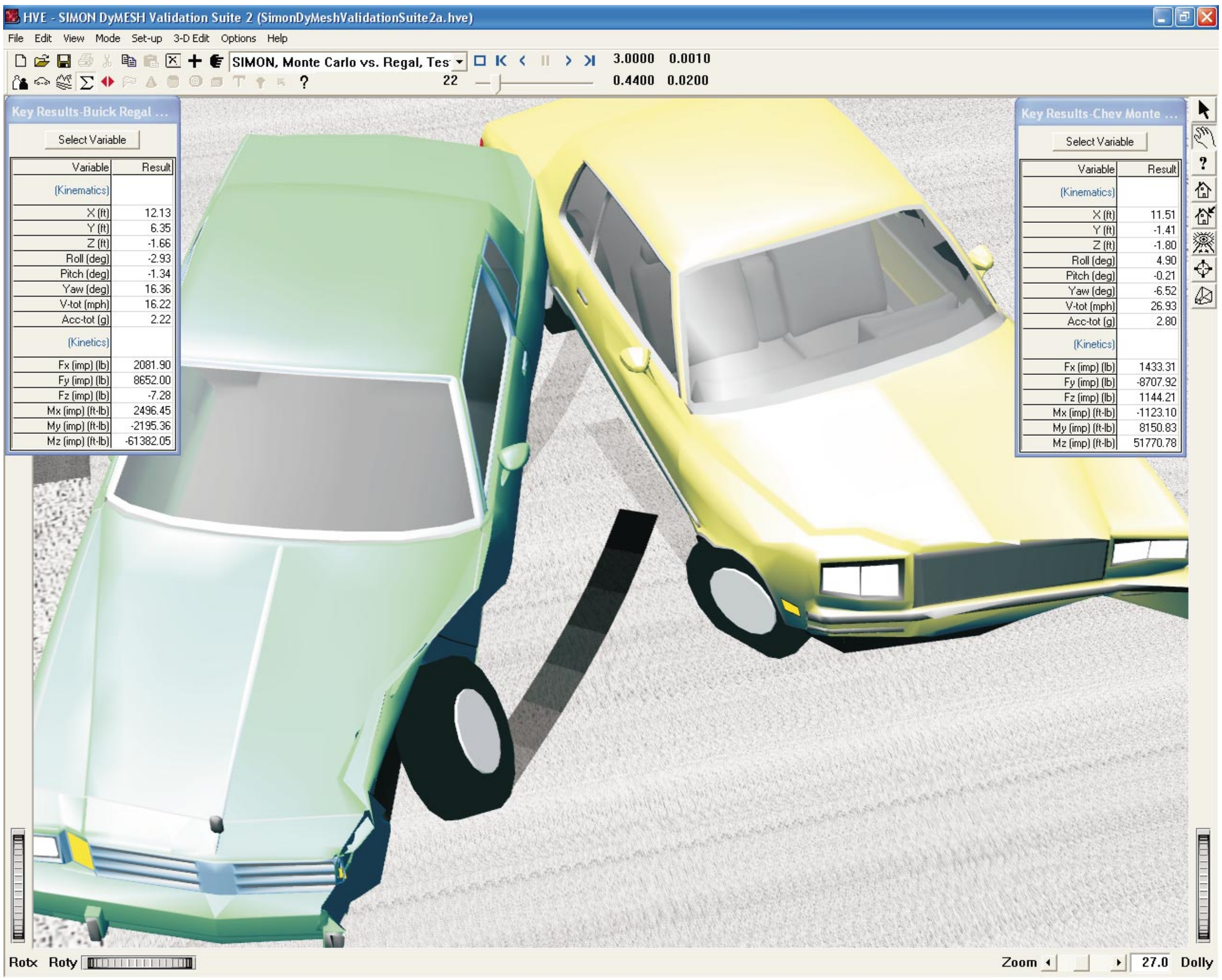
WINTER 2004 ENGINEERING DYNAMICS CORPORATION

Technical Newsletter

DyMESH - Available for HVE Version 5



This image is from the middle of a SIMON vehicle collision validation test run involving a Monte Carlo and a Buick Regal. The 3-D collision forces and moments and resultant vehicle damage from the first impact have already been calculated by DyMESH, and now the secondary impact calculations are in progress.

With the release of HVE Version 5.00, HVE users will be able to use the patented DyMESH 3-D collision algorithm in conjunction with the SIMON vehicle dynamic simulation model to perform 3-D dynamic collision simulations. Because this is such an extremely important technology and capability for accident reconstruction, this newsletter focuses on information about DyMESH and Version 5.00 of HVE and HVE-2D. For the latest news on DyMESH, and the availability of Version 5.00, please visit the EDC website at www.edccorp.com or contact EDC Customer Service at 503.644.4500.

Technical Session

This Technical Session is a high-level introduction to HVE's new DyMESH collision model. Although an overview is provided here, EDC will be holding a DyMESH Applications Workshop during the first week of May at the HVE Forum (see Page 8). The purpose of this seminar is to accelerate the learning curve. Users of DyMESH are strongly encouraged to attend the Forum workshops.

How DyMESH Works

First, a basic observation: DyMESH is not a program, it is a collision algorithm. As such, DyMESH calculates only collision forces and moments between two (or more) colliding vehicles. SIMON is the program (vehicle simulation model) that uses the collision forces and moments calculated by DyMESH. As a result of adding DyMESH, SIMON can be now be used for simulating the entire crash sequence (pre-crash, crash and post-crash). As such, SIMON is much like EDSMAC4, except that SIMON is 3-dimensional (a *huge* difference!).

Conceptually, DyMESH works on a very simple principle: When two meshes come into contact with each other, they become deformed (that is, the meshes' vertices are displaced; see Figures 1 and 2). Each vertex has force-deflection properties; it behaves like a spring. Therefore, pushing on a vertex produces a force. That force may be calculated as the product of its force-deflection properties and its displacement. This calculation is performed for all displaced vertices. Then, DyMESH sums the forces for each vertex, sums the moments about the CG, and *Voila!* DyMESH is done for the current timestep. SIMON's vehicle dynamics engine will add these collision forces and moments to those computed for the tires, connections and aerodynamic surfaces to calculate the vehicle's current acceleration, velocity and position.

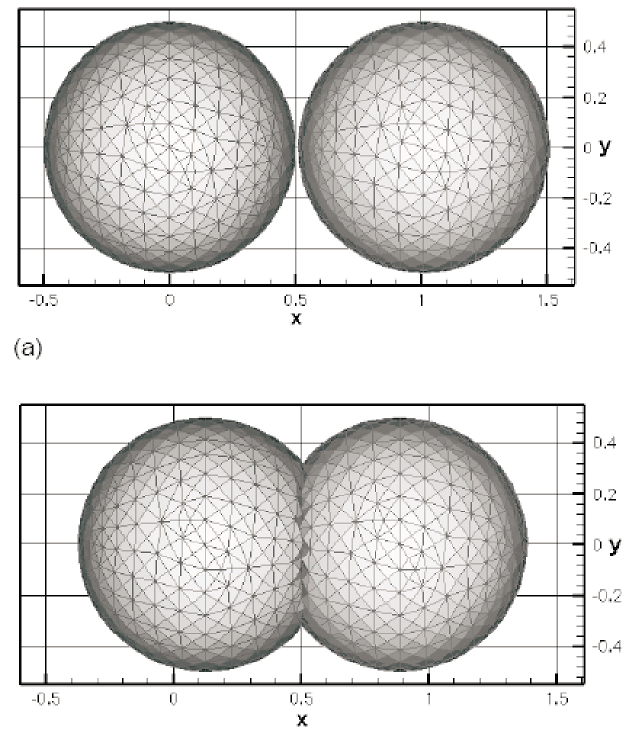


Figure 1 - Two meshes contacting each other and deforming

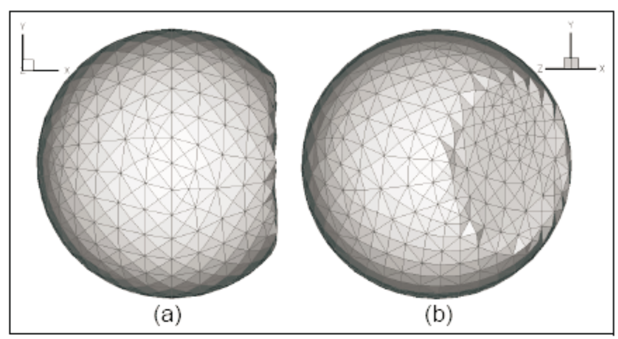


Figure 2 - Meshes after colliding with each other, showing vertex displacement (deformation)

Damage Simulation

Deformation is visualized inherently, simply by viewing the mesh with its displaced vertices. HVE always displays the vehicle mesh (whether the vertices are displaced or not; it makes no difference). The resulting damage profiles are 3-dimensional (see Figure 3)

Data Requirements

DyMESH has no additional data requirements, per se. The data required by DyMESH already exist in an HVE simulation. These are:

- a 3-D vehicle mesh
- stiffness coefficients
- inter-vehicle friction coefficient

If a custom 3-D vehicle mesh is not supplied, HVE automatically provides a generic mesh that can be tessellated (see Tessellation option, below) to any degree of coarseness; typically a 10 to 20 inch mesh size works well. The stiffness coefficients are derived from the traditional A and B coefficients used by EDSMAC4 and EDCRASH. A *Height Factor* is used to provide the 3rd dimension. The default Height Factor is 30 inches, because a typical barrier crash test results in about 30 inches of crush height. An inter-vehicle friction coefficient is provided for each pair of colliding vehicles, just as in EDSMAC4. HVE now includes an additional

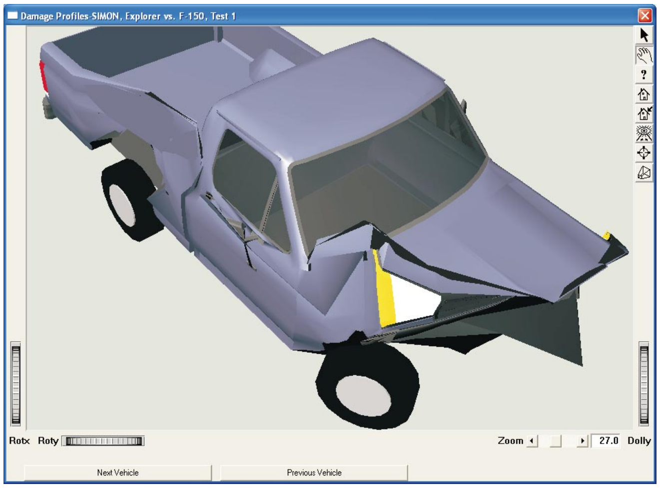


Figure 3 - 3-dimensional damage profile resulting from a DyMESH collision simulation that included secondary impact

feature: the inter-vehicle friction coefficient can be varied for each pair of colliding vehicles (both SIMON and EDSMAC4 now use this feature).

User Interface

HVE now includes a DyMESH Options dialog. This dialog provides access to various options that help DyMESH under certain conditions. These conditions generally arise when the mesh has extremely complex geometry (for example, the inside of a front grill) and the mesh folds back on itself as it crushes. In this and similar cases, the direction of vertex displacement needs close scrutiny; these options provide that scrutiny. There is a *Force to x-y Plane* option that is useful when the simulation predicts excessive over-ride (this phenomenon sometimes occurs when a large vehicle and small vehicle collide at a large closing speed). Several other options are also available, many of which were used during the development and debugging of the DyMESH algorithm (many or all of these options may be eliminated as we gain experience using DyMESH).

HVE also includes a new Vehicle Mesh dialog. This dialog provides two new capabilities: *Tessellation* and *Collision* options. The *Tessellation* parameter establishes a maximum length for the side of any polygon in the mesh. Setting this value has two important effects: First, it establishes the maximum size of the triangles in the mesh. Obviously a mesh with 10 inch polygons will provide more detail than a mesh with 30 inch polygons; see Figure 4. Second, it prevents a mesh from having triangles with large aspect ratios (that

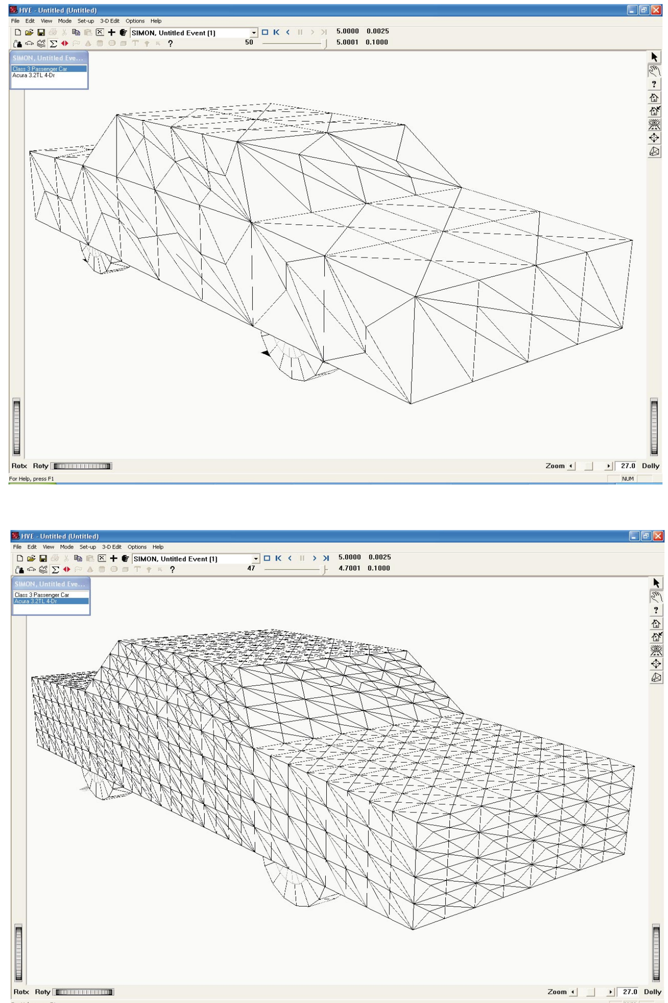


Figure 4 - Generic Vehicle shape with 30 inch tessellation (above) and 10 inch tessellation (below)

is, triangles that are long and skinny: these triangles can be problematic for DyMESH); see Figure 5.

The Vehicle Mesh dialog's Collision Options include Inter-vehicle *Friction* and *Restitution* parameters for each pair of colliding vehicles. EDSMAC4 also uses the *Friction* option. Note that this is a new capability; previous versions used the same inter-vehicle friction for all collisions in the event.

Applications

Generally speaking, DyMESH may be applied to all collisions of all types of vehicles (unit and articulated) and barriers. DyMESH is particularly useful for collisions that are beyond the scope of EDSMAC4. Examples include collisions resulting in 3-dimensional vehicle behavior, such as over-ride and collisions that

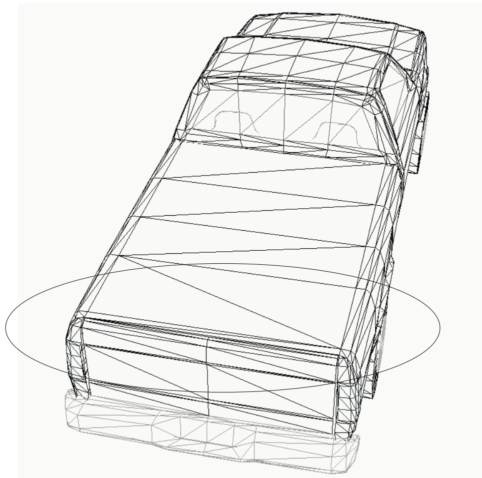


Figure 5 - Region of vehicle reveals large aspect ratio polygons (see inside oval)

produce significant roll and pitch. DyMESH inherently includes the capability to model a collision between the vehicle's body and the environment (after all, the environment is also a mesh!). However, this capability has not yet been integrated into HVE. When integrated (in the next release), DyMESH will allow SIMON users to simulate complete rollovers and collisions with roadside barriers and other obstructions. For the first time, complete rollover simulation of tractor-trailers will be possible.

Limitations

Although very powerful, DyMESH does have limitations, including:

No buckling of surfaces – It follows from the way DyMESH works (pushing on vertices) that surface buckling cannot be modeled. For example, the middle of a hood will not buckle upwards during a severe head-on collision. To model this type of behavior requires a finite element method. Also, vehicle decapitation (such as occurs when a car drives under a trailer, cutting off the top of the roof) and catastrophic collisions that result in the vehicle breaking in two are beyond the scope of DyMESH.

Wheel force not included – Interaction between the wheels and the body mesh is not modeled by DyMESH. Therefore, collision forces and moments produced when the wheel(s) of one vehicle contact the body of another vehicle are not simulated.

Unknown stiffness – HVE provides stiffness coefficients for all six surface of a vehicle (front, sides, back, top and bottom). However, the stiffness coefficients for the top and bottom are essentially unknown and the user must estimate them if these surfaces are deformed. Note that the default A and B stiffness coefficients for the top and bottom are set to 1000; this will result in an obviously unrealistic vehicle response. An example of this condition is the under-ride of a heavy truck or trailer. For these collisions, the A and B coefficients must be reduced.

One collision per vehicle – The initial release of DyMESH is limited to one collision per vehicle. For example, if Vehicle 1 collides with Vehicle 2, then Vehicle 1 continues on to collide with Vehicle 3, DyMESH will fail. This limitation will be eliminated in the next release of DyMESH.

Hardware Requirements

If you are thinking about upgrading your computer, now might be the time! EDC suggests a fast processor (2+ GHz) and a minimum of 512 MB RAM. The hard disk, Open GL-compatible graphics card and other hardware components found on today's computers are adequate.

Run Times

Run times for DyMESH collision simulations using a Pentium 3 GHz vary from about 2 minutes to 15 minutes. Run times are strongly correlated to the number of vertices in the vehicle mesh (vehicles in the HVE Vehicle Database typically have between 2000 and 5000 vertices) and the duration of the collision phase. In one instance, a highly tessellated mesh (approximately 18,000 vertices) undergoing a 3-second sustained contact collision required about 50 minutes to run to completion.

Validation

EDC is presenting a technical paper at the 2004 SAE International Congress on Thursday, March 11th. The paper title is "Validation of the SIMON Model for Vehicle Handling and Collision Simulation – Comparison of Results with Experiments and Other Models," SAE Paper No. 2004-01-1207. This paper includes the results from five staged collisions that were simulated using DyMESH. Please contact EDC if you would like to receive a copy of the paper. The runs in this paper represent a subset of validation runs for approximately ten handling tests and fourteen collision tests.

An important fact is that the validations were run with no tweaking of the DyMESH parameters. This was a major requirement before EDC deemed that DyMESH was ready for release.

Why SIMON?

HVE users have the choice of several 3-D physics simulation models for their work. So why would they possibly choose to use SIMON instead of EDVSM or EDVDS? One practical reason may be the ability to include any number of vehicles (including articulated vehicles) in a single simulation. This could result in a great time savings, as well as a convenience to the analyst. Other reasons may be for simulation capabilities offered only by SIMON.

Specific examples of why a HVE user may choose SIMON over EDVSM include:

- SIMON does not assume bilateral symmetry: the CG can be located to the left or right of the vehicle's geometrical centerline.
- Occupants and payloads may be added and they affect the CG location (including CG height).
- Vehicles with displaced wheels (as from collision damage) are properly modeled.
- Dual tires may be assigned at any wheel location and the actual tire deflection for each individual tire is used for the tire radial force calculations (for example, an outer dual tire climbing a curb is correctly modeled).
- The SIMON aerodynamics model is not limited to head-on forces in still air. SIMON simulates aerodynamic forces on all six surfaces (front, right, back, left, top, bottom) as well as up to two user-defined aerodynamic devices, such as an air dam or spoiler.

Specific examples of why a HVE user may choose SIMON over EDVDS include:

- SIMON models a wider range of vehicle-trailer configurations, including A-trains and B-trains with any number of trailers.
- SIMON models both independent and solid axle suspensions, so you could simulate a passenger car towing a utility trailer.
- SIMON includes aerodynamic drag, a feature missing from EDVDS. And wind speed and direction are accounted for, so the simulation of trailers in a cross-wind is possible.

Specific examples of why a HVE user may choose SIMON over EDSMAC4 include:

- SIMON with DyMESH is useful for under-ride, or any crash where three-dimensional collision dynamics are present. 3-D collision simulation is now possible!

SIMON and DyMESH Technical Papers

Our Technical Support line often receives calls from users wanting to know more about SIMON and DyMESH. We thought it might be helpful to remind users that papers written by EDC regarding HVE and HVE-compatible physics programs are available in the Technical Reference Library of our website. Many of these papers can actually be downloaded from the webpages of the Library. Here is a list of papers directly pertaining to SIMON and DyMESH that can be found at www.edccorp.com/library/techref.html:

- "The DyMESH Method for Three-Dimensional Multi-Vehicle Collision Simulation," SAE 1999-01-0104
- "Validation of DyMESH for Vehicles vs. Barrier Collisions," SAE 2000-01-0844
- "SIMON: A New Vehicle Simulation Model for Vehicle Design and Safety Research," SAE 2001-01-0503
- "A Simulation Model for Vehicle Braking Systems Fitted with ABS," SAE 2002-01-0559
- "Validation of the SIMON Model for Vehicle Handling and Collision Simulation - Comparison of Results with Experiments and Other Models," SAE 2004-01-1207 (Available for download immediately following 2004 SAE World Congress)

Additional papers related to SIMON which have been authored by HVE users can be found in the HVE White Papers section of the Library.

2004 HVE FORUM

The 2004 HVE Forum will be in San Francisco at the Union Square Crowne Plaza from May 3 - 7, 2004. The 2004 HVE Forum will include workshops on the use of HVE and HVE-2D, the physics programs, HVE Brake Designer, and also a brand new DyMESH Applications Workshop. It will also include the HVE White Paper Session, the HVE Jillionaire Game and the HVE Simulations Festival.

Workshops and hotel rooms are on a first-come, first-served basis, so be sure to register early to ensure you get the choice you want. Workshop schedules, registration forms and additional information are available to download from the EDC website at www.edccorp.com/service/hveforum.html.

HVE & HVE-2D Version 5.00 Release

The release of HVE and HVE-2D Version 5.00 is near! Extensive improvements and enhancements to the user interface have been included in this update, along with exciting new capabilities for several of the physics programs. Here is an overview of what users will find in their Version 5.00 updates:

1. DyMESH - HVE users will now be able to use this patented 3-D collision algorithm in conjunction with the SIMON vehicle dynamic simulation model to study complex real-world crashes involving underride, or any scenario where three-dimensional collision dynamics are present. For more information about DyMESH, refer to the Technical Session of this newsletter, visit the EDC website at www.edccorp.com.

2. Tessellation - Tessellation allows the user to add additional detail to the 3-D Geometry File of a vehicle (also referred to as a “mesh”). By selecting this option, each triangle in the mesh is evaluated and any side longer than the user specified value is cut in half until the resulting triangle has no sides longer than the specified value. This capability is very important for collision simulations using DyMESH. It can also be used to display greater detail in the damage profiles of an EDSMAC4 collision simulation involving generic vehicles, as shown in Figures 6 and 7.

2. Active Objects in Playback - Users can quickly access open reports and viewers in Playback Mode, simply by selecting the one they want to view from the Active Objects drop down list located in the center of the Toolbar.

3. Print All - Users who want to print all of their results at the same time no longer have to select and *Print* each output individually. Users can simply select *File, Print All* to print all open reports and viewers displayed in Playback Mode.

4. Multiple Cameras - Users can now assign and save up to 10 named cameras in their simulations. The camera can be attached to moving vehicles or a fixed point on the environment model. HVE users can even assign the camera view to track a moving object, even if the camera is attached to a different moving object. This new feature will allow users to quickly produce multiple-view simulation movies of their work.

5. New Vehicles in EDVDB - Nine vehicles, complete with exterior and interior geometry and parameter data sets have been added to the EDVDB database since the Version 4.40 release. These vehicles represent 38 model years of vehicles and are listed in Table I.

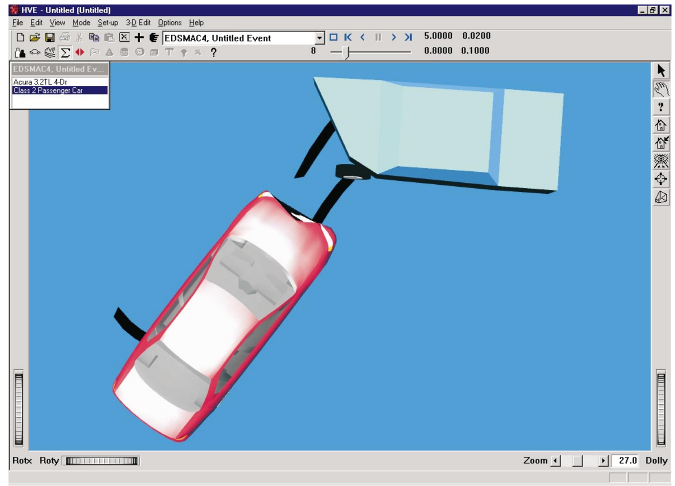


Figure 6 - EDSMAC4 simulation of a two car crash between an Acura 3.2 TL and a Generic Class 2 Passenger Car.

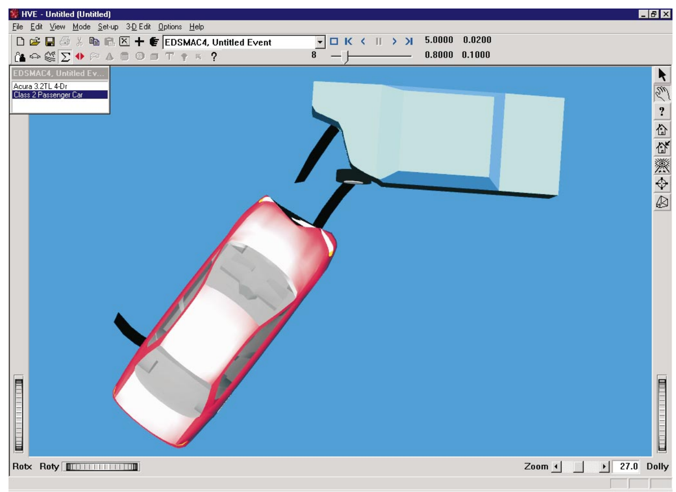


Figure 7 - The same EDSMAC4 simulation, but with Tessellation enabled and set to a size of 10 inches for the mesh of the Generic Class 2 Passenger Car.

Table I - Vehicles added to EDVDB Vehicle Database

Vehicle	Year Range
Cadillac Coupe de Ville	1977-1984
Ford Focus SE 4-Door	2000-2003
GMC Sierra 1500	1999-2003
Chevrolet Silverado 1500	1999-2003
Toyota Camry LE 4-Door	2002-2003
Subaru Legacy Outback Wagon	2002-2003
Toyota Corolla LE 4-Door	2003
Land Rover Discovery	1995-1998
Pontiac Grand Am 4-Door	1992-1998

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 have just replaced my old computer with one of the newest models available. When I run HVE on the new computer, I find that my simulation runs seem to go for a few timesteps and then stop. The program doesn't crash and the event controller still responds, but the run just stops. No matter how many times I reset and execute the event, I can't seem to get a complete run. HVE ran fine on my old computer, so what is happening on my new computer?

A: This behavior is caused by the Hyper-Threading (HT) Technology available in the latest Pentium 4 processors (available for 2.4 GHz and faster). Simply stated, the HT Technology is like a multi-processor system, where processes can be routed to separate processors to speed up the performance. With this technology enabled, your computer can mis-route the communication between the HVE Event Viewer and the physics program used for your simulation. This results in your simulation appearing to run for several timesteps and then just stop.

To correct your problem, all you have to do is disable the Hyper-Threading Technology setting in your BIOS. If you are not sure what you need to adjust in your system BIOS, the following Intel web page contains a detailed description of Hyper-Threading Technology and how to possibly enable and disable it on your computer.

www.intel.com/support/processors/pentium4/pentium4_ht.htm#2

If you require further assistance in accessing your system BIOS, you need to contact your computer manufacturer.

Q: I am using a 3-D vehicle geometry (VRML format) that is saved in the MyVehicles folder on my computer. I edited a generic vehicle in the Vehicle Editor to match the vehicle's performance parameters and dimensions, and I even imported the geometry onto the vehicle. Everything looks great in the Vehicle Editor. However, when I create an event involving this vehicle and I try to initially position the vehicle, I receive a error message dialog saying "Inventor Read Error: Can't open file "C:\ProgramFiles\hve\supportFiles\images\vehicles\mycar.wrl". I then close the dialog and I see that my actual geometry has been replaced by the generic image. Why has this happened?

A: This error message is telling you that your vehicle geometry file is not in the expected place where HVE looks for the vehicle geometry while in the Event Mode. The default path location for vehicle geometries is /hve/supportFiles/images/vehicles. If you will place your geometry file in this location, you will find that your vehicle geometry will be displayed in the Vehicle Editor and the event as expected.

Q: I am working on my environment model in the 3D Editor. I have downloaded a tree from a 3D modeling site on the Internet in VRML format and I want to add it directly in the environment. When I select the Library and then my tree file and try to bring it in, HVE crashes. What do I need to do to get this to work properly?

A: You need to bring in the tree first as an environment object and then save it into the library in the 3D Editor. That will then allow you to pull that object out of the library later and add it to any environment model.

Q: I have created a 3D terrain model in CAD and have imported it into HVE. I have a simulation that the vehicle travels along the road and at some point it jumps up or falls through the environment. Why?

A: The most likely answer is that the surface normal for the polygon that you are trying to drive over is facing the wrong direction. *GetSurfaceInfo()* must see the surface normal. You can either use the 3D Editor to reverse the direction of the surface normal for that polygon, or you can return to your CAD program and unify the normals so that they all point in the same direction and then import it once again into HVE.

F.A.Q.'s on EDC 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. Go to www.edccorp.com and follow the link to Support.

User Hints and Tips

This section contains useful hints and tips to help *HVE* and *HVE-2D* Users make the most of their software.

- Want to have one of the ¼ screen viewers in the 3D Editor temporarily full screen for a better view of your model? Try placing the cursor over the viewer and then click the right mouse button. On the pop-up menu, select *Full Screen*. To return to normal view, reverse the steps.

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 2005
Miami, FL . . . . November 2005

EDC Reconstruction

Los Angeles, CA . . . . .January 19 - 23, 2004
Miami, FL . . . . November 8 - 12, 2004

Theoretical & Applied Vehicle Dynamics

San Francisco, CA (short course). May 3 - 4, 2004

2004 *HVE* FORUM

San Francisco, CA . . . . .May 3 - 7, 2004

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 and ACTAR credits. See you at our next course!

Related Training Courses

Northwestern University Center for Public Safety (NUCPS) is offering the COMPTAR and MATAR courses once again. These courses are designed to provide law enforcement officers with a better understanding of using *EDCRASH* and *EDSMAC* for accident reconstruction. For more information or to register for these courses, you will need to visit the NUCPS website at www.northwestern.edu/nucps or by contacting the NUCPS office at 847-491-5476.

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