SUMMER 2006 ENGINEERING DYNAMICS CORPORATION

Technical Newsletter

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

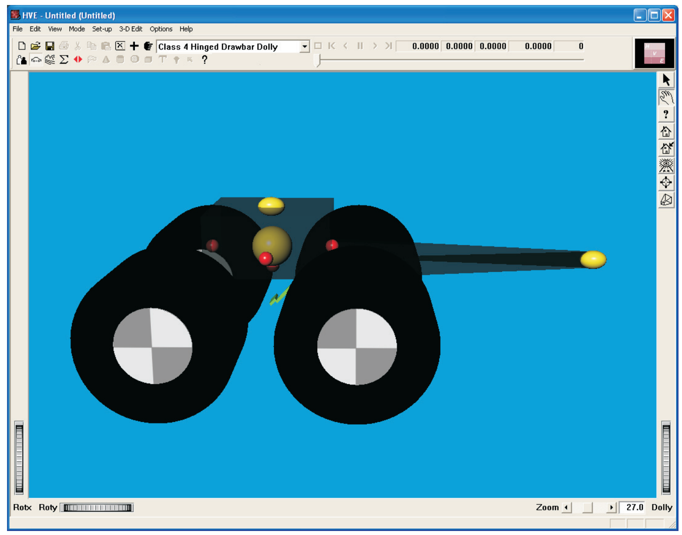
Sneak Preview of *HVE* & *HVE-2D* Version 5.20

Version 5.20 is in the final stages of development and is expected to be released in September. Several of the new features in Version 5.20 are described below:

- The Inter-Process Communication (IPC) has been redesigned to utilize shared memory. This redesign results in an amazing reduction in simulation runtimes. For example, a 20-second *SIMON* simulation with 0.02 second output intervals takes 38 seconds in Version 5.10 but only takes 8 seconds in 5.20. Additional examples are identified below:

Case/Event	5.10 Run Time	5.20 Run Time
EDSMAC4 Tutorial	13 sec	5 sec
EDVSM Tutorial L/R Tire Blowout	3 sec	1 sec
SimonDyMESHValidationSuite6 *EDSMAC4*, Test 11	57 sec	7 sec
SimonDyMESHValidationSuite6 *SIMON*, Test 12	8 min 10 sec	4 min 57 sec

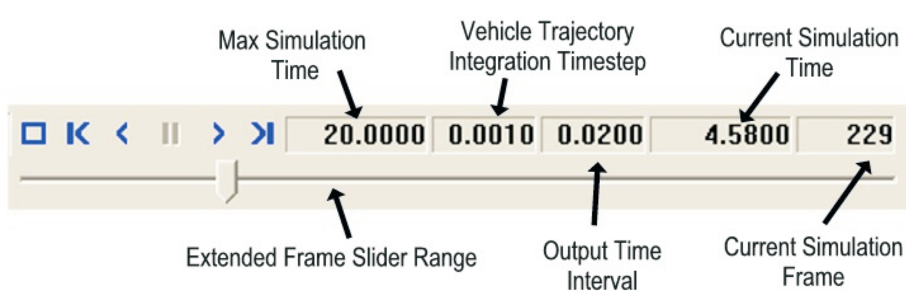
- The Air Brake Tool in the *HVE-2D* Vehicle Editor now supports long stroke configurations for GBF users.
- Icons for connections are now displayed in the Vehicle Editor. Users can click on the oval for front or rear connection and display the Connections dialog for easy editing.
- Users can now copy and paste data into all tables (e.g., Collision Pulse). This will be especially helpful to users needing to import accelerometer or other experimental results directly into *HVE*.
- The Event Controller layout has been modified to provide greater control when using the Frame Slider to rewind or advance simulation frames. The user first clicks on the extended frame slider to select it and then uses the thumb wheel on their mouse to advance frame by frame through the simulation.



Vehicle Editor (with Show Connections enabled) displaying a Generic Class 4 Hinged Drawbar Dolly. Note the egg-shaped connection icons at the tip of the drawbar and the top of the center block of the table showing the front and rear connection locations respectively.

- The Move CG dialog now includes an Apply button to allow the user to see results of changes before closing the dialog.
- A *HVE* cube logo in the upper right corner rotates during event execution as a visual cue to the user that calculations are being performed in the background

These are just a few of the enhancements in Version 5.20. More information will be posted on the EDC website as it becomes available.



Technical Session

This Technical Session investigates the use of the new Soft Soil Tire-Terrain Model in *HVE*. The Soft Soil Model uses Bekker's [1] equations for calculating tire sinkage and plow force (essentially a rolling resistance produced by tire sinkage into the soil). Bekker's model requires three empirical coefficients that describe the soil characteristics. These are

- Exponent of Soil Deformation, N
- Frictional Modulus of Soil Deformation, Kφ
- Cohesive Modulus of Soil Deformation (Kc)

These descriptors are derived from direct testing of the soil. Because reconstructionists will probably not have the opportunity to perform these tests, it is important to have representative values for N, Kφ and Kc for basic soil types.

Table 1 shows the values for N, Kφ and Kc for three commonly encountered soil types: unplowed sod, sandy loam and dry sand. These values come from reference 1, which includes a table of values for approximately 40 different soils.

Table 1 - Bekker Soil Descriptors

Soil	N	Kφ (lb/in^{N+1})	Kc (lb/in^{N+2})
Unplowed Sod	0.95	64	15
Sandy Loam (11% MC)	0.90	6	11
Dry Sand	1.1	3.9	0.1

Based on these soil descriptors the tire sinkage, *Z*, is

$$Z = \left(\frac{3F_Z}{(3-N)(K_C + W_T K_\varphi)\sqrt{2R_T}} \right)^{\frac{2}{2N+1}} \quad \text{(in)}$$

and the plow force, F_X, is

$$F_X = \frac{(3F_Z)^{\frac{2N+2}{2N+1}}}{(3-N)^{\frac{2N+2}{2N+1}} (N+1)(K_C + W_T K_\varphi)^{\frac{1}{2N+1}} (2R_T)^{\frac{N+1}{2N+1}}}$$

(lb)

where

F_Z = Vertical Tire Load (lb)
W_T = Tire Width (in)
R_T = Tire Unloaded Radius (in)

To determine the effect of soil type on vehicle behavior, a series of simulations was performed on each soil. The soils were selected from the *HVE* Environment Materials database (Figure 1) and applied to the Proving Ground environment (a flat, horizontal surface).

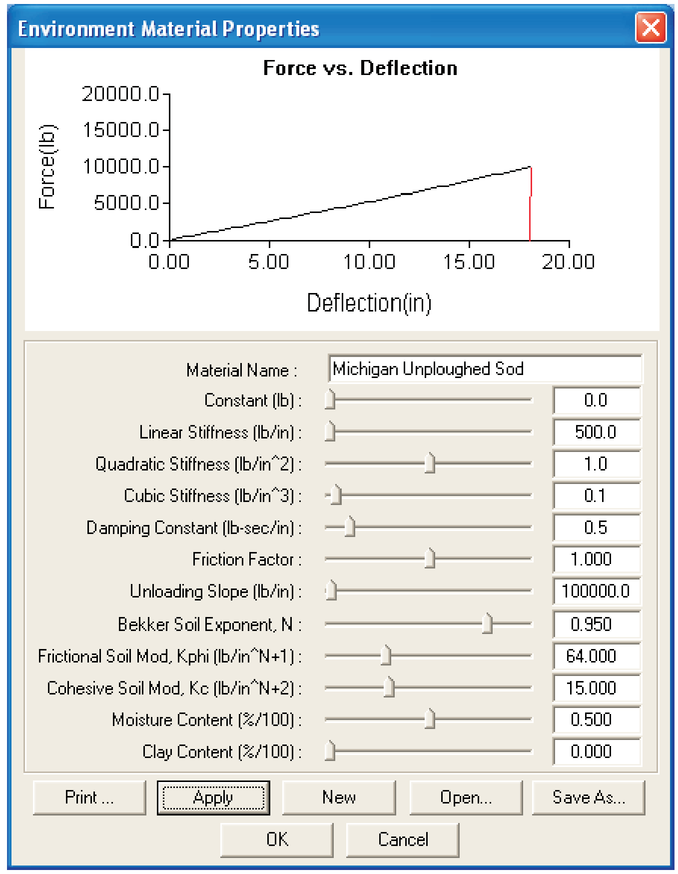


Figure 1 - Environment Materials dialog, used for assigning soft soil attributes to the selected terrain.

Three different vehicles were selected:

- 2005 Ford Taurus 4-Dr Sedan fitted with P225/60R16 tires
- 2004 Dodge Ram 2500 Quad Cab 4 x 4 fitted with LT265/75R16 tires
- 2004 Freightliner Columbia Truck Tractor fitted with 295/75R22.5 tires

The initial vehicle velocity was 35 mph. No steering, braking or throttle inputs were used. The Soft Soil Tire-Terrain Model was selected for all tires (Figure 2). The event was then executed. When the vehicle had slowed to 30 mph, the tire sinkage, vertical force and plow force for front and rear tires, and vehicle

[1] Bekker, M.G., *Introduction to Terrain-Vehicle Systems*, University of Michigan Press, Ann Arbor, 1969.

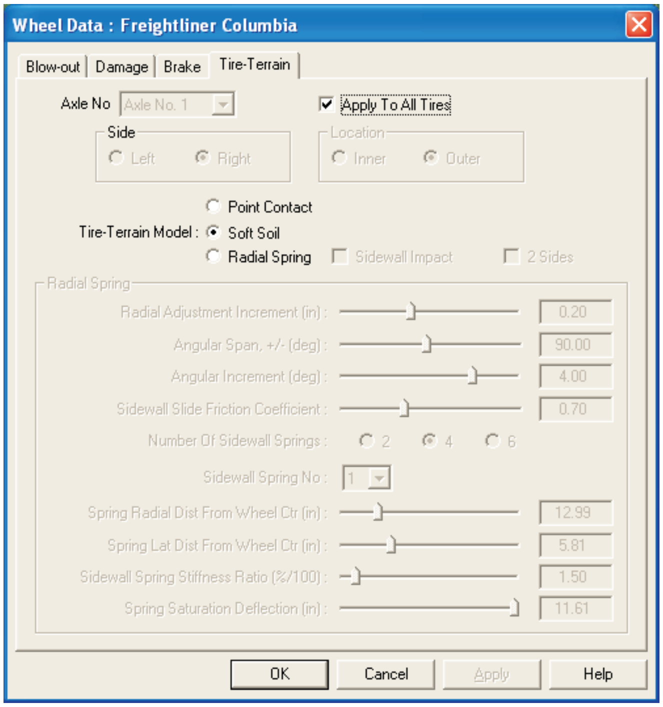


Figure 2 - Tire-Terrain dialog, used for assigning the Soft Soil Tire-Terrain model to each tire.

deceleration rate were recorded for each soil. Deceleration and tire rolling resistance force on a non-deformable (concrete) surface were also recorded for purposes of comparison.

Results

The results for concrete and each soil are displayed in Tables 2 – 5. Sinkage, plow force and deceleration increased for all soil types when compared to concrete (as expected). The increase was least for unplowed sod and greatest for dry sand.

Table 2 - Test Results for Concrete

Vehicle	Z (in)		Fz (lb)		Fx (rolling) (lb)		Acc (g)
	F	R	F	R	F	R	
Ford Taurus	n/a	n/a	1051	575	-9.16	-5.92	-0.01
Dodge Ram 4x4 Pickup	n/a	n/a	2048	1269	-19.31	-11.62	-0.02
Freightliner Columbia	n/a	n/a	5245	1199*	-50.4	-8.99*	-0.02

* Front Axle of Leading Tandem Axle

Table 3 - Test Results for Unplowed Sod

Vehicle	Z (in)		Fz (lb)		Fx (plow) (lb)		Acc (g)
	F	R	F	R	F	R	
Ford Taurus	0.64	0.40	1085	541	-127	-50	-0.11
Dodge Ram 4x4 Pickup	0.86	0.58	2118	1199	-262	-122	-0.12
Freightliner Columbia	1.41	0.50*	5400	1188*	-762	-99*	-0.12

* Front Axle of Leading Tandem Axle

Table 4 - Test Results for Sandy Loam (11% Moisture Content)

Vehicle	Z (in)		Fz (lb)		Fx (plow) (lb)		Acc (g)
	F	R	F	R	F	R	
Ford Taurus	3.09	1.74	1121	502	-287	-96	-0.22
Dodge Ram 4x4 Pickup	4.25	2.62	2197	1114	-605	-241	-0.25
Freightliner Columbia	7.16	2.40*	5610	1216*	-1786	-224*	-0.25

* Front Axle of Leading Tandem Axle

Table 5 - Test Results for Dry Sand

Vehicle	Z (in)		Fz (lb)		Fx (plow) (lb)		Acc (g)
	F	R	F	R	F	R	
Ford Taurus	4.22	2.50	1133	489	-339	-113	-0.26
Dodge Ram 4x4 Pickup	5.48	3.52	2207	1088	-690	-273	-0.29
Freightliner Columbia	8.59	3.33*	5671	1245*	-1918	-270*	-0.28

* Front Axle of Leading Tandem Axle

Discussion

The greatest sinkage was observed for the Freightliner front tires. In fact, the Freightliner probably would have gotten stuck in an actual event, as predicted by the message "Excessive Sinkage", followed by event termination. The *Maximum Tire Deflection* parameter was increased to allow these simulations to continue.

Reconstructionists will probably not have access to soil sample test results for the events they are investigating. Therefore, reconstructionists should proceed as follows:

1. Carefully note the depth of tire tracks left in the soil by each vehicle.
2. Choose a soil from the *HVE* Environment Materials database that most closely describes the soil under consideration.
3. Perform simulations using the Soft Soil Tire-Terrain Model and observe the resulting sinkage.
4. Increase or decrease $K\varphi$ as required to match the observed tire sinkage.

It should be noted that the above procedure is only an approximation. However, numerous simulation studies, as well as inspection of the equations for sinkage and plow force, reveal that sinkage and plow force are well correlated.

Differences in Delta-V Reported in *EDSMAC* and *EDSMAC4* Simulations

This Technical Session was originally published in the August 1997 EDC Technical Newsletter. It is reprinted here due to an increase in EDSMAC and EDSMAC4 Technical Support questions related to this issue.

Why does the ΔV reported in *EDSMAC*'s Damage Summary often differ from the difference between vector velocities at impact and separation? To answer this question requires a bit of background.

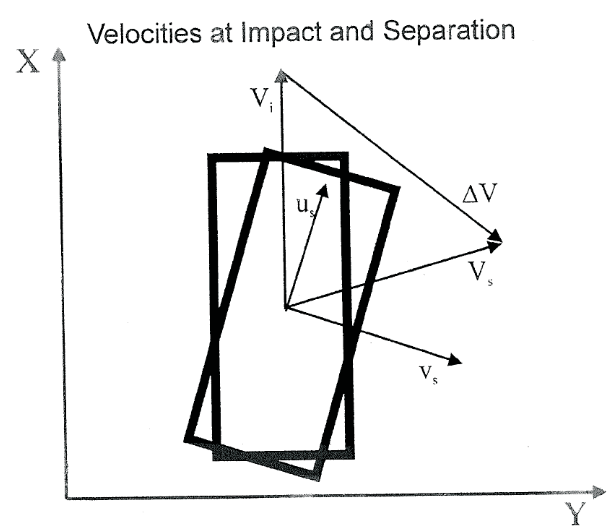
During a collision (defined in *EDSMAC* as the interval during which the total acceleration exceeds 1G), *EDSMAC* accumulates and stores the current vehicle-fixed acceleration, both magnitude and direction. From this information, *EDSMAC* calculates and stores the ΔV (area under the acceleration vs. time curve) for each clock direction (note the clock direction comes from the acceleration). Finally, *EDSMAC* stores the peak acceleration for each clock direction. Again, the preceding information is accumulated and stored during the entire collision phase.

At the end of the simulation , *EDSMAC* uses the stored information to assign a CDC, PDOF and delta-V to each vehicle damage region. If a vehicle has exactly one damage region, all delta-Vs within a one hour clock direction are summed and included as part of the reported delta-V. Those delta-Vs that lie outside this range are ignored. For this reason, the reported Delta-V may be slightly less than the difference between vector velocities at impact and separation.

EDSMAC also allows a vehicle to have more than one damage region. For example, during an intersection collision, a vehicle quite often has secondary damage at the (rear) quarterpanel resulting from rapid rotation and subsequent slapping together of the vehicles' rear ends. In this case, *EDSMAC* determines a CDC, PDOF and ΔV for each damage region. The direction for each acceleration peak is compared to the location of damage to determine the damage region to which PDOF and ΔV are assigned. If the direction of an acceleration peak is more than 60 degrees from the angle to the midpoint of the damage region, the CDC, PDOF and ΔV are assumed to belong to a different damage region.

The above logic involving multiple damage regions is very complex, and sometimes fails to match a CDC, PDOF and ΔV to a damage region. In that case, there may be a significant difference between the ΔV reported in the Damage Summary and the difference in vector velocities between impact and separation, especially if the unmatched ΔV is large.

Users often perform a simple calculation using the vector difference in impact and separation velocities displayed in *EDSMAC*'s Accident History report. This normally provides a reasonable estimate for the ΔV. However, if the vehicle undergoes significant rotation between impact and separation, this rotation must be accounted for. The following example illustrates the effect of rotation on the calculation:



	X (ft)	Y (ft)	Ψ (deg)	V-total (ft/sec)	u (ft/sec)	v (ft/sec)
Impact	0.0	0.0	0.0	45.4	45.4	0.0
Separation	1.4	0.7	11.0	21.5	12.7	17.3

Ignoring the rotation, the ΔV is calculated as follows:

$$\Delta V = V_s - V_i = \sqrt{(u_s - u_i)^2 + (v_s - v_i)^2}$$

$$= \sqrt{(12.7 - 45.4)^2 + (17.3 - 0)^2}$$

= 37.0 ft/sec

When rotation during impact is considered, the actual ΔV is calculated as follows:

$V = \psi + \beta = \psi +$ ATAN2(v/u)

= 0 + ATAN2(0/45.4) =0° (at impact)

= 11 + ATAN2(17.3/12.7) = 64.7° (at separation)

Calculating V_x and V_y relative to the earth-fixed coordinate system,

$V_x = V_t \cos(v)$

= 45.4cos(0) = 45.4 ft/sec (at impact)

= 21.5cos(64.7) = 9.2 ft/sec (at separation)

$V_y = V_t \sin(v)$

= 45.4sin(0) = 0.0 ft/sec (at Impact)

=21.5sin(64.7) = 19.4 ft/sec (at separation)

Then, the ΔV is

$$\Delta V = V_s - V_i = \sqrt{(V_{X,s} - V_{X,i})^2 + (V_{Y,s} - V_{Y,i})^2}$$

$$= \sqrt{(9.2 - 45.4)^2 + (19.4 - 0)^2}$$

= 41.1 ft/sec

As you can see, the ΔV is different when rotation is considered.

For normal amounts of rotation during impact, the difference is not great. However, the difference can become sizable when rotations are large. Note that the ΔV reported in the Damage Summary Report addresses this problem by reporting a ΔV for each CDC having a different clock direction.

2007 *HVE* Forum San Antonio, TX

The 2007 *HVE* Forum will take place from February 26 to March 2, 2007, in San Antonio, Texas. All events and activities will be held at the Hilton Palacio del Rio hotel, located just two blocks away from the Alamo, on the famous River Walk in downtown San Antonio.

A special room rate of $169/night has been arranged for attendees of the 2007 *HVE* Forum. To receive this rate, you will need to make your reservation directly with the hotel using the Group Reservation Code of "*HVE* Forum". More information about the 2007 *HVE* Forum, including workshop schedules, descriptions and registration forms is available on the 2007 *HVE* Forum pages on the EDC website.

Last year, the Advanced *HVE* Workshops were FULL, so don't wait too long to register! See you in San Antonio in 2007!

Call for 2007 *HVE* Forum White Papers

HVE users interested in presenting a technical paper in the "*HVE* White Paper" session for the 2007 *HVE* Forum are invited to submit an abstract for consideration. This session is an opportunity to showcase unique skills or specialized applications of *HVE* to other *HVE* users as well as to non-*HVE* users who may be interested in the utilizing the authors services. White Papers are made available to the general public on the *HVE* White Papers section of the EDC website following each years event.

The following subjects are considered: *HVE* Case Studies, Innovative Tips and Techniques Using *HVE*, or Any Application of *HVE* Showcasing its Capabilities.

If you are interested in presenting a white paper, please submit your abstract of 100 to 250 words in length to EDC Customer Service before September 30, 2006.

Upgrade From *HVE-2D* to *HVE*

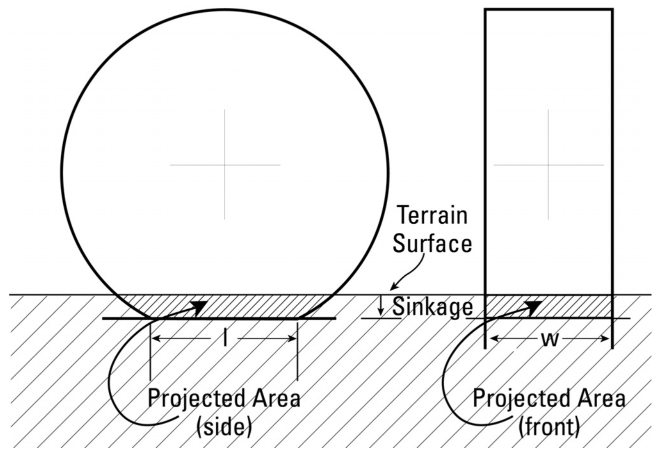
HVE-2D users can still take advantage of an upgrade offer allowing them to trade in their *HVE-2D* system software and vehicle database towards the purchase of the *HVE* system software and vehicle database. By upgrading from their *HVE-2D* software to *HVE*, users can expand their simulation capabilities to address driver visibility issues, effects of road crown, super-elevation or irregular terrain on vehicle trajectory, 3-D collision effects due to vehicle body inter-actions, and even occupant or pedestrian issues. Making the transition from 2D to 3D is easy because:

- All current physics programs are transferred across from *HVE-2D* to *HVE*
- All previous case work using *HVE-2D* transfers directly across to *HVE*, since case file formats are compatible between *HVE-2D* and *HVE*.
- Experience using *HVE-2D* transfers directly across to *HVE* since the Editors, dialogs and operations are the same. In fact, the *HVE* user interface is exactly the same as *HVE-2D*, but adds the Human Editor, extra dialogs in the Vehicle Editor, and access to additional physics models and set-up options in the Event Editor.

For information on upgrading from your *HVE-2D* to *HVE*, please contact EDC sales at 503.644.4500.

SIMON 3.01 Update

An interim update for *SIMON* users has been made available on the Support Downloads section of the EDC website. This update is only for *HVE* Version 5.10 users of the *SIMON* vehicle dynamics simulation model. It addresses a single issue - - In *SIMON* 3.00, the Soft Soil Tire-Terrain Model was calculating the tire plough force in the soil, and tire sinkage and plough force were being displayed properly in Key Results and Variable Output windows. However, the force was not included in the equations of motion. Thus, the plough force had no effect on vehicle behavior. This has been corrected in this *SIMON* 3.01 Update.



The download is a zip archive. The updated SIMON.exe must be downloaded and extracted to the appropriate folder locations. There is a set of instructions included in the zip archive. ***NOTE**: This update requires the user to install a new license file from EDC.*

EDKEY Driver for 64-bit Installations

The EDKEY driver installation included on the Version 5.10 CD supports Windows 32-bit Operating Systems. However, the availability of newer 64-bit processors and also the upcoming Windows Vista release requires some changes in the EDKEY drivers. If you have a 64-bit installation and you find that your EDKEY does not function properly, you will need to download a new driver from the Support Downloads section of the EDC website. NOTE*: This driver is only applicable for Windows XP-Pro 64-bit and Windows 2003 64-bit (AMD64/EM64T) installations - for Windows 64-bit Itanium, please contact EDC for further assistance.*

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: Every now and then I find that the X-Y crosshair manipulator for positioning a vehicle in the Event Editor disappears. If I move the camera inside the vehicle, I find that the manipulator is still present at the CG of the vehicle, but has become extremely small. What can I do to fix this issue?

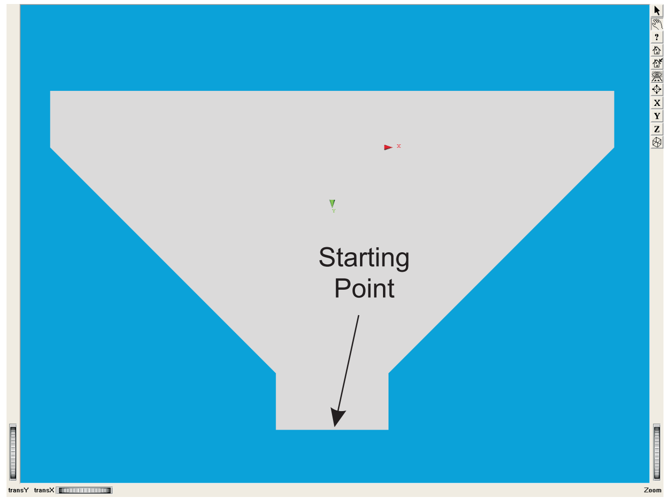
A: An optimization routine of your graphics card may be "stepping" on the scaling factor for the manipulator to be the proper size for use in *HVE*. Try disabling the "Enable Write Combining" setting of your graphics card. First locate your Display Properties dialog, then select the Settings tab, click the Advanced button, select the Troubleshooting tab and then simply uncheck the checkbox for Enable Write Combining.

Q. What is the recommended graphics card to use for running HVE on a desktop or laptop computer?

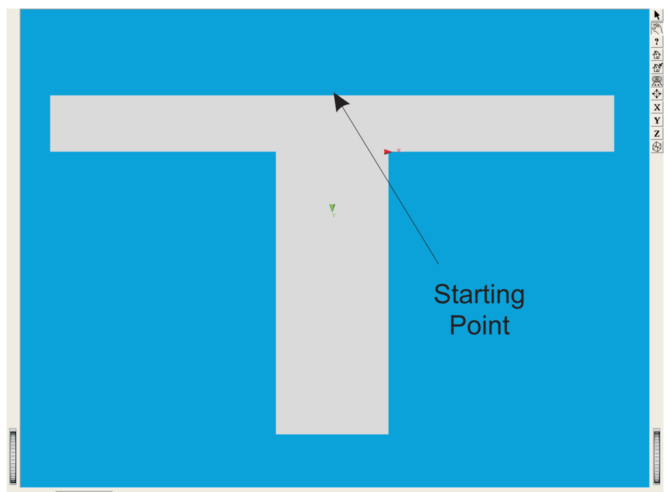
A. Our users have reported that NIVIDIA GeForce or Intel Integrated Graphics technologies provide the most stable support for *HVE* on either desktop or laptop computers. We still frequently hear about crashes related to ATI Radeon and ATI Mobility graphics technologies. If you have an ATI card, you may have to reduce your Hardware Acceleration settings to NONE in order to successfully run *HVE*.

Q. I'm trying to use the 3D Editor to build a continuous surface resembling a T - Intersection. I am developing the surface by selecting my points in a counter-clockwise direction, but I am having some problem getting the surface to properly look like a T-Intersection. I find that if I start at the bottom of the T it doesn't work properly, but if I start at the top of T, it works fine. What's happening?

A. The 3D Editor will properly complete the surfacing operation only if your starting point for building the surface can be "seen" from all other points of your surface without any interferences. If you start at the top center of the T, then every point used to build the T surface can be "seen" from the starting point. But if you start at the bottom of the T, and then try to continuously build the top right or top left portion of the T, an imaginary line drawn from the current point back to the starting point overlaps areas that you expect to be not included in your surface. See the examples of surfaces accompanying this answer.



T-Intersection surface built from points starting at the bottom of the T and working around the shape in a counter-clockwise direction until the surface is enclosed. The result shows that the surface has been improperly extended from the base to both arms of the T.



T-Intersection surface built from points starting at the center top of the T and then working around the shape in a counter-clockwise direction until the surface is enclosed. Imaginary lines drawn from the starting point to every point on the surface do not cross any edges of the surface.

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.

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