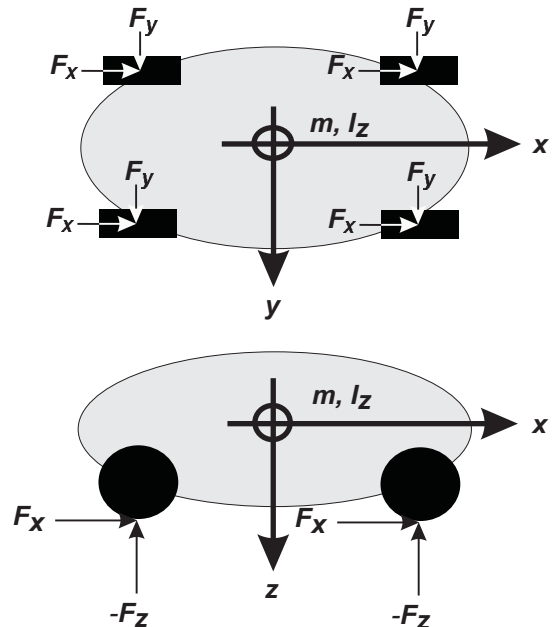

Figure 2 - Mathematical/physical model of a vehicle

If a collision is simulated, a collision model is also required. Although there are a number of ways this can be done, a collision model always boils down to calculating the force acting on the vehicle's crushed exterior. F_x and F_y crush forces are calculated at specified points along the damage profile based on Hooke's law:

$$F = kx$$

where

k = vehicle crush stiffness coefficient

x = displacement (crush)

Other forces may also be modeled (e.g., aerodynamic forces, connection forces for trailers).

Regardless of the number and type of forces considered, the output from the vehicle model is the total sum of all forces (tire + collision + …) acting at the vehicle's CG, and the total moment (rotational torque produced by all of these forces) about the CG. Mathematically, we have:

ΣF_x = sum of forces in x direction

ΣF_y = sum of forces in y direction

ΣM_z = sum of moments about z (vertical) axis

Derivatives Routine

The final step is easy. Given the total forces and moment acting on the vehicle, along with the vehicle mass (weight/g) and rotational inertia, we use Newton's 2nd law to calculate the accelerations. In general, $\Sigma F = ma$. We can rearrange this to get the forward, lateral and angular accelerations:

$$a_x = \frac{\Sigma F_x}{m}$$

$$a_y = \frac{\Sigma F_y}{m}$$

$$\ddot{\Psi} = \frac{\Sigma M_z}{I_z}$$

where

$\ddot{\Psi}$ = angular acceleration about the vertical (z) axis

One minor complication: Because we calculated the accelerations in a rotating reference frame (i.e., the vehicle), we need to transform the linear accelerations back to an inertial reference frame (i.e., the earth):

$$\dot{u} = a_x + v\dot{\Psi}$$

$$\dot{v} = a_y - u\dot{\Psi}$$

(Angular acceleration, $\ddot{\Psi}$, is the same in both reference frames.)

Back to Numerical Integration

The above accelerations are used by the numerical integration routine (refer back to the last part of Numerical Integration, above) to calculate the position and velocity at the end of the time interval, Δt. Since the vehicle can move in three directions (X, Y and Ψ), we need to calculate three new position components:

$$X(t_0 + \Delta t) = X_{t_0} + u\Delta t$$

$$Y(t_0 + \Delta t) = Y_{t_0} + v\Delta t$$

$$\Psi(t_0 + \Delta t) = \Psi_{t_0} + \dot{\Psi}\Delta t$$

and velocity components:

$$u(t_0 + \Delta t) = u_{t_0} + \dot{u}\Delta t$$

$$v(t_0 + \Delta t) = v_{t_0} + \dot{v}\Delta t$$

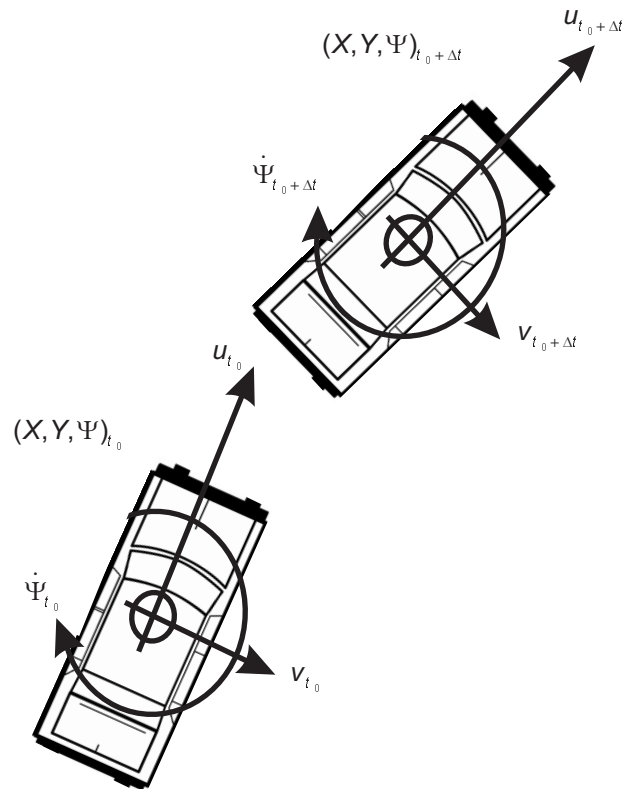$$\dot{\Psi}(t_0 + \Delta t) = \dot{\Psi}_{t_0} + \ddot{\Psi}\Delta t$$

Figure 3 - Vehicle position and velocity at t_0 and after time interval, Δt.

We now have the position and velocity of the vehicle after time interval, Δt (see Figure 3). So we are done for the current time interval and we're ready (i.e., we have the initial position and velocity) for the start of the next time interval. Control returns to the control routine (see Figure 1).

Back to Control Routine

Referring again to Figure 1, we have returned to the control routine. The control routine checks for termination conditions, time for output, as well as any other issues related to overall program flow. Unless we have a termination condition (which causes the program to exit), the control routine again passes the baton to the numerical integration routine and the process continues.

And So On…

A key observation is that the calculation sequence in a simulation program is very repetitive. The above process continues in a loop, marching forward during each calculation time interval to update the position and velocity of the vehicle until a termination condition is reached (usually the vehicle comes to rest).

2006 *HVE* FORUM RECAP

The 2006 *HVE* Forum was an excellent event once again according to attendees. The workshops, presentations and social hours were of great benefit to all users, no matter what level of experience they had.

New topics were covered in the Advanced *HVE* workshops, such as "Further techniques for setting vehicle stiffness parameters when using *DyMESH* for side-impact collisions", "Using the new Tire-Terrain models to study a curb-trip rollover using *SIMON*", "How to model vehicle - terrain interaction to analyze an overturn using *SIMON* and *DyMESH"* and *"*Using GBF results in *EDSMAC4* to help avoid significant errors from just assuming a certain deceleration rate for a heavy truck". We anticipate completely full Advanced *HVE* workshops at the 2007 *HVE* Forum, especially since the workshop evaluations indicated that over half of the attendees plan to attend again next year!

The Special Topic "Producing High-Quality Outputs From *HVE* & *HVE-2D*" showed users how to enhance the presentation of their simulations with techniques such as "How to overlay a timer and data from the *HVE* run onto video output", "How to overlay two or more different *HVE* runs on a video to show the differences in the runs" and "How to place "ghost" vehicles along the vehicle path in a movie". Don't miss the Special Topic next year!

HVE White Paper Session

The following White Papers are now available to download directly from the Library of the EDC website:

WP-2006-1 **"Presentation of *HVE* Validation Studies",** Eric Deyerl, P.E. - Quan, Smith and Associates, Fawzi P. Bayan, P.E., Anthony D. Cornetto, III, P.E. and Jonathan Anderson - SEA, Ltd.

WP-2006-2 **"Tractor-Semitrailer Handling Analysis Using *EDVDS* and *EDVTS"*,** Daniel A. Fittanto, M.S., P.E. and Louis V. Inendino, M.S., P.E. - Ruhl Forensic, Inc.

2006 Users' Wish Lists

Here are the results of the Wish Lists developed in the *HVE* and *HVE-2D* User's Group Meetings:

HVE Users' Top 10 Wish List

1. Add "Copy to Other Axle" on Tandem Axles
2. Visualize connections in Vehicle Editor
3. Automate Connection Z height values between vehicles for *EDSMAC4* events
4. Select same variable for all wheels in Key Results/Variable Output
5. Change defaults in Language.rsc actively within *HVE*, like Options, Preferences.
6. Allow Preferences for Key Results defaults.
7. Retain Previous Camera View
8. Surface Info From Friction Zone
9. Incorporate Tire Test Data
10. Many more than eight target positions

HVE-2D Users' Top 10 Wish List

1. Open browsers to previously selected folder
2. Cursor coordinate display
3. Undo
4. Append *HVE* Driver with Driver Steer Table
5. Ability to scale .jpg image as background (eliminate need to build surface and attach texture)
6. Output steer angle at steering wheel and axle, and include steering gear ratio in output report
7. Friction zone use notification in environment report
8. Optional time and date of report (and user name) in printed reports and also remove uneditable data
9. Measure tool in Event Editor (angle and distance)
10. Create *EDSMAC(4)* event from *EDCRASH* output, just like *EDVAP* (Rest positions as targets)

2007 *HVE* Forum San Antonio, TX

The 2007 *HVE* Forum is set for February 26 - March 2, 2007, at the Hilton Palacio del Rio hotel, located on the famous River Walk in downtown San Antonio, just two blocks away from the Alamo. A special room rate of $169/night has been arranged for attendees to the 2007 *HVE* Forum. Workshop schedules, descriptions and registration forms will be available to download from the EDC website this summer. See you in San Antonio in 2007!

Importing DXF Files Into *HVE* and *HVE-2D*

The release of AutoCAD 2007 has created an increase of Technical Support questions related to importing DXF geometries into *HVE* and *HVE-2D*. The reasons for these questions appear to be that AutoCAD 2007 does not support the output of R14 DXF files, but it can produce R12 or R2000 DXF files. Additionally, there are new features/abilities in AutoCAD 2007 that may not easily revert to an older DXF format which may cause "errors" to occur when trying to import the DXF into *HVE*.

When you import a DXF file, you are using the dxf2iv.exe application (supplied with both *HVE* and *HVE-2D*) which is a translator that converts DXF entities to Open Inventor 2.0 (.iv) format entities. This translator is AutoCAD R14 DXF compatible, meaning the entities supported for conversion are best recognized if the DXF file is in R14 "language". AutoCAD R12 and R2000 DXF formats may also be converted using the translator, but errors may occur during the conversion.

Here are some tips that can help users get their DXF files imported successfully into *HVE* and *HVE-2D*:

➢ You should have the WCS origin (0,0,0) in your CAD model located somewhere convenient to your simulation/reconstruction work area. The WCS origin of your CAD model will be the Environment X=0, Y=0, Z=0, which corresponds to the X,Y position where your vehicles first appear when setting-up your simulation or reconstruction event. If you have your CAD entities located a long distance (such as 5000 feet) from the WCS origin, you will not easily find your environment or your event vehicle positions when first displayed in *HVE*. In fact, if the objects are too far away from the WCS origin, the file may not be converted through the translator at all!

➢ If you find that your DXF file is imported but it is missing several lines or objects of the original model, try "exploding" the model before exporting out as a DXF. This is especially true for blocks.

➢ If you receive an "Assertion Failed" message from the translator during the import, press *Ignore* on the message dialog and continue with the translation process. This will allow the translator to skip the incompatible entities within the file. When the translation process is complete and your model is displayed in the Environment Editor, compatible objects that have been converted properly will be visible. To get your missing entities to appear, you will need to return to your CAD program and re-create those objects using a different technique than before in an effort to make them compatible with the translator.

➢ Remember to use the *Options* button on the Environment Information dialog to "Flip about the X axis" and to "Scale" the DXF file to match the *HVE* scale and orientation.

GBF Now Available for *HVE* and *HVE-2D*

Collision Engineering Associates has introduced GBF (Graphical Brake Forces), a new *HVE* and *HVE-2D* compatible program used to accurately determine the stopping distance and deceleration rate of a heavy truck, or tractor-trailer equipped with s-cam air brakes. This program is used to accurately determine the stopping distance and deceleration rate of a heavy truck, or tractor-trailer equipped with s-cam air brakes. GBF uses the mechanical properties and dimensions of the s-cam system to calculate the brake forces generated. Using the tire size, weight on the axle, and coefficient of friction, GBF determines the deceleration rate of the vehicle during a braking event. GBF includes the dynamic effects that occur during a stop, which are very difficult to complete in a hand-calculation. These dynamic effects include the stretching and expansion which occurs due to the temperature build-up and time it takes to stop. In addition, GBF includes the overall temperature effects on the s-cam system. ABS systems are supported by using an average air pressure drop during brake cycling.

Special introductory discount pricing is only available until June 1, 2006. For more information, contact Collision Engineering Associates at 480-655-0399.

Career Opportunities

Engineering Dynamics Corporation is seeking an automotive or mechanical engineer with MFC (C++) programming experience. Job involves UI programming and creating virtual vehicles for 3D simulation. Applicant must be a self-starter, well-organized, and enjoy wearing many hats while working in a small office.

For consideration, send your resume to EDC, 8625 SW Cascade Blvd., Suite 200, Beaverton, OR 97008 or by email to employment@edccorp.com. Additional details about this position can be found on the EDC website at edccorp.com/about/employ.html.

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'm using Version 5.10 and I find that occasionally I am unable to adjust the view in the Event Editor. I switch Editors and find that I still am not able to adjust the view. It appears that the viewer controls have become locked and cannot be adjusted. What do I do to "unlock" my viewer controls?

A: If you find that your viewer has become frozen, the best steps to follow is to save your current work, exit *HVE* (or *HVE-2D*), restart *HVE* (or *HVE-2D*) and then open your case file and continue working. A few users have reported this "viewer freeze" may happen occasionally on certain computers in their office when using Version 5.10. It appears to be related to a graphics card driver, but the exact cause has not been determined yet. There have been no reports of crashes or lost data related to the "frozen viewer". This issue will be corrected in a future release.

Q. I'm using EDSMAC4 in HVE and I am trying to study the effects of changing the Slide Friction properties of the tires on one of the vehicles. I am selecting the Tires in the Vehicle Editor, then selecting Friction on the menu and then editing the Slide Friction value displayed on the dialog. I'm doing it for all tires on the vehicle. I'm then returning to the Event Editor, resetting and running the event, but I do not see any changes in my results. Is there something I'm doing wrong?

A. You are simply not adjusting the correct data field for the Slide Friction tire properties used in *EDSMAC4* simulations. You need to do one additional step in the Friction dialog before you edit the Slide Friction value, and that is to click on the Load drop down list near the middle of the dialog and select the "middle" value on the list. Then when you adjust the Slide Friction, you will be adjusting the value used in *EDSMAC4* calculations.

The Tire Properties dialogs in *HVE* allow data entries for multiple loads and multiple speeds depending upon the available test data for the tire. For example, all Passenger Car tires in *HVE* have properties available for three different loads. Full 3-D simulation models such as *SIMON* use the values for all speeds and loads, but *EDSMAC4* uses just the values for what is referred to as the " middle load". If you want to see exactly what values from the Vehicle Editor are used in the calculations, look at the Vehicle Data report in the Playback Editor.

Q. I'm using the new Driver Control for the HVE Driver Model in an EDSMAC4 simulation involving a collision between two vehicles. The event terminates every time at the point of impact with a message indicating "Exceeded the Driver Comfort Level"? I've increased the Driver Comfort Level to the maximum of 2 g's, but the event still terminates with that message. What is happening?

A. You are using the *HVE* Driver Model in a situation that it was not designed for (i.e. a collision). The *HVE* Driver Model was included in *EDSMAC4* to allow the study of driver steering inputs required to negotiate an assigned path, such as the trajectory of a vehicle under the full control of the driver, possibly prior to loss-of-control or a crash. In your event, the collision with another vehicle results in an abrupt change of conditions which are not appropriate for further use of the *HVE* Driver Model. You have to have separate events for your *HVE* Driver studies and your collisions.

Version 5.10 and Your Internet Security Firewall

If after installing Version 5.10 you cannot create or execute events, it's most likely that you have a firewall application, such as Norton Internet Security or Zone Alarm, that is "blocking" the hve.exe or physics.exe files from communicating with each other.

To correct your problem, you need to configure your firewall to "Allow" or "Permit" the hve.exe and all physics.exe files. Try following these general steps: Open your application and choose to configure your firewall. Search the existing programs list and see if hve.exe or any of the physics are listed as blocked applications. If so, change their setting to "permit" or "allow". If you do not find them in the list, add them to the list. You will find the hve.exe file in the hve or hve2d program folder. You will find the physics.exe files in the supportFiles/calcMethods folder. Add them and "permit" them to run. You should now be able to start up Version 5.10 and find that you can create and execute events now.

Downloads and F.A.Q.'s Available on 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 this page to search for answers to your questions before contacting Technical Support for assistance.

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 2007

EDC Reconstruction

Los Angeles, CA . . . . January 2008

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

Theoretical & Applied Vehicle Dynamics

TBD. . . . . Fall 2006

2007 *HVE* FORUM

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

Vehicle Dynamics

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

Hands-on Training

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

Course Registration

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

Related Training Courses

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