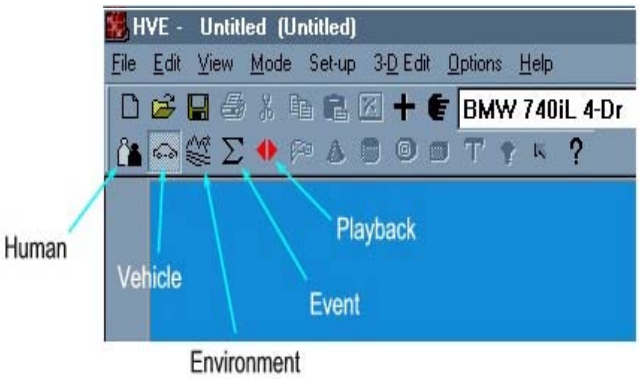
DECEMBER 2000 ENGINEERING DYNAMICS CORPORATION

Technical Newsletter

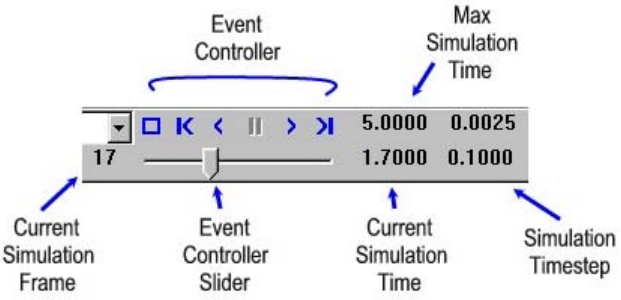
HVE Version 4 Offers Greater Efficiency

HVE Version 4 offers *HVE* users the same functionality and capability they expected in the SGI version, plus even greater power and speed! There are several new data-entry and control enhancements incorporated in *HVE* Version 4 designed to make it easier to set-up and execute events.

The new single-window interface provides the user with easy access to data entry dialogs, toolbars, event controllers and other time-saving features. Clicking on an Editor icon on the Toolbar takes the user quickly between the Human, Vehicle, Environment, Event and Playback Editors.



Setting up a simulation event is now even easier with the newly designed Position/Velocity dialog that allows you to immediately access Initial Position and any additional target positions without re-opening the dialog. The new driver controls dialogs allow the user to quickly enter data for all driver inputs, such as steering, braking, throttle, gear and Path Follower. The Event Controller slider now allows you to review your simulation results time-step by time-step directly in the Event Editor.



Once the simulation work is complete, the newly designed Playback Window allows users to quickly combine multiple simulation events into a complete sequence, produce compressed movie files for real-time playback, and route the real-time playback direct to videotape.

To order a copy of *HVE* Version 4 to experience the new interface for yourself, contact EDC Sales at 503.644.4500 ext 2 or email sales@edccorp.com.

INSIDE

Technical Session

4-Spring and Walking Beam Suspensions

The new versions of *SIMON* and *EDVDS* now model tandem axles with 4-spring and walking beam suspension types. These suspensions are different from solid axle suspensions in that the axle displacement of one axle affects the axle displacement of the other axle. The axle displacements, in turn, affect suspension forces. The result is a load-leveling effect between the leading and trailing axles. The modeling approaches for 4-spring suspensions and walking beam suspensions are different.

4-Spring Suspensions

In a 4-spring suspension, the front and rear leaf springs are connected by a pinned link (see Figure A). This link tends to transfer the load between front and rear suspensions. The result is that suspension force for the front and rear springs is equalized (or nearly so). The equalizing effect is modeled by calculating the average axle displacement from equilibrium and adding/subtracting this value to/from each spring deflection:

$$\begin{aligned}
\overline{\Delta}_{Leading} &= \dot{\overline{\Delta}}dt \\
\overline{\Delta}_{Trailing} &= -\dot{\overline{\Delta}}dt \\
\delta_{Spring,Leading} &= \delta_{0_{Spring,Leading}} - \overline{\Delta}_{Leading} \\
\delta_{Spring,Trailing} &= \delta_{0_{Spring,Trailing}} - \overline{\Delta}_{Trailing} \\
\dot{\delta}_{Spring,Leading} &= \dot{\delta}_{0_{Spring,Leading}} - \dot{\overline{\Delta}} \\
\dot{\delta}_{Spring,Trailing} &= \dot{\delta}_{0_{Spring,Trailing}} + \dot{\overline{\Delta}} \\
F_{Spring} &= f\left(K, C, C_f, \delta_{Spring}, \dot{\delta}_{Spring}\right) + \Delta F_{X-fer}
\end{aligned}$$

where

$\overline{\Delta}$ = Average spring deflection

$\dot{\overline{\Delta}}$ = Average spring velocity

dt = Integration timestep

δ = Spring deflection

$\dot{\delta}$ = Spring deflection rate

δ_0 = Axle deflection

$\dot{\delta}_0$ = Axle deflection rate

F_{Spring} = Suspension spring force

K = Spring rate

C = Spring damping coefficient

C_f = Spring coulomb friction

ΔF_{X-fer} = Inter-axle load transfer due to wheel torque

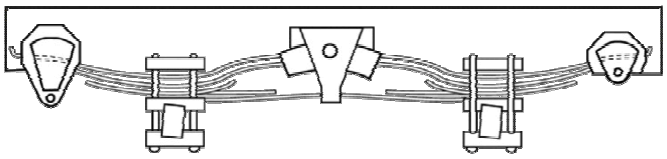


Figure A

Walking Beam Suspensions

In a walking beam suspension, both axles are supported by a single spring (see Figure B). Therefore, only the front axle suspension parameters are used when a walking beam suspension is selected. The approach for walking beam suspensions is quite similar to 4-spring suspensions:

$$\begin{aligned}
\overline{\Delta}_{Leading} &= 0.5\left(\delta_{0_{Leading}} - \delta_{0_{Trailing}}\right) \\
\overline{\Delta}_{Trailing} &= -\overline{\Delta}_{Leading} \\
\dot{\overline{\Delta}} &= 0.5\left(\delta_{0_{Leading}} + \delta_{0_{Trailing}}\right) \\
\overline{\Delta} &= \delta_{0_{Leading}} - \overline{\Delta}_{Leading} \\
F_{Spring} &= f\left(K, C, C_f, \overline{\Delta}, \dot{\overline{\Delta}}\right) + \Delta F_{X-fer}
\end{aligned}$$

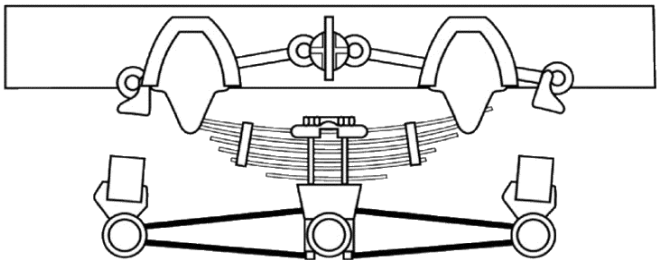


Figure B

Load equalization between axles is desirable as it prevents tire/suspension overloading while traveling over irregular terrain. Both the 4-spring and walking beam suspensions do a reasonable job in this regard.

Inter-Axle Load Transfer

Driving and braking torques result in an inter-axle load transfer for both suspension types. The reaction at the spring ends increases or decreases due to the applied torque (see Figure C). This reaction force increases or decreases the total spring force. The amount of load transfer is calculated from the applied axle torque and the user-supplied inter-axle load transfer coefficient,

$$\Delta F_{X-fer} = \gamma \frac{T_{Leading} + T_{Trailing}}{X_{Leading} - X_{Trailing}}$$

where

γ = Inter-axle load transfer coef (+ for load transfer from the rear axle to the front axle)
T = Wheel torque (+ for drive torque; - for brake torque)
X = Wheel vehicle-fixed x-coordinate

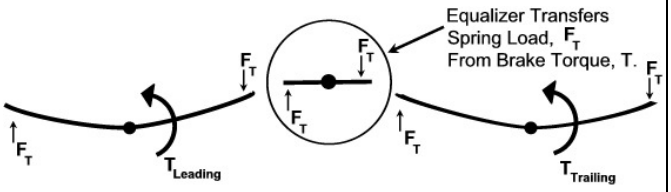


Figure C

The inter-axle load transfer coefficient represents the ratio of the vertical load transferred from the trailing axle to the leading axle, to the total applied wheel torque. Fancher* provides test results for inter-axle load transfer coefficients for several suspension systems. In general, inter-axle load transfer is negative for 4-spring suspensions (meaning that the spring force is reduced on the front axle and increased on the rear axle). –0.10 to –0.20 is a reasonable range for most 4-spring suspensions. Inter-axle load transfer is approximately zero for walking-beam suspensions.

* Fancher, P.S., et. al., "A Factbook of the Mechanical Properties of the Components for Single-Unit and Articulated Heavy Trucks," University of Michigan Transportation Research Institute, Ann Arbor, 1986, EDC Lib. Ref. No. 1053.

EDC Technical Reference Library

EDC has a library of technical papers and other publications that may be extremely helpful to you. In many cases the publications are free, while others require a fee to cover the cost of printing and handling. For a detailed listing of the publications, please visit the Library section of the EDC website at www.edccorp.com. Here is a list of a few of the available publications:

"An Overview of the Way *EDCRASH* computes Delta-V", SAE 870045, Engineering Dynamics Corp., 1987.

"An Overview of the Way *EDSMAC* computes Delta-V", SAE 880069, Engineering Dynamics Corp., 1988.

"Application and Misapplication of Computer Programs for Accident Reconstruction", SAE 890738, Engineering Dynamics Corp., OR, 1989.

"Further Validation of *EDCRASH* Using the RICSAC Staged Collisions", SAE 890740, Engineering Dynamics Corp., 1989.

"Further Validation of *EDSMAC* Using the RICSAC Stage Collisions", SAE 90010, Engineering Dynamics Corp., 1990.

"Validation of Several Reconstruction and Simulation Models in the *HVE* Scientific Visualization Environment", SAE 960891, Engineering Dynamics Corp., 1996.

"Validation of the *EDVSM* 3-Dimensional Vehicle Simulator", SAE 970958, Engineering Dynamics Corp., 1997.

"Differences Between *EDVDS* and Phase 4", SAE 1999-01-0103, Engineering Dynamics Corp., 1999.

"An Overview of the *EDSMAC4* Collision Simulation Model", SAE 1999-01-0102, Terry D. Day, Engineering Dynamics Corp., 1999.

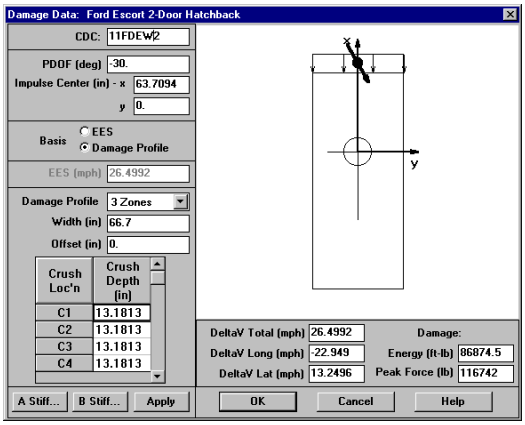
"Validation of *DyMESH* for Vehicles vs. Barrier Collisions", SAE 2000-01-0844, Terry D. Day, Engineering Dynamics Corp., Allen R. York, AR York Engineering, Inc. 2000.

"Applications and Limitations of 3-Dimensional Vehicle Rollover Simulation", SAE 2000-01-0852, Engineering Dynamics Corp., 2000.

User Hints and Tips

General

- *EDCRASH* uses the 7-character Collision Deformation Classification (CDC) code that describes damage profile characteristics including PDOF, Damage Location, Damage Width, and Average Crush Depth. Consider the CDC 11FDEW2 (shown below). "11" is the clock direction of the PDOF. "F" identifies the vehicle front as the general damage region, and "D" identifies the entire front as the specific damage region. "E" specifies that the damage occurred below the beltline. "W" means that the damage width was wide (> 16 inches). Finally, "2" pertains to the maximum extent of penetration.



The vehicle's damage profile default information can be edited once a CDC has been entered. An in-depth discussion of CDC can be found in SAE Information Report (SAE J224).

HVE-2D

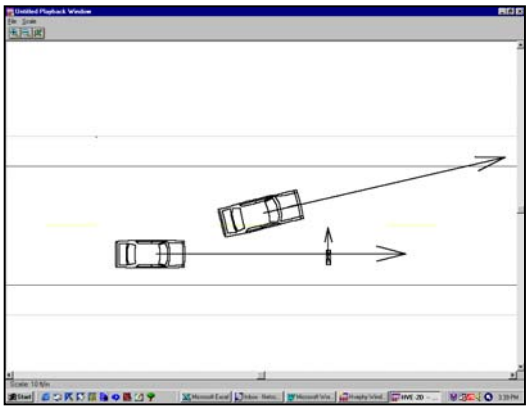
- *HVE-2D* version 1.33, shipped in December, contains an important change in the physics behind the Edit - Driver Controls – Wheel Data dialog. The dialog prompts the user to enter pre-impact braking as Percent of Total Wheel Lock-up, rather than Drag Factor. This accurately reflects the new equation for computing begin braking velocity (below). The interface has not changed, just the physics model. Your new documentation reflects this change. It is advised, therefore, that you reexecute any events in which a begin braking position was entered.

$$V_{bb} = \sqrt{V_{imp}^2 + 2g\theta\mu S}$$

where:
V_{bb} = velocity at begin braking
V_{imp} = velocity at impact
g = acceleration of gravity
θ = total wheel lock-up
μ = coefficient of friction
S = path length

- Although *HVE-2D* does not allow for vehicle to human collisions, moving barriers may be used to represent visually a human pedestrian or other moving object in time-distance studies. The dimensions of the barrier can be changed to the approximate size of a human, a velocity can be assigned, and driver controls can be used to dictate the speed and direction of the barrier. In the example below, two *EDSMAC* events are combined in a Playback Window to simulate a vehicle maneuvering around a pedestrian who is crossing the street.

  Caution: Moving barriers must not be used to simulate collisions with vehicles. The simulation will terminate at the start of the collision.



- Sometimes it is desired to have *HVE-2D* up and running without seeing your desktop icons in the background. In order to have *HVE-2D* occupy the entire screen, follow these simple instructions.

  (1) Right click on the *HVE-2D* icon, and then choose Properties.
  (2) In the Properties dialog, select the Shortcut tab. In the Run command line, choose Maximized from the drop down list.
  (3) Press OK, and you are finished.
  (4) Start *HVE-2D*.

  Note: If you need to view the event information dialog in the Event Editor, you must first hide the key results, under the Options menu.

HVE and HVE-2D FAQ

This section contains answers to questions submitted to Technical Support by users of *HVE* and *HVE-2D*.

Q: I am reviewing the work of another reconstructionist who is using *HVE* or *HVE-2D*. What information do I need to request from that expert in order to evaluate his or her results?

A: For *HVE-2D*, you should request the case file (with the events executed) and the environment geometry file. While the environment is not used by the physics, it may be important for visualization studies.

If you are reviewing *HVE* results and are a user of *HVE*, you should request the case file (with the events executed). The case file will contain all environment (including 3-D geometry) and vehicle data. The case file does not contain any vehicle 3-D geometry files. These files are required for reproducing *DyMESH* simulations involving collisions and *EDVSM* simulations involving rollover. These 3-D geometry files are licensed property and cannot be transferred without permission of the vendor (EDC, Viewpoint, or whomever). These files may, however, also be purchased from the vendor.

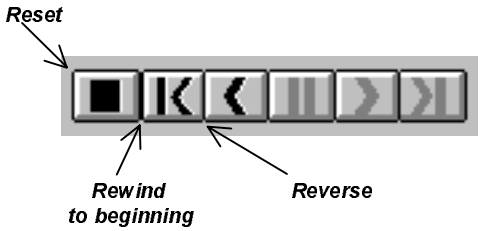
If you are reviewing *HVE* results and are not a user of *HVE*, you should request all of the numeric output reports, including Messages, and a video of any Trajectory Simulations or event Playbacks.

Q: When using *EDSVS*, why is the yaw moment of inertia that I enter in the Vehicle-Inertias dialog different from the one reported in the Vehicle Data output report?

A: The value for yaw moment of inertia that you enter in the Vehicle-Inertias dialog is the value about the vehicle's center of gravity, as expected. *EDSVS* is based on a model developed at the University of Michigan, TBST. In this model, the yaw moment of inertia is resolved about the geometric center of the vehicle. *EDSVS* uses the same logic. As for all variables, the value given in the output report is the value actually used by the program.

Q: Are the data in the output reports updated when I reexecute an event?

A: Yes, the data in the output reports are updated when you reexecute an event. In order to reexecute an event, you must first press the Reset button on the Event Controller (see below). This will effectively erase all of your previous results but will not effect input values. If you did not reset the event, you will just be replaying the results from before you made your changes, and the numeric reports will be identical.



Q: Why do I get Security Error 2 when I try to start *HVE-2D* on my Gateway G6 computer running Windows 98?

A: There is a known conflict between some soundcard drivers on Gateway G6 computers and the EDKEY driver. The soundcard on these computers overwrites the memory used by the EDKEY System Driver. The solution is to go to the Gateway Computer website, http://www.gateway.com/support/product/drivers/index.shtml, and download the latest driver for your particular soundcard.

Q. When I open the Damage Profile Preview Window for an *HVE-2D EDSMAC* simulation, the vehicle does not look damaged. Why?

A. You must open both a Trajectory Simulation and a Damage Profile Preview Window for your event in the Playback Editor to view properly vehicle damage. Similar to playing a Trajectory Simulation, when you press the Play button in the Playback Editor you will see the damage displayed as a function of time. More detailed instructions on viewing damage are included in the file HVE2d/damage.DOC.

EDCRASH Damage Energy Message Explained

EDCRASH performs a number of comparisons between the results of the damage and momentum analyses in order to both refine the results and give the user diagnostic feedback. One of the most common informative messages issued by the program pertains to the damage energy:

WARNING: The Damage-based estimates for damage energy grossly violate the conservation of energy.

If both damage and scene data are entered, *EDCRASH* performs a compatibility check between the damage energies computed from:

(1) Damage Profiles
(2) Scene Data with damage based ΔV
(3) Linear momentum based ΔV

These values should be equal. If value (2) or (3) differs from value (1) by more that 50 percent, the above message is issued.

Using all three calculation methods, the total damage energy is equal to the sum of the individual vehicle damage energies (Eqn. 1).

$$E_{dam} = E_{dam1} + E_{dam2} \quad \text{(Eqn. 1)}$$

where:
E_{dam} = total damage energy
E_{dam1} = damage energy for vehicle 1
E_{dam2} = damage energy for vehicle 2

(1) Damage Profiles

Damage energy based on each vehicle's damage profile can be determined within the Damage Profile dialog. The total damage energy is the sum of the individual damage energies (Eqn. 1).

(2) Damage and Scene Data

The damage energy based on scene data is equal to the loss of kinetic energy caused by the collision. Kinetic energy is equal to

$$KE = \frac{1}{2}mV^2 + \frac{1}{2}I_z\dot{\psi}^2 \quad \text{(Eqn. 2)}$$

where:
m = mass
V = linear velocity
I_z = yaw moment of inertia
$\dot{\psi}$ = angular velocity

Thus, damage energy is calculated separately for each vehicle (Eqn. 3) and summed using Equation 1.

$$E_{dam} = \frac{1}{2}mV_{imp}^2 - \frac{1}{2}mV_{sep}^2 - \frac{1}{2}I_z\dot{\psi}_{sep}^2 \quad \text{(Eqn. 3)}$$

where:
imp = impact
sep = separation

To calculate damage energy based on scene data with damage based ΔV, use the longitudinal and lateral damage based ΔV (available in the Accident History report) to calculate impact velocity in each direction using Equation 4. Then, compute total impact velocity (Eqn. 5).

$$V_{imp} = V_{sep} - \Delta V \quad \text{(Eqn. 4)}$$

$$(V_{imp})_{Total} = \sqrt{(V_{imp})_{Long}^2 + (V_{imp})_{Lat}^2} \quad \text{(Eqn. 5)}$$

Insert this value into Equation 3 and solve for damage energy of the vehicle.

(3) Linear Momentum

To calculate the damage energy based on the linear momentum based ΔV, use Equations 1, 3, and 4, as above, but insert the momentum based ΔV into Equation 4.

What To Do

If you receive the above message after executing an *EDCRASH* event, there are a number of steps that we recommend you consider in attempting to discover the cause of the incompatibility between damage and scene data.

1. Make sure that both damage and scene data were entered correctly. Pay particular attention to the angles entered in the scene.
2. Scrutinize the damage data to be sure they were measured accurately. Remember to include induced damage.
3. Scrutinize the PDOF's, especially for narrow damage widths, remembering the effect of the energy magnification factor.
4. Scrutinize the crush stiffness coefficients (A and B). Consider adjusting these values if the damage was to a particularly stiff (e.g., wheel) or soft (e.g., fender or grill) area. Increasing the stiffness will increase the energy dissipated, and decreasing the stiffness will decrease the energy dissipated.

Product Announcements

Progress Report on *DyMESH*

EDC has received a patent for the *DyMESH* (Dynamic MEchanical SHell) 3-D Collision method. This breakthrough technology employs methods from finite element technology for collision detection and stress-strain relationships for force calculations. HVE includes the data necessary to use *DyMESH* for all collision simulations, particularly severe under-ride or any crash where three-dimensional impact-mechanics are present. A detailed overview of *DyMESH* can be found in SAE Technical Paper 1999-01-0104 "The *DyMESH* Method for Three-Dimensional Multi-Vehicle Collision Simulation". A copy of this paper is available from the EDC Technical Reference Library webpage.

DyMESH is presently undergoing extensive validation against data from actual staged vehicle to vehicle crash tests. This testing is expected to last several months. SAE Technical Paper 2000-01-0844 "Validation of DyMESH for Vehicle vs Barrier Collisions" describes the results from validation of DyMESH for vehicle to barrier collisions. A copy of this paper is available from the EDC Technical Reference Library webpage.

DyMESH will be available for crash simulations using the SIMON vehicle simulation model in early 2001. For more information about DyMESH or SIMON, please visit our website or contact EDC Sales.

HVE-2D v1.33 Now Shipping!

All HVE-2D users with current Update/Technical Support policies were shipped HVE-2D Version 1.33 in early December. This minor update focuses on a change to EDCRASH's calculation of pre-impact braking speed. This update was accompanied by updated documentation. All HVE-2D users are encouraged to install this update as soon as convenient. Please call EDC Customer Service if you have any questions.

Past Technical Sessions Now Available

EDC has reformatted and compiled all of the Technical Session, Tips, and Contributor's Corner columns from each Technical Newsletter, dating from Jan/Feb 1986 to present. The valuable information presented in these columns will increase your knowledge of the physics models and the HVE, HVE-2D, and EDVAP programs, as well as provide examples of powerful applications of the software. The price for the document is US $45.00 and includes shipping within the US. International customers will pay additional shipping charges to their delivery address.

EDC's Website

For the latest product news and training course announcements, be sure to visit the EDC website on a regular basis. Recently we updated our Education & Training pages with downloadable course information and registration forms. The Library pages have been updated with the latest offering of Technical Reference Publications and many of these can be downloaded straight from the webpage. We have also created HVE and HVE-2D FAQ pages full of important information for both new and long-time users. We have many more updates planned for the coming months, so be sure to bookmark www.edccorp.com and visit often!

Technical Support

Technical Support can be reached by telephone between 8:00 AM and 5:00 PM PST at 503.644.4500 and by email at support@edccorp.com. Please be ready to provide your user ID#, your name, your company name and contact phone number when you call or include it directly in your email.

HVE Regional Demos

EDC is offering personal demonstrations of *HVE* for those who would like a private, 1½-hour look at this powerful tool. Currently planned regional demos are:

Los Angeles, CA .....January 22-25, 2001
Phoenix, AZ.....January 29-31, 2001
Detroit, MI.....March 5-8, 2001

Please call us in advance to make arrangements for your personal, hands-on demonstration.

Training Courses

Vehicle Dynamics

Theoretical and Applied Vehicle Dynamics extends the theory of the SAE course and includes direct applications using the *HVE* three-dimensional simulation environment as well as a solid theoretical background for such simulations. The course is focused toward those with an advanced interest in vehicle dynamics, accident reconstruction and simulation.

EDC Reconstruction & EDC Simulation

EDC provides excellent 1-week training courses on the use of EDC Reconstruction or Simulation software. Even long-time users agree that the courses are extremely beneficial and challenging.

The courses are designed to investigate fully the program's inner workings. Lectures are full of helpful hints gained from years of experience.

HVE Forum

The *HVE* Forum is an excellent opportunity for *HVE*, *HVE-2D* and *EDVAP* users to jump to a new level of ability. By participating in workshops and special lectures, attendees can brush up on their present skills, learn new techniques of applying simulation modeling, 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 and information.

Course Registration

Our courses are typically full, so be sure to register early to avoid missing out! You may register for a course simply by contacting EDC Customer Service at 503.644.4500, or by sending an email to training@edccorp.com. We look forward to seeing you at our next course!

Engineering Dynamics Corporation
Training Courses

EDC Simulations

Los Angeles, CA.....January 22-26, 2001
Coral Gables, FL..... November 13-17, 2001

EDC Reconstruction

Coral Gables, FL.....2002

Theoretical and Applied Vehicle Dynamics

Phoenix, AZ.....January 29-31, 2001

Future dates and locations to be announced.

2001 *HVE* Forum

Santa Fe, NM..... May 7-11, 2001

NUCPS Training

NUCPS offers four different courses using *EDVAP* and/or *HVE-2D*. For more information about the courses and registration, please contact NUCPS at 800.323.4011.

Northwestern University Center for Public Safety Training Courses

MATAR (*EDCRASH*)

Evanston, IL .....March 19-23, 2001

COMPTAR I (*EDCRASH*)

Evanston, IL .....March 12-16, 2001

COMPTAR III (*EDSMAC*)

Evanston, IL .....Call for Dates

COMPTAR IV (*EDCRASH* & *EDSMAC* Extended)

Evanston, IL .....March 26-30, 2001

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