Technical Newsletter

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

See You in Austin!

The 2015 *HVE* Forum will be held during the week of March 2-6 in Austin, Texas, in the downtown convention center area on 6th street. This is a fabulous venue, with lots of nearby restaurants and other attractions.

But the main reason you'll want to go to Austin is the *HVE* Forum workshops – over 30 of them! – each focusing on an particular topic. There are introductory workshops for new or potential *HVE* users, mid-level workshops for those who want to improve their skills, and advanced workshops for the seasoned *HVE* or *HVE-2D* user who wants to become a real power user.

Vehicle Building Class Updated

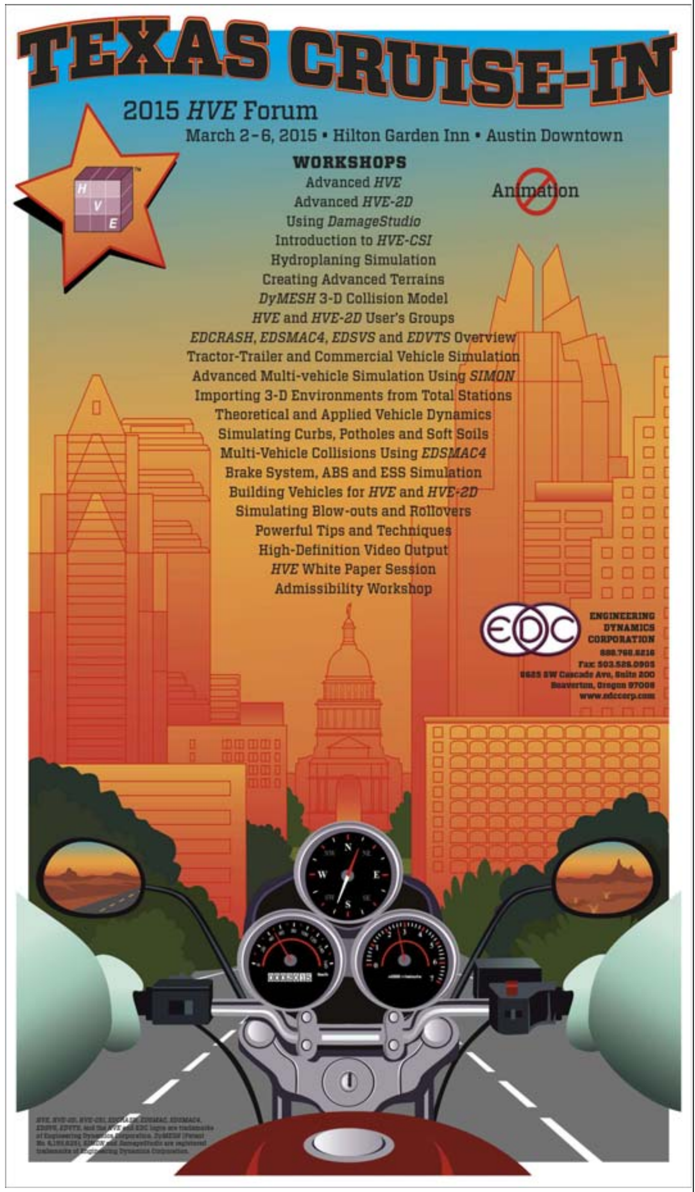
In one of the most popular and important Forum workshops, attendees learn how to build vehicles for *HVE* and *HVE-2D*. This workshop has been updated to include instruction on adding vehicle light systems and textures for grills and undercarriages. Adding textures is a great way to improve realism. And, of course, adding headlights, running lights, brake lights and turn signals not only improves realism, it also provides an opportunity to illustrate how these driver controls might have affected the crash sequence.

HVE White Paper Session

Seven white papers will be presented at the 2015 Forum. Topics range from validation to developing highway design standards for rollover mitigation. The session has been expanded to fill the entire afternoon on Wednesday.

Admissibility Workshop

A new workshop on admissibility of *HVE* results was presented at the 2014 *HVE* Forum. The purpose of the workshop is to provide a clear framework for *HVE* users working to have their results admitted in state and federal courts. The focus of the workshop is on the admissibility of *HVE* results, not on the more general subject of giving expert testimony. This workshop is getting a sophomore update for 2015. The Admissibility Workshop is important for almost every *HVE* and *HVE-2D* user.



Workshop Registration

Mark your calendar for the week of March 2 – 6, 2015. Workshop schedules, descriptions and registration forms are available to view and download at www.edccorp.com/2015HVEForum.. See you in Austin!

Technical Session

The *DyMESH* Wheel Impact model allows the user to simulate crashes that involve collision forces applied directly to one or more wheels. This Technical Session provides a backgrounder and tutorial for the *DyMESH* Wheel Impact model.

Model Overview

The *DyMESH* Wheel Impact model was introduced in *DyMESH* Version 3. Each wheel is treated as an independent *DyMESH* object, just like the vehicle's sprung mass (body). Like the sprung mass, each wheel is represented using a mesh. In the case of a wheel, the mesh is automatically generated according to the tire size designation (tire diameter, rim diameter and width); for a dual tire, the mesh width is determined according

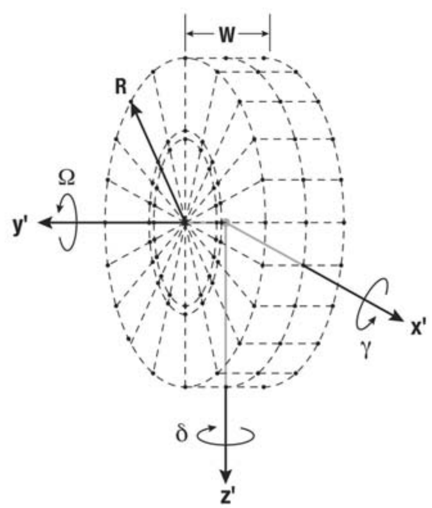


Figure 1 - Wheel mesh definition with 122 nodes

Table 1 - Wheel and tire stiffness

	Standard Vehicles	Heavy Trucks & Trailers
Rim		
A (lb/in^2)	8.33	16.7
B (lb/in^3)	1.67	3.33
Tire		
A (lb/in^2)	1.67	1.67
B (lb/in^3)	*	*

* B is calculated based on tire radial stiffness, K_t, and contact patch area, A: $B = K_t/A$

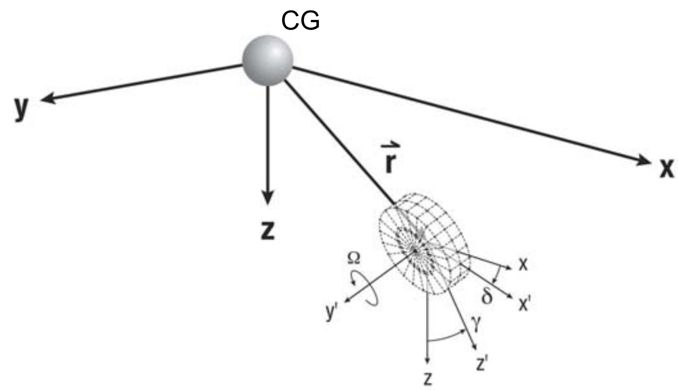


Figure 2 - Vehicle and wheel coordinate systems

to the tire width and inter-dual spacing. The auto-generated mesh includes 122 nodes (vertices), as shown in Figure 1. An A-B stiffness model is used. Stiffnesses are assigned as shown in Table 1.

Each wheel has a position vector, $\vec{r}$, that defines the wheel's vehicle-fixed x,y,z coordinates, as shown in Figure 2. Wheel orientation is defined by camber (γ), spin (Ω), steer (δ) angles. Wheel z-coordinate and spin angle are calculated rigorously (i.e., using equations of motion). Steer angle and camber angle use tables (exception: if the Steer DOF model is used, steer angles are calculated rigorously). Forces applied to the individual wheel vertices are summed in the wheel's coordinate system to produce the total forces and moments about the wheel center. The x,y wheel forces are transformed to the vehicle-fixed coordinate system. These forces and moments are then added to the equations of motion for the sprung mass. The z wheel force is added to the z suspension force component and added to the equations of motion for the unsprung mass. Likewise, wheel camber and steer moments are transformed to the vehicle-fixed coordinate system and added to the equations of motion for roll and yaw. The wheel spin moment is added to the equations of motion for wheel spin. The individual forces and moments acting at each wheel can be displayed in the variable output Wheels group.

DyMESH forces are calculated between the following objects:

- Sprung Mass vs. Sprung Mass
- Sprung Mass vs. Environment (terrain)
- Wheel(s) on one vehicle vs. Sprung Mass of the other vehicle(s)
- Wheel(s) on one vehicle vs. Wheel(s) of the other vehicle(s)

The most common application for the *DyMESH* Wheel Impact model is an intersection collision between the front of the bullet vehicle and a front or rear wheel on the side of the target vehicle.

An application uniquely suited to the *DyMESH* Wheel Impact model is a trailer under-ride crash (i.e., a collision between the front of the bullet vehicle and *only* the wheel(s) of a trailer). Another application, of course, is a crash between two Formula 1 (open-wheeled) race cars!

DyMESH forces are not calculated between the following objects:

- Wheel(s) vs. Environment (terrain)
- Wheel(s) on one vehicle vs. Sprung Mass of the same vehicle

In the case of wheel(s) vs. the environment, *DyMESH* is not used because the *DyMESH* wheel impact forces would be redundant with the forces already calculated by the tire model. In the case of wheel(s) vs. the sprung mass of the same vehicle (e.g., tire encroachment with damaged sheet metal in the wheel well), this may be included in the future, but will first require significant experiential testing.

Tutorial

As a typical example, we will set up an intersection collision wherein a significant portion of the collision pulse goes through the target vehicle's left front wheel. Let's get started.

➢ Start *HVE*.
➢ Go to the Vehicle Editor.
➢ Add a 2008 Acura TL 4-Dr passenger car.
➢ Add a 2014 Subaru XV Crosstrek 5-Dr SUV.
➢ Go to the Environment Editor.
➢ Add an environment.
➢ In the Terrain page, click *Terrain*. A file browser is displayed, showing all the available H3D environment terrain files.
➢ Change the Files of Type to *VRML.* The browser now displays all the available WRL (VRML) terrain files.
➢ Select *HVE*_Intersection, followed by *OK* to add the terrain file to the current environment.
➢ Click *OK*.

The *HVE*_Intersection terrain is displayed in the Environment Editor. Let's continue.

➢ Go to the Event Editor.
➢ Add an event that includes the 2008 Acura and the 2014 Subaru. Select the *SIMON* calculation model.
➢ Enter the following event name: *w/o DyMESH Wheel Impact Model.*
➢ Click *OK.*

The terrain is displayed in the Event Editor.

Because this event involves a collision, we need to activate *DyMESH*:

➢ From the Options menu, choose *DyMESH*. The *DyMESH* options dialog is displayed.

Click the *DyMESH Is Used* checkbox to activate *DyMESH*.

By default, the *DyMESH* options dialog automatically sets the integration timestep to 0.001 seconds and the simulation output interval to 0.02 seconds. These values are suitable for vehicle collisions, wherein the accelerations are briefly very high.

The next step is to set up each of the vehicles:

➢ Select the 2008 Acura in the Event Humans and Vehicle listbox (it's probably already selected).
➢ From the Set-up menu, assign the Position/Velocity as follows: X = -50.0 ft, Y = 18.0 ft, Ψ = 0.0 deg, Vtotal = 30.0 mph.
➢ Assign a brake force table as follows: At t = 0.95 seconds, Pedal Force = 0.0 lb; at t = 1.05 seconds, Pedal Force = 100 lb.
➢ Select the 2014 Subaru in the Event Humans and Vehicle listbox.
➢ From the Set-up menu, assign the Position/Velocity as follows: X = -7.0 ft, Y = -40.0 ft, Ψ = 90.0 deg, Vtotal = 40.0 mph.
➢ Assign a brake force table as follows: At t = 0.5 seconds, Pedal Force = 0.0 lb; at t = 0.6 seconds, Pedal Force = 100 lb.

Before executing the *SIMON* simulation, let's set up our Key Results windows to monitor some important variables:

➢ If the Key Results windows are not displayed, choose the *Options* menu and click the *Show Key Results* option. The Key Results windows are now displayed for each vehicle.
➢ In the Key Results window for the 2014 Subaru Crosstrek, click *Select...* The Variable Selection dialog is displayed.
➢ Click *Clear All Selections* to de-select all the current variables.

- Choose the *Kinematics* output group and select the following Kinematics variables: *X, Y, Z, Roll, Pitch, Yaw, V Tot, Sideslip, Acc Tot, Fwd Acc, Lat Acc, Vert Acc*.
- Choose the *Kinetics* output group and select the following Kinetics variables: *Fx Imp, Fy Imp, Fz Imp,*
- Click *OK* to add the selected variables to the Subaru's Key Results window.

Now, let's repeat the process for the 2008 Acura TL:

- In the Key Results window for the Acura, click *Select…* The Variable Selection dialog is displayed.
- Click *Clear All Selections* to de-select all the current variables.
- Choose the *Kinematics* output group and select the following Kinematic variables: *X, Y, Z, Roll, Pitch, Yaw, V Tot, Sideslip, Acc Tot, Fwd Acc, Lat Acc, Vert Acc*.
- Choose the *Kinetics* output group and select the following Kinetics variables: *Fx Imp, Fy Imp, Fz Imp.*

Although it is not yet known to us, the collision we're about to simulate involves a pretty good impact to the Acura's left front wheel. Let's add that impact force to the Acura's Key Results window:

- Choose the *Wheels – Axle 1, Left* output group and select the following variables: *Fx Imp, Fy Imp, Fz Imp.*

NOTE: These are the forces acting on the selected wheel, as opposed to the Kinetics output group values, which are total forces (the sum of forces on the sprung mass and the wheel(s)).

- Click *OK* to add the selected variables to the Acura's Key Results window.

Now let's execute the *SIMON* event:

- Click the *Play* button in the Event controller.

The simulation runs to termination (see Figure 4). Replay the event a few times to gain an understanding of the basic crash sequence.

Now, let's activate the *DyMESH* Wheel Impact model. Here's a smart move: We're going to make a copy of this event so we can easily note the difference in the outcome with and without the *DyMESH* Wheel Impact model:

- Click the *Copy* icon on the *HVE* toolbar. The Copy Event dialog is displayed.
- Change the event name to *w/ DyMESH Wheel Impact Model.*
- Click *OK*.

To activcate the *DyMESH* Wheel Impact model:

- Choose *Set-up, Wheels.* The Wheels Set-up dialog is displayed and the current page is selected (the current page is saved from session to session).
- If the Damage page is not currently displayed, click the *Damage* tab to display the Damage page for the 2008 Acura (see Figure 3).

The *DyMESH* Wheel Impact parameters are displayed in the lower part of the dialog, below the Use *DyMESH* checkbox. Noting from our prior simulation that impact occurred at the left front wheel, let's activate the required parameters as follows:

- Click on the Axle No. dropdown list and select *Axle No. 1.*
- Click on the *Left Side* radio button.

No wheel damage parameters are yet enabled.

- Click the *Wheel Is Damaged* checkbox. The Wheel Damage variables are now enabled, including the *Use DyMESH* checkbox.
- Click the *Use DyMESH* checkbox.

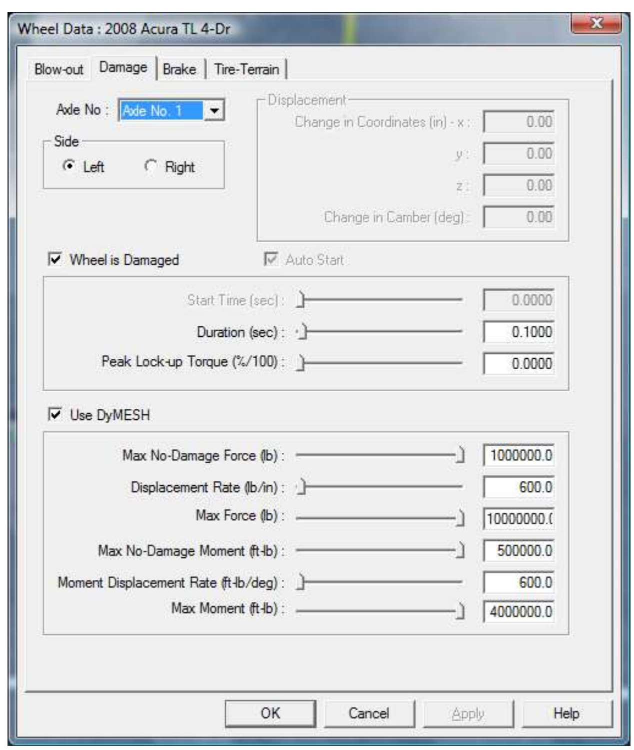


Figure 3 - Set-up Wheel Damage page

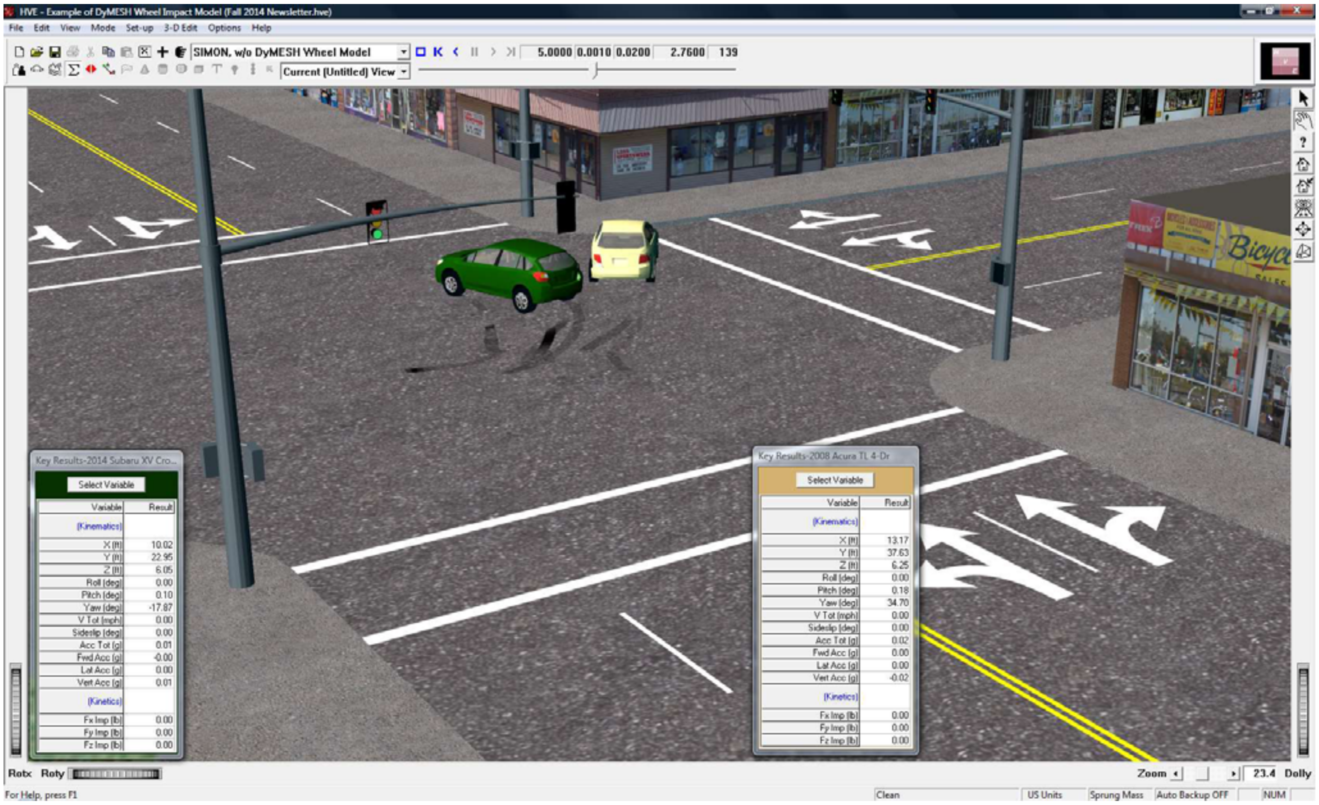


Figure 4 - Simulation without the *DyMESH* Wheel Impact model, shown with vehicles at their final/rest positions.

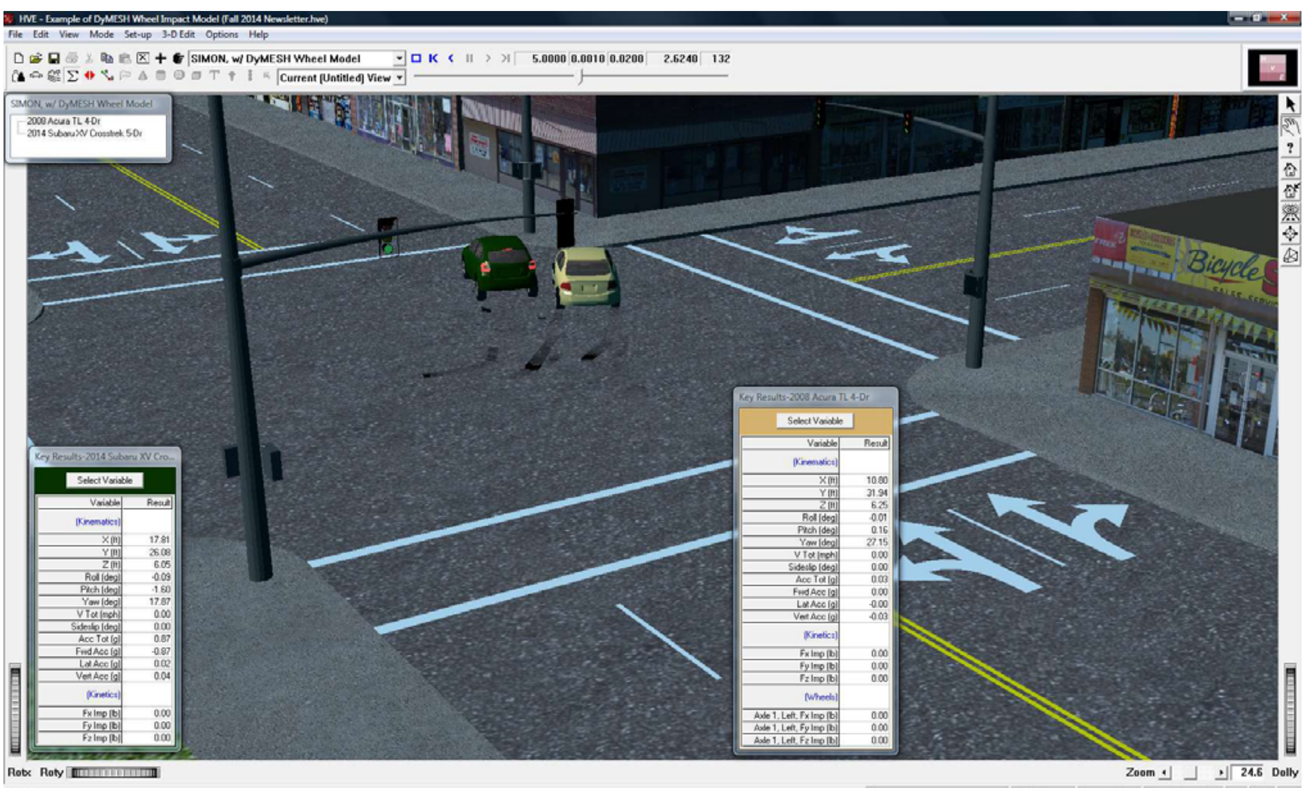


Figure 5 - Simulation with the *DyMESH* Wheel Impact model, shown with vehicles at their final/rest positions.

The *DyMESH* Wheel Impact model is now activated for the selected wheel. The *DyMESH* parameters for that wheel are also enabled. Note that the Displacement group and the *Start Time* field are now disabled. That's because the *DyMESH* Wheel Impact model will calculate the start time, as well as any resulting wheel displacement.

Let's edit the wheel force/moment vs. displacement parameters to make the suspension effectively rigid:

- ➢ Increase the values for Max No-Damage Force and Max No-Damage Moment to their maximum values (see Figure 3).
- ➢ Increase the values for *Max Force* and *Max Moment* to their maximum values.
- ➢ Click *OK*.

Let's execute the simulation.

- ➢ Click *Reset.*

This clears the results of the original simulation.

- ➢ Click *Play*.

The simulation executes. *SIMON* is now including the additional forces and moments applied directly to the Acura's wheel during the collision. Looking at the Acura's Key Results, you can see the total forces displayed in the Kinetics output group, and the forces acting directly on the wheel in the Wheels output group.

Allow the simulation to run to completion. Then, compare the final/rest positions and orientations with the earlier results (this is easy to do by simply switching back and forth between events). See Figures 4 and 5. The difference is the direct result of including the wheel impact forces and moments in the simulation.

User-editable Parameters

Let's discuss the *DyMESH* Wheel Impact parameters (refer to the dialog in Figure 3). The *DyMESH* Wheel Impact model allows *DyMESH*-produced forces and moments to act on a wheel. If these forces are large enough, it is possible that the suspension elements supporting the wheel will fail and the wheel will become displaced. To model that phenomenon, the *DyMESH* Wheel Impact model assumes a linear force-displacement model of the suspension components that support the wheel. This is analogous to an A-B stiffness model, wherein the A coefficient represents the force required to begin displacing the wheel and the B coefficient is the force vs. displacement relationship. Thus, the magnitude of the wheel linear displacement, δ, is

$$\delta = \frac{F_{Imp} - A_{Linear}}{B_{Linear}}$$

The direction of the displacement is determined by the vehicle-fixed wheel force components, $F_{x\ Imp}$, $F_{y\ Imp}$. Note that $F_{z\ Imp}$ is not involved in this calculation because any z-displacement goes into wheel jounce or rebound.

A similar angular wheel damage displacement is also modeled using a linear model. The magnitude of the wheel angular displacement is

$$\alpha = \frac{M - A_{Angular}}{B_{Angular}}$$

where $A_{Angular}$ is the moment required to begin an angular deformation, and $B_{Angular}$ is the moment vs. angular displacement relationship. Angular displacement occurs about the camber axis and, if the Steer DOF is not used, about the steer axis. There is no moment-induced angular displacement about the spin axis because this moment simply causes the wheel spin to increase or decrease according to the equations of motion for wheel spin.

The *DyMESH* Wheel Impact model was derived using classical engineering modeling methods. However, the force and moment vs. displacement parameters required by the model were unknown and experimental test results were not available. Therefore, the model was in beta testing for two years while EDC acquired enough user-feedback to provide reasonable estimates for these parameters. The resulting default parameters were estimated based on vehicle weight, W, (excluding payload) and the number of wheels, N. The procedure for assigning default values is as follows:

- The vehicle weight, W, is rounded down to the nearest 1000 lb.
- X (an intermediate value) = $2 \times W \times N$
- $A = X$ (force/moment threshold)
- $B = X \div 10$ (displacement rate)
- $M = 10 \times A$ (maximum force/moment)

These values provide a reasonable starting point for both the force and moment vs. displacement coefficients. If the observed linear or angular wheel displacement is greater than (or less than) the displacement actually observed on the damaged vehicle, simply decrease (or increase) A and/or B in such a way as to cause the simulated wheel displacement to match the actual displacement. If the goal is to ensure there is no wheel displacement, simply increase A to its maximum value (as we did in our tutorial example).

The simulation will terminate with an error message (excessive wheel force/moment from *DyMESH* wheel impact) if the simulated force or moment exceeds M. Again, if the goal is to ensure the simulation does not terminate due to an excessive force or moment, simply increase M to its maximum value.

Summary

As this common example shows, including the impulsive force acting at a wheel during a collision can be quite important (if you looked carefully at the Acura's Key Results during the collision phase, you noticed that the wheel impact accounted for a very large fraction of the overall collision force).

The Technical Session in our next Newsletter will illustrate another example using the *DyMESH* Wheel Impact model: An under-ride collision involving the wheels of a semi-trailer. The model needs to (and does) account for the unique issues that arise in this type of collision involving a solid axle suspension.

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!

EDC Simulations January 19 - 23, 2015 Burbank, CA

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 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 damage-only analysis, collinear collision analysis and oblique collision analysis.

Links to download your course registration form and to make your hotel reservations at the Burbank Airport Marriot 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 *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: While installing HVE, I enter in my user information, point the HVE installer to my license file and then click 'Next' to begin the installation. But I receive a circular progress wheel and nothing else happens. The progress wheel just keeps spinning, and HVE never installs.

A: This occurs when a computer's anti-virus software or firewall blocks *HVE* from being installed. Anti-virus software and firewalls have ways to add *HVE* to their "Safe" lists but the easiest solution is to reboot your computer in Safe Mode and then install HVE. This resolves the issue 100% of the time on all computers. Once HVE is successfully installed simply restart your computer one more time so it can boot regularly and then you'll be all set. You can reboot a computer in Safe Mode by hitting the "F8" key as soon as, or just before, the Windows splash screen appears. Windows 8 users may have trouble with this because the computer boots so quickly. In that case try clicking the F8 key repeatedly while computer reboots. If that does not work,you can follow the suggestions provided at the following link:

http://www.howtogeek.com/107511/how-to-boot-into-safe-mode-on-windows-8-the-easy-way/

Q: My generic vehicle shows no damage in the Collision Data report, even though I can visually see the collision damage within my EDSMAC4 simulation. Why?

A: If you are using any generic vehicle geometries, make sure you tessellate each vehicle. To tessellate a vehicle, select it in the Event Editor and then click the *Set-up* menu and choose *Vehicle Mesh*. Within the Vehicle Mesh Options dialog check the *Tessellate* checkbox. The default value (20 inches) is suitable for most situations. The EDSMAC4 physics module does not require you to tessellate generic vehicles because the visual mesh is not used in the physics calculations. But the Collision Data report needs the tessellated mesh because it uses the mesh vertex damage to calculate the CDC and related damage profile information. The "Traditional" Damage Data Format calculates the damage data from the collision routine's rho vectors, and thus, it does not require a tessellated mesh.

Visit the Support section of www.edccorp.com to download software updates and to view more FAQ's 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 10 - 14, 2014
Los Angeles, CA . . . . January 2016

EDC Simulations

Los Angeles, CA . . . . January 19 - 23, 2015
Miami, FL . . . . November 2015

Theoretical & Applied Vehicle Dynamics

Upon Request

2015 *HVE* FORUM

Austin, TX . . . . . . March 2 - 6, 2015

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.

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