SUMMER 2015 ENGINEERING DYNAMICS CORPORATION

Technical Newsletter

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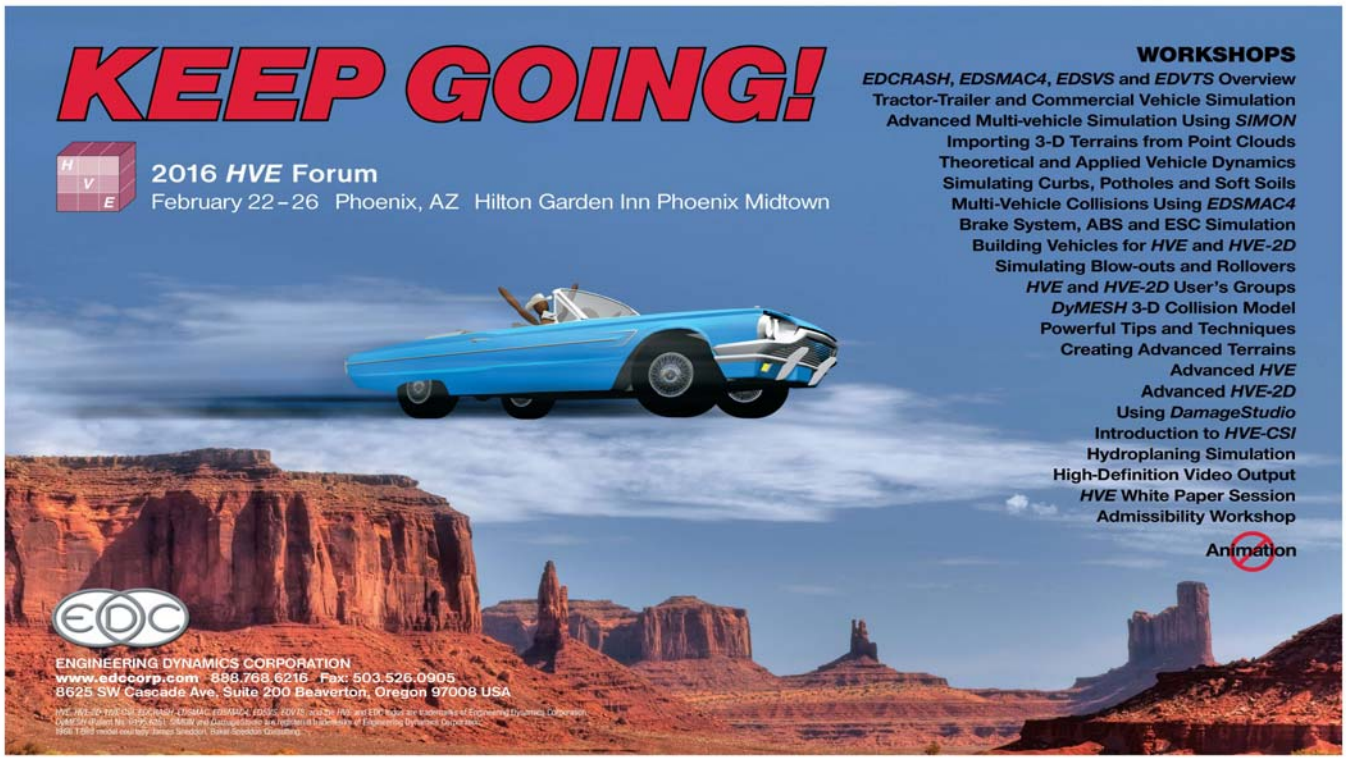

By the Time You Get to Phoenix...

The 2016 *HVE* Forum will be held in Phoenix, Arizona, during the week of February 22-26 at the Hilton Garden Inn Downtown. Make sure to mark your calendars!

The *HVE* Forum is the premier event for *HVE* users, with more than 30 workshops, each focusing on specific *HVE* and *HVE-2D* program features. Workshops are designed for all types of users, from beginners to the most advanced. Users Groups for both *HVE* and *HVE-2D* meet to discuss their cases and create their annual "Wish Lists" for new *HVE* program features. The *HVE* Forum is also a great networking opportunity, with hosted social hours at the end of each day.

The schedule of workshops, registration form with hotel information and other details are available at edccorp.com. See you in Phoenix!

EDSMAC4 Update

The newest *EDSMAC4* update is available for download from the EDC website. The new version has the following new features:

- A payload can be added to each vehicle.
- The Event Data output report includes a table of static axle loads for each unit vehicle or vehicle-trailer combination. The table displays loads for both empty and loaded (if a payload exists) conditions.
- The user can specify the basis for the Impact and Separation conditions displayed in the Accident History output report. The basis can be either an acceleration threshold (the historical method) or the presence of a non-zero impact force (new method; the default for all new events).

(See Also: SIMON Update, page 6)

Technical Session

This Technical Session provides the details for understanding the vehicle data set that exists in every *HVE* vehicle. A great reconstruction begins with great vehicle data. The comprehensive detail in the *HVE* vehicle data set is a key to understanding what distinguishes *HVE* from other reconstruction methods.

Overview

An *HVE* vehicle is selected from a hierarchical database according to vehicle *Type* (the available types are Passenger Car, Pickup, Van, SUV/CUV, Truck, Trailer and Dolly), *Make*, *Model*, *Year* and *Body Style*. The vehicle's primary attributes are the number of axles, driver location, engine location and drive axle(s).

Each *HVE* vehicle data set is composed of the following data groups:

Sprung Mass – Properties associated with the vehicle body and all of its components

Wheels – Properties associated with the unsprung masses

Exterior – Properties associated with body's exterior surfaces

Steering – Properties associated with the vehicle's steering system

Brake – Properties associated with the vehicle's brake system

Drivetrain – Properties associated with the vehicle's drivetrain

Each of these data groups is described below.

Sprung Mass

The sprung mass group has the following parameters:

Inertial – These parameters start with the vehicle's total mass (multiplied by the gravity constant to define total vehicle weight). Also included are the vehicle's rotational (roll, pitch and yaw) inertias. *All* of these parameters are required in order to use Newton's 2nd Law to calculate the vehicle's 3-dimensional motion. It is impossible to calculate a vehicle's roll, pitch or yaw rotational motion without these rotational inertias. NOTE: If you are reviewing another's reconstruction and the vehicle is rolling over, you should ask what value was used for roll inertia!

Move CG – Allows you to move the location of the vehicle's center of gravity. The current CG height is also displayed. In 3-dimensional physics, the CG Height is not an independent value; it is calculated according to the vehicle's wheel center z coordinates and tire radii. For example, if you change the right, front tire from a P225/75R15 to a P275/40R18, the CG Height will change accordingly (try it!).

Color – Allows the user to assign the correct vehicle color (everyone knows that a red car is faster than a white car).

Geometry File – Allows you to change the vehicle's mesh. This mesh is composed of 3-D vertices that make the Ford Focus *look* like a Ford Focus. In addition, each vertex has physical properties that define its force vs. displacement relationship. Of course, this is a requirement for 3-dimensional collision simulation. Each vehicle in the *HVE* Vehicle Database includes a digitized mesh. If you are creating a new vehicle (one that does not exist in the *HVE* Vehicle Database), you can purchase a mesh from any of several sources on the internet and edit this mesh so it's *HVE*-compatible. The procedures for performing this task are presented in a workshop at the *HVE* Forum (yet another great reason to attend the Forum!).

Contact Surfaces – Allows users of human occupant and pedestrian simulation programs to assign vehicle surfaces that interact with the human's body. These surfaces have force vs. displacement relationships that define how forces are produced during human vs. vehicle interaction.

Belt Restraints – Allows users performing human occupant simulations to add and/or edit lap and shoulder belts properties. These parameters include belt physical properties (e.g., stretch) and vehicle-fixed belt anchor points.

Airbag Restraints – Allows users performing human occupant simulations to add up to nine individual airbags to a vehicle. Each airbag has dimensional properties as well as thermodynamic properties that affect how the airbag fills and deflates.

Connections – Note that there is no such thing as an *HVE* vehicle type called "Tractor-Trailer." That approach would be very limiting. Instead, *HVE* vehicle types include unit vehicles (Passenger Cars, Pickups, Vans, SUVs, Trucks), Trailers and Dollys. An articulated vehicle (e.g., a Tractor-Trailer or a Ford Focus towing a U-Haul; it makes no difference) is created by connecting a tow vehicle and a trailer vehicle. The Connections parameters allow the user to

assign to each vehicle a front connection (Hitch, Kingpin, Pintle Eye) and a rear connection (Ball, Fifth Wheel, Pintle Hook) with location coordinates and physical properties. The forces and moments produced at a Ball/Hitch connection are very different from a Fifth Wheel/Kingpin connection or a Pintle Hook/Eye connection. A trailer train composed of a tow vehicle and multiple trailers is simply a unit (tow) vehicle, followed by a trailer, a dolly, another trailer, another dolly, another trailer…

Aerodynamic Drag – Every *HVE* vehicle has six surfaces (front, right, back, left, top and bottom). Each of these surfaces has aerodynamic drag properties that determine how the surrounding air produces forces against the vehicle. The *HVE* Environment Editor allows the user to assign wind speed and direction, as well as ambient temperature and barometric pressure. These parameters are used to calculate the air density and the direction of the relative motion between the vehicle and the wind. The user may also define two additional surfaces, such as a spoiler or an air dam.

Body Torsion – The sprung mass is currently assumed to be rigid. This data group (not currently used) defines the body's torsional flexibility.

Handling – Anyone familiar with vehicle dynamics will appreciate the data presented in this dialog. They include the vehicle's understeer gradient and several other classic vehicle dynamics parameters that define a vehicle's handling characteristics. It is interesting to move the CG or change suspension rates or tire size and note the effect on handling. This dialog displays those effects!

Lights – This option presents a dialog that displays a list of all the lights in the vehicle's light system. The light system components are actually included in the vehicle's geometry file (see above), and include headlights, driving lights, running lights, fog lights, brake lights, backup lights, emergency flashers and turn signals. All recently-added vehicles include a complete light system. To add a light system to an earlier vehicle, contact EDC for a complete set of "how-to" instructions.

Wheels

The Wheels group has the following parameters:

Suspension – An *HVE* vehicle may have an independent suspension or a solid axle suspension. The equations of motion required for calculating suspension forces are very different for these two suspension types. The Suspension parameters include spring and shock rates, solid axle inertias (part of the unsprung mass), auxiliary roll stiffness produced by a sway bar, jounce and rebound suspension stops, camber change, half-track change, roll steer and steering geometry (which plays an important role in the self-steering behavior of a vehicle).

Brake – Each wheel on an *HVE* vehicle has a detailed brake actuator that produces brake torque. The parameters that define each actuator are the brake torque ratio, push-out pressure, proportioning valve and ABS parameters. The calculation of brake torque is a crucial ingredient in the equations of motion for wheel spin, which, in turn, are used to determine available braking force at the tire-road interface. ABS and Electronic Stability Control calculations are not possible without these parameters. NOTE: The *HVE* Brake Designer is a tool that is used to design brake actuators for different types of brakes, e.g., Disk, Drum, S-Cam, ... EDC uses the Brake Designer to assign the default brake actuator properties for each vehicle.

Tire – Perhaps no other portion of the data set is as important as the tire data; especially for 3-dimensional simulation wherein the tire characteristics are both load-dependent and speed-dependent. The *HVE* vehicle data set includes friction, cornering stiffness and camber stiffness data for up to three loads and three speeds. The physical tire parameters define tire dimensions, radial stiffness (required for blow-out simulation), inertial parameters (again, part of the unsprung mass), and other important tire properties.

Wheel Location – This is simply the vehicle-fixed x,y,z coordinates of the center of each wheel. Interestingly, *HVE* allows the user to build and simulate an asymmetrical vehicle!

Wheel Image – The wheel rim is visualized using a photo bitmap attached to the wheel rim. This feature is important because it allows the user to visualize wheel rotation.

Exterior

The Exterior group has the following parameters:

Dimensions – Each vehicle surface (front, right, back, left, top and bottom) has vehicle-fixed dimensions (i.e., distance relative to the CG).

Stiffness – Each exterior surface also has mechanical stiffness properties. Both 2-D and 3-D stiffness parameters are included. They are displayed graphically as force vs. crush characteristics. These parameters are used to calculate the collision force acting at each vehicle vertex.

Steering System

The vehicle's Steering System group has the following parameters:

Steering Gear Ratio – This ratio defines how many degrees of driver steering wheel input are required to produce 1 degree of steering at the tire.

Mechanical Properties – These properties include the steering system's stiffness, rotational inertias and internal friction. These parameters are used by the Steer Degree of Freedom model.

Brake System

The Brake System group has the following parameters:

Brake Pedal Ratio – This ratio defines the relationship between force applied by the driver to the brake pedal (you enter the brake pedal force in the Event Editor's Driver Controls) and the resulting brake system pressure. This pressure makes its way through the proportioning valve and to the individual wheels' brake actuators to produce brake torque at each wheel.

ABS – This identifies that the vehicle is equipped with an anti-lock braking system (ABS) . ABS-equipped vehicles have additional properties that influence how the ABS system modulates the brake system pressure delivered to each wheel's brake actuator.

Note: Other brake system parameters are defined in the Wheels group for each wheel; see above.

Drivetrain

The Drivetrain group has the following parameters:

Engine Power vs. Engine Speed – This information defines the classic power curve that determies engine torque, and includes both wide-open throttle and closed throttle relationships (the closed throttle relationship is required to calculate engine braking).

Transmission – These parameters include all transmission gear ratios (including reverse gear), and the upshift/downshift characteristics for automatic transmissions.

Differential – These parameters include the differential gear ratio(s). Up to 3-speed differentials can be modeled.

ESC/TCS – These parameters are required by *HVE*'s electronic stability control (ESC) and traction control (TCS) system models.

Validation

EDC does not use vehicle geometries found on the internet. *That is illegal!* Instead, EDC finds exemplar vehicles and brings them to our facility for inspection. During inspection, each vehicle is digitized using a Faro Arm to produce the geometry. The vehicle's light system, inherently included in this geometry, is documented. The vehicle dimensions are measured using the Faro Arm. The weight and weight distribution are measured using a platform scale under each wheel. The drivetrain, steering and brake system features are documented. Then, various data sources (e.g., the vehicle manufacturers' specifications) are used to assign engine, transmission and differential data. The steering gear ratio is directly measured. The *HVE* Brake Designer is used to calculate wheel brake torque ratios. CG height is directly obtained or estimated using published NHTSA research documents. Frontal stiffness coefficients are calculated using NHTSA crash test data. Side and rear stiffness coefficients are assigned using generic data. Top and bottom stiffness coefficients are assigned reasonable engineering estimates. A large volume of generic tire data sets has been developed over the 20+ years that EDC has been building vehicles. The original source for the tire data is the TIRF flat-bed tire testing machine at Calspan.

Every vehicle undergoes a thorough validation and check-in procedure, wherein a "second set of eyes" reviews each piece of data. Finally, each vehicle is run through a robust series of *SIMON* handling (steering, accelerating, braking) and collision simulations to confirm the expected vehicle behavior.

At the completion of the above process, the vehicle is "checked in" and will become part of the next EDC Vehicle Database update.

Our friends at Vehiclemetrics also build *HVE*-compatible vehicles. We have visited their facility and it is very impressive. After working with Vehiclemetrics and their vehicles for several years, we have concluded that they are a great addition to the family of *HVE*-compatible products.

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. Thank you!

Ongoing *HVE* Development

Several changes are in the works for the next *HVE* update. Some of them are not readily visible to the user; others are very obvious!

Internal changes include refinements to *HVE*'s graphics subsystem which make the code more efficient, more stable, and require less memory.

The more visible changes to *HVE* include the following:

Spiral/Spline Post-impact Path Definition - *HVE*'s Options menu has been extended with the addition of a new option, called *Show Curved Path*. This new feature includes several components:

- **Show Curved Path Dialog -** This dialog (see Figure 1) allows the user to visualize the post-impact vehicle path for a reconstruction-type program (e.g., *EDCRASH*). It includes two important options:
  - The path may be defined as either *Circular* (constant radius) or *Spiral*.
  - The path may be defined as tangent to either the vehicle's *Heading Vector* or its *Velocity Vector*.
- **Dragable Velocity Vector -** The user can click and drag the velocity vector in much the same way as he/she drags the vehicle into position. The current sideslip angle is displayed in the Position/Velocity dialog. Dragging the velocity vector directly influences the resulting path if the *Velocity Vector* path tangent option is selected, as shown in Figure 2.

EDCRASH has been redesigned to take advantage of this new feature: *EDCRASH* is now able to calculate the separation velocity for a vehicle that travels a post-impact trajectory that does not have a constant path radius. This represents the first major enhancement in the physics of an *EDCRASH* analysis in well over a decade: The correct value for departure angle is important for an accurate linear momentum result.

Export Option - *HVE*'s File menu has a new option, called *Export*. The Export feature allows the user to quickly export data in pre-defined formats for importing into other programs, such as 3D Studio, Rhino and Madymo. *HVE* likes to play well with others.

DWG Option - *HVE*'s new DXF translator has been extended to work with DWG files, Autocad's native format.

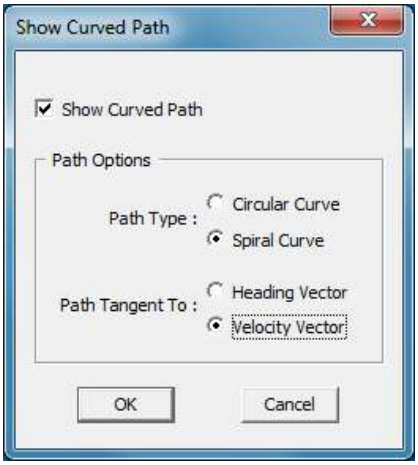

Figure 1 - *HVE*'s new Show Curved Path dialog

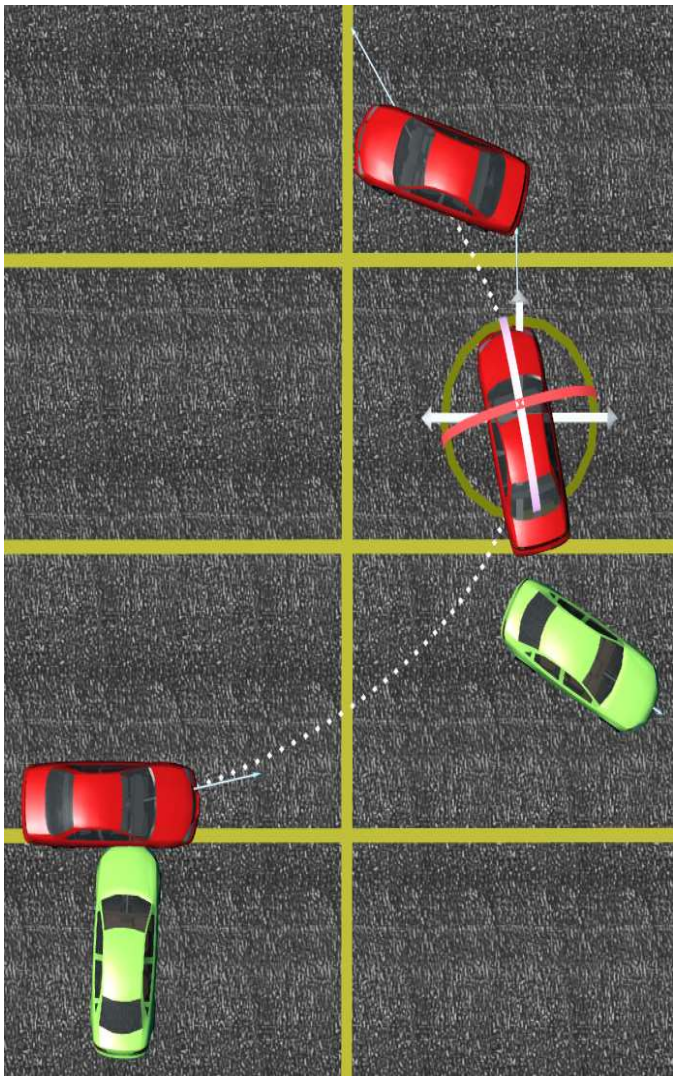

Figure 2 - Spiral post-impact path trajectory defined by the vehicle velocity vectors

EDC Simulations November 9 - 13, 2015 Miami, FL

EDC Simulations is an extensive one-week training seminar that offers an excellent way to learn the inner workings of *EDSMAC, EDSMAC4, EDSVS* and *EDVTS*. The course focuses on the physics models, the calculations and the underlying assumptions for each simulation's major calculation procedures.

EDC Simulations is designed to be like a college physics course - a combination of morning lectures and afternoon hands-on lab exercises. The fact that this course has been presented annually for over 25 years ensures that students benefit from a well designed and well executed week of instruction.

EDC Simulations has been pre-approved for 30 ACTAR CEUs. All course materials, including a handbook, training manual, software and temporary licenses will be provided to each student.

Bring your scientific calculator and laptop computer. Lab exercises include loss-of-control simulations, parametric studies, collision simulations and setting up the pre-impact phase of a 15-second crash sequence.

Links to download your course registration form and to make your hotel reservations at the University of Miami Holiday Inn, Coral Gables, are available on the EDC Simulations page in the Training section of edccorp.com. Contact EDC at 888.768.6216 to sign up today!

HVE and Point Cloud Terrains

The benefits of using point cloud data to create 3-D terrains are significant. *HVE* can import 3-D terrains created from point cloud data. However, there is currently no formal work flow for this process; different users have different techniques. EDC is working with FARO and others to develop a recommended workflow for importing point cloud data.

With this in mind, EDC is reaching out to *HVE* users for input. If you have a method or procedure that works well and would like that method to be considered as we develop our recommendations, please contact EDC Technical Support via email at support@edccorp.com or call 888-768-6216. Thank you in advance for your important contribution.

SIMON Update

The newest *SIMON* update is available for download from the EDC website. The new version of *SIMON* has the following features:

- The Event Data output report includes a table of static axle loads for each unit vehicle or vehicle-trailer combination. The table display loads for both empty and loaded (if an occupant or payload exists) conditions.
- The *HVE* Automatic Transmission model would not shift from Reverse Gear to Drive. This problem has been corrected.

To download this and other software updates, go to the *Support* page at www.edccorp.com and choose *Downloads*. Follow the instructions provided. You can also contact EDC Technical Support by email at support@edccorp.com, or call 888-768-6216. We're glad to help!

The Simulations Festival is Back!

The *HVE* Simulations Festival returns for the 2016 *HVE* Forum in Phoenix. The Simulations Festival is a way for users to showcase (a.k.a., *show off!*) their great work. Users' simulation videos will be running all week long on a large-screen display in the registration lobby. In the past, this has been a competition. But we've changed the approach this year: We simply want to provide a venue for *HVE* users to look at what other *HVE* users are doing. This is a starting point for conversations between users. The ultimate goal is to help improve the results obtained by every *HVE* user.

To include your work in the Simulations Festival, simply submit a video to EDC before February 1, 2016. Make sure to include credits and other titles so everyone will know who made it!

Call for *HVE* White Papers

All users interested in presenting an *HVE* White Paper at the 2016 *HVE* Forum are invited to submit an abstract (approximately 150 to 250 words in length) for consideration. *HVE* White Paper topics include *HVE* case studies, novel applications that showcase *HVE*'s capabilities, and any tips and techniques that show other *HVE* users how to take full advantage of *HVE*'s power features. Submit your abstract via email to forum@edccorp.com. Abstracts are due by November 1, 2015.

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: When importing a DXF environment into HVE 11.00 or 11.01, surfaces of the same color are no longer grouped together. Now when I try to add a texture or apply a Friction Factor to the surfaces using the 3D Editor, the changes are applied to each individual polygon instead of the entire road, not the entire surface. Why?

A: EDC implemented a new DXF Translator for *HVE* version 11.00. There are two issues involved in this problem: First, the new DXF translator groups surfaces by layer instead of color (the old translator put all colors on the same layer, essentially making color and layer synonymous). Now, you can place different colored objects on the same layer. This is different, and definitely an improvement. The second issue is a bug. In the translator shipped with Version 11.00, entities on the same layer were not grouped. This bug was partially corrected in the newest translator (you can download this translator by going to the Support section of the EDC website). This translator correctly groups 3D Face entities, but does not group other types of entities. A complete correction for this problem is currently in testing and will be downloadable on 9/15/2015.

Q: I seem to be receiving the memory error more often when using HVE 11.00 or HVE 11.01 as compared to previous versions of HVE. Why?

A: There are two issues: Version 11.00 had several memory issues, many of which were resolved in Version 11.01. However, Version 11.01 still uses more memory that pre-Version 11 versions. We are working to resolve these issues in the next *HVE* release. The biggest user of memory has to do with textures used for vehicle undercarriages and aerial images used for environments. The next *HVE* release is planned for the Fall, 2015 (see Ongoing *HVE* Development, earlier in this Newsletter).

Q: When I subtract the Separation Velocity from the Impact Velocity displayed in the Accident History, the result is different from the Delta-V reported in the Damage Data output report. Why?

A: This is a recurring question. The answer was originally presented in our August 1997 Newsletter, and presented again in the Summer 2006 Newsletter. Briefly, part of the issue has to do with vehicle rotation: Not including rotation in your calculation will result in an error in the calculation of Delta-V. For a complete discussion of this issue and the correct calculation procedure, please go to www.edccorp.com and review the Technical Session in the Summer 2006 Newsletter.

There are also other issues in play: The Accident History output report displays velocity at initial Impact and at final Separation; nothing in between. If the event sequence includes multiple impacts, the multiple impact collision is nicely captured in the Damage Data output report because it shows the Delta-V for each individual impact (impulse). Another potential reason for the difference: a threshold acceleration (user-assignable; default = 1.0 g) was used to define the Impact and Separation conditions displayed in the Accident History in earlier versions of EDSMAC4 and *SIMON*; both now use the presence of a non-zero impact force to determine the Impact and Separation conditions. This is the same method used in the Damage Data output report, and is more robust than the earlier method that used a threshold acceleration.

Q: I'm running EDCRASH. When I use the vehicle Damage Profiles dialog to assign the damage profile, the values for Impulse Center x,y coordinates are not updated after editing the crush depths. Why?

A: When you enter or edit a CDC in the Damage Profiles dialog, a default damage profile with four crush depths (three zones) is created and displayed according to your CDC. The default values for Damage Width, Offset, Crush Depths and Impulse Center are also displayed. When you edit the Width, Offset or Crush Depths, the Damage Centroid for the new damage profile is calculated and displayed, and the damage profile is updated in the viewer.

But, if you explicitly edit the Damage Centroid x,y coordinates, *HVE* stops over-writing your values when you continue to edit the Width, Offset or Crush Depth. The reason is that *HVE* doesn't want you to have to re-enter the Damage Profile x,y coordinates that you already entered.

If you want *HVE* to automatically calculate and update the Damage Centroid coordinates, you can simply edit the CDC. That tells the Damage Profiles dialog to return to its default behavior, that is, to display the default Damage Centroid for the current damage profile.

Visit the Support section of www.edccorp.com to download software updates and to view more FAQs from the Knowledge Base.

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 **EDC Simulations** courses are designed to fully investigate the inner workings of these *HVE*-compatible 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 lab exercises 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 HVE user interface.* For courses that focus on the *HVE, HVE-2D* or *HVE-CSI* user interface, check out the workshops at the *HVE* Forum.

HVE Forum

The ***HVE* Forum** offers over 30 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 Reconstruction

Miami, FL . . . . . November, 2016
Los Angeles, CA . . . . . January 18 - 22, 2016

EDC Simulations

Los Angeles, CA . . . . . January, 2017
Miami, FL . . . . . November 9 - 13, 2015

Theoretical & Applied Vehicle Dynamics

Upon Request

2016 *HVE* FORUM

Phoenix, AZ . . . . . February 22 - 26, 2016

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 888-768-6216 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 *HVE*-compatible physics programs. The list of *HVE* Training Partners may be found at www.edccorp.com.

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.

Engineering Dynamics Corporation
8625 SW Cascade Blvd, Suite 200
Beaverton, Oregon 97008 USA
Phone 888.768.6216 / FAX 503.526.0905
Email: info@edccorp.com
Website: www.edccorp.com