ENGINEERING DYNAMICS COMPANY

EDSMAC

HVE Human Vehicle Environment

Markdown Edition — revised to describe the current version of the software

Contents

1. EDSMAC — Vehicle Collision Simulator
2. Chapter 1 — EDSMAC Program Description
3. Chapter 2 — EDSMAC Program Input
4. Chapter 3 — EDSMAC Program Output
5. Chapter 4 — Calculation Method
6. Chapter 5 — EDSMAC Tutorial
7. Chapter 6 — Messages
8. Chapter 7 — Technical References
9. Chapter 8 — Index

EDSMAC — Vehicle Collision Simulator

Engineering Dynamics Company Simulation Model of Automobile Collisions

Version 4 — Fifth Edition (January 2006), converted to Markdown and updated to match the current HVE release (July 2026 edition).

EDSMAC is a simulation analysis of single- or two-vehicle crashes, based on the SMAC program developed at Calspan for NHTSA, with extensions by Engineering Dynamics Company, LLC. This manual describes the model features and use; input parameters and output reports are described at a high level. It is intended to be used in conjunction with the HVE-2D User's Manual, which provides in-depth coverage of the vehicle and environment models, as well as the Event Editor and Playback Editor.

Contents

1. Chapter 1 — EDSMAC Program Description — Overview, model inputs and outputs, validation, basic procedure
2. Chapter 2 — EDSMAC Program Input — Vehicles, environment, event set-up, driver controls, simulation controls, calculation options, barrier collisions
3. Chapter 3 — EDSMAC Program Output — Alpha-numeric reports, variable output tables, trajectory and damage profile simulations
4. Chapter 4 — Calculation Method — Equations of motion, collision phase, trajectory phase, assumptions
5. Chapter 5 — EDSMAC Tutorial — A complete visibility/avoidability study, from vehicle creation to printed reports
6. Chapter 6 — Messages — Complete list of fatal, diagnostic and informative messages
7. Chapter 7 — Technical References
8. Chapter 8 — Index — Topic-to-chapter guide (replaces the printed page index)

Related pages

- EDSMAC Calculation Options — dialog reference giving defaults, ranges and the current Get Surface Information Options dialog.

Notes on this edition

This Markdown edition preserves the substance of the Fifth Edition manual and has been checked against the current EDSMAC physics model and the current HVE user interface. Where the original manual was stale, the text follows the current program behaviour and is marked with

(updated: ...)

notes. Key updates:

- Calculation option defaults and labels (Vector Spacing default 2.0 deg; the vector force tolerance is now labelled "Max Pressure Error").
- Corrected descriptions of the two friction options (Inter-vehicle Friction is the friction coefficient; Minimum Velocity for Friction is the minimum relative velocity).
- The restitution model $e = C_0 - C_1 \delta + C_2 \delta^2$ with current default coefficients.

- Terrain search options are now in the separate Get Surface Information Options dialog; the "By Elevation" method is not supported.

Screenshots from the original manual are not reproduced; italic placeholders give the figure caption for each.

Chapter 1 — EDSMAC Program Description

Overview

EDSMAC (**E**ngineering **D**ynamics Company **S**imulation **M**odel of **A**utomobile **C**ollisions) is a simulation analysis of single- or two-vehicle crashes. It is based on the program called SMAC [1,2,3,4,5], developed at Calspan for NHTSA, and includes several major extensions and enhancements developed by Engineering Dynamics Company, LLC [6,7]. EDSMAC uses a set of assumed or estimated initial conditions, including positions, velocities and driver controls, provided by the user for each vehicle. EDSMAC then predicts the outcome of a crash by simulating the vehicle trajectories and damage profiles.

The output generated by EDSMAC is a time history of the vehicle kinematics (position, velocity, and acceleration), kinetics (summation of tire and collision forces and moments acting at the CG), and tire skidmarks for the duration of the crash sequence. The program also computes the resulting damage profiles, the Collision Deformation Classifications, or *CDC* (see reference 8; also refer to your EDCRASH Physics manual, Program Inputs, or HVE-2D User's Manual), Principal Direction of Force, or *PDOF* (again, see reference 8 or User's Manual), delta-V (a measure of crash severity) and peak acceleration for each damage range. EDSMAC also produces a collision pulse (acceleration vs time history).

Accident investigators can use EDSMAC to determine how the crash may have occurred. By repeated adjustments of the initial conditions and driver braking (or acceleration) and steering inputs, the user will converge on the data that best match the known accident site evidence (usually rest positions, skidmarks, and vehicle damage).

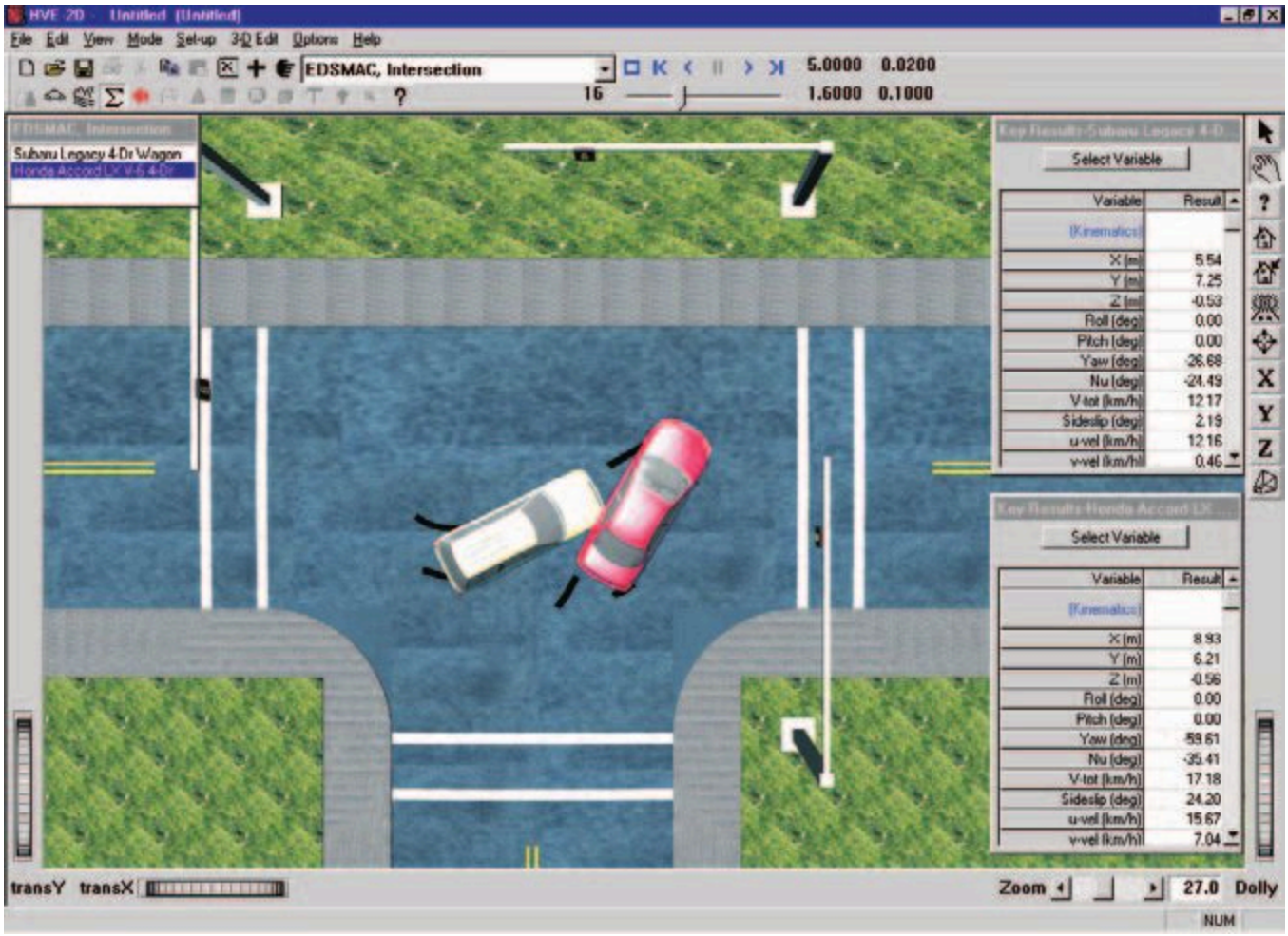


Figure 1-1: Typical EDSMAC Event, showing an intersection collision involving two vehicles. Current simulation results are displayed in Key Results windows aligned along the right edge of the viewer.

Users of EDCRASH will find it convenient to first analyze the accident using EDCRASH to estimate the impact speeds, then use these speeds as the initial conditions for the EDSMAC program. The resulting confirming analysis is both very complete and very powerful.

Accident researchers can use EDSMAC to simulate an actual staged collision test. This can be done

before

the test in order to predict or anticipate the results and help during test preparations. Test parameters may be adjusted based on EDSMAC results to help ensure the test is successful. After the test, the researcher can note the differences between the actual and simulated collision and modify the EDSMAC input in order to obtain a better match.

An extremely useful feature of EDSMAC is the ability to quickly and easily review the results associated with different input scenarios. Termed

what-if

analysis, changes can be made to an isolated variable or set of variables in order to identify their effect on the outcome. Only the inputs that change need to be modified; the program saves all the previously entered information. For example, the sensitivity of the results to initial velocity, or post-impact driver control, can be studied by merely changing those parameters.

Another useful feature of the program is the ability to display the results in viewers. These trajectory simulations display the vehicles at user-specified time intervals during the sequence. Using the Playback Editor, it is simple and easy to create a digital movie file.

Model Inputs

EDSMAC inputs include one or two vehicles, and an optional environment with terrain geometry. Event set-up parameters include vehicle initial positions and velocities and driver controls (steering, brakes and throttle).

Model Outputs

EDSMAC output reports include Accident History, Damage Data, Messages, Program Data, Vehicle Data, Variable Output, Trajectory Simulations and Damage Profile Simulations.

Validation

EDSMAC was validated first by direct comparison with earlier versions of EDSMAC to ensure the basic model was intact after porting the original codes to the C programming language and making the model HVE-2D-compatible. Additional validation was performed comparing EDSMAC results to other models as well as direct comparison with controlled collision experiments [1].

Basic Procedure

The procedure for using EDSMAC is substantially the same as using any simulator in the HVE-2D environment:

1. Use the Vehicle Editor to add one or more vehicles to the case.
2. Optionally, use the Environment Editor to create a visual and physical environment.
3. Use the Event Editor to set up and execute the EDSMAC simulation model by performing the following steps:
4. Choose one or two vehicles from the list of vehicles created earlier.
5. Choose the EDSMAC calculation model.
6. Position the vehicle(s) in the environment, and assign velocities.
7. Assign driver controls (Steering, Braking, Throttle) to each vehicle.
8. Execute the simulation event, comparing the simulation results with actual or measured results.
9. Modify the inputs as required to achieve the desired match between the simulation and the actual event.

Finally, use the Playback Editor to view the various reports and trajectory simulations. If desired, include the event along with other events in the Playback Window and produce a digital movie of the simulation.

Next: Chapter 2 — EDSMAC Program Input

Chapter 2 — EDSMAC Program Input

This chapter defines the objects (vehicles and environment) and the event set-up parameters (positions, driver controls, and so forth) used by the EDSMAC analysis. In general, the chapter is divided into the following sections:

- **Objects** — The number of vehicles, and the specific vehicle parameters actually used by EDSMAC.
- **Events** — The various options available for setting up and executing an EDSMAC event.

Objects Overview

The objects used by the EDSMAC model are:

- **Vehicles** — One or two vehicles may be studied by EDSMAC.
- **Environment** — Like the *real* world, EDSMAC has exactly one environment.

> NOTE: The environment is used in any reconstruction or simulation model.

The following sections describe how the vehicle and environment provide the required inputs to the EDSMAC calculation model.

Vehicles

EDSMAC uses one or two vehicles created using the Vehicle Editor (see Figure 2-1). Vehicles are selected from the Vehicle Database by choosing the following attributes:

- **Type** — EDSMAC supports the following vehicle types: *Passenger Car, Pickup, Sport-Utility, Van,* and *Truck,* within the limits defined by number of axles and drive axles; see below.
- **Make** — EDSMAC supports all available vehicle makes.
- **Model** — EDSMAC supports all available vehicle models, within the limits defined by number of axles and drive axles; see below.
- **Year** — EDSMAC supports all available vehicle years.
- **Body Style** — EDSMAC supports all available vehicle body styles.

Each vehicle also has the following additional user-editable parameters:

- **Driver Location** — The *Driver Location* is not used by EDSMAC. However, if you would like the vehicle to have any steerable axles, *Driver Location* must not be *None*.
- **Engine Location** — The *Engine Location* is not used by EDSMAC. However, if you would like the Throttle Table to be available during Event mode, *Engine Location* must not be *None*.
- **Number of Axles** — EDSMAC supports only 2-axled vehicles.
- **Drive Axle(s)** — The *Drive Axle* is used by EDSMAC to determine which wheels to include in the Throttle Table during Event mode.

To add a vehicle to the current case, perform the following steps:

1. Choose Vehicle Mode. The Vehicle Editor is displayed.

2. Choose *Add New Object*. The Vehicle Information dialog is displayed.
3. Click on the *Type, Make, Model, Year* and *Body Style* option buttons to select a vehicle from the database.
4. If desired, modify the *Driver Location, Engine Location, Number of Axles* and *Drive Axle(s)* for the current vehicle.
5. Enter a name for the current vehicle. A default name is supplied for each selected vehicle. Its name is user-editable, and does not affect calculations.

> NOTE: Duplicate vehicle names are not allowed in the same case.

1. Click *OK* to add the vehicle to the current case.

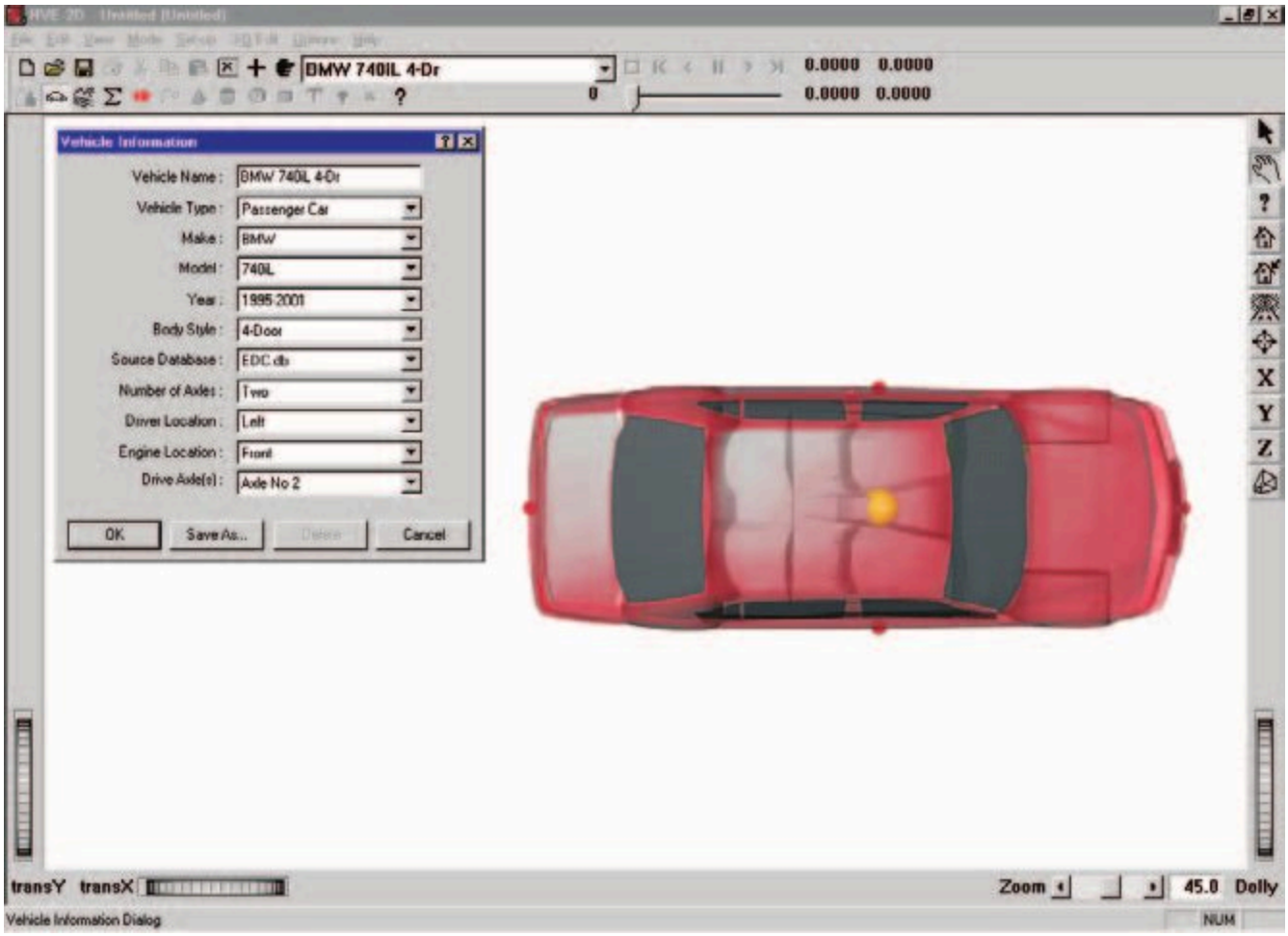


Figure 2-1: Vehicle Editor.

The following Vehicle Parameter groups are assigned using the Vehicle Editor:

- Sprung Mass (Inertias, Move CG, Inter-vehicle Connections)
- Unsprung Mass (Wheel Location, Tire Data, Suspension Data)
- Exterior (Overall Dimensions, Stiffness Coefficients)
- Steering System

The specific data used in each of the above parameter groups are defined in Tables 2-1 through 2-3.

Sprung Mass

Table 2-1. Vehicle Sprung Mass Parameters Used By EDSMAC.

Parameter	Description
Weight	Total vehicle weight
Total Yaw Inertia	Rotational inertia about the vehicle-fixed z axis
Move CG x	Relocates the CG in the vehicle-fixed x direction. This entry causes an automatic adjustment of all other vehicle dimensions to reflect the new CG location.

Inertias

EDSMAC uses the total vehicle weight (converted to mass according to the current gravitational constant; see Environment), and the yaw rotational inertia.

> NOTE: The yaw inertia displayed in the Inertias dialog applies only to the sprung mass. EDSMAC does not include independent degrees of freedom for the unsprung masses. Therefore, the inertial contributions of the unsprung masses are added to the sprung mass yaw inertia to calculate the total yaw inertia used by EDSMAC.

Move CG

Move CG is not used directly by EDSMAC. Its current value does not show up in the results. However, the Move CG fields may be used to quickly move the vehicle's center of gravity. The x coordinates for the wheels are updated to reflect the new CG location.

Geometry File

The Geometry File is not used by EDSMAC.

Inter-vehicle Connections

Inter-vehicle connections are not used by EDSMAC.

Unsprung Mass

Table 2-2. Vehicle Unsprung Mass Parameters Used By EDSMAC.

Parameter	Description
Wheel Location	The vehicle-fixed x,y wheel center coordinates
Dual Tire	Flag indicating position has dual tires. **Not supported by EDSMAC** — a vehicle with dual tires at any wheel position is rejected at event initialization with a fatal error. Use EDSMAC4 for such a vehicle.
Tire Slide Friction	The slide coefficient of friction for each tire
Tire Cornering Stiffness	Tire lateral force per unit of tire lateral slip for small amounts of lateral slip

Wheel Location

Although HVE-2D provides values for the vehicle-fixed x,y coordinates of each wheel, EDSMAC uses the following three parameters: a, the distance from the CG to the front axle; b, the distance from the CG to the rear axle; tw, the average of the front and rear track widths.

> NOTE: EDSMAC uses the average x_{wheel} for the front wheels to calculate a and the average x_{wheel} for the rear wheels to calculate b. Similarly, EDSMAC uses the total distance between right-side and left-side tires to calculate track width. Bilateral symmetry is assumed. Finally, EDSMAC does not use z_{wheel} for calculations.

Tire

The HVE-2D tire parameters provide the following data groups:

- Friction Data
- Cornering Stiffness Data
- Slip-vs Rolloff Table

EDSMAC's use of these parameters is described below.

Friction Data

EDSMAC uses the slide friction coefficient.

> NOTE: If there is any doubt about which value is actually used by EDSMAC, you can check the Vehicle Data output report.
>
> NOTE: During an event, the actual tire-terrain friction used during the current timestep is the product of the slide friction coefficient and the terrain friction multiplier for the polygon beneath the tire. Mathematically,

$$\mu_{Tire\text{-}terrain} = \mu_{Slide} \times Mult_{Polygon}$$

Cornering Stiffness Data

EDSMAC uses the Cornering Stiffness value.

> NOTE: If there is any question about which value is actually used by EDSMAC, you can check the Vehicle Data output report.

Slip-vs Rolloff Table

EDSMAC does not use the Slip-Rolloff data.

Suspension

EDSMAC does not use the Suspension data.

Brake

EDSMAC does not use the Brake data.

Exterior

EDSMAC uses the following Vehicle Exterior data:

- Exterior Dimensions
- Frontal K_v Stiffness Coefficient

Table 2-3. Vehicle Exterior and Steering System Parameters Used By EDSMAC.

Parameter	Description
CG to Front, Right, Back and Left	The vehicle's exterior dimensions
Frontal K_v Stiffness Coefficient	The stiffness of the vehicle exterior (assumed to be uniform on all sides)
Steering Gear Ratio	Ratio of the angle at the steering wheel to the angle at the wheel

> NOTE: EDSMAC assumes the exterior structure is homogeneous and does not use different stiffness values for the front, sides, and rear. The K_v stiffness coefficient entered for the frontal surface is applied to all other surfaces of the vehicle!

Steering System Data

EDSMAC uses the Steering System to determine which axles are steerable. Only steerable wheels are displayed in the Driver Controls, Steer Table. In addition, if the Steer Table

At Driver

option is used, the steering gear ratio parameter is used to compute the steer angle at each steerable tire.

Brake System Data

EDSMAC does not use the Brake System data.

Environment

EDSMAC uses the environment created by the Environment Editor (see Figure 2-2). The environment is created by defining the following groups of attributes:

- Visual Data
- Physical Data

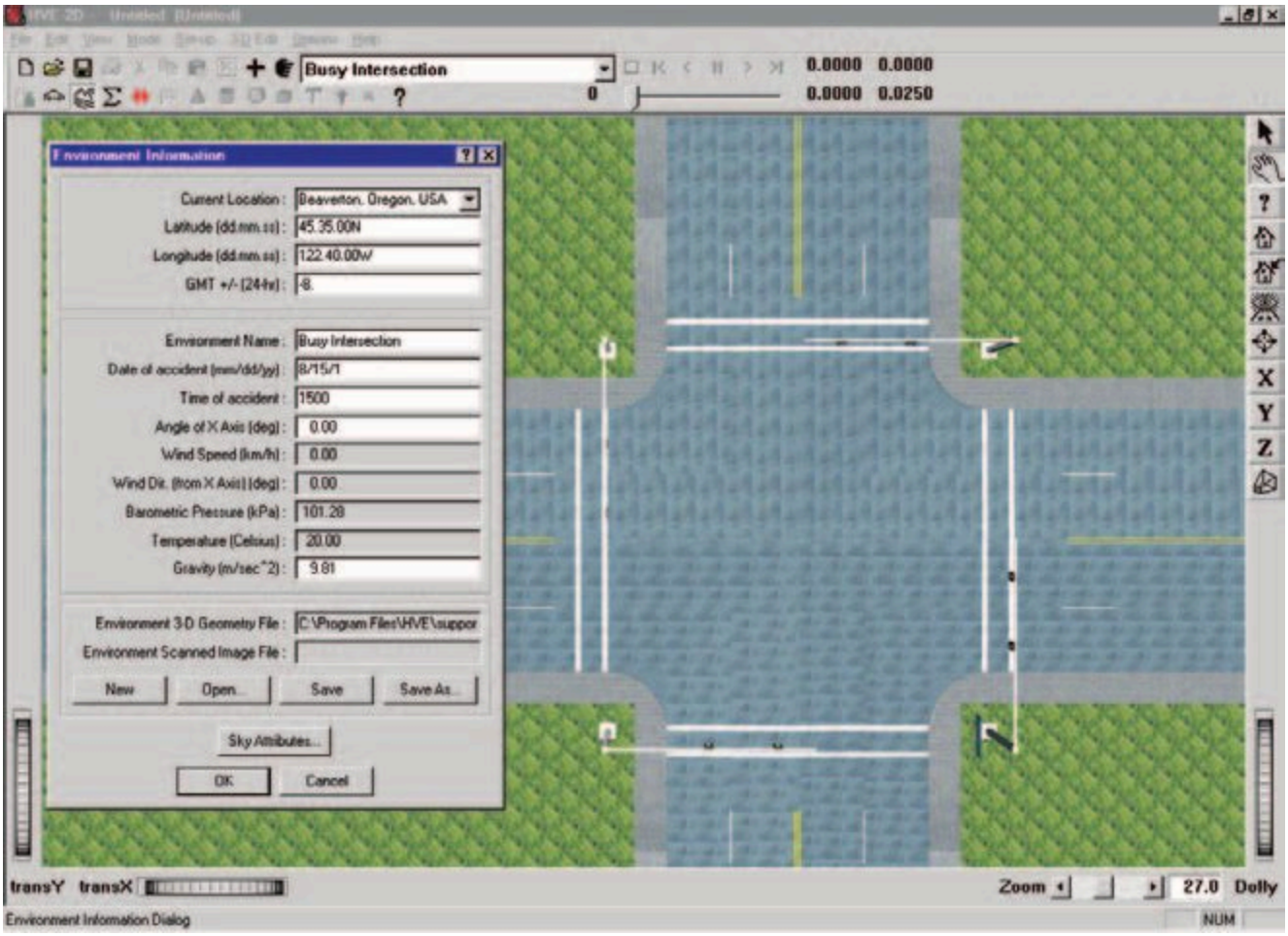


Figure 2-2: Environment Editor.

Creating an Environment

To add an environment to the current case, perform the following steps:

1. Choose Environment Mode. The Environment Editor is displayed.
2. Click *Add New Object*. The Environment Information dialog is displayed.
3. Click on the *Location* combo box to select the desired city, state and country, and associated *Latitude*, *Longitude* and *GMT*.
4. Edit the *Time* and *Date* for the event.
5. Edit the *Angle of the X Axis, Wind Speed* and *Direction*, *Barometric Pressure* and *Temperature* for the event.
6. Edit the *Gravity Constant* for the event.
7. Edit the environment name. A default name is supplied for the current environment. The name is user-editable, and does not affect calculations.
8. Click *OK* to add the environment to the current case.

Visual Data

The following visual parameters may be edited:

- **Environment Location** — A database containing the name (City/State/Country), Latitude and Longitude and GMT for the selected location.
- **Time and Date** — The local standard time and date for the event.

The visual data are not used by the event; they are provided for studies related to visibility at the time of an event (e.g., avoidability of an accident).

> NOTE: The visual data (Location, Time, Date and Angle of earth-fixed X axis) affect the lighting of the event! Depending on your view (Camera Position) the scene may be shaded and difficult to see. If the time is after sundown, the view will be dark.

Physical Data

The Physical Data groups are:

- Angle of X Axis
- Wind Speed and Direction
- Atmospheric Temperature and Pressure
- Gravity Constant
- Surface Geometry

The specific physical environment data used by EDSMAC are described below and in Table 2-4.

Table 2-4. Environment Parameters used by EDSMAC.

Parameter	Description
Gravitational Constant	The local acceleration of gravity
Surface Geometry, Friction Factor	The polygon database used to create the environment

Angle Of X Axis

The angle of the X axis is used to position the earth-fixed coordinate system on the surface of the earth.

> NOTE: The angle is specified relative to true north. If you are using a compass to determine direction at the scene of an accident, you should provide a local correction factor before entering this angle.
>
> NOTE: The angle of the X axis affects how you visualize an EDSMAC event because it affects the location of the sun.

Wind Speed and Direction

EDSMAC does not use the Wind Speed or Direction.

Atmospheric Temperature and Pressure

EDSMAC does not use the atmospheric temperature and pressure.

Gravitational Constant

The gravitational constant converts mass to force. An object's mass and rotational inertias are properties that are the same throughout the universe; however the weight of an object is dependent on the local gravitational constant.

> NOTE: All user-entered weights are divided by this gravitational constant and stored as mass.

Surface Geometry

The Surface Geometry is used by the tire model in EDSMAC to calculate the friction multiplier for the current X,Y position of each tire.

Event

EDSMAC uses the Event Editor (see Figure 2-3) to create, set up and execute an event. Each of these topics is described below.

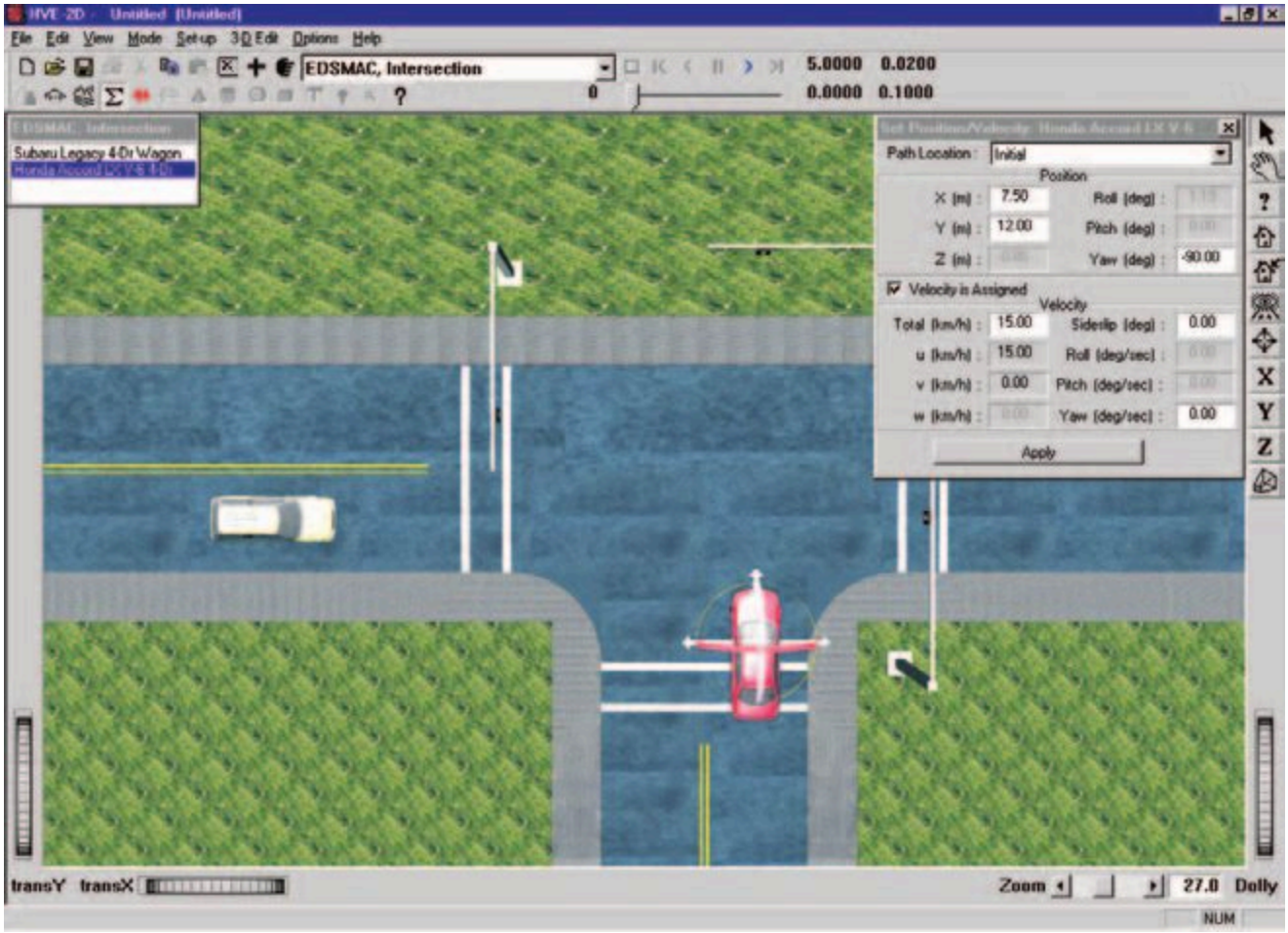


Figure 2-3: Event Editor, setting up and executing an EDSMAC event.

Creating an Event

An EDSMAC event is created using the Event Information dialog.

To create an EDSMAC event:

1. Choose Event Mode. The Event Editor is displayed.
2. Click *Add New Object*. The Event Information dialog is displayed.
3. Select one or two vehicles from the Active Vehicles list.
4. Select the calculation model, *EDSMAC*, from the Calculation Model options list.
5. Enter an event name. A default name is supplied for the selected event. The name is user-editable, and does not affect calculations.

> NOTE: Duplicate event names are not allowed in the same case.

1. Click *OK* to create the EDSMAC event.

> NOTE: If you choose a vehicle that is not compatible with EDSMAC, a message will be displayed describing the problem. You will not be allowed to proceed until EDSMAC-compatible objects are selected.

Setting Up an Event

EDSMAC uses the following

event set-up

options:

- Position/Velocity
- Driver Controls

The specific Event Set-up data used by EDSMAC are defined in Table 2-5.

Table 2-5. Event Set-up Parameters used by EDSMAC.

Parameter	Description
Vehicle Initial Position	The earth-fixed X,Y coordinates and yaw angle of each vehicle at the start of the simulation
Vehicle Initial Velocity	The forward and lateral linear velocities, and the yaw angular velocity, at the start of the run
Driver Controls, Steer Table	Steer Table Option; Steering Wheel Angle vs Time or Tire Steer Angle vs Time
Driver Controls, Brake Table	Brake Table Option; Wheel Force vs Time or Percent Available Friction vs Time
Driver Controls, Throttle Table	Throttle Table Option; Wheel Force vs Time or Percent Available Friction vs Time

Position/Velocity

Each vehicle is positioned relative to the earth-fixed coordinate system by supplying the X,Y,Z coordinates of its CG, and the roll (Φ), pitch (Θ) and yaw (Ψ) angles about the vehicle's x, y and z axes, respectively.

> NOTE: Z is equal to the CG height above ground, and roll and pitch are equal to 0.0.

The vehicle velocities are supplied in the form of a total velocity and sideslip angle.

> NOTE: The vehicle-fixed u (forward) and v (side) velocity components are calculated according to the user-entered total velocity and sideslip angle. Vertical velocity is set to zero.

EDSMAC uses the following positions and velocities:

- **Initial Position** — The X,Y coordinates and heading angle of the vehicle at the start of the simulation. Only the initial position is used by EDSMAC.

> NOTE: Other positions may be supplied as target positions, used to assess how closely the simulated path matches the actual path during a run. Refer to the User's Manual, Options Menu, for more information about Target positions.

- **Initial Velocity** — The total velocity and sideslip angle of the vehicle(s) at the start of the simulation.

> NOTE: Initial positions and velocities must be entered for each vehicle in an EDSMAC event.

Driver Controls

EDSMAC uses the following Driver Controls:

- **Steering** — A table of steering inputs as a function of time. The *At Driver* and *At Axle* options are supported.
- **Braking** — A table of braking inputs as a function of time. The *Wheel Force* and *Percent Available Friction* options are supported.
- **Throttle** — A table of throttle inputs as a function of time. The *Wheel Force* and *Percent Available Friction* options are supported.

Brake

Typical values for non-braking rolling resistance for passenger car tires are provided for reference in Table 2-6 [11]. These values should be entered in the Driver Controls - Brakes dialog using the Percent Available Friction option.

Representative values for locked-wheel (slide) friction coefficients for passenger car tires on a variety of surfaces are also provided, in Table 2-7 [10]. While the table is very complete, EDC makes no claim as to the accuracy of the data. The user is urged to perform thorough research in order to supply EDSMAC with the best possible data.

Table 2-6. Rolling Resistance Braking Inputs for Pavement [11].

Tire/Wheel Condition	% Available Friction
Normal Inflation	0.010 / μ
Partial Inflation	0.013 / μ
Damaged	0.0 to 1.0
Engine Braking — High Gear	0.150 / μ to 0.200 / μ
Engine Braking — Low Gear	0.200 / μ to 0.400 / μ

Table 2-7. Tire-Ground Friction Coefficients on Various Surfaces [10].

Surface	Dry <30 mph	Dry >30 mph	Wet <30 mph	Wet >30 mph
Portland Cement — New, Sharp	0.80 - 1.20	0.70 - 1.00	0.50 - 0.80	0.40 - 0.75
Portland Cement — Traveled	0.60 - 0.80	0.60 - 0.75	0.45 - 0.70	0.45 - 0.65
Portland Cement — Polished	0.55 - 0.75	0.50 - 0.65	0.45 - 0.65	0.45 - 0.60
Asphalt or Tar — New, Sharp	0.80 - 1.20	0.65 - 1.00	0.50 - 0.80	0.45 - 0.75
Asphalt or Tar — Traveled	0.60 - 0.80	0.55 - 0.70	0.50 - 0.80	0.45 - 0.75
Asphalt or Tar — Polished	0.55 - 0.75	0.45 - 0.65	0.45 - 0.65	0.40 - 0.60
Asphalt or Tar — Excess Tar	0.50 - 0.60	0.35 - 0.60	0.30 - 0.60	0.25 - 0.55
Gravel — Packed, Oiled	0.55 - 0.85	0.50 - 0.80	0.40 - 0.80	0.40 - 0.60
Gravel — Loose	0.40 - 0.70	0.40 - 0.70	0.45 - 0.75	0.45 - 0.75
Cinders — Packed	0.50 - 0.70	0.50 - 0.70	0.65 - 0.75	0.65 - 0.75
Rock — Crushed	0.55 - 0.75	0.55 - 0.75	0.55 - 0.75	0.55 - 0.75
Ice — Smooth	0.10 - 0.25	0.07 - 0.20	0.05 - 0.10	0.05 - 0.10
Snow — Packed	0.30 - 0.55	0.35 - 0.55	0.30 - 0.60	0.30 - 0.60
Snow — Loose	0.10 - 0.25	0.10 - 0.20	0.30 - 0.60	0.30 - 0.60

Damage Profile

EDSMAC does not use the Damage Profile data.

> NOTE: EDSMAC produces a simulated damage profile.

Payload

The Payload Data are not used by EDSMAC. Payload inertias may be added to the vehicle inertias and the CG may be moved longitudinally and/or vertically using the Move CG dialog.

Wheels

Wheel Data is not used by EDSMAC.

Accelerometers

EDSMAC does not support accelerometers.

Simulation Controls

EDSMAC uses the Vehicle Collision, Separation and Trajectory integration timesteps and the maximum simulation time parameters in the Simulation Controls dialog (see Options Menu, Simulation Controls). The Simulation parameters used by EDSMAC are shown in Table 2-8.

Table 2-8. Simulation Control Parameters used by EDSMAC.

Parameter	Description
Vehicle Collision Integration Timestep	The integration timestep used during the collision phase
Vehicle Separation Integration Timestep	The integration timestep used for the first 100 time steps of the simulation (or until collision occurs); also used for the first 100 after the end of the collision phase
Vehicle Trajectory Integration Timestep	The integration timestep used before and after the collision phase (after 100 timesteps without collision, as described above)
Output Interval	The timestep used to send output results back to HVE-2D or HVE
Maximum Simulation Time	Maximum length of the run
Min Linear Velocity	The linear velocity used to terminate the run (if the linear and angular velocities for both vehicles are simultaneously less than these termination velocities, the run terminates)
Min Angular Velocity	The angular velocity used to terminate the run (if the linear and angular velocities for both vehicles are simultaneously less than these termination velocities, the run terminates)

The output time interval is the interval at which output results (positions, velocities, accelerations, forces) are reported back to HVE-2D. This has a direct effect on the tabular results available in the Playback Editor, Variable Output table (see Chapter 3 — Output, Variable Output).

> NOTE: For analyses of gross vehicle motion, damage, and rest position, an output interval of 0.10 is generally sufficiently small.
>
> NOTE: For analyses of vehicle accelerations or collision pulses, smaller output intervals are recommended.
>
> NOTE: The output time interval should be an even multiple of the vehicle trajectory integration timestep. For example, if the integration timestep is 0.02, the output interval might be 5 x 0.02, or 0.10.

Calculation Options

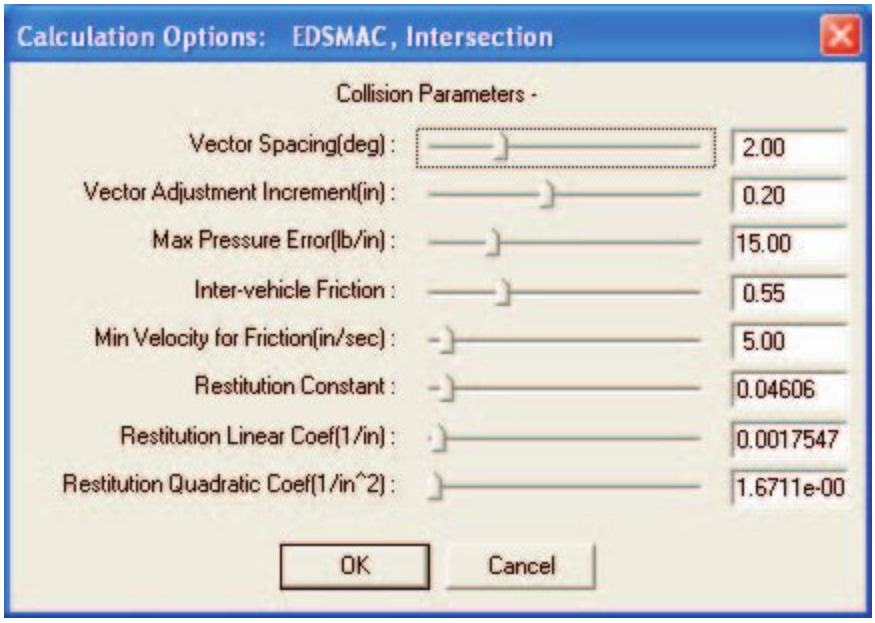


Figure 2-4: EDSMAC Event Calculation Options dialog, available from the Options menu.

EDSMAC has the following parameter options (see the reference page EDSMAC Calculation Options for defaults and allowed ranges):

- **Vector Spacing** — This angle, $\Delta\psi$, determines the angular interval between RHO vectors (see Calculation Method). The default value is 2 degrees (range 1 to 5 degrees). *(updated: the original manual recommended 1 degree; the current default in the dialog is 2.0 degrees.)*
- **Vector Adjustment Increment** — This increment, $\Delta\rho$, determines the incremental adjustment for each RHO vector as the collision routine seeks to establish force equilibrium between vehicles. Default 0.20 in (range 0.01 to 0.5 in).
- **Max Pressure Error** (Vector Force Tolerance) — This value, λ, is the allowable difference in the force per unit width exerted by RHO vectors for each vehicle. A small value is obviously preferable. In general, it should not exceed 50 lb/in (about 100 N/cm). Default 15 lb/in.
- **Inter-vehicle Friction** — This value, μ, represents the coefficient of sliding friction between the vehicle exteriors. Default 0.55.
- **Minimum Velocity for Friction** — This value, ζ_v, represents the minimum relative surface velocity at which the full inter-vehicle friction is achieved. Default 5 in/sec. *(updated: the original manual swapped the descriptions of these two options; Inter-vehicle Friction is the friction coefficient and Minimum Velocity for Friction is the minimum velocity.)*
- **Restitution Coefficients** — These three values, C_0, C_1, and C_2, are the constant, linear and quadratic terms used for the parametric restitution model used in EDSMAC ($e = C_0 - C_1\delta + C_2\delta^2$, with defaults 0.04606, 0.0017547 /in and 1.6711×10^{-5} /in²).

Get Surface Information

Both HVE and HVE-2D use a terrain search, called Get Surface Information, to determine on which environment polygon the tire is riding. It searches below the X,Y coordinates of each tire contact patch, and uses a user-editable algorithm to determine the friction and other characteristics of the surface beneath.

The default method for Get Surface Information is *From Previous Polygon, Sorted*. This results in fast execution while enforcing friction-zone precedence. Refer to the User's Manual and to the Get Surface Information Options notes for further information about how the terrain search works. *(updated: these terrain search options are now set in the separate Get Surface Information Options dialog rather than in the EDSMAC Calculation Options; the "By Elevation" method is not supported.)*

Executing An Event

To execute an EDSMAC event, use the Event Controller, shown in Figure 2-3 as a component of the Event Editor, and again in Figure 2-5. The Event Controller's buttons have the following functions:



Figure 2-5: Event Controller, used for starting and stopping event execution; it can also replay previously executed events, both forward and backward.

- **Reset** — Reinitialize the calculation model for re-execution
- **Rewind to Start** — Return to the start of the simulation
- **Reverse** — Play the simulation backwards
- **Pause** — Pause the simulation
- **Play** — Execute the event or play the simulation forwards
- **Advance to End** — Advance to the end of the simulation

> NOTE: If you make changes to any of the vehicle or environment parameters or event set-up options (see previous sections), those changes will have no effect unless you press Reset before pressing Play.
>
> NOTE: Remember to use the Options Menu to choose useful options, such as Key Results, Axes, Velocity Vectors and Skidmarks.

Barrier Collisions

The collision algorithm used by EDSMAC was not designed to accommodate barrier collisions (barrier being defined as an infinitely rigid object that absorbs no energy during impact). The reason is clear upon close inspection of the collision algorithm; it requires that both colliding objects be deformable (see Chapter 4 and references 3, 4, 6, and 7 for a detailed description of the collision algorithm).

That being said, EDSMAC may often be used successfully for barrier collisions and pole impacts by making certain adjustments. These adjustments are as follows:

- To create the barrier, start by choosing any supported vehicle type from the Vehicle Database.
- Increase the barrier's front stiffness to about 1000 lb/in^2.
- If the object being struck is an immovable barrier, such as a bridge abutment or large pole, increase the weight to 1,000,000 lb and the yaw inertia to 1,000,000 lb-sec^2-in to help prevent its movement during impact.
- Change the object's dimensions as required.

> NOTE: The EDSMAC collision algorithm views the object as a rectangle, regardless of the shape of the geometry file.

- From EDSMAC's Calculation Options dialog, reduce the Vector Adjustment Increment to 0.02 in (from the default value, 0.2 in), and increase the Vector Force Tolerance (Max Pressure Error) to 25 lb/in (from its default value, 15 lb/in).
- For fixed barriers, select the Driver Controls, Brakes dialog and assign a large braking value (i.e., Percent Available Friction = 1.0) to further help prevent movement.
- Finally, set up the simulation so the first timestep involving a collision force occurs with a small overlap between the vehicle and barrier. This may be accomplished by reducing the trajectory and separation integration timesteps or by adjusting the initial positions as required for a small overlap at the start of the collision phase.

> NOTE: This is especially true for pole impacts! The pole may be completely engulfed by the vehicle before a collision is detected, resulting in a fatal error during the collision phase.

Previous: Chapter 1 — Program Description | Next: Chapter 3 — EDSMAC Program Output

Chapter 3 — EDSMAC Program Output

This chapter defines the outputs available from an EDSMAC event. The reports produced by EDSMAC are available in the Playback Editor.

Output Overview

EDSMAC produces three types of output reports:

- **Alpha-Numeric Reports** — Reports containing text and numeric information, such as vehicle dimensional parameters
- **Variable Output Tables** — Reports containing tabular simulation results as a function of time
- **Trajectory Simulations** — Viewers containing dynamic, visual simulations

> NOTE: Each of these reports may be printed on the system printer. To print a report, click on the menu bar of the desired output report (the menu bar will change colors indicating that it is selected), then either choose Print from the Files menu or click on the Print icon in the toolbar. Refer to the User's Manual for further details.

To view any of these reports, perform the following steps:

1. Choose Playback Mode. The Playback Editor is displayed.
2. Choose *Add New Object*. The Report Window Information dialog is displayed, showing a list of all the current events in the case.
3. Select an EDSMAC event from the list. Once an event is selected, the Report Type list is displayed, containing all the available reports for the selected event.
4. Select the desired report in the Report Type list. To open several reports at once, select more than one (*Select All* selects every report); each opens in its own Report Window.
5. If desired, edit the Name. A default name is supplied for the report window. The name is user-editable, and does not affect calculations.

> NOTE: Duplicate Report Window names are not allowed. Because the name is truncated to 30 characters, you should ensure that two truncated names are not the same.

1. Click *OK* to display the report.

Alpha-Numeric Reports

EDSMAC produces the following alpha-numeric reports:

- **Accident History** — A table of initial, impact, separation and final positions and velocities for each vehicle in the current event
- **Damage Data** — A table containing the vehicle collision ('RHO') vectors in both cylindrical and Cartesian coordinates, and a table containing the beginning and end of each damage range, its CDC, PDOF, total delta-V and peak acceleration
- **Messages** — A list of messages produced by the current event

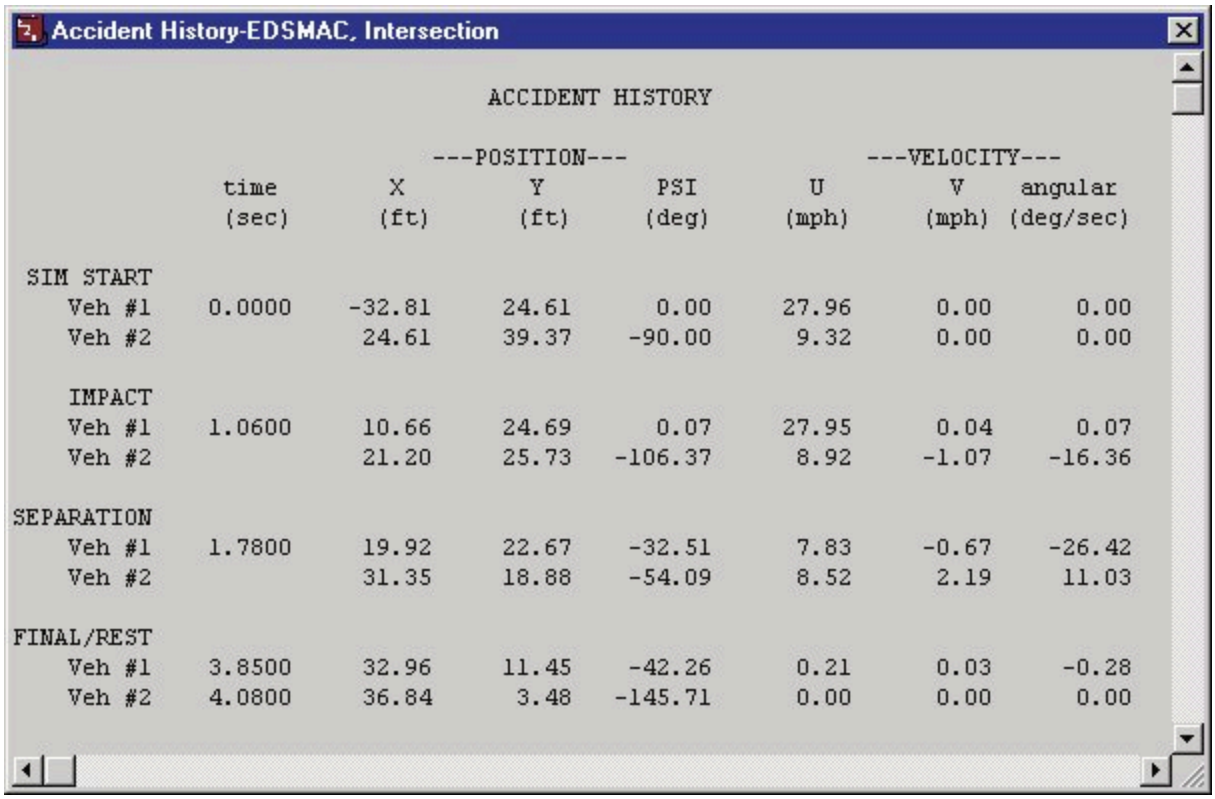
- **Program Data** — A table containing program control information for the current event
- **Vehicle Data** — A series of tables containing the vehicle data and driver controls data used by the current EDSMAC event

An example of each of these numeric output reports from EDSMAC is described below.

Accident History

The Accident History Report displays a table of initial, impact, separation and final positions and velocities for each vehicle. For each of the phases SIM START, IMPACT, SEPARATION and FINAL/REST, the report lists the time, the position (X, Y in ft, and heading angle PSI in deg) and the velocity (forward u and lateral v in mph, and angular velocity in deg/sec) of each vehicle.

For how the impact and separation times are detected, see Chapter 4 — Impact and Separation Times.



	time (sec)	---POSITION--- X (ft)	Y (ft)	PSI (deg)	---VELOCITY--- U (mph)	V (mph)	angular (deg/sec)
SIM START							
Veh #1	0.0000	-32.81	24.61	0.00	27.96	0.00	0.00
Veh #2		24.61	39.37	-90.00	9.32	0.00	0.00
IMPACT							
Veh #1	1.0600	10.66	24.69	0.07	27.95	0.04	0.07
Veh #2		21.20	25.73	-106.37	8.92	-1.07	-16.36
SEPARATION							
Veh #1	1.7800	19.92	22.67	-32.51	7.83	-0.67	-26.42
Veh #2		31.35	18.88	-54.09	8.52	2.19	11.03
FINAL/REST							
Veh #1	3.8500	32.96	11.45	-42.26	0.21	0.03	-0.28
Veh #2	4.0800	36.84	3.48	-145.71	0.00	0.00	0.00

Figure 3-1: Typical Accident History Output Report issued by EDSMAC.

Damage Data

The Damage Data Report includes the following information:

- **Vehicle Damage Summary** — A table containing the collision ('RHO') vector information in two forms: RHO vector length and angle, and RHO vector x,y endpoint coordinates.

> NOTE: This table is used to define the damage profile.

- **Vehicle Damage Ranges** — A table containing the starting and ending points for each damage range, along with its CDC, PDOF, total delta-V and peak acceleration. For how these are determined, see Chapter 4 — Collision Severity

Results.

> NOTE: A **J-point**, marked with a double asterisk in the damage summary, is a point on the damage profile that could not be established from the vehicle's own radial vector and was constructed from the other vehicle's CG instead. Restitution is not computed at these points.

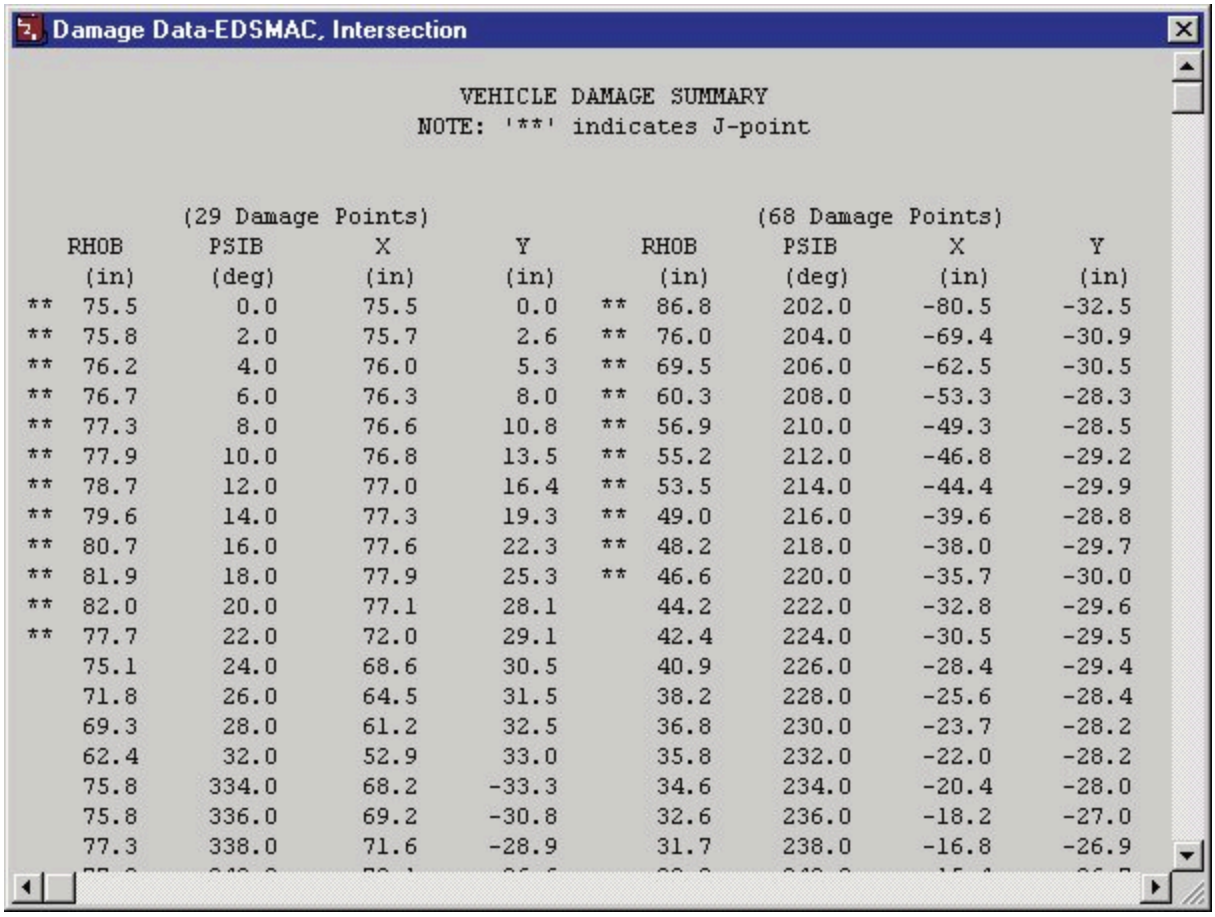


*Figure 3-2: Typical Damage Data Output Report issued by EDSMAC (only a portion of the complete report is shown); '**' in the summary indicates a J-point.*

Messages

A typical Messages Report simply lists the messages (or "No Messages") produced during event execution. For a complete listing of messages issued by EDSMAC, see Chapter 6 — Messages.

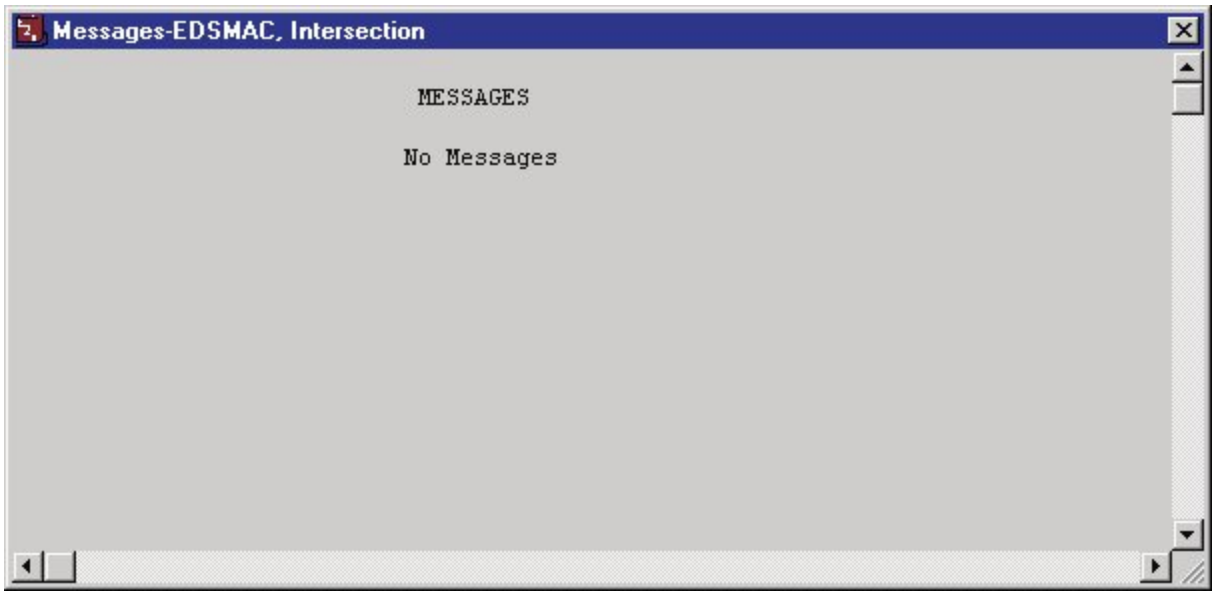


Figure 3-3: Typical Messages Output Report issued by EDSMAC.

Program Data

The Program Data Report includes the following information:

- **Simulation Controls** — Integration parameters used for the current event (maximum simulation time; collision, separation and trajectory phase timesteps; output interval; linear and angular termination velocities).
- **Collision Parameters** — Parameters used within the collision model (Vector Spacing, the angular sweep interval; Vector Adjustment Increment, the radial depth interval; Max Pressure Error; Inter-vehicle Friction; Minimum Velocity for Friction; and the restitution coefficients C_0, C_1 and C_2).
- **Collision Criteria** — Parameters used to determine which side (front, back, right or left) a RHO vector intersects; used to determine the RHO vector's initial length (the eight clock-angle limits that bracket each side, together with the corresponding initial RHO vector length tests).

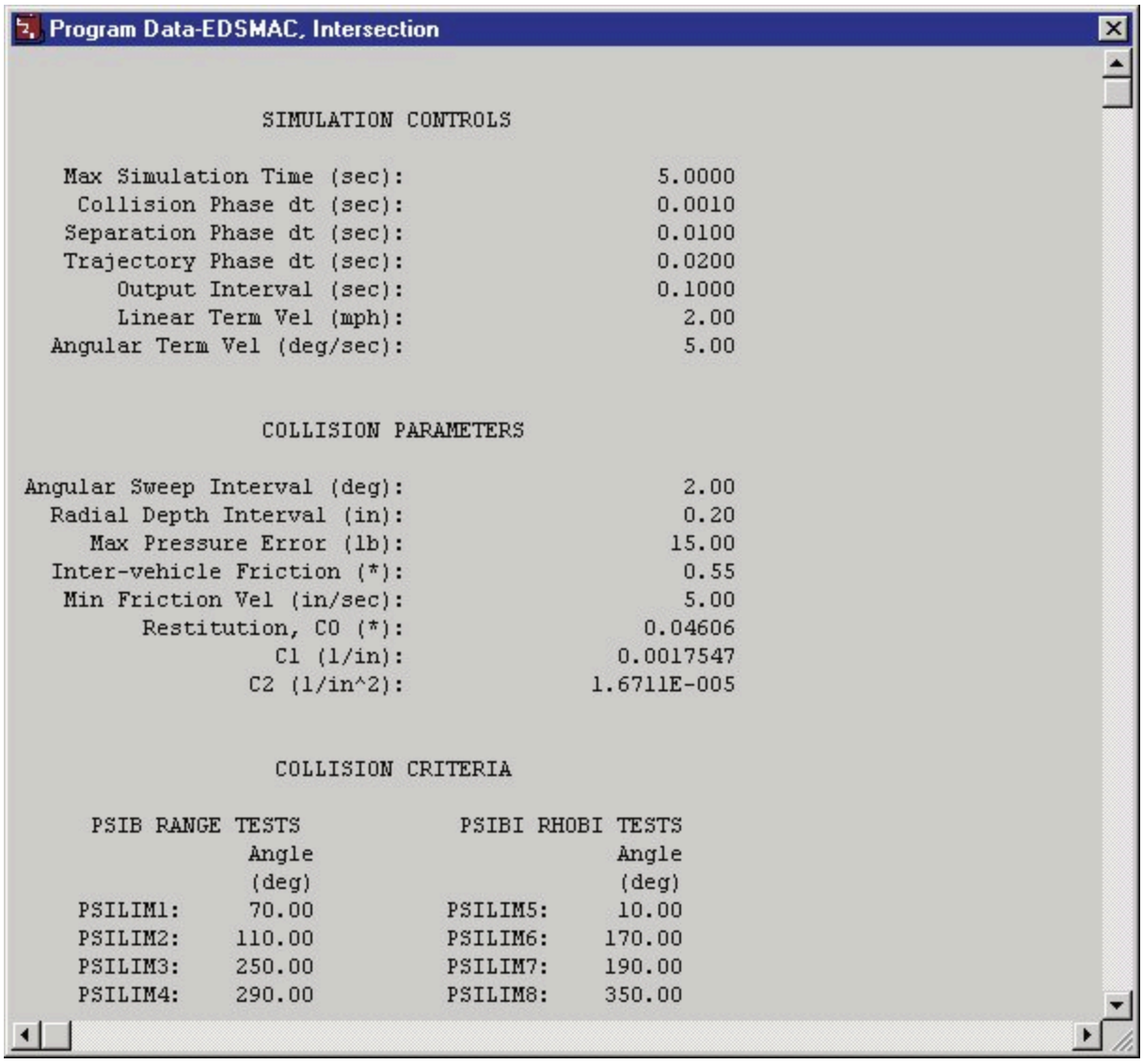


Figure 3-4: Typical Program Data Output Report issued by EDSMAC.

Vehicle Data

The Vehicle Data Report includes the following information:

- **Vehicle Dimensional and Inertial Properties** — The dimensional and inertial parameters used by each vehicle in the current event (CG to front and rear axle, track width, yaw inertia, mass, weight, body length to front and rear, overall body width, and crush stiffness K_v).

> NOTE: The yaw inertia displayed in the Vehicle Data report includes the inertial contributions of the unsprung masses. These masses are added to the sprung mass yaw inertia to calculate the total yaw inertia used by EDSMAC.

- **Tire Properties** — The tire parameters used by each vehicle in the current event (slide friction, velocity dependence, cornering stiffness, for each axle and side).
- **Driver Data** — Individual Driver Control tables for steering, braking and throttle used by each vehicle in the current event.

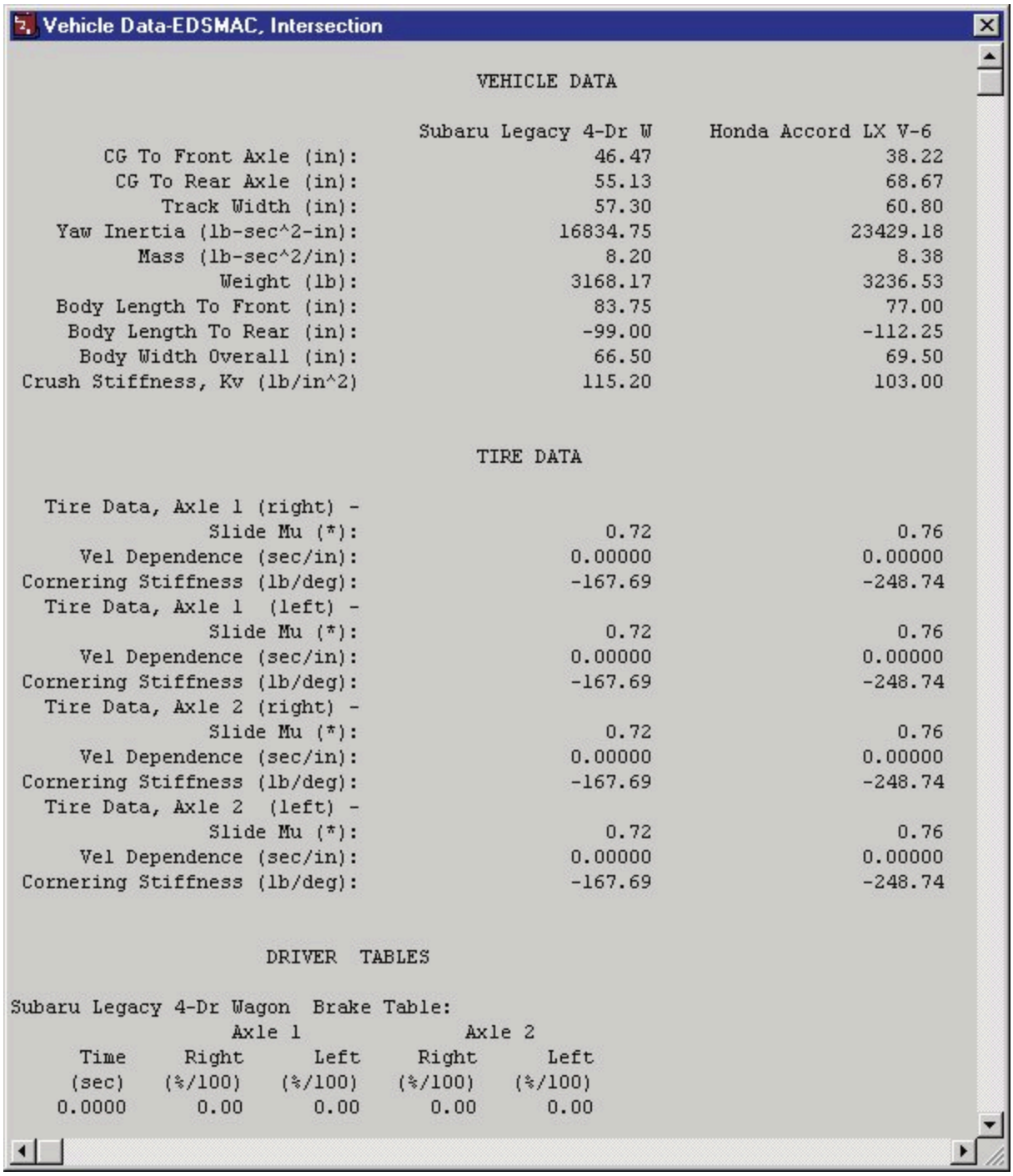


Figure 3-5: Typical Vehicle Data Output Report issued by EDSMAC (only a portion of the complete report is shown).

Graphic Reports

EDSMAC produces no Graphic Output Reports.

> NOTE: Graphs of simulation results vs time may be produced using the Variable Output window (see next section).

Variable Output Table

EDSMAC produces a Variable Output table containing the time-based simulation results. The Variable Output groups produced by EDSMAC are as follows:

Vehicle Output Groups

- **Kinematics** — Position, velocity and acceleration for each vehicle
- **Kinetics** — Summation of collision forces and moments acting at the CG of each vehicle
- **Tire** — The tire output parameters existing at the tire contact patch (compare with Wheel Output, below)
- **Wheel** — The wheel output parameters existing at the wheel's hub. Information about the position of each wheel (compare with Tire output, above).
- **Driver** — Current levels of driver inputs (steering, braking and throttle)

An example of a Variable Output table is shown in Figure 3-6. A detailed listing of each Variable Output parameter produced by EDSMAC is found in Table 3-1.

Table 3-1. Vehicle Variable Output Data

Parameter	Description
Vehicle Kinematic Data	X,Y,Z position of CG; Φ, Θ, Ψ orientation; total linear velocity, u,v,w components; sideslip angle; r angular velocity; total linear acceleration, fwd and side components; u-dot, v-dot linear components; r-dot angular components
Vehicle Kinetic Data	ΣF_x, ΣF_y, ΣM_z (collision); ΣF_x, ΣF_y, ΣM_z (tires)
Tire Data	X,Y,Z position of tire contact patch; slip angle; F'_x, F'_y, F'_z; skid flag
Wheel Data	x,y,z location of each wheel; F_x, F_y, F_z; steer angle (δ) at each steerable wheel
Driver Data (*)	Steering wheel angle

(*) If Driver Control option was 'At Driver'

Variable Output-EDSMAC, Intersection

Select... Graph... Edit...

Time (sec)	Subaru Legacy X (ft)	Subaru Legacy Y (ft)	Subaru Legacy Yaw (deg)	Subaru Legacy V-tot (mph)	Subaru Legacy Acc-tot (g)	Honda Accord L X (ft)	Honda Accord L Y (ft)	Honda Accord L Yaw (deg)
1.5000	17.14	24.15	-24.34	7.71	0.51	27.98	21.33	-67.44
1.5250	17.41	24.07	-25.00	7.63	0.55	28.32	21.09	-65.19
1.5500	17.68	23.98	-25.68	7.58	0.01	28.66	20.85	-63.09
1.5750	17.93	23.88	-26.19	7.58	0.45	28.99	20.61	-61.31
1.6000	18.19	23.77	-26.73	7.58	0.61	29.31	20.38	-59.67
1.6250	18.44	23.65	-27.35	7.63	0.84	29.62	20.16	-58.28
1.6500	18.68	23.50	-28.24	7.72	0.58	29.92	19.95	-57.35
1.6750	18.92	23.34	-29.18	7.75	0.44	30.21	19.75	-56.66
1.7000	19.16	23.19	-30.13	7.77	0.30	30.49	19.55	-55.98
1.7250	19.40	23.03	-31.07	7.80	0.16	30.78	19.34	-55.29
1.7500	19.64	22.87	-31.84	7.83	0.40	31.05	19.14	-54.66
1.7750	19.87	22.70	-32.38	7.87	0.84	31.30	18.93	-54.15
1.8000	20.10	22.53	-32.88	7.83	0.51	31.54	18.71	-54.02
1.8250	20.32	22.35	-33.35	7.79	0.38	31.77	18.50	-53.95
1.8500	20.54	22.17	-33.81	7.75	0.24	32.00	18.29	-53.87
1.8750	20.76	22.00	-34.28	7.71	0.10	32.23	18.08	-53.79
1.9000	20.98	21.82	-34.56	7.65	0.09	32.43	17.85	-54.00
1.9250	21.20	21.65	-34.79	7.59	0.11	32.63	17.62	-54.27
1.9500	21.42	21.48	-35.02	7.52	0.13	32.82	17.40	-54.55

Figure 3-6: Typical Variable Output table from EDSMAC.

Trajectory Simulation

EDSMAC produces a trajectory simulation of the current event. The trajectory simulation is a visualization of the vehicle position data displayed in the Variable Output table (see previous section).

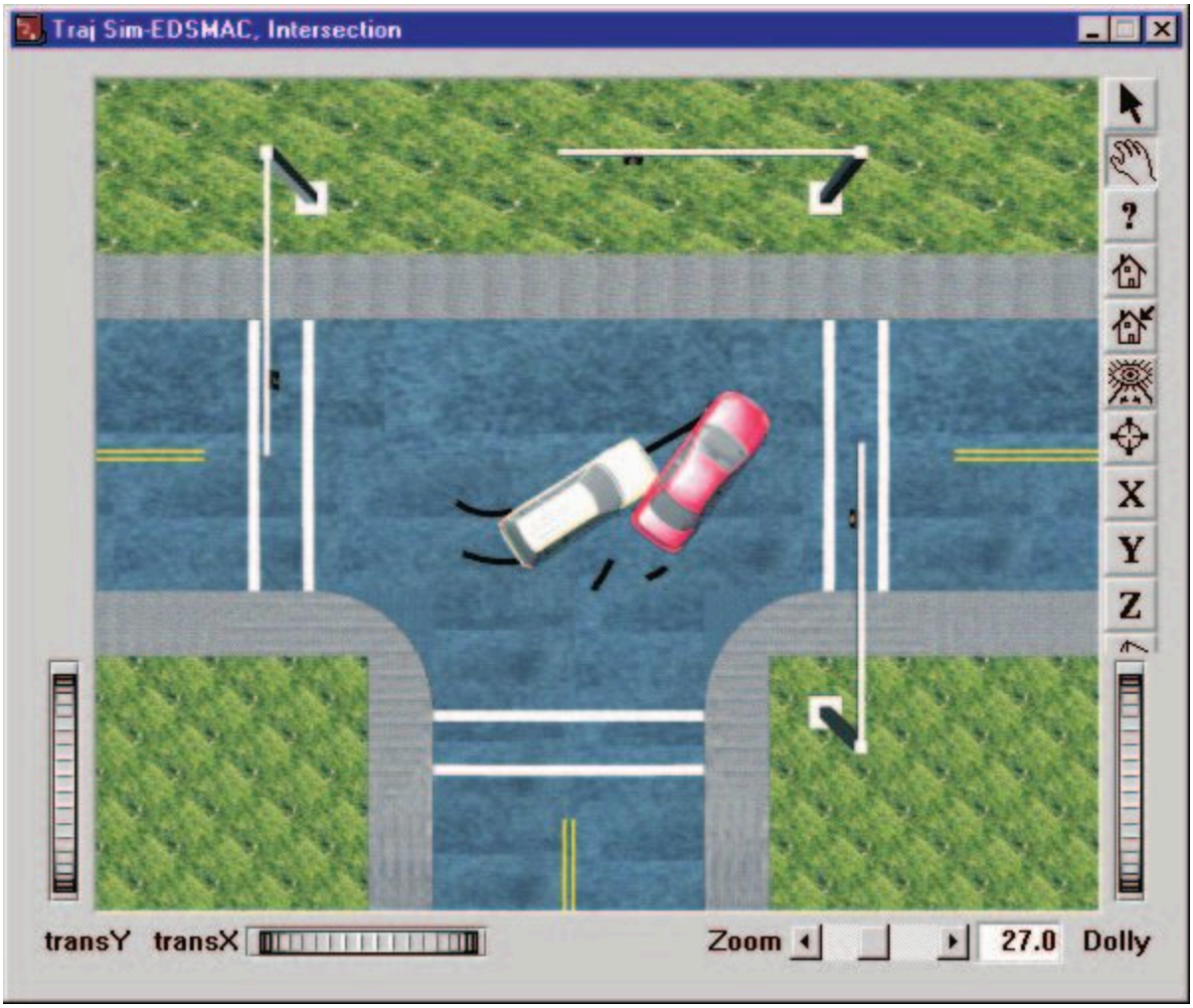


Figure 3-7: Typical EDSMAC Trajectory Simulation.

Displaying a Trajectory Simulation

The Trajectory Simulation is controlled using the Playback Controller (see Figure 3-8). The Playback Controller's buttons have the following functions:

- **Reset** — Return to the start of the simulation
- **Rewind to Start** — Return to the start of the simulation
- **Reverse** — Play the simulation backwards
- **Pause** — Pause the simulation
- **Play** — Execute the event or play the simulation forwards
- **Advance to End** — Advance to the end of the simulation



Figure 3-8: Playback Controller, used for controlling Trajectory and Damage Profile Simulations.

Displaying a Damage Profile Simulation

EDSMAC produces a dynamic simulation of the vehicle damage profile. The simulated damage is displayed in the Damage Profile viewer (see Figure 3-9). The vehicle is initially displayed in its original shape without damage. To display a time-history of the damage, use the Playback Controller (see Figure 3-8).

> NOTE: A Trajectory Simulation window must be open in order to enable the Playback Controller.

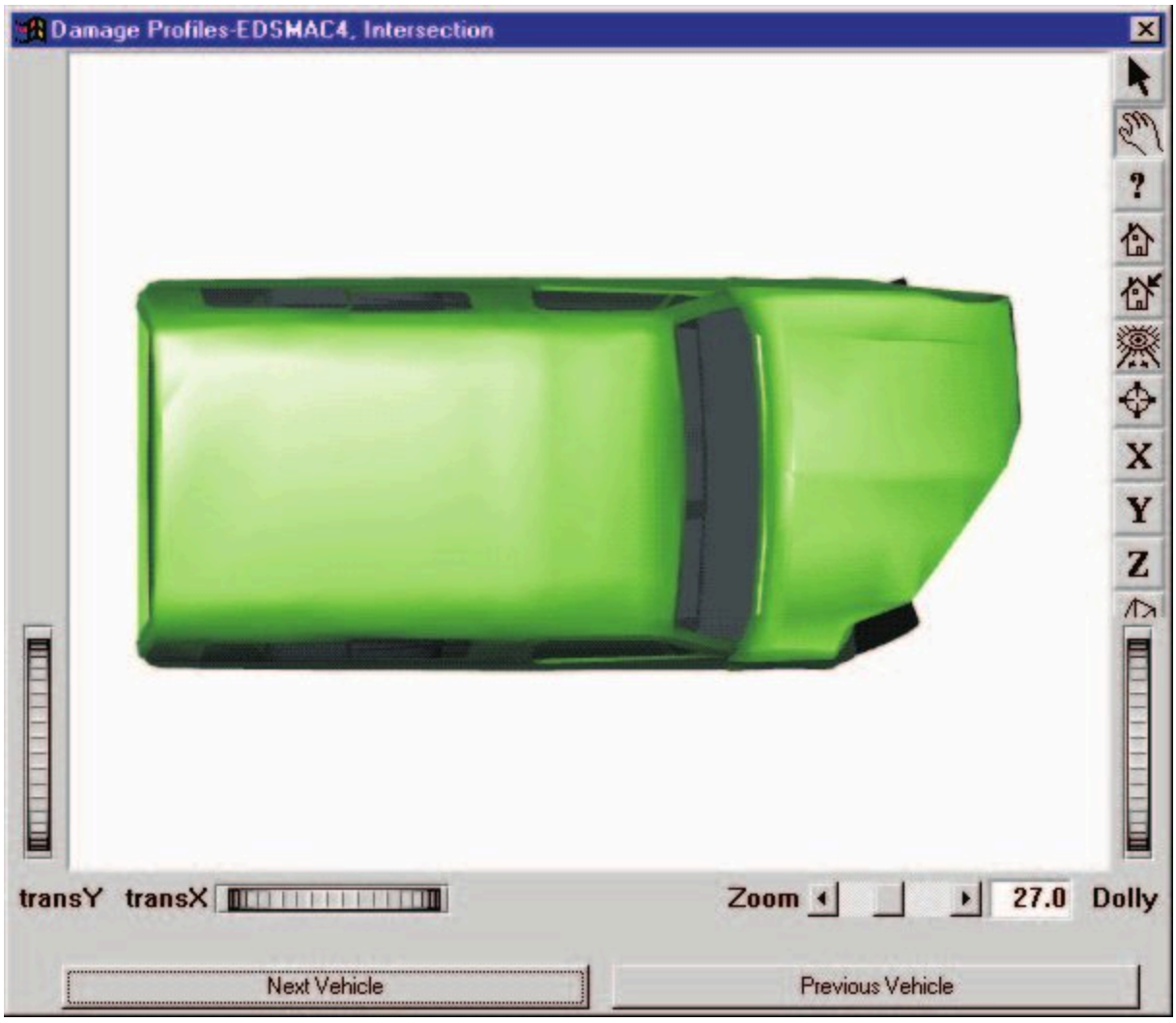


Figure 3-9: Typical EDSMAC Damage Profile Simulation.

Previous: Chapter 2 — Program Input | Next: Chapter 4 — Calculation Method

Chapter 4 — Calculation Method

Basis for Analysis

EDSMAC is a dynamic analysis of a crash sequence involving one or two vehicles moving in the horizontal (yaw) plane. The program uses a tire model to calculate forces acting on the vehicle at the tire-road interface. If contact between vehicles is detected, collision forces are also computed. Newton's laws of motion are solved at discrete, user-entered time steps for each vehicle. The resulting accelerations are integrated to update the position and velocity at the end of each time step.

The mathematical model for EDSMAC was developed and validated at Calspan [1-5, 11-13]. Extensions provided by EDC are explained in references 6 and 7.

To use EDSMAC successfully, a good understanding of vehicle dynamics is extremely useful and is recommended. However, the following discussion is limited to the general analytical approach. The discussion describes the solution procedure while the vehicles are in contact during the collision phase and while they are separated (before and after impact) during the trajectory phases. For a detailed treatise on the subject of vehicle dynamics and simulation programs, the user is referred to the references listed at the end of this Physics Manual as well as those listed in HVE-2D User's Manual, Appendix VI.

Equations of Motion

EDSMAC is a 3-degree of freedom analysis. Vehicle motion is calculated in the earth-fixed X and Y directions and rotation about the vertical Z axis. The vector velocity (amplitude and direction) is resolved in the vehicle-fixed coordinate system by resolving its components along the vehicle's forward (u-velocity) and lateral (v-velocity) directions. For more information, refer to SAE J670e — Vehicle Dynamics Terminology, portions of which are found in the Help Index.

The required equations of motion, applicable to each vehicle, are written below:

$$\Sigma F_x = m(\dot{u} - vr)$$

$$\Sigma F_y = m(\dot{v} + ur)$$

$$\Sigma M_z = I_z \dot{r}$$

where:

Symbol	Meaning
m	mass
I_z	yaw moment of inertia
u	forward velocity
v	lateral velocity
r	angular yaw velocity about z axis
ΣF_x	summation of external forces in the vehicle-fixed x-direction
ΣF_y	summation of external forces in the vehicle-fixed y-direction
ΣM_z	summation of external moments about the vehicle-fixed z axis

EDSMAC solves these equations of motion at discrete, user-entered time intervals (see Simulation Controls, Timesteps), then uses numerical integration to advance to the next time step and the calculations are repeated.

There are no degrees of freedom (and hence, no equations of motion) for vertical translation nor pitch or roll rotation. Thus, roll, pitch and vertical accelerations are ignored.

Collision Phase

The collision phase occurs when interference is detected between the vehicles. This condition is confirmed using simple geometry. Given interference exists, the widest damage range that is geometrically possible is bracketed between a beginning and a final azimuth angle measured from the vehicle CG, and the search for contact is confined to that range. The inter-vehicle force is then computed. The resulting acceleration of each vehicle is computed using Newton's second law (force equals the product of mass and acceleration), and is integrated twice in order to compute the changes in velocity and position.

The procedure for computing the inter-vehicle force is based on the concept of a linear spring. The exterior of each vehicle is surrounded by such springs with the user-entered spring constant, or stiffness.

When the vehicles are in contact, the springs of each vehicle press against each other. From this simple fact, several important observations can be made. First, the force between them is equal (Newton's third law). Second, since the displacement of each spring is proportional to the force, the crush (damage) profile of a given vehicle is defined by the end of its springs. Third, the motion of each vehicle resulting from the forces and moments can be computed. This is all the information EDSMAC needs at a given time step. The results determine how the vehicles respond during the impact phase.

To implement the collision model, the user must provide data which describe the vehicle exterior and control the simulation at each collision time interval.

The vehicle exterior is described by its crush stiffness, K_v. This parameter has the properties of a linear spring. However, since the spring properties are distributed around the vehicle exterior, the stiffness spring rate has units of pound per inch of crush depth per inch of crush length. The resulting units for stiffness are lb/in². Note that this is not a true "pressure", since the two-dimensional analysis results in a body exterior that has no vertical dimension and, therefore, has no area. The apparent units of area in the denominator result from the crush depth dimension related to the spring rate, lb/in.

Default values for K_v are assigned to each vehicle and may be edited using the HVE-2D Vehicle Editor. Values for K_v may also be computed from crash test data. The method is described in the literature [14].

*(updated: EDSMAC takes the vehicle's **frontal** stiffness and applies it to the entire perimeter — the side and rear stiffness values stored with the vehicle are not read. A vehicle struck in the side or rear is therefore modeled with its frontal stiffness. A fixed barrier is given a stiffness of 500 lb/in².)*

> NOTE: When computing K_v from crash test data, remember EDSMAC assumes the force vs deflection curve goes through the origin (i.e., $b_0 = 0$).

Three simulation control parameters are required for the collision model. The **Vector Spacing**, $\Delta\psi$, is the incremental angular spacing of each of the springs distributed about the vehicle exterior. The crush displacement of each spring is produced along radial vectors from the vehicle center of gravity to the locations on the original (before damage) vehicle exterior defined by the incremental spring spacing. The force on each vehicle is proportional to the crush displacement. Since the forces on each vehicle must be equal (Newton's third law — for every action there is an equal and opposite reaction), the current crush displacement is adjusted between both vehicles along each of the radial vectors. The user-entered increment of each radial vector adjustment, the **Vector Adjustment Increment**, $\Delta\rho$, is subtracted from one vehicle and added to the other until the forces on the vehicles are approximately equal.

Because the adjustments are finite increments of crush displacement, the forces on the two vehicles will not be exactly equal. EDSMAC will continue to adjust the length of each radial vector until the difference in the forces is less than the user-entered **Max Pressure Error** (also labelled Vector Force Tolerance), λ. For solution stability, there must be a RHO vector length tested for which the difference in inter-vehicle forces is less than the Max Pressure Error. This requires you to select a Max Pressure Error such that $\lambda > K_v\ \Delta\rho$ — that is, greater than the crush stiffness times the Vector Adjustment Increment — for the stiffnesses of both vehicles. Failure to meet this criterion may result in an error message (see Chapter 6 — Messages).

> **NOTE:** EDSMAC does not adjust the Max Pressure Error for you. (EDSMAC4 does raise it automatically when it is too small for the stiffnesses in use.) If the value is too small, the iterative adjustment simply fails to converge and the run stops with a fatal message after 200 attempts.

Tangential forces are developed due to inter-vehicle sliding friction and intermingling between individual vehicle components. This effect is accounted for by the user-entered inter-vehicle friction coefficient, the **Inter-vehicle Friction** option, μ. A friction force is transmitted whenever there is relative motion between the vehicles. The user-entered **Minimum Velocity for Friction**, ζ_v, is the minimum relative velocity at which full inter-vehicle friction is developed; below it the friction force is scaled linearly with the sliding velocity.

EDSMAC allows for the effect of restitution after impact, thus giving the vehicle exterior some elasticity. This elasticity is modeled by allowing the length of each spring to increase slightly after it reaches its deflected length. The restitution varies non-linearly with the degree of deformation. Three values, C_0, C_1 and C_2, provide a 2nd-order polynomial fit that gives a restitution fraction between zero and one, used at the end of each timestep to blend each RHO vector between its crushed length and its original undeformed length:

$$e(\delta) = C_0 - C_1\,\delta + C_2\,\delta^2$$

where δ is the change in length (crush depth) of the RHO vector. The restored vector length is

$$\rho_{Restored} = e(\delta)\,\rho_{Original} + (1 - e(\delta))\rho_{Crushed}$$

so e = 0 leaves the vector fully crushed and e = 1 restores it completely.

The crush-force relationship and force equilibrium

Along each RHO vector the crush force per unit width — the

pressure

, in the sense used by the collision model — is simply the crush stiffness times the crush depth:

$$p = K_v \, C$$

which is the linear spring described above, passing through the origin. Where a vector engages a single face, C is the deformation normal to that face; in the corner region, where a vector engages both a side and an end, the two components are blended so that the crush varies smoothly around the corner.

The forces along a pair of corresponding vectors must be equal and opposite, and they are made so by iteration. While the difference between the two pressures exceeds the **Max Pressure Error**, λ, both vectors are shortened and the pressures recomputed. The amount by which they are shortened is normally a single **Vector Adjustment Increment**, $\Delta\rho$. Where the two vehicles' crush stiffnesses differ by more than a factor of two, a single increment would converge far too slowly, so the program instead estimates how many increments are needed from the combined stiffness of the pair and jumps most of the way in one step:

$$\Delta = (\lfloor \frac{p_j - p_i}{(K_{v,i} + K_{v,j})\Delta\rho} \rfloor + \tfrac{1}{2})\Delta\rho$$

Up to 200 adjustments are allowed at a vector pair; exceeding that is a fatal error. This is the mechanism behind the requirement stated above that $\lambda > K_v \, \Delta\rho$: if the tolerance is smaller than the pressure change one increment produces, no vector length exists at which the test can succeed, and the iteration runs to its limit no matter how many passes are allowed.

> **NOTE:** EDSMAC4 allows 3200 adjustments at a vector pair and raises the tolerance automatically when it is too small. EDSMAC does neither, which is why the choice of Max Pressure Error matters more here.

Restitution is not computed for **J-points** — points on the damage profile that could not be established from the vehicle's own radial vector and had to be constructed from the other vehicle's CG instead. These points are marked with a double asterisk in the Vehicle Damage Summary table of the Damage Data report.

(updated: earlier editions gave the polynomial without saying how its value is used. It is a blend fraction, not a length.) (Note: restitution is applied only while $\delta < C_1 / (2C_2)$, the vertex of the parabola; see the EDSMAC Calculation Options reference.)

Trajectory Phase

All of the external forces applied to the vehicle which direct its motion during the pre- and post-impact phases are applied at the tires.

> NOTE: The tire forces continue to exist during the collision phase.

Accurate computation of the tire forces is essential. Unfortunately, pneumatic tires do not behave in an easy-to-calculate manner. Rather, these properties are functions of several variables, and are extremely non-linear.

In order to calculate tire forces, EDSMAC uses the Fiala tire model [10]. This model has seen use in many popular simulations, and is used in EDSVS, EDVTS, and EDCRASH. The user supplies the tire cornering stiffness, C_α, and tire/road slide friction data. The friction may be velocity dependent. A friction circle is used to limit longitudinal and lateral tire forces during combined braking and steering.

EDSMAC allows the vehicle to accelerate, brake and steer. The attempted acceleration, braking and steering are supplied by the user in tabular form using the Event Editor. It is important to understand these driver controls result in

attempted

forces; the Fiala tire model determines if these forces are sustainable at the tire-road interface and accounts for the condition if the available force is exceeded.

(updated: earlier editions stated that EDSMAC's vehicle model allows the user to study vehicles with dual tires. It does not. A vehicle with dual tires at any wheel position is rejected at event initialization with a fatal error and the event will not run. Use EDSMAC4, which does support dual tires, for such a vehicle.)

Tire force calculation

At each wheel, the friction coefficient is the tire's slide friction scaled by the friction multiplier of the surface beneath that wheel, then adjusted for speed:

$$\mu = \mu_{Slide}\, f_{Surface}(1 + C_\mu\, s)$$

where s is the wheel's total speed and C_μ the speed reduction factor. A zero speed reduction factor leaves the friction speed-independent. The surface beneath each wheel is looked up separately, so the vehicle can straddle a friction change. The force available at the tire-road interface is then

$$F_{Avail} = \mu\, F_z\, n_z$$

where F_z is the wheel load and n_z the vertical component of the surface normal, which reduces the available force on a sloped surface.

The attempted longitudinal force is the sum of the throttle and brake table entries at the current time. For the Percent Available Friction table method, those entries are fractions and are multiplied by F_{Avail}. The longitudinal force actually developed, F_c, is the attempted force limited by what the tire can supply:

$$F_c = \text{sgn}(u)\, \min\left(|F_{Attempt}|,\ F_{Avail}\cos\alpha\right)$$

for braking, and limited to F_{Avail} for acceleration. At forward speeds below 2 in/sec the braking force is scaled by $|u| / 2$, so that a nearly stopped wheel does not develop full braking force. The scaling applies to braking only; drive force is not reduced at low speed.

Whatever longitudinal force is used is unavailable laterally. The remaining lateral capacity follows the friction circle:

$$F_{s,max} = \sqrt{F_{Avail}^2 - F_c^2}$$

The Fiala model is then applied to that remaining capacity through the non-dimensional sideslip parameter

$$\bar{\beta} = \frac{C_\alpha\, \alpha}{F_{s,max}}$$

giving the lateral force

$$F_s = \begin{cases} F_{s,max}\left(\bar{\beta} - \frac{\bar{\beta}|\bar{\beta}|}{3} + \frac{\bar{\beta}^3}{27}\right), & |\bar{\beta}| < 3 \\ [10pt] F_{s,max}\ \operatorname{sgn}\bar{\beta}, & |\bar{\beta}| \geq 3 \end{cases}$$

The lateral force is set to zero, and the wheel is flagged as skidding, when either the longitudinal force has consumed essentially all of the available friction or the wheel's speed components are both below half an inch per second. A wheel is also flagged as skidding when the Fiala model saturates.

Finally the two components are resolved through the wheel's steer angle, δ, into vehicle-fixed components:

$$F_y = F_s \cos\delta + F_c \sin\delta, \qquad F_x = -F_s \sin\delta + F_c \cos\delta$$

(updated: earlier editions described the tire model in prose only. The equations above are given for comparison with the other EDC programs. Note that EDSMAC applies the Fiala polynomial to the slip angle directly, and normalizes by the friction-circle remainder rather than by the peak friction force, so its lateral force differs from the EDSVS and EDVTS form even for identical tire data.)

Impact and Separation Times

The impact and separation times reported in the Accident History bound the collision phase.

Impact is declared on the first timestep at which the two vehicle perimeters interfere, which is tested geometrically by checking whether any corner of either vehicle lies inside the other. At that moment the time, position, heading, forward and lateral velocities and yaw rate of both vehicles are recorded for the Accident History, and the integration timestep changes to the Vehicle Collision Integration Timestep. These impact conditions are recorded only once; a later contact between the vehicles does not update them, so in a multiple-impact event the impact row always describes the first contact.

> **NOTE:** Unlike EDSMAC4, EDSMAC offers no choice of criterion. The acceleration threshold used below is fixed at 1 g and cannot be changed.

Separation is declared by either of two routes:

- **The vehicles are no longer interfering.** Separation follows at the next time falling on a Vehicle Separation Integration Timestep boundary.
- **The vehicles are still interfering, but neither is accelerating.** If the total acceleration of *both* vehicles is 1 g or less, a counter is advanced. Once that counter reaches six, separation is declared at the next separation timestep boundary. The delay exists because numerical integration can produce a single quiet timestep in the middle of a collision, and the program should not mistake it for the end of contact.

In both cases the separation time, positions and velocities are recorded, the timestep changes to the separation timestep, and the trajectory timestep resumes 100 timesteps later.

Because the acceleration test uses the vehicle's

total

acceleration, tire forces count toward it. This matters only at the 1 g threshold, which hard braking on a high-friction surface can approach.

A second impact after separation requires both that the perimeters interfere again and that at least one vehicle's total acceleration exceed 1 g. The collision phase therefore restarts slightly after renewed contact, once the contact has built up enough force to register.

> **NOTE:** The counter described above is not reset when the acceleration rises back above the threshold, so the six timesteps need not be consecutive. In a long collision whose acceleration crosses 1 g repeatedly, separation is declared after six sub-threshold timesteps in total.

Collision Severity Results: PDOF, Delta-V and Peak Acceleration

The PDOF, delta-V and peak acceleration reported for each damage range are derived from the vehicle's acceleration history, not from the inter-vehicle contact force.

The PDOF is reported in the conventional CDC sense (see reference 8) — a 12 o'clock PDOF is a force directed from front to rear, so the reported angle is 180 degrees opposite the direction in which the force acts on the vehicle. Angles are measured in the vehicle-fixed frame with zero forward and positive toward the right side.

Acceleration peaks. A peak is recorded each time a vehicle's total acceleration rises above 1 g and falls back below it. The peak magnitude, its forward and lateral components and its time are stored. Up to ten peaks are kept, after which a message is issued; the peaks are then sorted into descending order of magnitude.

Delta-V of a peak is the integral of the acceleration **magnitude** over the peak, computed by the trapezoidal rule:

$$\Delta V = \int |\mathbf{a}| \, dt$$

Because this is a scalar integral rather than a vector one, a peak whose direction rotates produces a larger delta-V than the corresponding change in velocity. To limit this, the direction of the acceleration is tracked in sectors, and the contribution of an acceleration that has changed sector is suppressed.

PDOF of a peak is the direction of the acceleration at the instant of the peak, converted to the conventional sense described above.

Matching peaks to damage. Each damage range found on the crush profile is matched to the acceleration peak whose clock direction is closest to the mid-point of that range. The search widens in 15-degree steps; if no peak lies within 60 degrees of the mid-point, the largest peak is used instead and a message is issued. This is a common and harmless outcome for sideswipes and secondary impacts.

Total delta-V of a damage range is the sum of the delta-Vs of *all* acceleration peaks whose clock direction lies within one hour either side of the matched peak's clock direction, so delta-V arising from separate impacts in the same general direction is combined into a single figure for that range. If only one peak was found, all delta-V is assigned to it.

Peak acceleration reported for a range is the magnitude of the matched acceleration peak, and the reported time is the time at which it occurred. As with delta-V, it is the vehicle's total acceleration and so includes the tire contribution.

Assumptions

In order to provide a useful analysis without becoming burdensome and overly complex, EDSMAC makes several simplifying assumptions. If the user is to use EDSMAC properly, it is important these assumptions and their consequences be understood. In some cases, data which violate these assumptions will cause a fatal error, along with a message indicating the reason for the error. In other cases, the error is not with the data but with the use of the program under conditions which violate the assumptions inherent to the computations. EDSMAC will issue results which may not be valid for the circumstances of the accident. Before using EDSMAC, be sure your accident is within the scope of EDSMAC's original design.

A thorough list of assumptions and how to properly use the program can be found in the References [1-7, 11-13, 15]. Some of the major program assumptions are defined below:

No Rollover Allowed

EDSMAC is a 3-degree of freedom analysis and does not consider roll or pitch degrees of freedom. If a vehicle rolls over, the equations of motion that apply during the trajectory phases no longer apply since forces are no longer applied at the tires but are applied between the vehicle exterior and road. EDSMAC makes no provision for this condition.

All External Forces Applied at Tires

Other than during the collision, all forces which affect vehicle motion are applied at the tire/road interface. Aerodynamic effects are ignored. This assumption may become a factor at excessive speeds. In addition, forces caused by contact between the undercarriage and ground (sometimes resulting from impact damage) are not considered.

Homogeneous Vehicle Exterior

The collision phase analysis assumes the same linear force vs crush relationship for all vehicle surfaces (front, sides or rear) — specifically, the vehicle's frontal stiffness, applied everywhere. The stiffness is assumed to be uniform for the entire surface. This means, for example, that the side stiffness is the same at the front fender, wheels, bumpers, doors and quarterpanel.

Previous: Chapter 3 — Program Output | Next: Chapter 5 — EDSMAC Tutorial

Chapter 5 — EDSMAC Tutorial

Description

This tutorial illustrates a very common use of EDSMAC, that is, to perform a time-distance study to evaluate accident avoidability. We'll be able to watch as the vehicles approach each other and determine the first point of visibility between vehicles.

This tutorial is a continuation of the EDCRASH Tutorial, wherein the initial vehicle velocities were estimated. You may wish to review that tutorial before continuing.

Like all EDSMAC events, the procedure involves the following basic steps:

- Create the vehicle(s)
- Create the environment
- Execute the EDSMAC event
- Review the EDSMAC output reports

This basic procedure is described in detail in this tutorial.

> NOTE: It is assumed that HVE-2D is up and running, and that the user is familiar with HVE-2D's basic features, such as using dialogs and viewers, as well as the HVE-2D Editors. The purpose of this tutorial is to illustrate those features while setting up and executing an EDSMAC event.

Getting Started

> NOTE: If you just finished the EDCRASH Tutorial, you have already created your vehicles and environment and may proceed directly to Creating the Events. The same suggestion applies if you already did the EDCRASH Tutorial and saved the case; if so, simply open that case and skip ahead.

As in other tutorials, before we get started with our current tutorial, let's set the user options so we're all starting on the same page.

> NOTE: All options simply affect the appearance in a viewer during Event or Playback mode.
>
> NOTE: Some of the following options are "Toggles" that switch between two different modes. Make sure these options are set correctly.

To set the initial user options, choose the following from the Options Menu:

- *ON:* Show Key Results
- *OFF:* Show Axes
- *OFF:* Show Velocity Vectors
- *ON:* Show Skidmarks
- *OFF:* Show Targets

- *ON:* AutoPosition
- Units equals *S.I.*

> NOTE: As we'll see when we create the environment, our EDSMAC Tutorial takes place in Australia; thus, we require metric units.

- Render Options:
- Show Vehicles as *Actual*
- *Phong* Render Method
- Complexity equals *Object*
- Render Quality equals *5*
- Texture Quality equals *1*
- Anti-aliasing equals *1*

The remaining options will automatically initialize to their default conditions. We're now ready to proceed with the tutorial.

Creating the Vehicles

Let's add the vehicles to our case. The first vehicle is a white, 1996 Ford Escort 2-Door Hatchback; the second vehicle is a dark red 1995 Nissan Sentra 4-door Sedan. Let's add the first vehicle:

1. If the Vehicle Editor is not the current editor, choose *Vehicle Mode*. The Vehicle Editor is displayed.
2. Click *Add New Object*. The Vehicle Information dialog is displayed. The Vehicle Information dialog allows the user to select the basic vehicle attributes according to *Type, Make, Model, Year* and *Body Style*.

> NOTE: The Vehicle Information dialog also allows you to edit the Driver Location, Engine Location, Number of Axles and Drive Axle(s). These options are assigned default values for each vehicle. For our tutorial, only driver location must be edited.

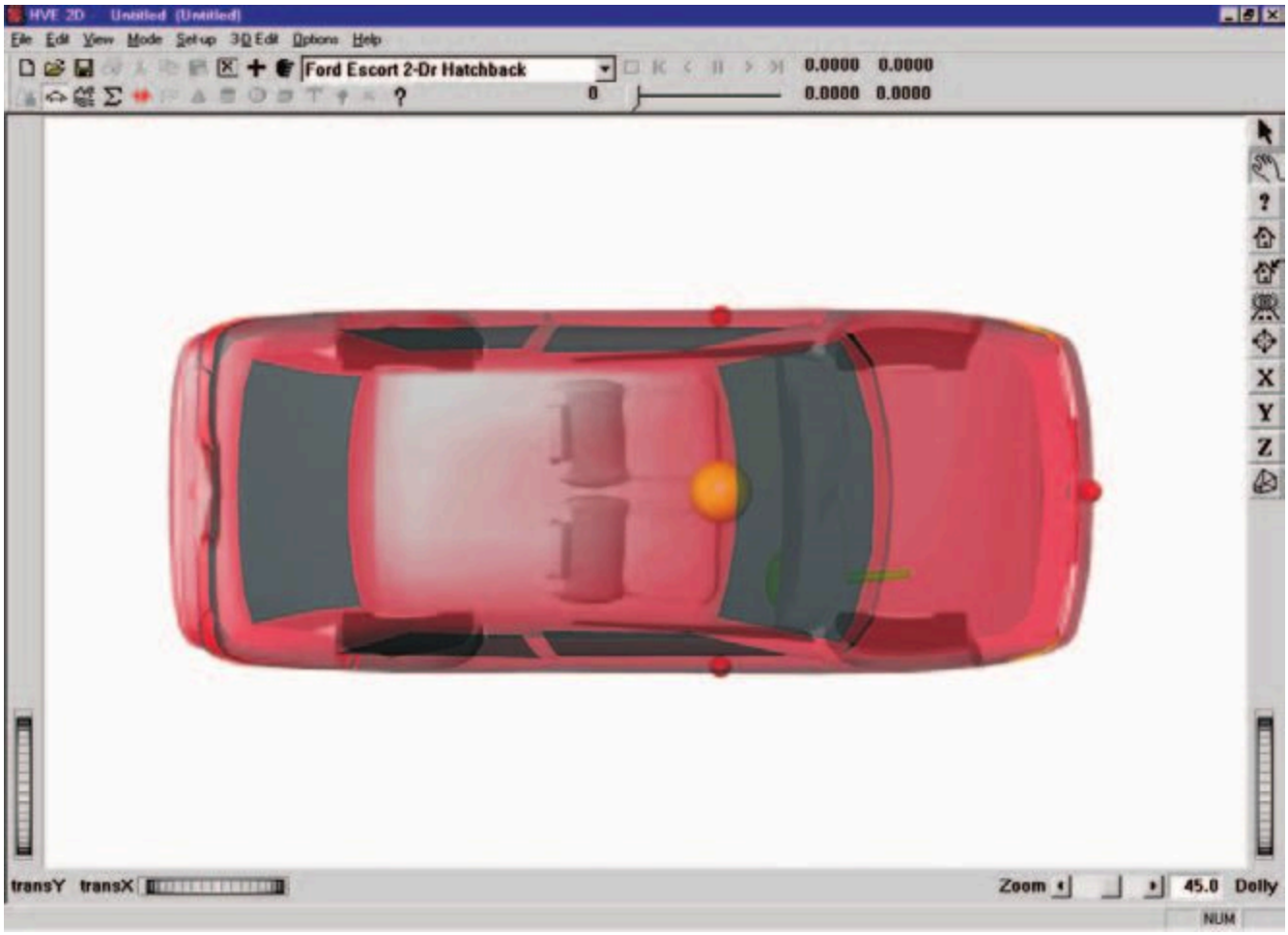
1. Using the option buttons, click each button to choose the following vehicle from the database:
2. Type = *Passenger Car*
3. Make = *Ford*
4. Model = *Escort*
5. Year = *1991-1996*
6. Body Style = *2-Door Hatchback*
7. Source Database = *Tutorial.db*
8. Driver Location = *Right*
9. Click *OK* to add *Ford Escort* to the Active Vehicles list.

The Ford Escort is added to the case. Next, let's add the Nissan Sentra.

1. Click *Add New Object*. The Vehicle Information dialog is displayed.
2. Using the option buttons, click each button to choose the following vehicle from the database:

3. Type = *Passenger Car*
4. Make = *Nissan*
5. Model = *Sentra*
6. Year = *1995-1999*
7. Body Style = *4-Door*
8. Source Database = *Tutorial.db*
9. Driver Location = *Right*
10. Click *OK* to add *Nissan Sentra* to the Active Vehicles list.

We now have the vehicles required for our study, as shown in Figure 5-1.



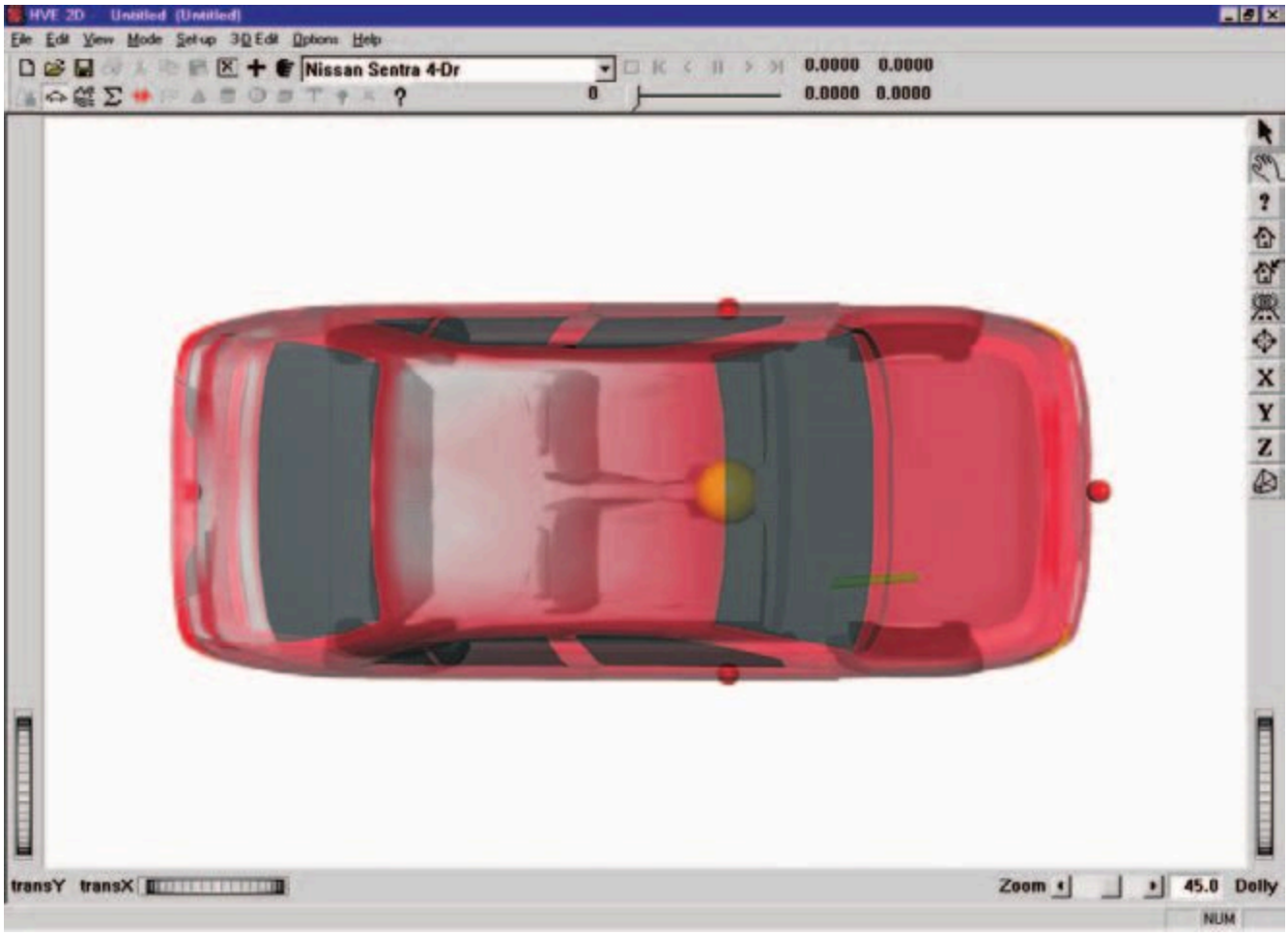


Figure 5-1: Ford Escort (above) and Nissan Sentra (below).

Editing the Vehicles

Next, we'll edit the vehicles to change their color and weight. In addition, we'll change the stiffness of the Nissan Sentra, using values derived from our initial reconstruction analysis.

Start by changing the color of the Ford Escort:

1. Select the *Ford Escort* from the Active Vehicles drop-down list, making it the current vehicle. The Ford Escort is now displayed in the Vehicle Editor.
2. Click on the CG and choose *Color*. The Vehicle Color dialog is displayed (see Figure 5-2), showing the vehicle's current color (the small black square, or *hot spot*, in the color wheel) and intensity (the arrow in the intensity slider). Click on the hot spot and drag it to the center of the circle. To lighten the vehicle, click on the intensity slider and drag it to the far right end.

> NOTE: The color chip on the left shows the current color.

1. When the color is to your liking, close the dialog by clicking the close button on the upper right corner of the dialog.

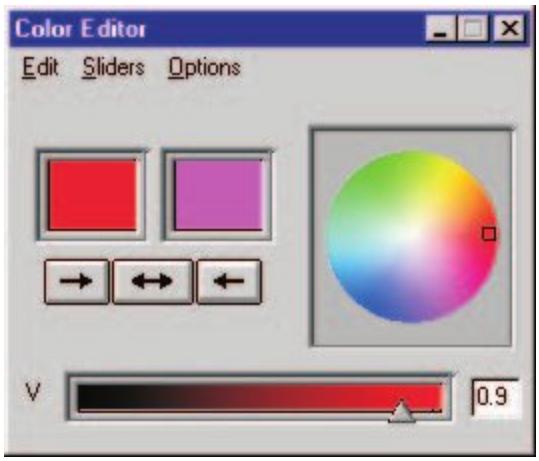


Figure 5-2: Vehicle Color dialog, used for assigning the vehicle color.

> NOTE: The vehicle's apparent color may be slightly misleading because the vehicle is translucent when displayed in the Vehicle Editor. The actual color will be used whenever the vehicle is displayed during Event and Playback mode.

Next, let's change the Escort's weight. Perform the following steps:

1. Click on the CG and choose *Inertias*. The Inertias dialog is displayed (see Figure 5-3), and we're ready to change the vehicle's weight.
2. In the *Total Weight* text field, replace the existing weight, `10283` Newtons, with the measured value, `11037` Newtons.

> NOTE: The weight is entered as a force (Newtons). Mass units (kg) are calculated and displayed.
>
> NOTE: The dialog might display 10283.5, or a similar number, because the weight is actually divided by the current gravity constant and stored as mass. Extra precision results when the mass is multiplied by the current gravity constant and redisplayed.

1. If not already selected, click the checkbox for *Auto Update Inertia When Weight Changes*.
2. Press *OK* to accept the weight value and update the Total Yaw Inertia of the vehicle.

The Ford Escort is now ready for use in our tutorial. Using the viewer thumb wheels and/or manipulators, pan, zoom and look at the vehicle.

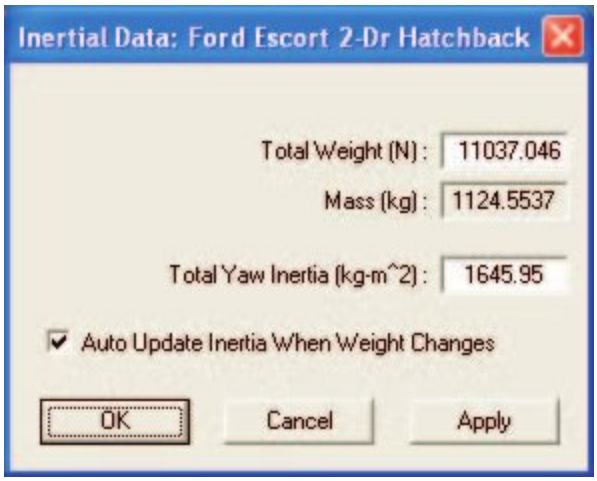


Figure 5-3: Vehicle Inertias dialog, used for editing the current weight and yaw inertia.

> NOTE: It is important to be able to manipulate (pan and zoom) the objects in the current viewer. Refer to the User's Manual (see Window Manager Basics) for more information.

Now, let's change the color, weight and stiffness of the Nissan Sentra:

1. Click on *Nissan Sentra* in the Active Vehicles list, making it the current vehicle. The Nissan Sentra is now displayed in the Vehicle Editor.
2. Click on the CG and choose *Color*. The Vehicle Color dialog is displayed. The vehicle's color is fine, but we need to darken it. To darken the vehicle, click on the intensity slider and drag it to the middle of the range.
3. When the color is to your liking, close the dialog by clicking the close button on the upper right corner of the dialog.

Next, let's change the Nissan's weight:

1. Click on the CG and choose *Inertias*. The Inertias dialog is displayed.
2. In the *Total Weight* text field, replace the existing weight, `10858` Newtons, with the measured value, `11282` Newtons.

> NOTE: Again, the value displayed in the dialog may contain extra precision, for reasons explained earlier.

1. If not already selected, click the checkbox for *Auto Update Inertia When Weight Changes*.
2. Press *OK* to accept the weight value and update the Total Yaw Inertia of the vehicle.

Finally, let's change the stiffness of the vehicle. From a previous reconstruction analysis, the A and B stiffnesses were re-calculated in order to balance the forces (the technique is described in references [20] and [21]). Based on this analysis, a new K_v stiffness was calculated.

1. Click on the front side surface icon (red sphere). The CG to Front dialog is displayed.
2. Click *Stiffness*. The Stiffness Coefficients dialog for the front surface is displayed, as shown in Figure 5-4.

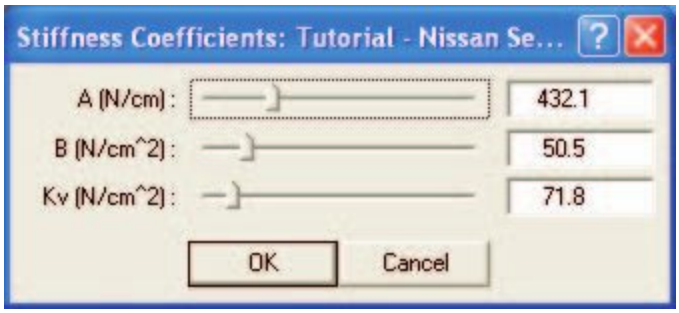


Figure 5-4: Vehicle Stiffness dialog, used for editing the current A, B and Kv stiffness coefficients for the current surface. Note that EDSMAC uses the front side value of Kv for the entire vehicle.

> NOTE: It is obviously of great importance to recognize that EDSMAC assumes the stiffness is uniform about the exterior of the vehicle, and that EDSMAC uses the value assigned for the FRONT surface.

To edit the current K_v stiffness value:

1. In the K_v Stiffness field, replace the current value, `71.8`, with the calculated value, `89.2` N/cm².
2. Click *OK* to update the stiffness.
3. Click *OK* again to remove the CG to Front dialog.

The Nissan Sentra is now ready for use in our tutorial. Using the viewer controls (thumb wheels and manipulators), view the vehicle.

Now, we have both vehicles ready for our study.

Saving the Case

Now that we've created vehicles for our case, let's save the case file.

1. Click on the *File* menu and choose *Save*. The Save-as File Selection dialog is displayed.

> NOTE: If you began this case using the EDCRASH Tutorial, your case will be saved using the existing filename, EdcrashTutorial.
>
> NOTE: If you started this tutorial as a new case, the Save-as dialog is displayed because the case has not been saved previously, so we need to enter a filename. Continue with the following steps.

1. In the Case Title text field, enter `EDSMAC Tutorial, Visibility Study`.

> NOTE: The Case Title is displayed as a heading on all printed output reports.

1. In the Filename text field, enter `EDSMACTutorial`.
2. Click *SAVE*. The current case data are saved in the `/supportFiles/case` subdirectory.

> NOTE: Saving the file occasionally is a highly recommended practice.

Creating the Environment

Now, let's add the environment:

1. Choose *Environment Mode*. The Environment Editor is displayed.
2. Click on *Add New Object*. The Environment Information dialog is displayed.
3. Using the Location Database combo box, choose *Sydney, NSW, Australia*. The latitude (35.30.00S), longitude (151.10.00E) and GMT, hours from the prime meridian (+10) are displayed for the selected location.

> NOTE: If Sydney were not included in your Location Database, you could add it simply by typing in a new location name, latitude, longitude and GMT.

1. Edit the name for the accident site, `Blind Intersection`.
2. Edit the date and time of the incident we are studying, `7/23/97` and `1330`, respectively.
3. Edit the angle from *true north* to the earth-fixed X axis in our environment, `-10` degrees.

> NOTE: The Latitude, Longitude, GMT, Date/Time and angle from true north are used to position the sun in the scene. This is, of course, important because the sun is the primary light source for the scene.

1. To add the environment geometry file to our case, click on *Open*. The Environment Geometry File Selection dialog is displayed.
2. Assure that the *Files of Type* option is set to *HVE Geometry Files (*.h3d)*. A list of environment geometry files using the .h3d file format is displayed in a list box. Double-click on *EdcrashEdsmacTutorial_2D.h3d* to choose the environment file and remove the dialog.
3. Press *OK*.

The selected environment is added to our case and displayed in the Environment Viewer (see Figure 5-5). Use the viewer thumb wheels to view the scene.

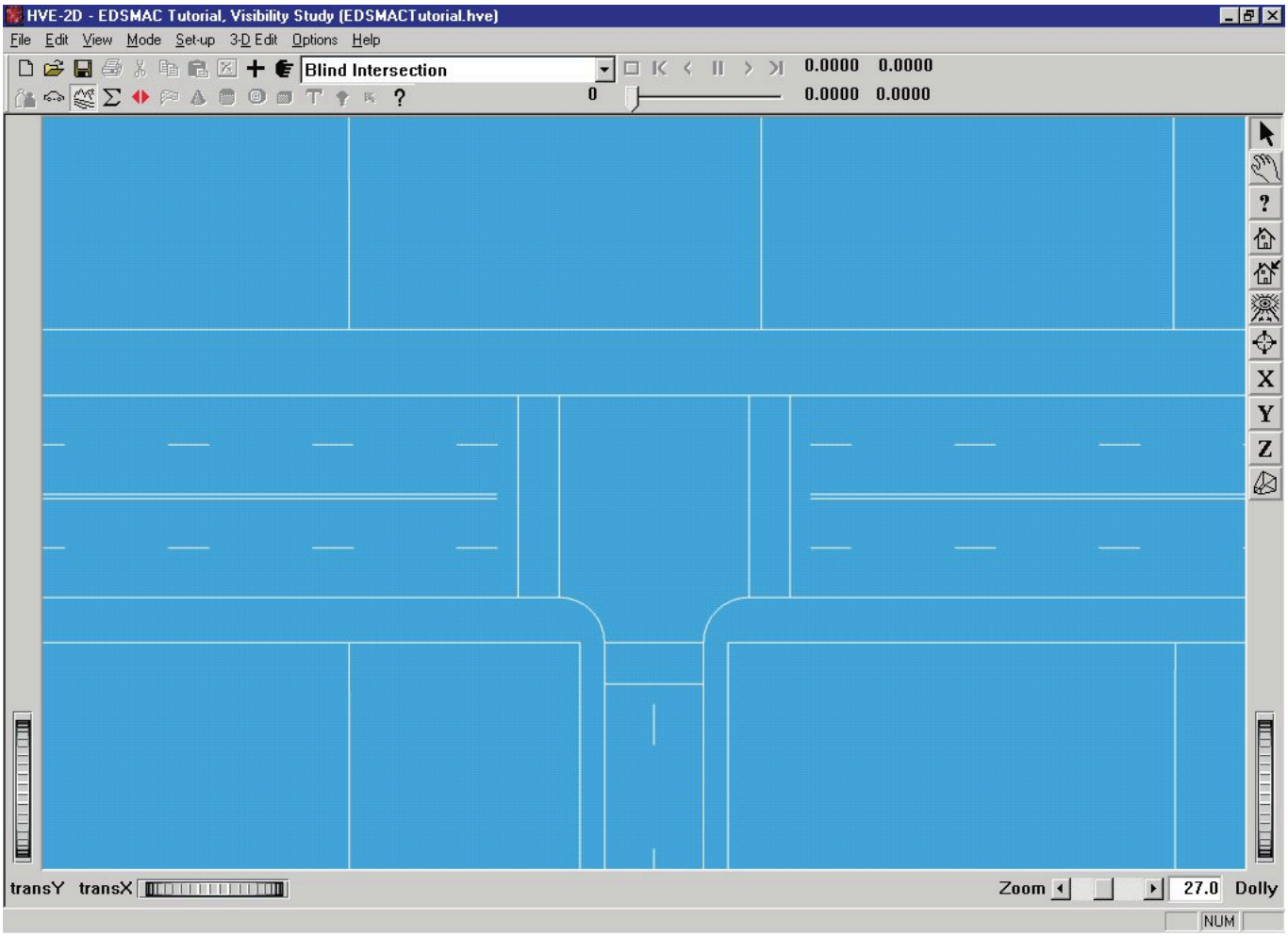


Figure 5-5: Environment used for our EDSMAC tutorial.

Creating Events

As mentioned at the outset, this EDSMAC tutorial is an avoidability study in which visibility plays a key role. With this in mind, we will start simulating the event well before impact to illustrate the visibility between vehicles, as obstructed by the building on the southwest corner of the intersection.

To create the event, perform the following steps:

1. Choose *Event Mode*. The Event Editor is displayed.
2. Click on *Add New Object*. The Event Information dialog is displayed.
3. Select *Ford Escort* and *Nissan Sentra* from the Active Vehicles list. The vehicles are added to the Event Humans and Vehicles list.
4. Select *EDSMAC* from the *Calculation Method* options list.
5. Enter a name for the event, `Visibility Study`.

> NOTE: The name of the calculation method will be appended to the event name, thus the complete event name will become "EDSMAC, Visibility Study."

1. Press *OK* to display the event editor.

Now, we're ready to set up the event. This step involves placing the vehicles in the environment and assigning driver controls:

1. Select *Ford Escort* from the Event Humans & Vehicles list.
2. Choose *Set-up* from the menu bar, select *Position/Velocity*. The Escort is displayed in its initial position at the earth-fixed origin.
3. Click on the vehicle's X-Y manipulator (see Figure 5-6), wait for it to turn bright yellow (indicating it has been selected), and drag it to its initial position, X=`35` m, Y=`15` m. Click the yaw manipulator and rotate it to its heading angle, `180` degrees.

> NOTE: To select the X-Y manipulator, the viewer must be in Pick mode, as indicated by the highlighted arrow in the upper right corner of the viewer (see Figure 5-6).
>
> NOTE: Adjust the viewer by dollying back (using the Dolly thumb wheel) until you can see the entire intersection.
>
> NOTE: Be sure to keep the mouse button depressed while you drag the manipulators.
>
> NOTE: If you can't position the vehicle at the exact coordinates, simply enter them in the dialog (in fact, it's often easier to directly enter the coordinates using the dialog).
>
> NOTE: When entering coordinates using the Position/Velocity dialog, remember to press \<Enter>; otherwise, the values will not be assigned.

1. Click the *Velocity Is Assigned* checkbox. Enter the initial total velocity, `40` km/h, followed by *Apply* (or simply press \<Enter>).

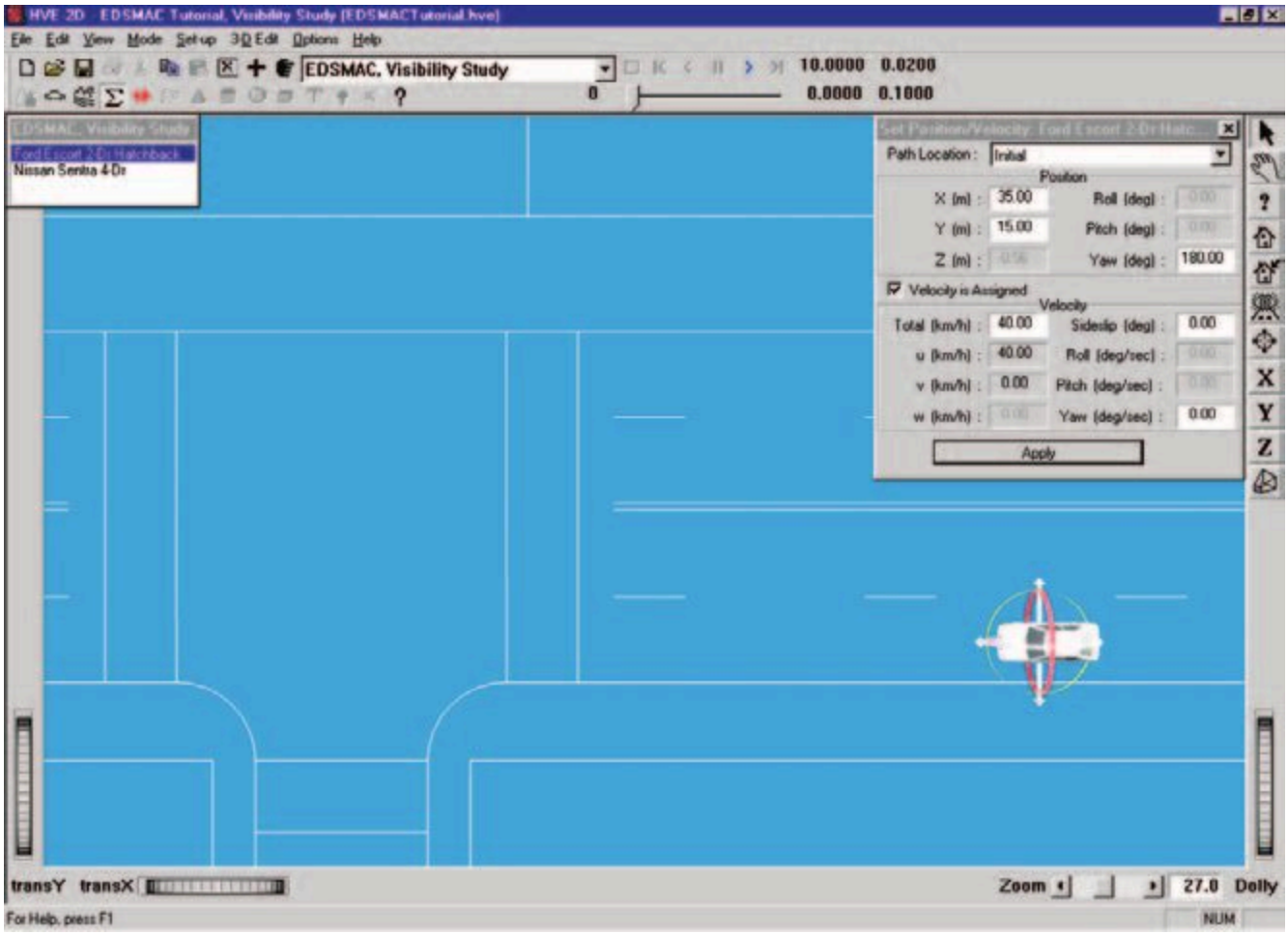


Figure 5-6: Positioning the Ford Escort using the Event Editor. The manipulators can be used to drag and drop the vehicle into position. Click on the cross-bars to drag the vehicle on the road surface; click on the circular yellow ribbon to rotate the vehicle about its yaw axis.

Next, let's enter the driver controls:

1. Choose *Set-up* from the menu bar, select *Driver Controls*. The Driver Controls dialog is displayed. The default driver control table, *Steering*, is also displayed for editing.

> NOTE: Two Steer Table options are available: 'At Steering Wheel' and 'At Axle'. We'll use the default method, 'At Steering Wheel'.

1. Enter the values shown in Table 5-1 into the steer table.

Table 5-1. Steer table entries for the Ford Escort.

Time (sec)	Steer Angle at Steering Wheel (degrees)
1.50	0.0
2.00	90.0

Next, let's assign the Brake Table for the Ford Escort:

1. Click the *Brake* tab on the Driver Controls dialog. The Brake dialog is displayed for the Ford Escort.

> NOTE: Two Brake Table options are available: 'Available Friction' and 'Wheel Force'. We'll use the default method, 'Available Friction'.

1. Enter the Escort's brake table using the *% Available Friction* (default) method — enter the values shown in Table 5-2 into the table.
2. Click *OK* to accept the Ford Escort's steering and brake tables.

Table 5-2. Brake table for Ford Escort.

Time (sec)	R/F	L/F	R/R	L/R
2.25	0.00	0.00	0.00	0.00
2.35	1.00	1.00	1.00	1.00
2.70	1.00	1.00	1.00	1.00
2.80	1.00	1.00	0.01	0.01

(Percent Available Friction, %/100)

Event set-up for the Ford Escort is now complete. Let's set up the Nissan Sentra:

1. Select the Nissan Sentra from the Event Humans and Vehicles list.
2. Choose *Set-up* from the menu bar, select *Position/Velocity*. The Nissan is displayed at its initial position at the earth-fixed origin.
3. Click on the vehicle's X-Y manipulator (see Figure 5-7), wait for it to turn bright yellow (indicating it has been selected), and drag it to its initial position, X=`3.5` m, Y=`39` m. Click the yaw manipulator and rotate it to its heading angle, `-90` degrees.

> NOTE: Be sure to keep the mouse button depressed while you drag the manipulators.

1. Click the *Velocity is Assigned* check box and enter the initial velocity, `35` km/h, followed by \<Enter>.

> NOTE: Remember to press Apply or \<Enter>. Otherwise, the value will not be assigned.

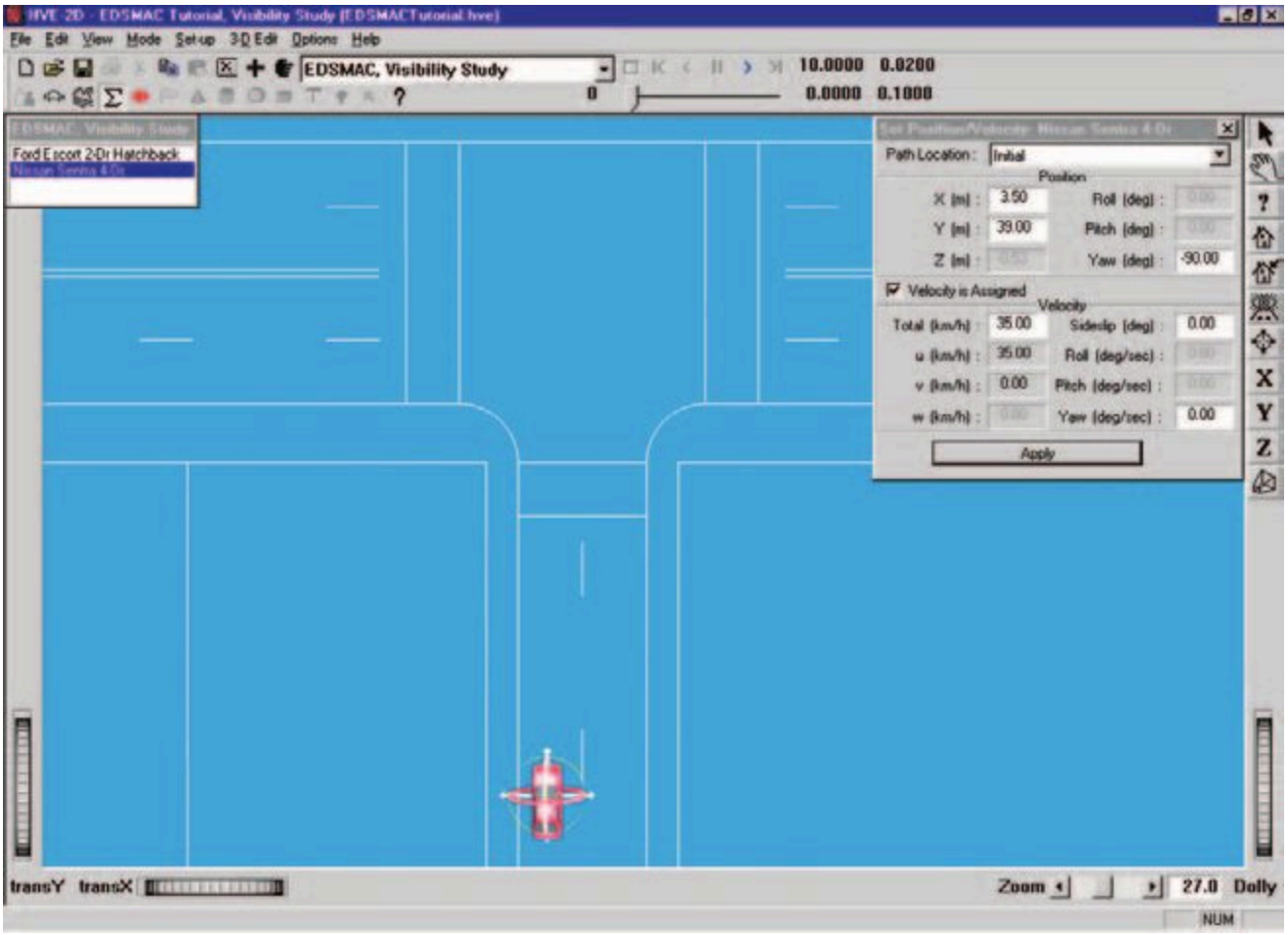


Figure 5-7: Positioning the Nissan Sentra using the Event Editor.

The Nissan's initial position and velocity are now established. Let's enter the driver controls. In this case, there are no driver inputs, per se. However, after impact the vehicle coasts to rest, so we need to enter rolling resistances:

1. Choose *Set-up* from the menu bar, and select *Driver Controls*. The Driver Controls dialog is displayed.
2. Click the *Brake* tab. The Brake Table is displayed.
3. Click on the *Table Is* option list and choose the *Available Friction* option.
4. Enter the rolling resistances after impact, as shown in Table 5-3.
5. Press *OK* to accept the table.

Table 5-3. Post-impact rolling resistances for the Nissan Sentra.

Time (sec)	R/F	L/F	R/R	L/R
2.70	0.00	0.00	0.00	0.00
2.80	0.20	0.20	0.01	0.01

(Percent Available Friction, %/100)

This event lasts more than 5 seconds. To prevent premature termination, let's increase the default maximum simulation time.

1. Click on the Options menu and choose *Simulation Controls*. The Simulation Controls dialog is displayed.

2. Edit the *Maximum Time*, changing it from `5` to `10` seconds.
3. Press *OK* to update the simulation controls.

Now, we're ready to position the camera to view the event.

- Use the viewer controls (thumb wheels, zoom slider and direct *hand-in-viewer* manipulator) to set the view similar to that shown in Figure 5-8.

Next, let's set up the Key Results windows:

- If Key Results windows are not displayed, choose *Show Key Results* from the Options menu.
- Drag the Key Results windows to a convenient location, where they do not block the view but still allow us access to the viewer thumb wheel controls (in case we want to change the view).

Now, we're ready to execute the event.

- Using the Event Controller, press *Play* to execute the event.

Watch as the vehicles approach each other, collide, and roll to their rest positions.

> NOTE: You can adjust the view while the event is executing, or you can press Pause/Stop to temporarily stop the event while setting the view, then press Play to continue it.
>
> NOTE: Remember to pay attention to the Key Results windows; in this case, you might be interested in the position and velocity of each vehicle at initial visibility.

We have now completed the event.

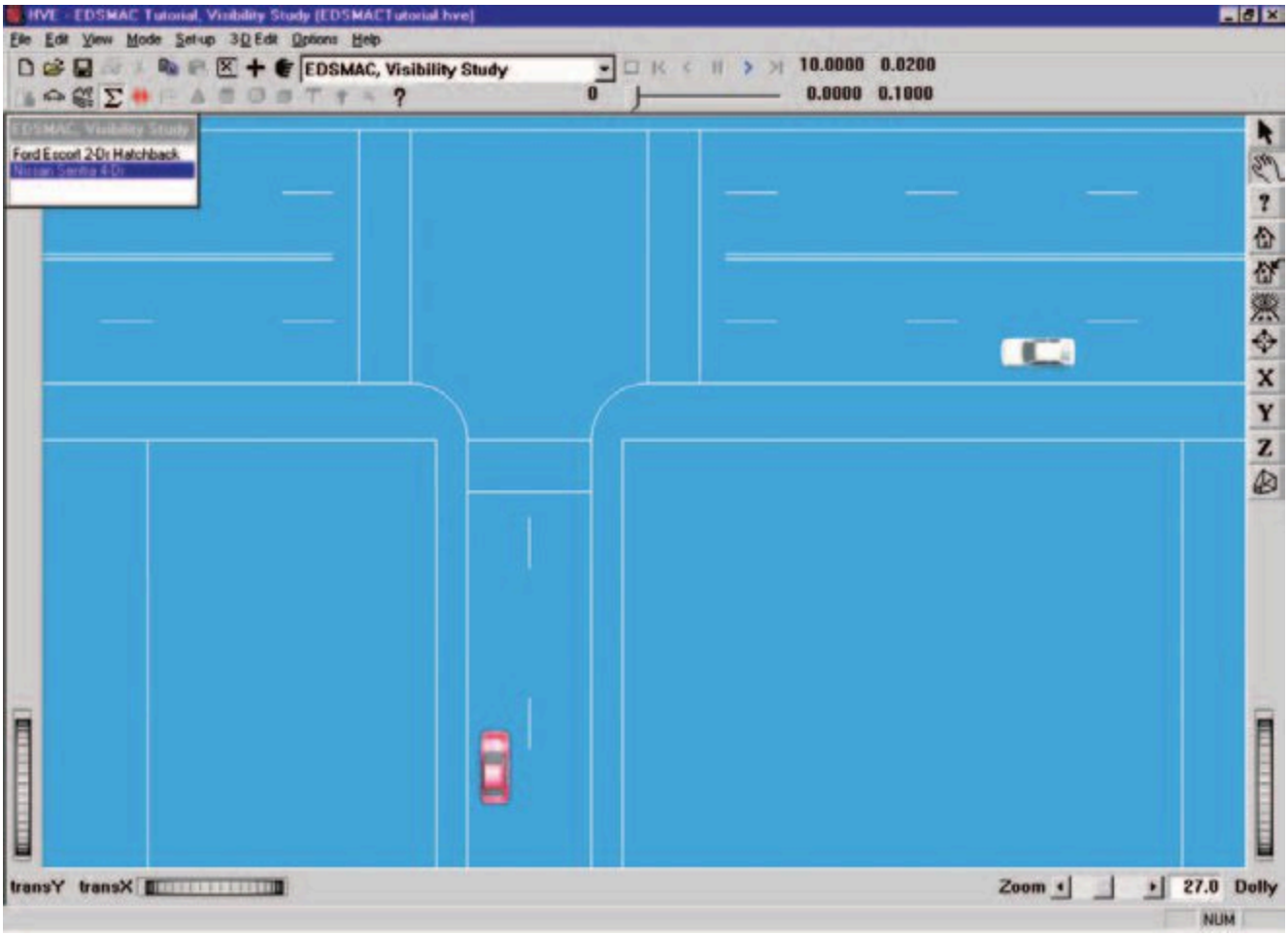


Figure 5-8: Overall view of the scene after event set-up is complete.

Viewing Results

Now that we have produced our EDSMAC simulations, let's take a detailed look at the results. The Playback Editor is used for reviewing and printing reports for each event in the current case, as well as for producing video output.

EDSMAC produces the following reports:

- **Accident History** — A table of initial, impact, separation and final positions and velocities for each vehicle
- **Damage Data** — A table of damage profile coordinates, CDC, PDOF, Delta-V and Peak Acceleration for each vehicle
- **Damage Profiles** — A 3-D visualization of the damage to each vehicle, linked to the Playback Controller
- **Messages** — A list of messages produced by the current run
- **Program Data** — A table containing program control information
- **Trajectory Simulation** — A 3-D visualization of the event, displayed at a user-selectable time interval
- **Variable Output** — A table containing user-selectable, time-dependent simulation results for each vehicle
- **Vehicle Data** — Tables containing all of the vehicle data and driver control data used by the simulation

To view the output reports, we need to be in Playback mode:

- Choose *Playback Mode*. The Playback Editor is displayed.

Report Windows

The reports listed above are displayed by selecting Report Windows. Each Report Window contains an individual report.

To view the reports produced by the

EDSMAC, Visibility Study

event, perform the following steps:

1. Choose Playback Mode. The Playback Editor is displayed.
2. Click *Add New Object*. The Report Window Information dialog is displayed, as shown in Figure 5-9, and includes a list of the active events (*EDSMAC, Visibility Study* is the only event in this tutorial). The Report Window Information dialog also includes the user-editable *Report Window Name* text field and the *Report Type* list.
3. Select *EDSMAC, Visibility Study* from the Active Events list.
4. In the *Report Type* list, select one or more of the available reports. *Select All* selects every report; each selected report opens in its own Report Window.
5. Press *OK* to display the report.

The selected report will be displayed in a resizable window. The following pages illustrate the reports produced for the

EDSMAC, Visibility Study

event.

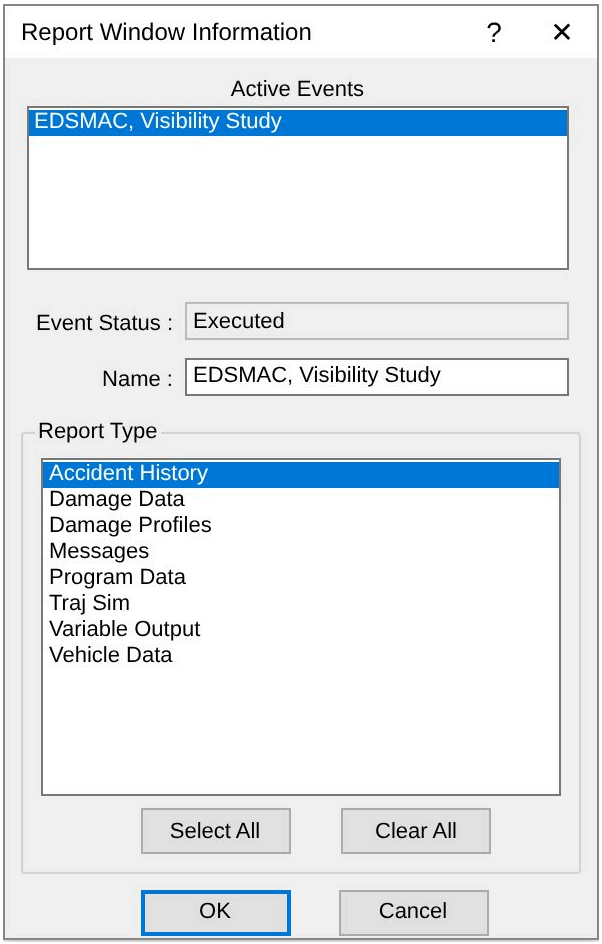


Figure 5-9: Report Window Information dialog, showing the name of the event(s) in the current case.

Accident History

The Accident History report displays the positions and velocities for each vehicle at key times (Start of Run, Impact, Separation and Final/Rest) during the run.

To view the Accident History report for the

EDSMAC Visibility Study

event, perform the following steps:

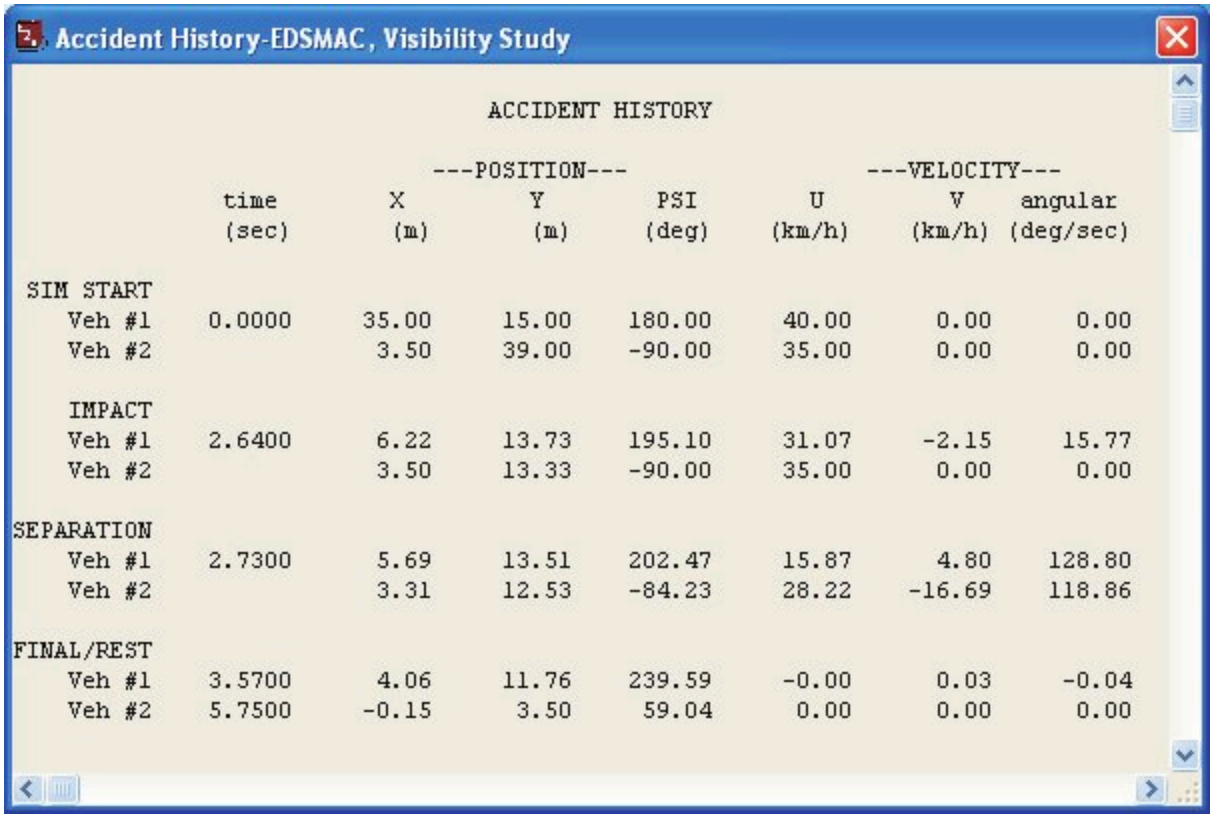
1. Click *Add New Object*. The Report Window Information dialog is displayed.
2. Select *EDSMAC, Visibility Study* from the Active Events list.
3. In the *Report Type* list, select *Accident History*.
4. Press *OK*.

The Accident History report is displayed for the

EDSMAC, Visibility Study

event, as shown in Figure 5-10.

> NOTE: The vehicles are listed in the order in which they were selected when creating the event. This is the same order in which they appear in the active objects list in the Event Editor.



	time (sec)	---POSITION--- X (m)	Y (m)	PSI (deg)	---VELOCITY--- U (km/h)	V (km/h)	angular (deg/sec)
SIM START							
Veh #1	0.0000	35.00	15.00	180.00	40.00	0.00	0.00
Veh #2		3.50	39.00	-90.00	35.00	0.00	0.00
IMPACT							
Veh #1	2.6400	6.22	13.73	195.10	31.07	-2.15	15.77
Veh #2		3.50	13.33	-90.00	35.00	0.00	0.00
SEPARATION							
Veh #1	2.7300	5.69	13.51	202.47	15.87	4.80	128.80
Veh #2		3.31	12.53	-84.23	28.22	-16.69	118.86
FINAL/REST							
Veh #1	3.5700	4.06	11.76	239.59	-0.00	0.03	-0.04
Veh #2	5.7500	-0.15	3.50	59.04	0.00	0.00	0.00

Figure 5-10: Accident History Report for EDSMAC, Visibility Study.

Damage Data

The Damage Data report displays a table of collision vector results for each vehicle. The collision vectors determine the total force on each vehicle. In addition, the endpoints of the collision vectors define the damage profile.

The collision vectors are displayed both in cylindrical coordinates (RHO, PSI) and Cartesian coordinates (x,y).

Following the table of collision vectors, the Damage Ranges are displayed. The Damage Ranges report includes the beginning and ending point for each damaged region on the exterior (up to 10 regions may be displayed for each vehicle), followed by the CDC, PDOF, Delta-V and Peak Acceleration for each damage region.

To view the Damage Data report for the

EDSMAC Visibility Study

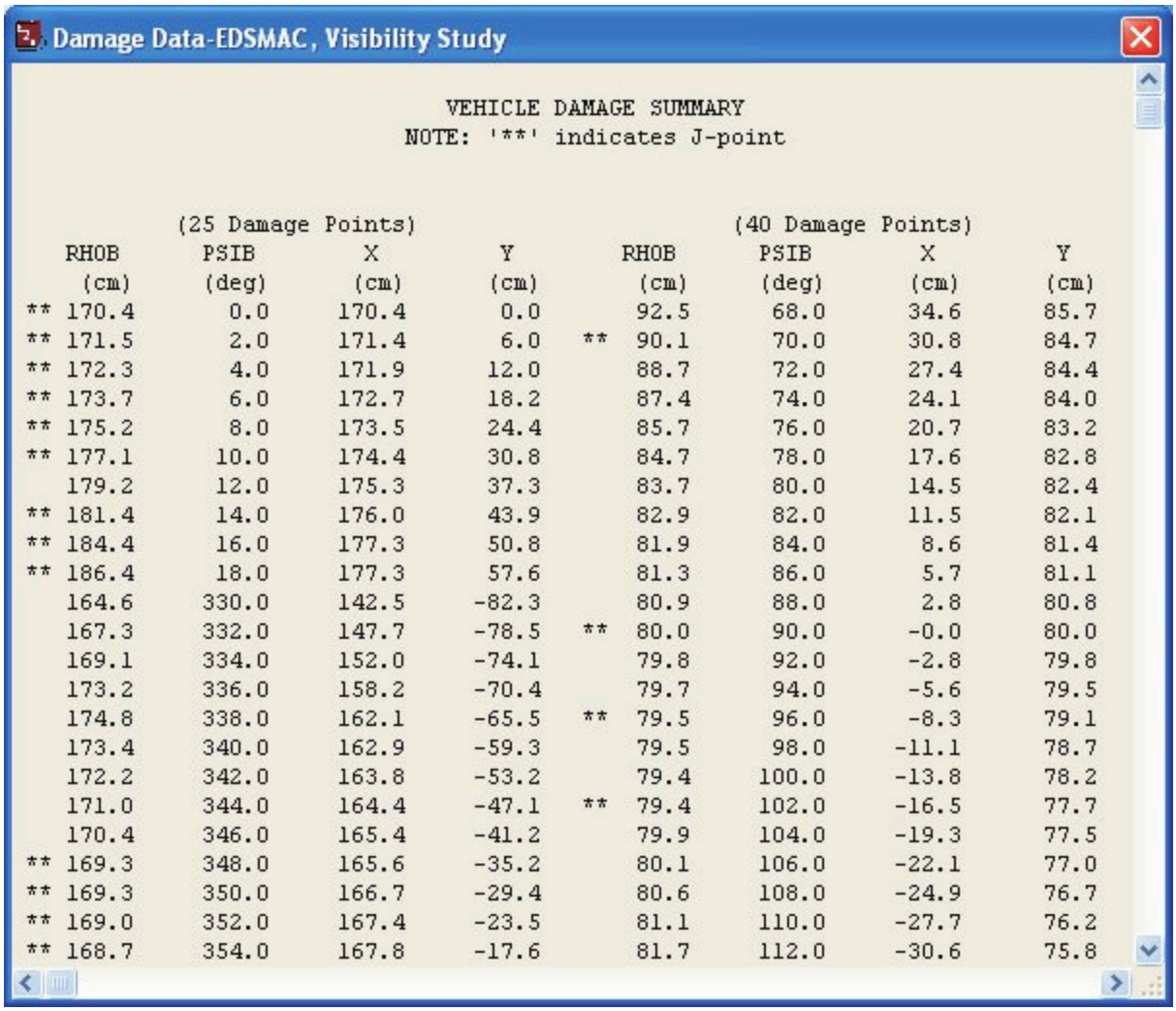
event, perform the following steps:

1. Click *Add New Object*. The Report Window Information dialog is displayed.
2. Select *EDSMAC, Visibility Study* from the Active Events list.
3. In the *Report Type* list, select *Damage Data*.
4. Press *OK*.

The Damage Data report is displayed for the

EDSMAC, Visibility Study

event, as shown in Figure 5-11.



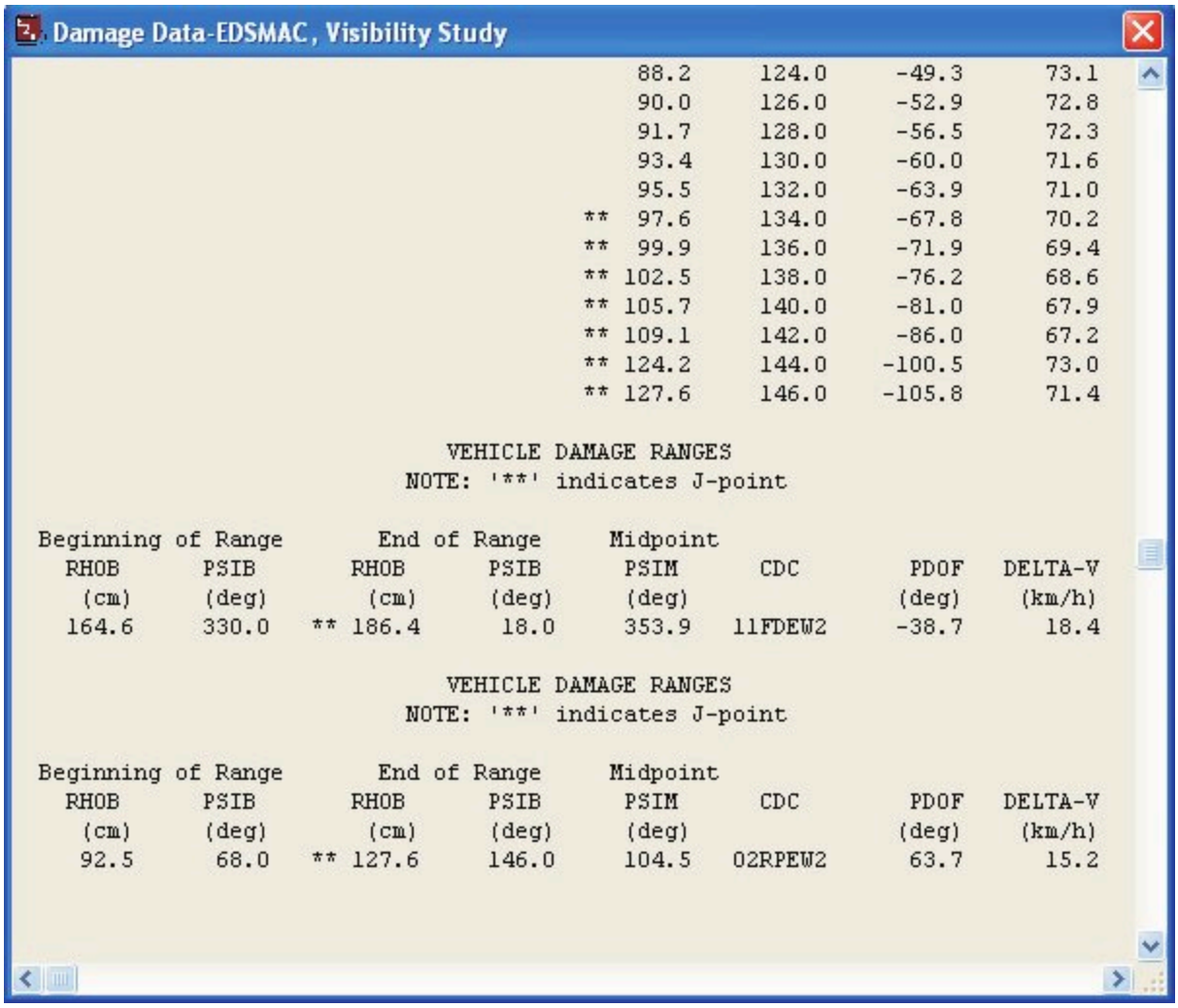


Figure 5-11: Damage Data Report for EDSMAC, Visibility Study. The two images show the top and bottom portions of the report which contain important information about the event.

Damage Profiles

The Damage Profiles report provides a visual representation of the damage to each vehicle. This report is linked to the Playback Controller through the Trajectory Simulation. Therefore, in order to see any damage in the Damage Profiles report window, you must first open a Trajectory Simulation for the event.

To view the Damage Profiles report produced by the

EDSMAC, Visibility Study

event, perform the following steps:

1. Click *Add New Object*. The Report Window Information dialog is displayed.
2. Select *EDSMAC, Visibility Study* from the Active Events list.
3. In the *Report Type* list, select *Damage Profiles*.
4. Press *OK*.

With a Trajectory Simulation also open, use the Playback Controller to view the damage to each vehicle dynamically.

The Damage Profiles simulation for the Nissan Sentra in

EDSMAC, Visibility Study

is shown in Figure 5-12.



Figure 5-12: Damage Profile Report for Nissan Sentra in EDSMAC, Visibility Study.

Messages

EDSMAC produces several messages, depending on the outcome of the run. For a complete list and explanation of these messages, refer to Chapter 6.

To view the Messages report produced by the

EDSMAC, Visibility Study

event, perform the following steps:

1. Click *Add New Object*. The Report Window Information dialog is displayed.
2. Select *EDSMAC, Visibility Study* from the Active Events list.
3. In the *Report Type* list, select *Messages*.
4. Press *OK*.

The Messages report for the

EDSMAC, Visibility Study

event is shown in Figure 5-13.

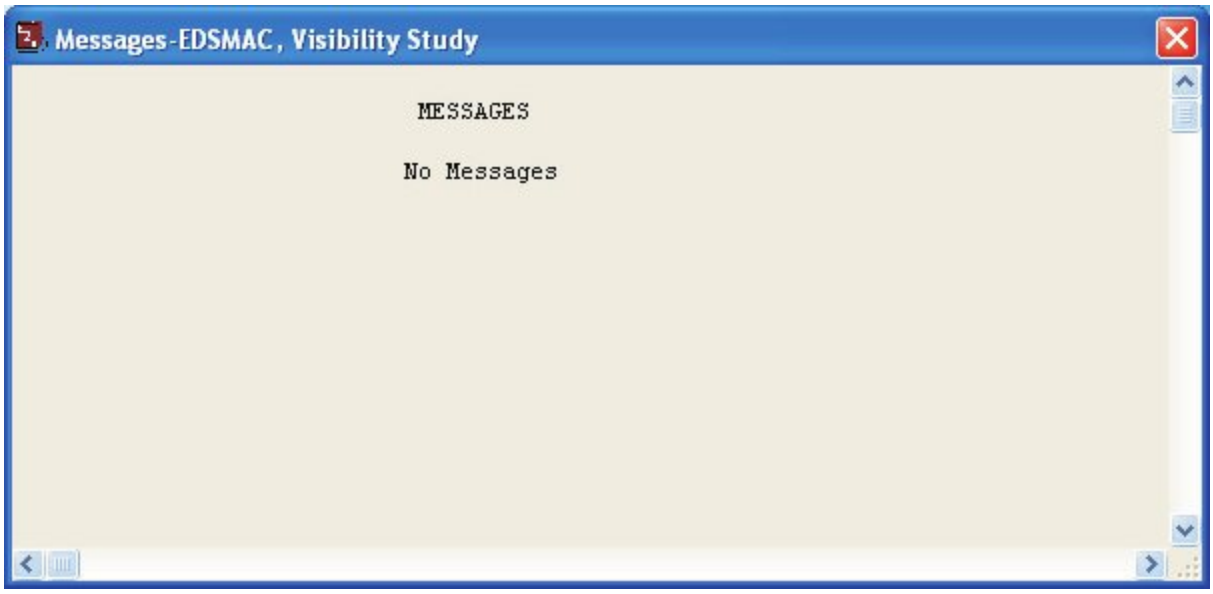


Figure 5-13: Messages Report for EDSMAC, Visibility Study.

Program Data

The Program Data report displays the simulation controls (integration time steps and termination conditions), collision parameters used by the EDSMAC collision algorithm and the fixed values (RHOB Tests), which cannot be changed by the user, that determine whether a vector passes through the end (front or back) or side (left or right).

To view the Program Data report for the

EDSMAC, Visibility Study

event, perform the following steps:

1. Click *Add New Object*. The Report Window Information dialog is displayed.
2. Select *EDSMAC, Visibility Study* from the Active Events list.
3. In the *Report Type* list, select *Program Data*.
4. Press *OK*.

The Program Data report is displayed for the

EDSMAC, Visibility Study

event, as shown in Figure 5-14.

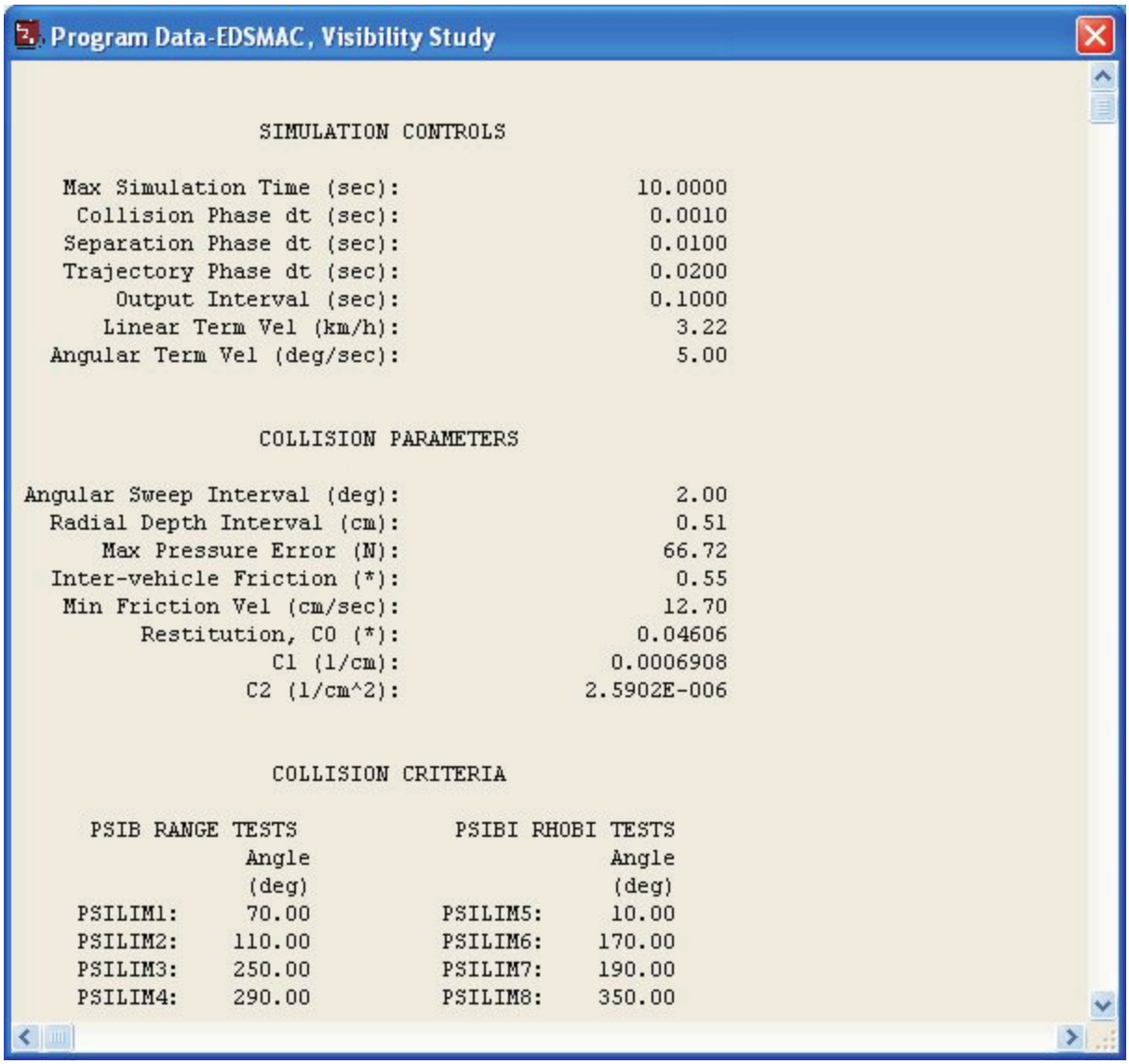


Figure 5-14: Program Data Report for EDSMAC, Visibility Study.

Trajectory Simulation

The Trajectory Simulation report is a dynamic visualization, much like the Event mode viewer, controlled by the Event Controller.

> NOTE: A significant difference between the simulation in the Event Editor and the Playback Editor is that no calculations take place in Playback mode.

To view the Trajectory Simulation for the

EDSMAC, Visibility Study

event, perform the following steps:

1. Click *Add New Object*. The Report Window Information dialog is displayed.
2. Select *EDSMAC, Visibility Study* from the Active Events list.
3. In the *Report Type* list, select *Trajectory Simulation*.

4. Press *OK*.

The Trajectory Simulation viewer is displayed for the

EDSMAC, Visibility Study

event. The vehicles are shown at their initial positions.

To visualize the motion, perform the following steps:

1. Click *Play* (single right-arrow). The simulation begins and is displayed at the current Playback output interval.
2. Click *Pause*. The simulation stops.
3. Click *Reverse* (single left-arrow). The simulation plays in reverse.
4. Click *Pause*. The simulation stops.
5. Click *Rewind* (left arrow with bar). The simulation returns to the start.

Click

Advance to End

(right arrow with bar) — the simulation advances to the end of the run.

The Trajectory Simulation for

EDSMAC, Visibility Study

is shown in Figure 5-15.

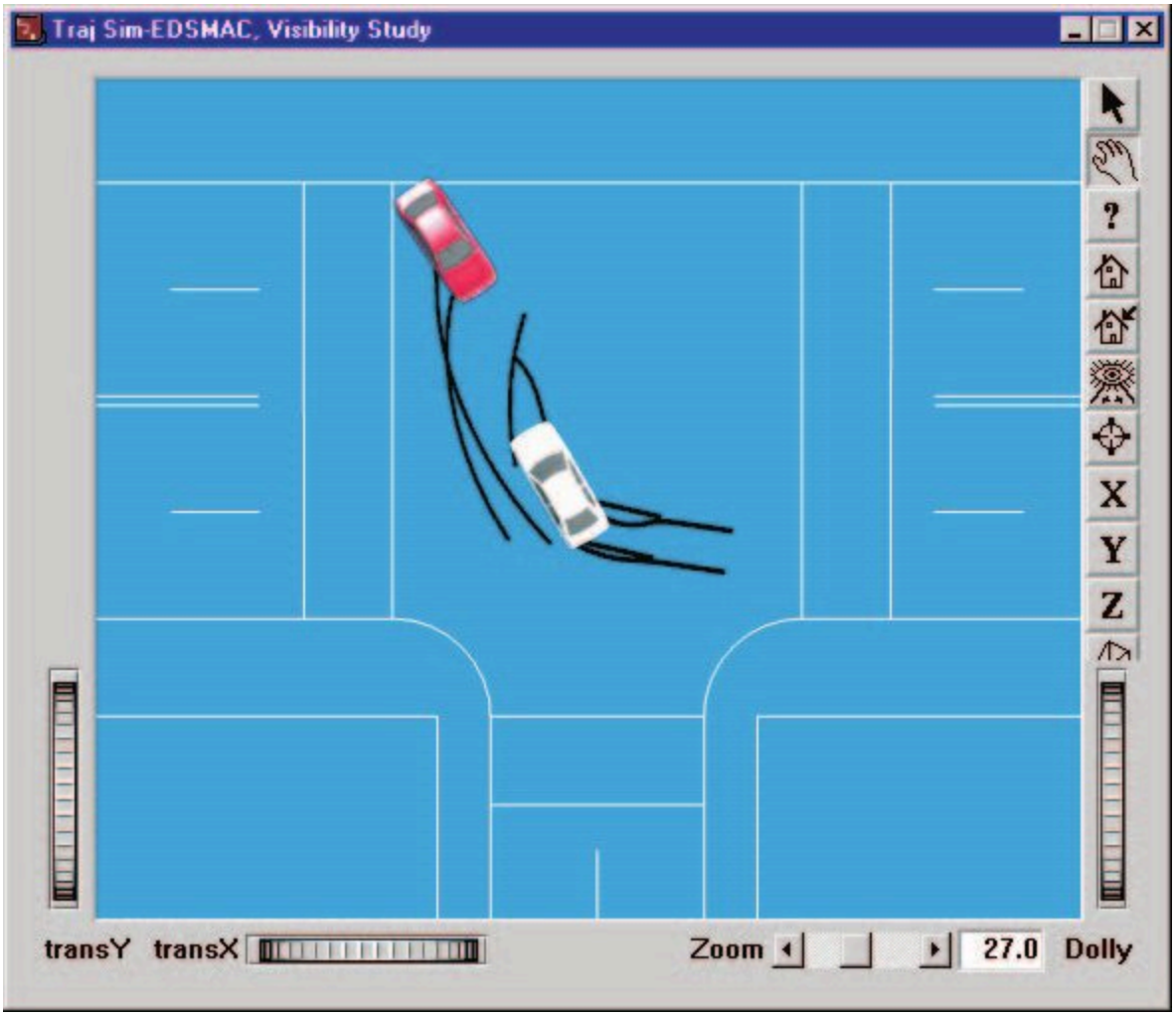


Figure 5-15: Trajectory Simulation for EDSMAC, Visibility Study, displaying the crash sequence at the end of the event.

Variable Output

The Variable Output table displays all the time-dependent results computed by EDSMAC. To view the Variable Output report for the

EDSMAC, Visibility Study

event, perform the following steps:

1. Click *Add New Object*. The Report Window Information dialog is displayed.
2. Select *EDSMAC, Visibility Study* from the Active Events list.
3. In the *Report Type* list, select *Variable Output*.
4. Press *OK*.

The Variable Output report is displayed for the

EDSMAC, Visibility Study

event. The next step is to select the time-dependent results we wish to display in the table.

Variable Selection

The purpose of our EDSMAC study is to evaluate the avoidability of the accident based on speeds and visibility. To document the path positions as a function of time, let's select the position, velocity and acceleration from the Variable Selection dialog.

1. Click on *Select Variables* in the Variable Output window. The Variable Selection dialog is displayed, as shown in Figure 5-16.

The Object Name option list displays the first vehicle, *Ford Escort 2-Dr Hatchback*. The *Kinematics* output group is the default selection and the Kinematics Variables list is displayed. Let's add X, Y, Yaw, V_{total} and Accel total to the Key Results window:

1. Select *X, Y, Yaw, V-tot* and *Acc-tot* from the list.

Next, let's add the same parameters for the Nissan Sentra:

1. Click on the *Object Name* option list and choose *Nissan Sentra 4-Dr*. The Kinematics variable list is displayed.
2. Select *X, Y, Yaw, V-tot* and *Acc-tot* from the list.

> NOTE: Feel free to add additional variables to the Variable Output window.

1. Press *OK* to add the selected variables to the Variable Output window.

The Variable Output report for the

EDSMAC, Visibility Study

event now includes position, velocity and acceleration for both vehicles, plus any other variables you may have added (see Figure 5-17).

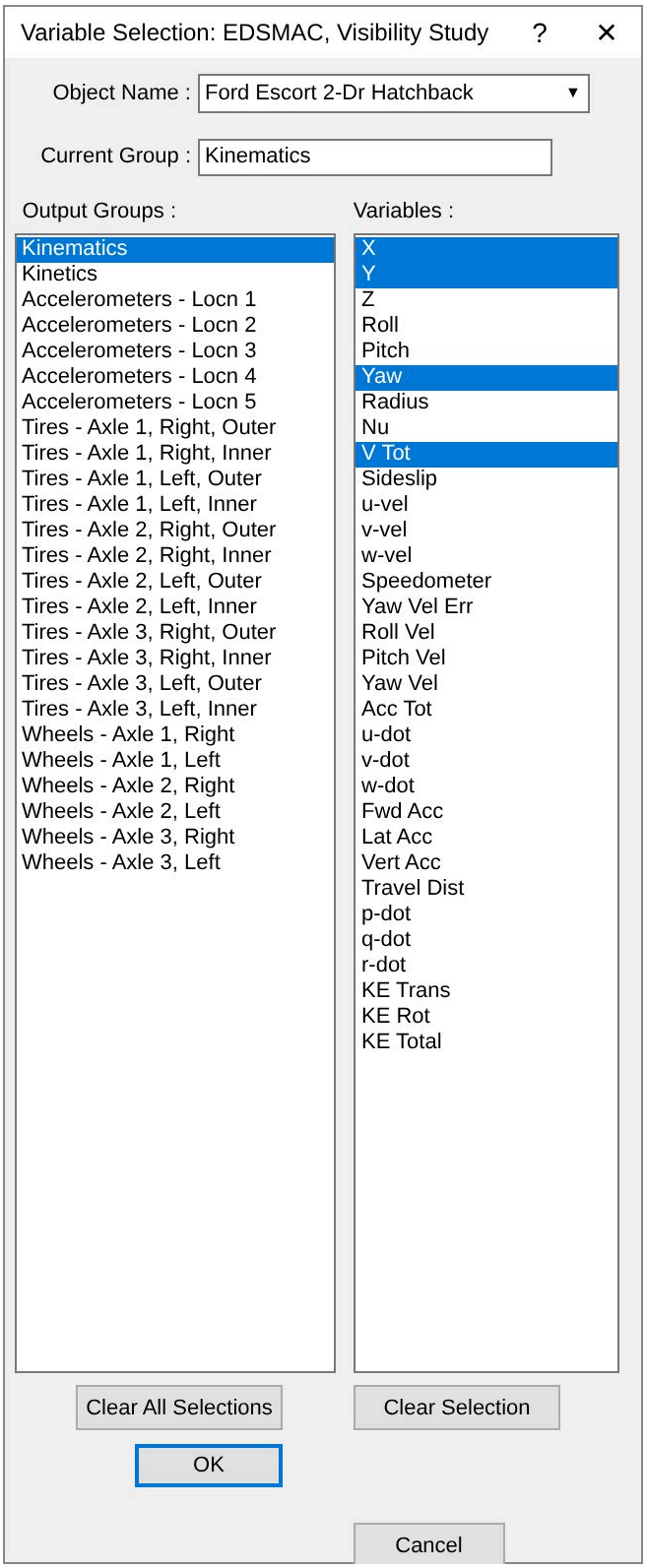
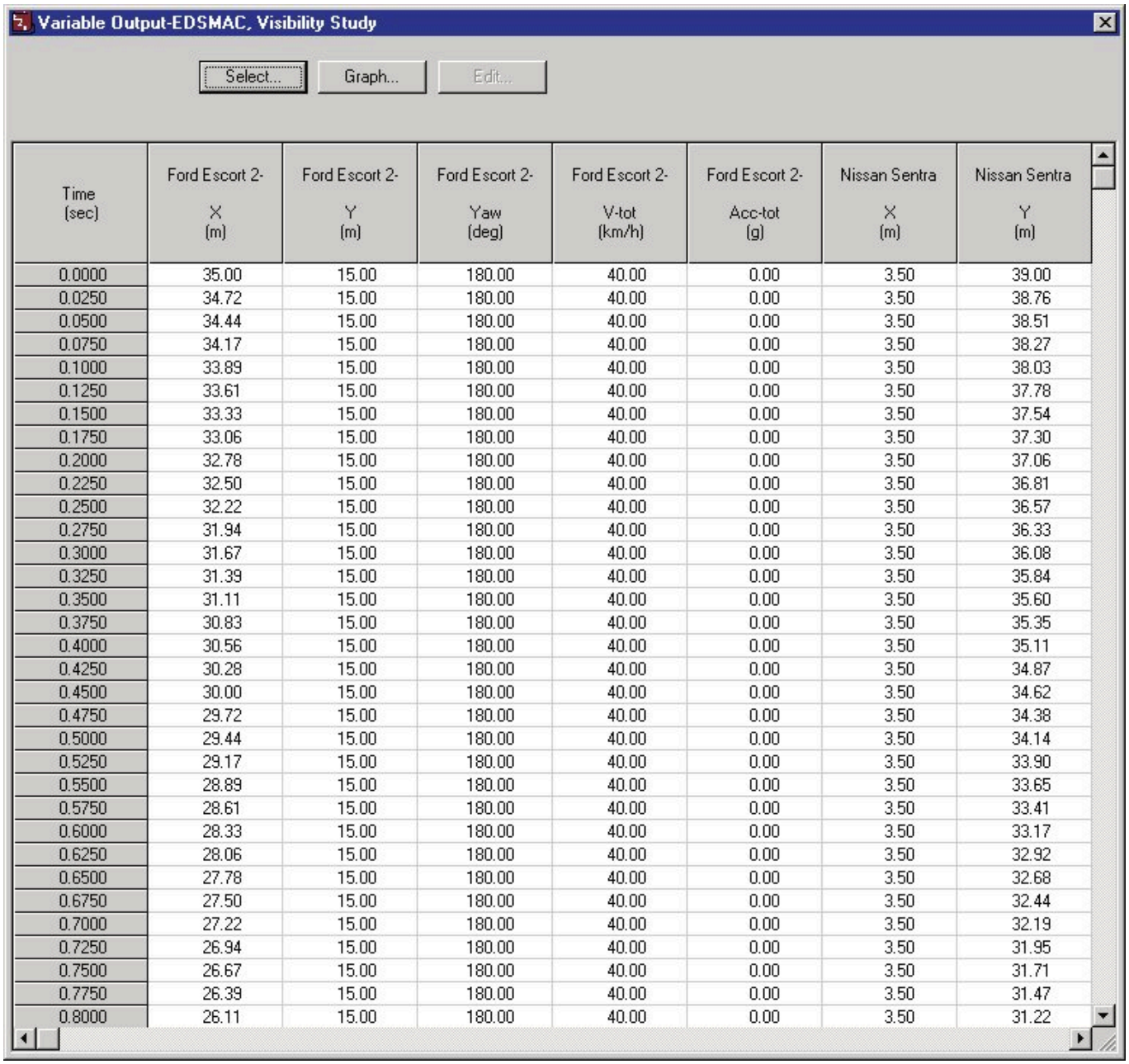


Figure 5-16: Variable Selection dialog, used for selecting the results displayed in the Output Report.



Time (sec)	Ford Escort 2- X (m)	Ford Escort 2- Y (m)	Ford Escort 2- Yaw (deg)	Ford Escort 2- V-tot (km/h)	Ford Escort 2- Acc-tot (g)	Nissan Sentra X (m)	Nissan Sentra Y (m)
0.0000	35.00	15.00	180.00	40.00	0.00	3.50	39.00
0.0250	34.72	15.00	180.00	40.00	0.00	3.50	38.76
0.0500	34.44	15.00	180.00	40.00	0.00	3.50	38.51
0.0750	34.17	15.00	180.00	40.00	0.00	3.50	38.27
0.1000	33.89	15.00	180.00	40.00	0.00	3.50	38.03
0.1250	33.61	15.00	180.00	40.00	0.00	3.50	37.78
0.1500	33.33	15.00	180.00	40.00	0.00	3.50	37.54
0.1750	33.06	15.00	180.00	40.00	0.00	3.50	37.30
0.2000	32.78	15.00	180.00	40.00	0.00	3.50	37.06
0.2250	32.50	15.00	180.00	40.00	0.00	3.50	36.81
0.2500	32.22	15.00	180.00	40.00	0.00	3.50	36.57
0.2750	31.94	15.00	180.00	40.00	0.00	3.50	36.33
0.3000	31.67	15.00	180.00	40.00	0.00	3.50	36.08
0.3250	31.39	15.00	180.00	40.00	0.00	3.50	35.84
0.3500	31.11	15.00	180.00	40.00	0.00	3.50	35.60
0.3750	30.83	15.00	180.00	40.00	0.00	3.50	35.35
0.4000	30.56	15.00	180.00	40.00	0.00	3.50	35.11
0.4250	30.28	15.00	180.00	40.00	0.00	3.50	34.87
0.4500	30.00	15.00	180.00	40.00	0.00	3.50	34.62
0.4750	29.72	15.00	180.00	40.00	0.00	3.50	34.38
0.5000	29.44	15.00	180.00	40.00	0.00	3.50	34.14
0.5250	29.17	15.00	180.00	40.00	0.00	3.50	33.90
0.5500	28.89	15.00	180.00	40.00	0.00	3.50	33.65
0.5750	28.61	15.00	180.00	40.00	0.00	3.50	33.41
0.6000	28.33	15.00	180.00	40.00	0.00	3.50	33.17
0.6250	28.06	15.00	180.00	40.00	0.00	3.50	32.92
0.6500	27.78	15.00	180.00	40.00	0.00	3.50	32.68
0.6750	27.50	15.00	180.00	40.00	0.00	3.50	32.44
0.7000	27.22	15.00	180.00	40.00	0.00	3.50	32.19
0.7250	26.94	15.00	180.00	40.00	0.00	3.50	31.95
0.7500	26.67	15.00	180.00	40.00	0.00	3.50	31.71
0.7750	26.39	15.00	180.00	40.00	0.00	3.50	31.47
0.8000	26.11	15.00	180.00	40.00	0.00	3.50	31.22

Figure 5-17: Variable Output report for EDSMAC, Visibility Study, displaying the selected results.

Vehicle Data

The Vehicle Data report displays the vehicle data, tire data and driver tables for each vehicle in the event.

To view the Vehicle Data report for the

EDSMAC, Visibility Study

event, perform the following steps:

1. Click *Add New Object*. The Report Window Information dialog is displayed.
2. Select *EDSMAC, Visibility Study* from the Active Events list.
3. In the *Report Type* list, select *Vehicle Data*.
4. Press *OK*.

A portion of the Vehicle Data report is displayed for

EDSMAC, Visibility Study

in Figure 5-18.

> NOTE: The Vehicle Data, Damage Data (previous pages) and several other reports contain more information than fits into the default window size. Use the scroll bars, resize the dialog, or adjust the font size to view the entire report.

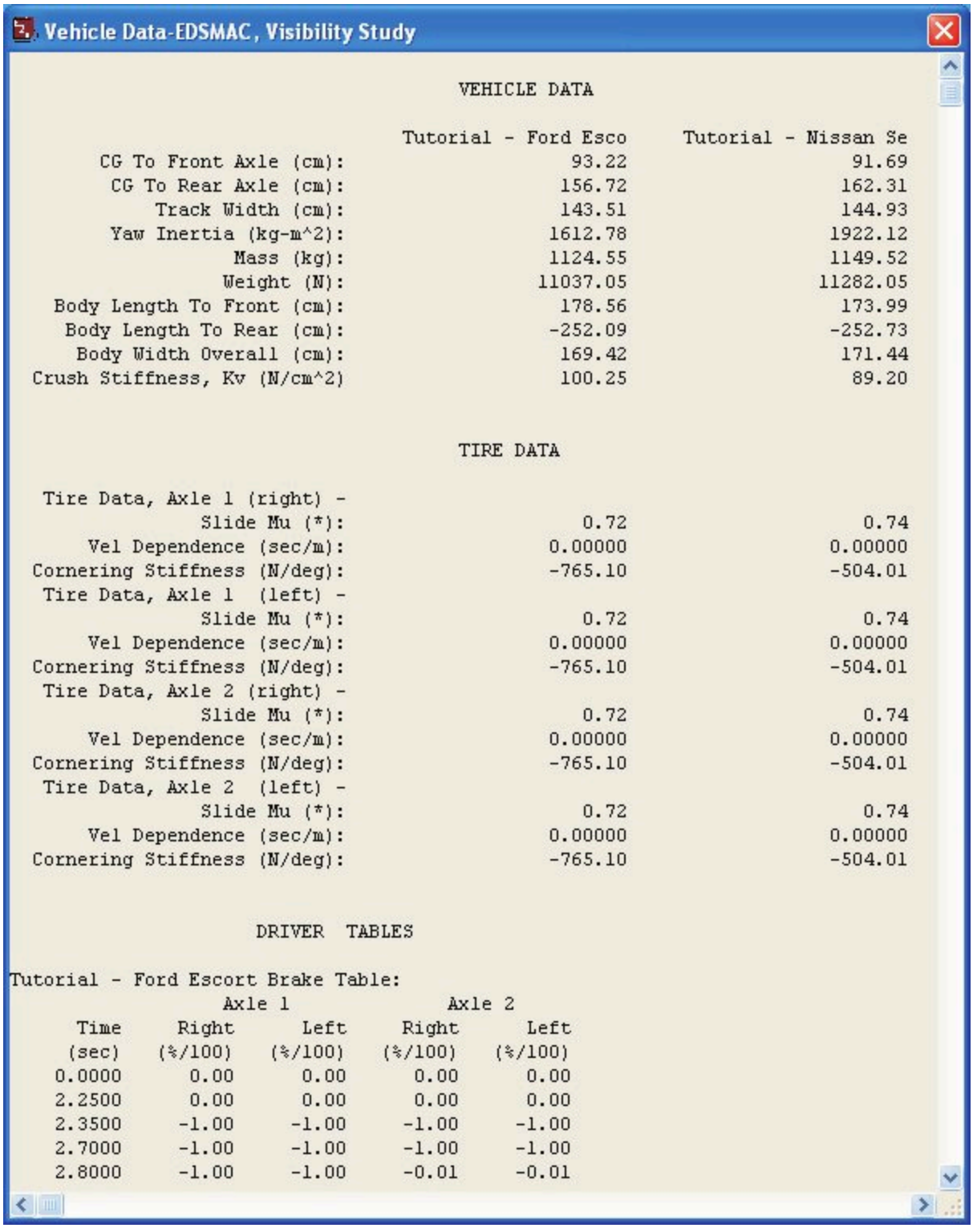


Figure 5-18: Vehicle Data Report for EDSMAC, Visibility Study. Only a portion of the report is displayed; use the scroll bars to review the remaining report.

Printing

The final step is to print the above reports. Printing reports is simple. All you do is choose a report and print it. For example:

1. Click on the *Variable Output - EDSMAC, Visibility Study* report window. The window is highlighted and pops to the top of the display (if it isn't there already), indicating it is the current window.
2. Click on the *File* menu and choose *Print*. The Print dialog is displayed, allowing the user to select from several available print options.

> NOTE: Alternatively, you can click on the print icon in the main menu bar.

1. Press *OK*. The Variable Output report is printed on the system printer.

That's all there is to it! You can print any other report using the same three steps described above.

> NOTE: The Print dialog provides several options. Refer to your Windows or printer manual for more information.
>
> NOTE: For several reports it may be best to print in landscape rather than portrait mode.
>
> NOTE: The font size of both the printed reports and screen display may be edited by clicking on the Options menu and choosing Preferences. Use the Font Size option list to change the size.

Previous: Chapter 4 — Calculation Method | Next: Chapter 6 — Messages

Chapter 6 — Messages

Messages can be issued by either the operating system, HVE-2D or by EDSMAC. Some of the more common operating system messages are described in the Appendix. A more thorough discussion of operating system messages may be found in the operating system manual.

Messages produced by HVE-2D are described in the User's Manual, Appendix II.

Errors issued by EDSMAC appear in the EDSMAC output and may be one of three types:

- **Fatal Messages (Level 1)** — These messages halt execution and are caused by the program's inability to continue the calculation procedure based on intermediate results that are inconsistent or incompatible with basic program assumptions.
- **Diagnostic Messages (Level 2)** — These messages do not halt execution, but are the result of the internal consistency checks performed by the program and suggest inconsistencies in the results of which the user should be aware. These inconsistencies may be the result of bad or suspicious data.
- **Informative Messages (Level 3)** — These messages do not halt execution, but provide information about execution, not affecting accuracy, but suggestive of something the user may want to review to ensure data were as intended.

All messages issued by EDSMAC are listed below. Each message includes a description or nature of the cause, the level of the message (Informative, Diagnostic or Fatal), and the recommended action to eliminate the problem. If you receive an error message not listed below, first check to see if it is an HVE-2D or operating system message by referring to the User's Manual Appendix or your computer's operating system manual. If the message is not listed in either place, please contact EDC immediately with the offending error.

> *NOTE: A CDC and clock direction were not computed for vehicle 1.*
>
> *NOTE: A CDC and clock direction were not computed for vehicle 2.*

(Level 3 — Informative)

If execution is halted by the user prior to the end of calculations, the damage tables may not be complete. The last damage calculation to be performed is the CDC (Collision Deformation Classification). If all the information necessary to produce the CDC is not available, this message is produced.

No response by the user is necessary.

> *ERROR: An error occurred during the collision phase because RHOBIC became negative after restitution calculations.*

(Level 1 — Fatal)

During the collision phase, crush occurs along the vector, RHO, from the vehicle exterior towards the CG (refer to Chapter 4, Calculation Method). The quantity named in the message is the adjusted length of the current RHO vector, after restitution has been accounted for. This message indicates that, while seeking equilibrium of the RHO vector lengths for both vehicles, one of their lengths became negative. The angle reported with the message is the clock angle of the defective vector.

Since this error occurs during the iterative adjustment phase, reducing the Vector Adjustment Increment (the quantity the message text calls DELRHO; see Calculation Options) may eliminate the problem. If you continue to experience the problem, send the offending input file to EDC for evaluation.

> *ERROR: An error occurred during the collision phase because RHOBIT became negative.*

(Level 1 — Fatal)

During the collision phase, crush occurs along the vector, RHO, from the vehicle exterior towards the CG (refer to Chapter 4, Calculation Method). The quantity named in the message is the initial length of a RHO vector, computed from the vehicle's exterior dimensions before the restitution adjustment begins. This message indicates that the initial length of one of these vectors was zero or negative, which points to inconsistent or invalid vehicle exterior dimensions rather than a failure during the iterative adjustment phase.

Unlike the preceding message (which is issued when a vector length becomes negative

during

the restitution calculations), this error occurs at the outset of the collision phase. Check the vehicle exterior geometry for the reported vehicle. If the dimensions appear correct, send the offending input file to EDC for evaluation.

> *ERROR: An error occurred during the collision phase because the damage range spanned more than half the vehicle. If the damage spanned more than half the vehicle's exterior, the collision is beyond the scope of EDSMAC.*

(Level 1 — Fatal)

The damage range computed by EDSMAC spanned more than 180 degrees of vehicle *'s outer surface. This error usually occurs in a very severe collision when the inter-vehicle forces go beyond the CG of one of the vehicles.

If the suspected damage did go beyond half of the vehicle's exterior, there is no correction for this error. The condition exceeds the capabilities of EDSMAC. However, if the results are questionable, increasing the stiffness coefficient for the vehicle may improve the results. (See Calculation Options.)

> *ERROR: An error occurred during the collision phase because the longitudinal and lateral components of damage were both equal to zero.*

(Level 1 — Fatal)

Execution was halted due to an internal error associated with the angle of the damage vector used during the collision phase.

This is a mathematical error which should be prevented by the editing done by EDSMAC during the input session. Thus, if this error occurs, it is a symptom of another problem. Send the offending input file to EDC for evaluation.

> *ERROR: An error occurred during the collision phase because the damage increment was too coarse.*

(Level 1 — Fatal)

Execution was halted due to an excessive increment of damage. This error is sometimes caused by the proximity of the vehicles at impact, particularly if they are overlapping. In this case, the integration subroutine has failed to stabilize during the simulation.

Check to ensure the vehicles are not overlapping at impact; if necessary, separate the vehicles at their initial positions.

This condition may also occur for some impact configurations when the angle between the RHO vectors for vehicle 1 and vehicle 2 approach 90 degrees. A slight adjustment of impact positions may help to solve the problem.

> *ERROR: An error occurred during the collision phase because the damage region required more than 100 collision vectors to span its width. To correct the error, try doubling the value of DELPSI (EDSMAC Program Options).*

(Level 1 — Fatal)

EDSMAC divides the damage region into a number of small, discrete angular intervals. Up to 100 discrete intervals are allowed for each damage region. The width of each interval is the user-entered Vector Spacing (the quantity the message text calls DELPSI; see Calculation Method). If the Vector Spacing is too small, the number of intervals required to span the entire damage width will exceed 100 and the above error message is issued.

Increase the Vector Spacing (see Calculation Options).

> *ERROR: An error occurred during the collision phase because the difference in inter-vehicle contact pressure was greater than the user-entered maximum value of ALAMB after 200 bisections. To correct the error, try halving the value of DELRHO or doubling the value of ALAMB (EDSMAC Program Options).*

(Level 1 — Fatal)

During the collision phase, force equilibrium is sought between each of the vehicle crush vectors using an iterative adjustment of the vector lengths, RHO. Up to 200 adjustments are allowed. If, after 200 adjustments, the force equilibrium is not reached (i.e., the difference in the inter-vehicle contact force is greater than the user-entered acceptable limit, the Max Pressure Error, which the message text calls ALAMB), the above error is issued.

Increase the Max Pressure Error or decrease the Vector Adjustment Increment (see Calculation Options).

> *At the time processing was interrupted, the vehicle(s) were still moving (see Accident History).*

(Level 3 — Informative)

If either vehicle is still moving at the end of the simulation, whether halted as a result of an interruption by the user, or as a result of reaching the maximum simulation time, this message is issued to indicate that both vehicles have not reached their rest positions.

No response by the user is necessary.

> *Processing was interrupted by the user.*

(Level 3 — Informative)

If the user terminates execution during processing, calculations will stop prior to reaching the termination velocities or maximum simulation time.

No response by the user is necessary.

> *NOTE: The collision resulted in more than 10 individual ranges. Only the first 10 ranges are stored. Additional peaks are ignored. The simulation results in Variable Output are not affected by this condition.*
>
> *NOTE: An error occurred while saving the acceleration or damage array maxima. Only the first 10 acceleration peaks are stored. Additional peaks are ignored. The simulation results in Variable Output are not affected by this condition.*

(Level 3 — Informative)

Rapid rotation during the collision may result in subsequent inter-vehicle contact. EDSMAC allows up to ten individual ranges of impact damage. If more than ten individual damage regions are detected, only the first ten are stored and the additional acceleration peaks are ignored; the above message is issued. Execution continues, and the simulation results in Variable Output are unaffected.

> *NOTE: The damage midpoint (PSIM) does not match the PDOF specified by the clock direction. This condition is fairly common for sideswipes and collisions involving secondary impact.*

(Level 3 — Informative)

During the collision phase, a clock direction of the PDOF is computed for each vehicle damage range. The angle at the midpoint of each damage range is also computed (see PSIM, Summary of Damage Ranges output report). If the angle of the PDOF is more than 60 degrees different from the associated damage midpoint, the above message is issued. This message reflects a failure in an EDSMAC post-processing routine; the simulation results are still valid.

> *NOTE: An error occurred while calculating column 3 or 4 of the CDC.*

(Level 2 — Diagnostic)

EDSMAC divides the vehicle exterior into specific damage regions. Each region is associated with a location of damage defined by the Collision Deformation Classification (CDC; see SAE J224 [8]). This message indicates a logical error occurred while assigning the 3rd or 4th character of the CDC. Please send the HVE case file to EDC for evaluation.

This message reflects a failure in an EDSMAC post-processing routine; the simulation results are still valid.

> *NOTE: A general error occurred while calculating the CDC. Please send the offending event to EDC for evaluation.*

(Level 2 — Diagnostic)

EDSMAC divides the vehicle exterior into specific damage regions. Each region is associated with a location of damage defined by the Collision Deformation Classification (CDC; see SAE J224 [8]). This message indicates a logical error occurred while assigning one or more characters of the CDC. Please send the HVE case file to EDC for evaluation.

This message reflects a failure in an EDSMAC post-processing routine; the simulation results are still valid.

Previous: Chapter 5 — EDSMAC Tutorial | Next: Chapter 7 — Technical References

Chapter 7 — Technical References

1. McHenry, R.R., and DeLeys, N.J., "Vehicle Dynamics in Single Vehicle Accidents — Validation and Extensions of a Computer Simulation", Calspan Report No. VJ-2251-V-3, NTIS-PB 182 663, 1968.
2. McHenry, R.R., Segal, D.J., Lynch, J.P., Henderson, P.M., "Mathematical Reconstruction of Highway Accidents", NTIS PB-220 150, January, 1973.
3. McHenry, R.R., "Development of a Computer Program to Aid the Investigation of Highway Accidents", Calspan Report No. VJ-2979-V-1, DOT HS 800 821, December, 1971.
4. McHenry, R.R., Jones, I.S., Lynch, J.P., "Mathematical Reconstruction of Highway Accidents — Scene Measurement and Data Processing System," Calspan Report No. ZQ-5341-V-2, DOT HS-801 405, December, 1974.
5. Solomon, P.L., "The Simulation Model of Automobile Collisions (SMAC) Operator's Manual", US DOT, NHTSA, Accident Investigation Division, Washington, D.C., 1974.
6. Day, T., Hargens, R., "An Overview of the Way EDSMAC Computes Delta-V", SAE Paper No. 880069, Society of Automotive Engineers, 1988.
7. EDSMAC Version 2 Source Code Listing, EDC Library Ref. No. 2006, Engineering Dynamics Corp., Lake Oswego, 1989.
8. "Collision Deformation Classification", SAE Technical Report J224 MAR80, Society of Automotive Engineers, March, 1980.
9. *U.S. and Foreign Passenger Car Specifications*, Motor Vehicle Manufacturers Association, Detroit, 1982, EDC Library Ref. No. 1046, Engineering Dynamics Corporation, Lake Oswego.
10. Fiala, E., "Seitenkräfte am Rollenden Luftreifen" (Lateral Forces on Rolling Pneumatic Tires), *Zeitschrift V.D.I.*, 96, No. 29, 1954, EDC Library Ref. No. 1011, Engineering Dynamics Corporation, Lake Oswego.
11. Jones, I.S., Baum, A.S., "Research Input for Computer Simulation of Automobile Collisions, Volume IV — Staged Collision Reconstructions", Calspan Report No. ZQ-6057-V-6, HS 805 040, December, 1978.
12. Jones, I.S., "Results of Selected Applications to Actual Highway Accidents of the SMAC Reconstruction Program", SAE Paper No. 741179, Society of Automotive Engineers, 1974.
13. Jones, I.S., "The Application of the SMAC Accident Reconstruction Program to Actual Highway Accidents", Proceedings of the Eighteenth Conference of the American Association of Automotive Medicine, 1974.
14. Vehicle Crush Stiffness Coefficients for Model Years 1970-1984, EDC Lib. Ref. No. 1042, Engineering Dynamics Corporation, Lake Oswego, 1986.
15. Day, T., Hargens, R., "Application and Misapplication of Computer Programs for Accident Reconstruction," SAE Paper No. 890738, Society of Automotive Engineers, March, 1989.
16. Taborek, J.J., "Mechanics of Vehicles", *Machine Design*, The Penton Publishing Co., Cleveland, 1957.
17. Baker, J.S., *Traffic Accident Investigation Manual*, The Traffic Institute, Northwestern University, Evanston, Ill., 1975.
18. Noga, T., Oppenheim, T., "CRASH3 User's Guide and Technical Manual", U.S. DOT, Washington, D.C., January, 1981.
19. Hargens, R.H., Day, T.D., "Data Sources for Accident Reconstruction," SAE Paper No. 880068, Society of Automotive Engineers, February, 1988.
20. Day, T.D., Siddall, D.E., "Validation of Several Reconstruction and Simulation Models in the HVE 3-D Environment," SAE Paper No. 960891, Society of Automotive Engineers, February, 1996.

21. Hull, W.C., Newton, B.C., "Estimating Crush Stiffness When Reconstructing Vehicle Accidents," SAE Paper No. 930898, Society of Automotive Engineers, February, 1993. 21a. Neptune, J.A., Flynn, J.E., "A Method for Determining Accident Specific Crush Stiffness Coefficients," SAE Paper No. 940913, Society of Automotive Engineers, February, 1994. *(The original manual numbers this entry "21" as well — a duplicate; the numbering below follows the original.)*
22. *EDC Technical Newsletter, Technical Session*, Engineering Dynamics Corporation, Beaverton, OR, December, 1997.
23. Day, T., "An Overview of the EDSMAC Collision Simulation Model," SAE Paper No. 1999-01-0102, Society of Automotive Engineers, Warrendale, PA 1999.
24. Day, T., "An Overview of the HVE Developer's Toolkit," SAE Paper No. 940923, Society of Automotive Engineers, February, 1994.

Previous: Chapter 6 — Messages | Back to Contents

Chapter 8 — Index

The original printed manual concluded with an alphabetical index keyed to page numbers. Page-number references do not apply to this Markdown edition, which is full-text searchable; the index is therefore replaced by the following topic-to-chapter guide.

Topic	Where to look
Accident History report	Ch. 3 — Alpha-Numeric Reports; Ch. 5 — Viewing Results
Assumptions (rollover, tire forces, homogeneous exterior)	Ch. 4 — Assumptions
Barrier and pole collisions	Ch. 2 — Barrier Collisions
Brake data / Brake table	Ch. 2 — Driver Controls; Ch. 5 — Creating Events
Calculation method (equations of motion, collision and trajectory phases)	Ch. 4
Calculation Options (Vector Spacing, Vector Adjustment Increment, Max Pressure Error, Inter-vehicle Friction, Minimum Velocity for Friction, restitution coefficients)	Ch. 2 — Calculation Options; Calc Options reference
CDC (Collision Deformation Classification)	Ch. 1; Ch. 3 — Damage Data; Ch. 6 — Messages
Damage Data report / Damage Profiles	Ch. 3; Ch. 5
Delta-V, PDOF	Ch. 1 — Overview; Ch. 3 — Damage Data
Driver controls (steer, brake, throttle tables)	Ch. 2 — Driver Controls
Environment (visual and physical data, gravity, surface geometry)	Ch. 2 — Environment
Event creation, set-up and execution	Ch. 2 — Event; Ch. 5 — Creating Events
Fiala tire model, tire friction, cornering stiffness	Ch. 2 — Unsprung Mass; Ch. 4 — Trajectory Phase
Get Surface Information (terrain search options)	Ch. 2 — Get Surface Information; Calc Options reference
Inertias, Move CG, weight	Ch. 2 — Sprung Mass
Max Pressure Error (Vector Force Tolerance)	Ch. 2 — Calculation Options; Ch. 4 — Collision Phase; Ch. 6 — Messages; Calc Options reference
Messages (fatal, diagnostic, informative)	Ch. 6
Program Data report	Ch. 3; Ch. 5
Restitution model	Ch. 4 — Collision Phase; Calc Options reference
RHO vectors (collision vectors)	Ch. 3 — Damage Data; Ch. 4 — Collision Phase
Simulation Controls (timesteps, output interval, termination)	Ch. 2 — Simulation Controls
Stiffness coefficients (Kv)	Ch. 2 — Exterior; Ch. 4 — Collision Phase; Ch. 5 — Editing the Vehicles
Trajectory Simulation / Playback	Ch. 3 — Trajectory Simulation; Ch. 5 — Viewing Results
Tutorial (Visibility Study)	Ch. 5
Variable Output table and variable selection	Ch. 3 — Variable Output Table; Ch. 5 — Variable Output
Vehicle data and parameters	Ch. 2 — Vehicles; Ch. 3 — Vehicle Data

Previous: Chapter 7 — Technical References | Back to Contents